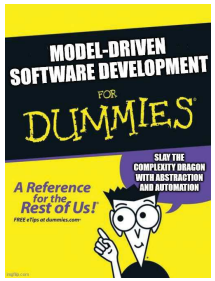
CISC836: Beyond code: An Introduction to Model-Driven Software Development



Topic: EMF

- Meta modeling
- Languages for meta models: Ecore
- Using EMF and Ecore to define a data model
- Using EMF to generate code for data model

⇒ Prep for Xtext

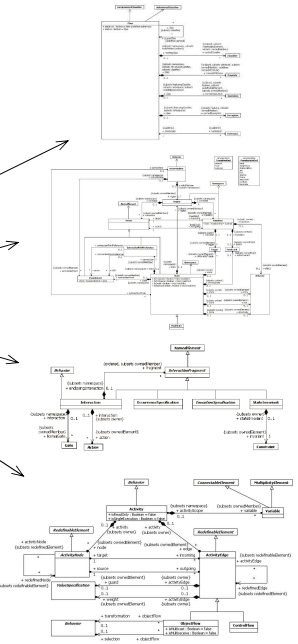
Juergen Dingel
Nov 2021

Metamodeling

Can use concepts from Class models/diagrams to describe structure ("abstract syntax") of modeling concepts in UML:

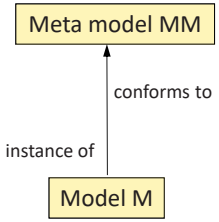
- Classes: Section 11.4.2 in [UML2.5]
- Statemachines: Section 14.2.2
- Interactions: Section 17.2.2
- Activities: Section 15.2.2
- Packages: Section 12.2.2
- Behaviour
- Classification: Classifiers, Features, Properties, Operations

These class models are metamodels, i.e., models describing models



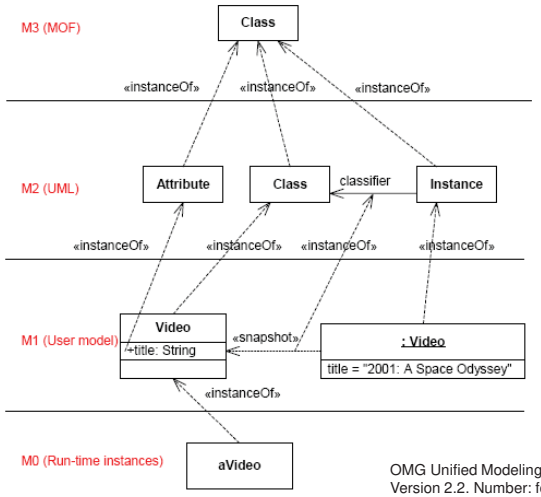
Metamodeling (Cont'd)

- Meta model MM: model (a specification) of a set of models (i.e., a modeling language L(MM))
- Instance M of meta model MM: well-formed model in modeling language L (i.e., M∈L(MM))



- Languages for expressing meta models
  - Meta Object Facility (MOF):
    - OMF standardized language for defining modeling languages
    - subset of UML class diagrams: types (classes, primitive, enumeration), generalization, attributes, associations, operations
  - ECore:
    - Eclipse version of MOF; used by Xtext
  - Object Constraint Language (OCL):
    - declarative language to express well-formedness rules (e.g., *"the inheritance hierarchy is acyclic"*)

Metamodeling (Cont'd)

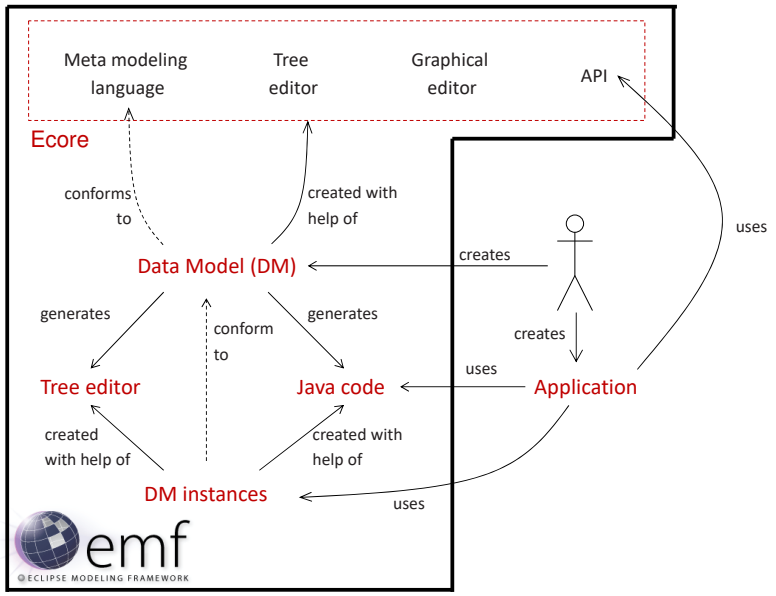


OMG Unified Modeling Language, Infrastructure, Version 2.2. Number: formal/2009-02-04

Figure 7.8 - An example of the four-layer metamodel hierarchy

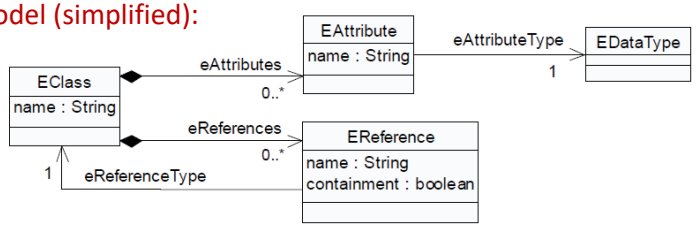
Eclipse Modeling Framework

- Eclipse-based open-source framework supporting the development of applications requiring a structured data model (DM)
- Consists of
  - Ecore
    - Meta modelling language for the description of DMs with support for
      - change notification (via the Observer design pattern),
      - persistence (via XMI serialization), and
      - generic object manipulation (via reflective API)
  - EMF.Codegen
    - Generates code implementing the DM and supporting the development of tools creating and manipulating data model instances:
      - Model: Java interfaces and implementation of DM (using Factory design pattern)
      - Editor: plugin for tree-based editor of DM instances
      - Edit: implementation classes adapting DM classes for editing and display (via Adapter Factory design pattern)
  - Large user community: http://www.eclipse.org/emf

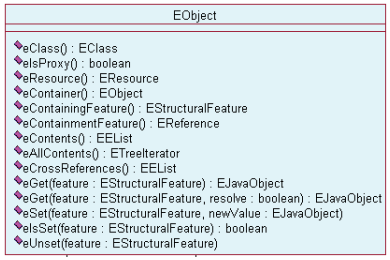


Ecore: Metamodeling Language

- Metamodel (simplified):



- EObject
  - Base of every Ecore class and every generated class
  - Provides support for notification and persistence



[Summary of package org.eclipse.emf.ecore]

[Steinberg, Budinsky, Paternostro, Merks. EMF: Eclipse Modeling Framework (2nd Ed.). 2008]

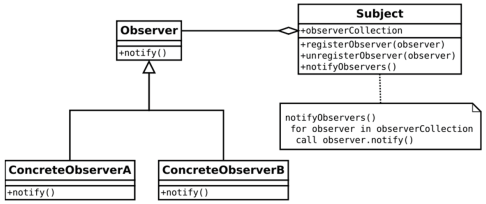
EMF: Supporting Technology

- Eclipse
  - Editors are Eclipse plugins
- Sirius
  - Framework for automatic generation of graphical editors
- JUnit
  - Supported by generated test code
- Design patterns
  - Observer
  - Factory
  - Adapter Factory

Observer Design Pattern

Object, called **subject**, maintains list of its dependents, called **observers**, and notifies them automatically of any state changes, usually by calling one of their methods.

Used for MVC pattern.




```
import java.util.Observable;
import static java.lang.System.out;

class MyApp {
    public static void main(String[] args) {
        out.println("Enter Text >");
        EventSource eventSource = new EventSource();

        eventSource.addObserver((Observable obj, Object arg) -> {
            out.println("\nReceived response: " + arg);
        });

        new Thread(eventSource).start();
    }
}
```

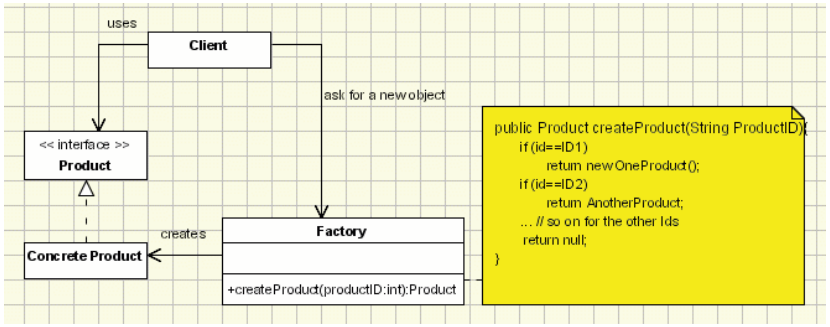
```
import java.util.Observable;
import java.util.Scanner;

class EventSource extends Observable implements Runnable {
    public void run() {
        while (true) {
            String response = new Scanner(System.in).next();
            setChanged();
            notifyObservers(response);
        }
    }
}
```

[Wikipedia. Observer pattern. https://en.wikipedia.org/wiki/Observer_pattern. 2016]

Factory Design Pattern

Object, called the **Factory**, encapsulates details of creation of different **Products**



[OODesign.com. Factory pattern. http://www.oodesign.com/factory-pattern.html. 2016]

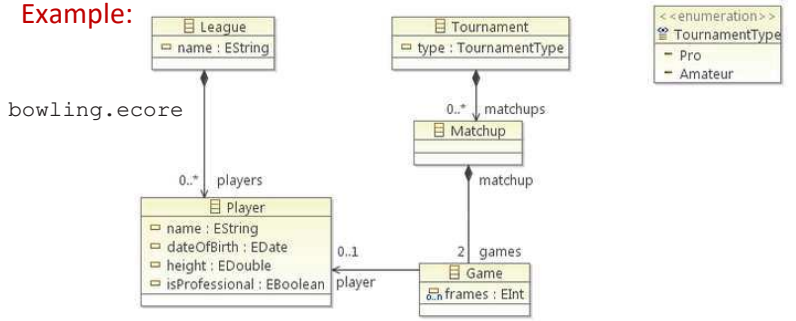
Using EMF: Getting Started

- Download and installation
  - http://www.eclipse.org/modeling/emf
- Documentation
  - http://www.eclipse.org/modeling/emf/docs/
- Tutorials
  - http://www.vogella.com/tutorials/EclipseEMF/article.html
  - http://eclipsesource.com/blogs/tutorials/emf-tutorial/
  - http://www.philmann-dark.de/EMFDocs/tutorial.html

Using EMF: Create Domain Model (DM)

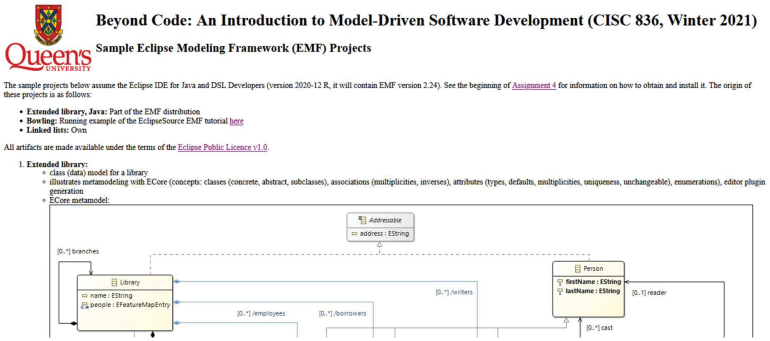
http://eclipsesource.com/blogs/tutorials/emf-tutorial/

- Example:



- Root classes: `League`, `Tournament`
- Containment relationship b/w `Matchup` and `Game` is bi-directional
  - "Containment = true" for reference `games`
  - **`matchup`** is opposite of **`games`**:
    for all **`m:Matchup,`** if **`g:Game`** in **`m.games, then g.matchup == m`**

EMF Sample Models



Beyond Code: An Introduction to Model-Driven Software Development (CISC 836, Winter 2021)

Sample Eclipse Modeling Framework (EMF) Projects

The sample projects below assume the Eclipse IDE for Java and DSL Developers (version 2020-12 R, it will contain EMF version 2.24). See the beginning of Assignment 4 for information on how to obtain and install it. The origin of these projects is as follows:

- **Extended library, Java:** Part of the EMF distribution
- **Bowling:** Running example of the EclipseSource EMF tutorial here
- **Linked lists:** Own

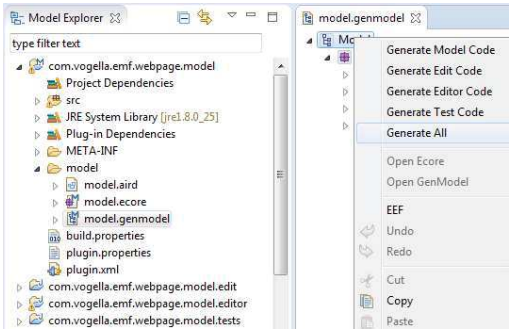
All artifacts are made available under the terms of the Eclipse Public Licence v1.0.

1. **Extended library:**
   - class (data) model for a library
   - illustrates metamodeling with ECore (concepts: classes (concrete, abstract, subclasses), associations (multiplicities, inverses), attributes (types, defaults, multiplicities, uniqueness, unchangeable), enumerations), editor plugin generation
   - ECore metamodel:

EMF Sample Models

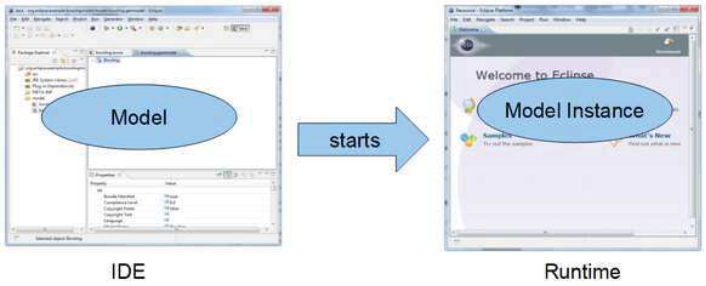
Using EMF: Generate Code from DM

- Genmodel
  - Generated from .ecore model
  - Contains additional info necessary for code generation (package names, source paths, project names, generator settings)
  - Automatically synchronized with .ecore model when .ecore model is saved
- To generate:
  - Open .genmodel
  - right-click root node
  - select plugin to generate

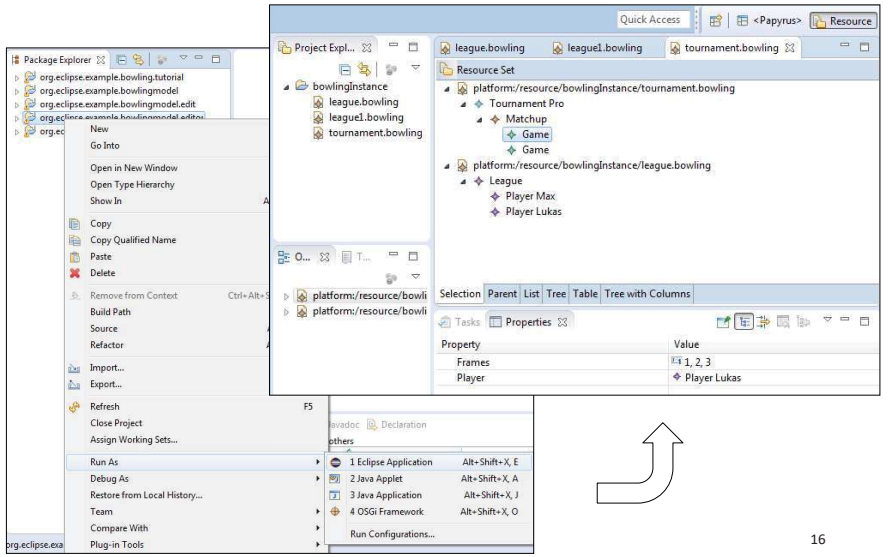


Using EMF: Use Generated DM Editor

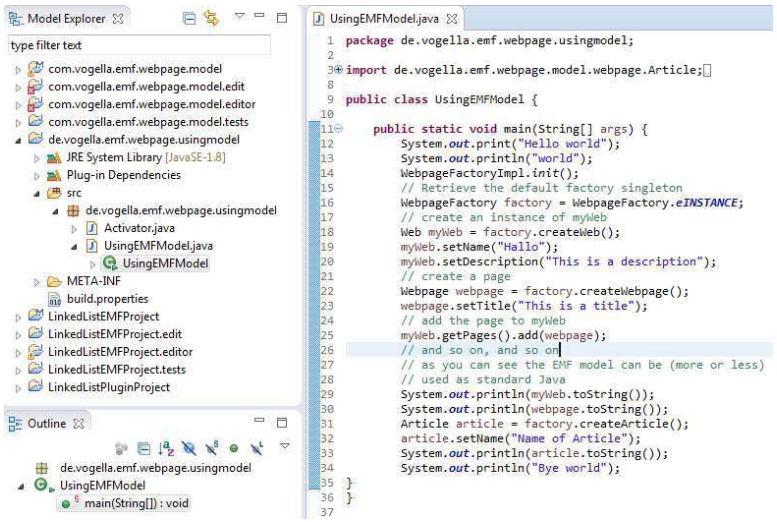
- Code for DM editor generated as Eclipse plugin
- Invocation of the editor will create another instance of Eclipse in which the editor will execute



Using EMF: Use Generated DM Editor (Cont'd)



Using EMF: Use Generated DM Java Code



Using EMF: Demo

- Using generated test code
- Generating JavaDoc
- Generating method bodies

EMF: Pros and Cons

- Pros
  - Quite powerful, stable, adequate documentation
  - Integral part of Eclipse Modeling ecosystem:
    - EMF Forms: for generation of form-based UI
    - Xtext: for DSL implementation
    - ATL: for model-to-model transformation
- Cons
  - Inherit Eclipse “baggage”

EMF: More Info

- Installation
  - http://www.eclipse.org/modeling/emf
- Documentation
  - http://www.eclipse.org/modeling/emf/docs/?
- Tutorials
  - http://eclipsesource.com/blogs/tutorials/emf-tutorial/
  - http://www.vogella.com/tutorials/EclipseEMF/article.html
  - http://www.philmann-dark.de/EMFDocs/tutorial.html
- Book
  - Steinberg, Budinsky, Paternostro, Merks. EMF: Eclipse Modeling Framework (2nd Ed.). Addison-Wesley Professional. 2008.