Model-Based Software Engineering

Lecture 05 – Concrete Syntax

Prof. Dr. Joel Greenyer

May 3, 2016

Acknowledgment

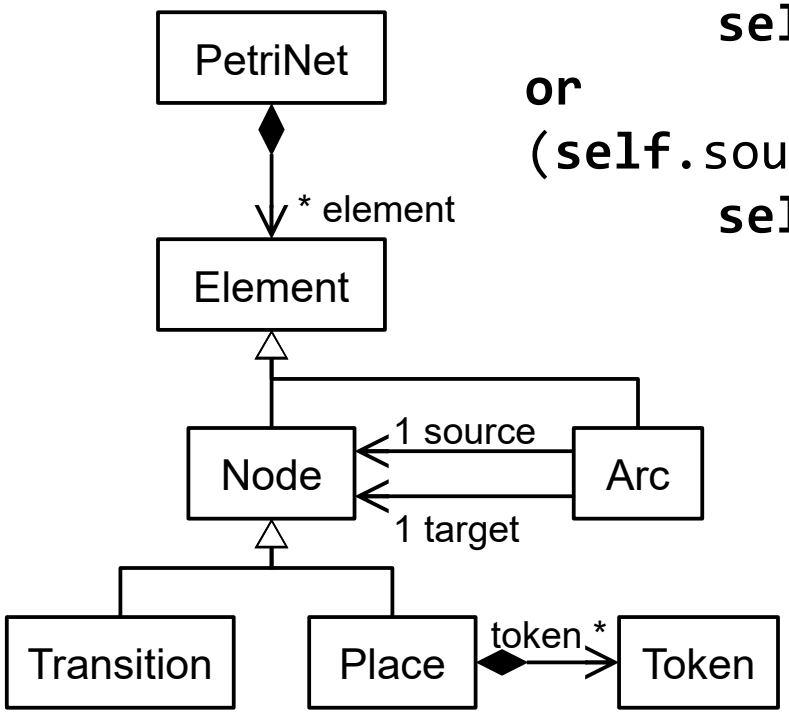
- The slides of this lecture are inspired by lecture slides from
  - *Ekkart Kindler*: Course on Advanced Topics in Software Engineering, DTU Compute, 2015.
    - http://www2.imm.dtu.dk/courses/02265/f15/schedule.shtml
  - *Ina Schäfer, Christoph Seidl*: Modellbasierte Software-entwicklung, TU Braunschweig, 2015.
  - *Steffen Becker*: Model-Driven Software Development, Universität Paderborn, 2013
  - The Eclipse Open Model CourseWare (OMCW) Project:
    - https://eclipse.org/gmt/omcw/

OCL – Example

in the last lecture...

- Invariant constraint written in the **Object Constraint Language (OCL):**

```
context Arc
inv “No Arcs Between Nodes Of The Same Kind”:
((self.source.oclIsKindOf(Place) and
        self.target.oclIsKindOf(Transition))
or
(self.source.oclIsKindOf(Transition) and
        self.target.oclIsKindOf(Place) ) );
```



OCLinEcore Editor
Example: Company

in the last lecture...

company.ecore

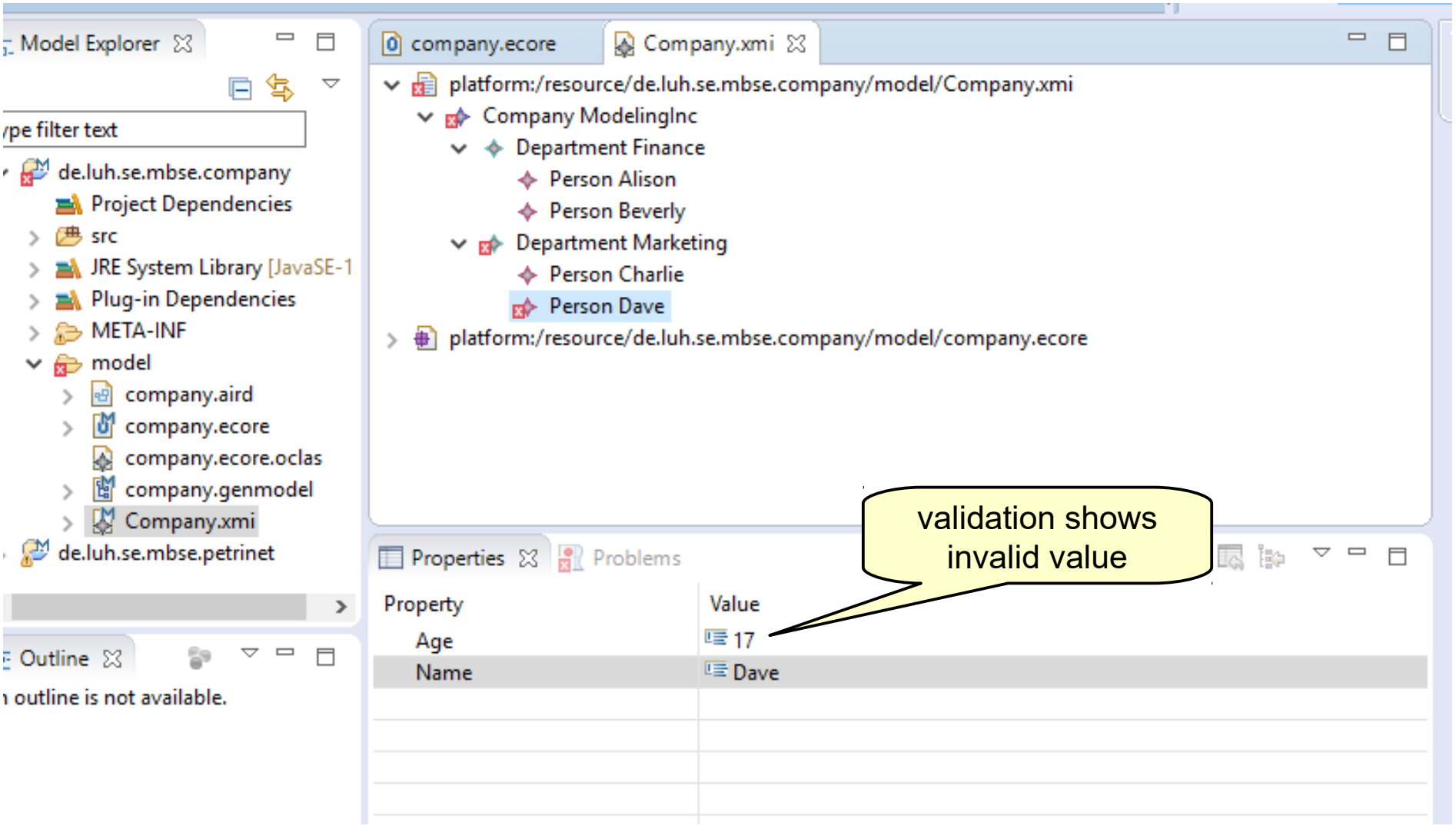
```
1  import ecore : 'http://www.eclipse.org/emf/2002/Ecore' ;
2
3  package company : company = 'http://www.example.org/company'
4  {
5      class Company extends NamedElement
6      {
7          property department : Department[*] { ordered composes };
8      }
9      class Department extends NamedElement
10     {
11         property employee : Person[*] { ordered composes };
12         attribute ageSumOfEmployees : ecore::EInt[?] { derived readonly transient volatile }
13         {
14             initial: self.employee->iterate(p; sum:Integer = 0 | sum + p.age);
15         }
16     }
17     class NamedElement
18     {
19         attribute name : String[?];
20     }
21     class Person extends NamedElement
22     {
23         attribute age : ecore::EInt[?];
24         invariant AllEmployeesMustBeAdults: self.age >= 18;
25     }
26 }
```

derived attribute

invariant

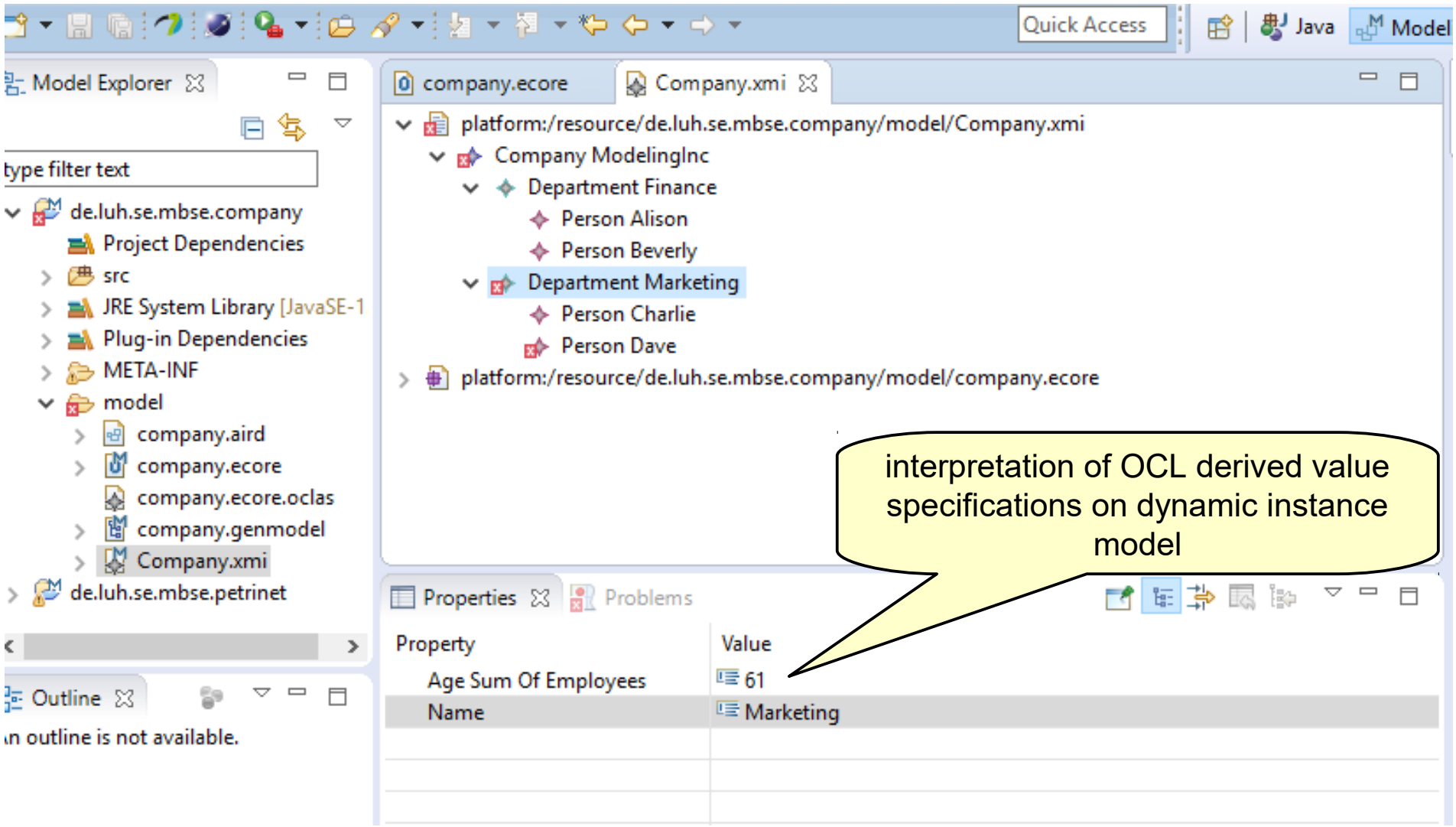
OCLinEcore Editor Example: Company

in the last lecture...



OCLinEcore Editor Example: Company

in the last lecture...



Model-Based Software Engineering

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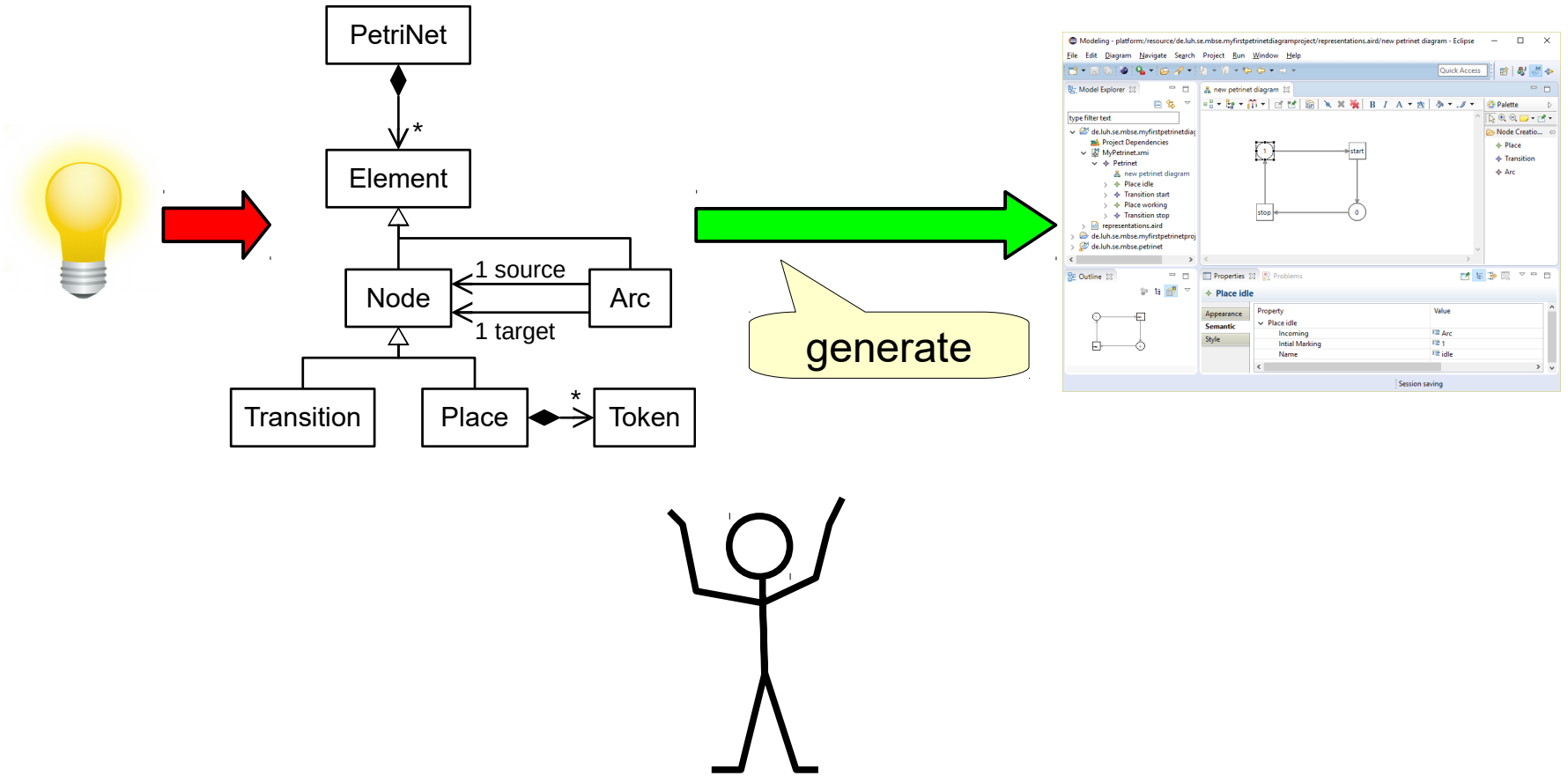
Build a Petri Net Modeling Tool

in a previous lecture...

- Model-based approach for building modeling tools: Provide only a few conceptual models and generate tool automatically



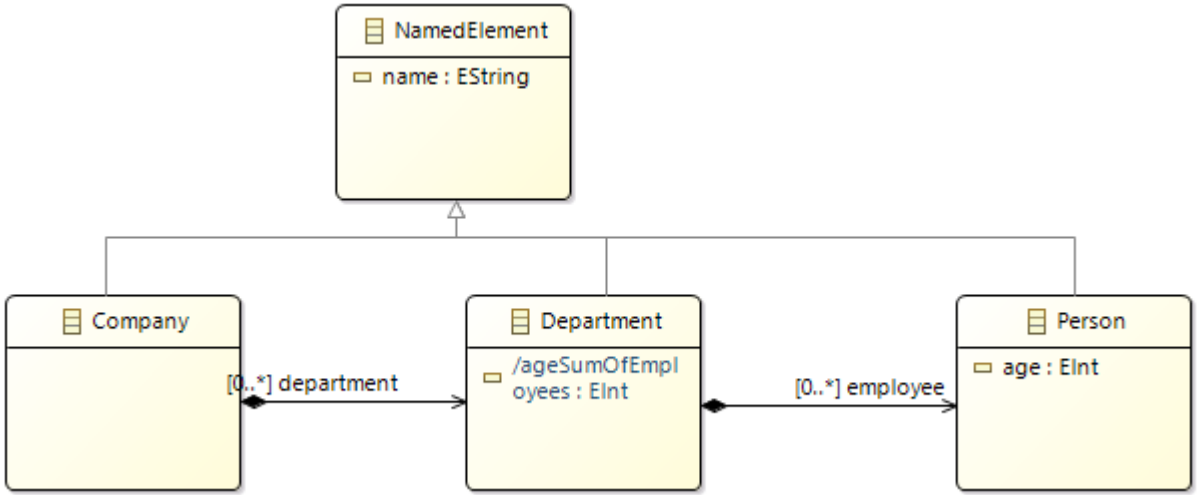
Concrete Syntax: Textual or Graphical

- Example: textual vs. graphical syntax for Ecore

```
package company : company = 'http://www.example.org/company'{
    class Company extends NamedElement{
        property department : Department[*] { ordered composes };
    }
    class Department extends NamedElement{
        property employee : Person[*] { ordered composes };
    }
    class NamedElement{
        attribute name : String[?];
    }
    class Person extends NamedElement{
        attribute age : ecore::EInt[?];
    }
}
```

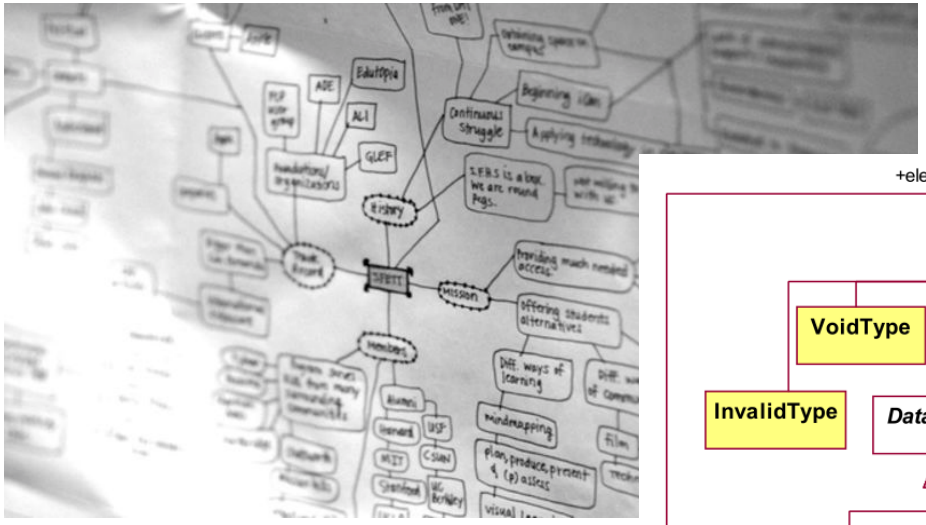
textual Ecore class model syntax

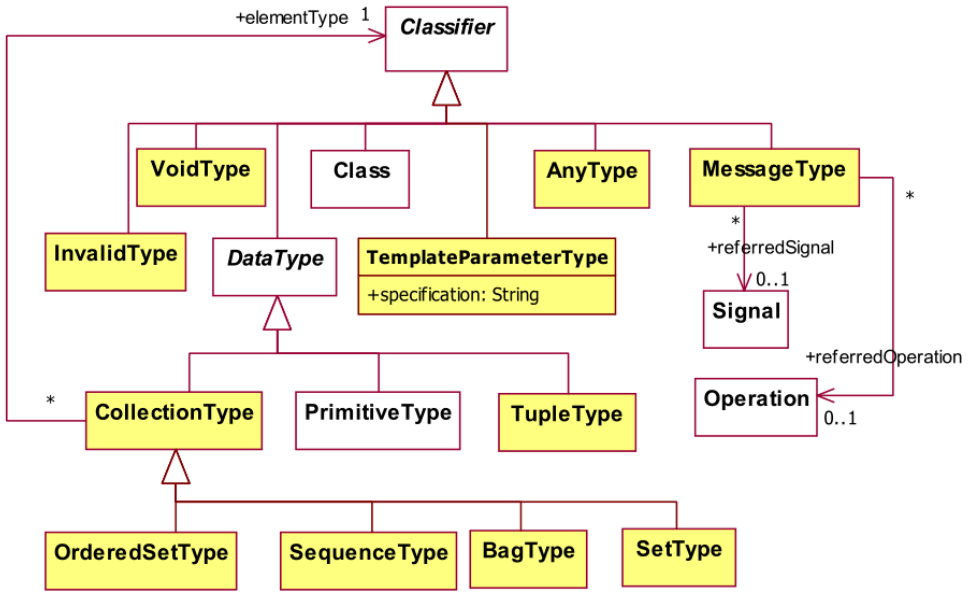
graphical Ecore class model ("class diagram") syntax



Textual vs. Graphical Syntax

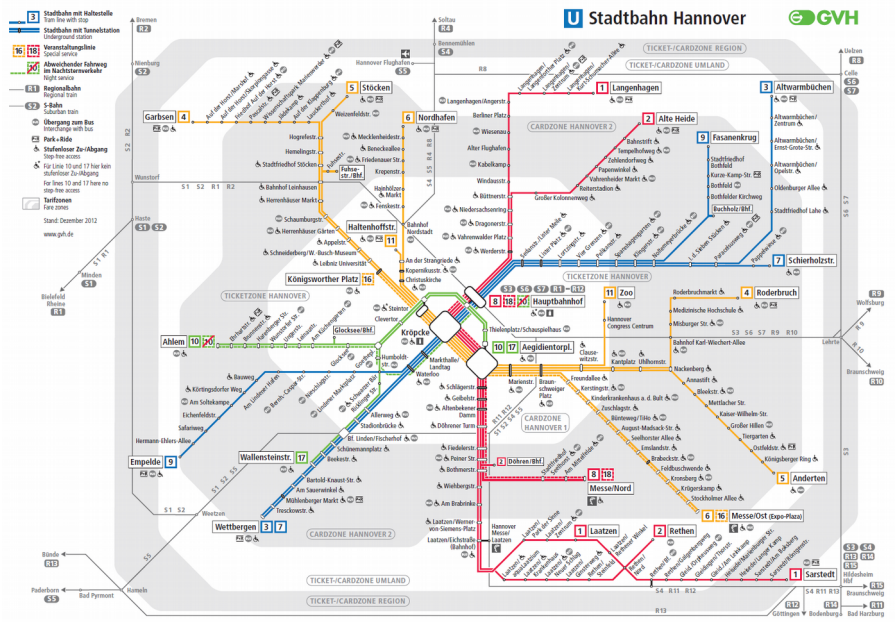
- **Benefits** of **graphical** syntax (vs. textual syntax):
  - **Objects-and-relationships concepts** (graphs) are easier understand when displayed graphically
    - mind maps, organigrams, class diagrams, etc.

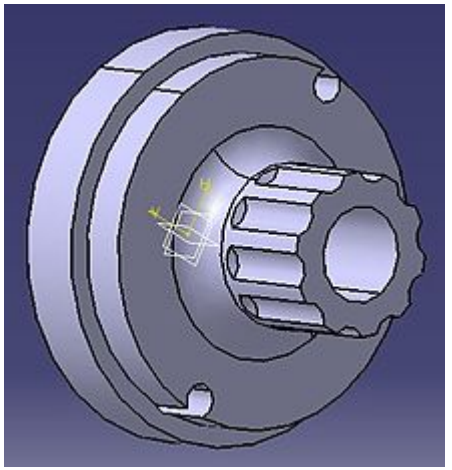




Textual vs. Graphical Syntax

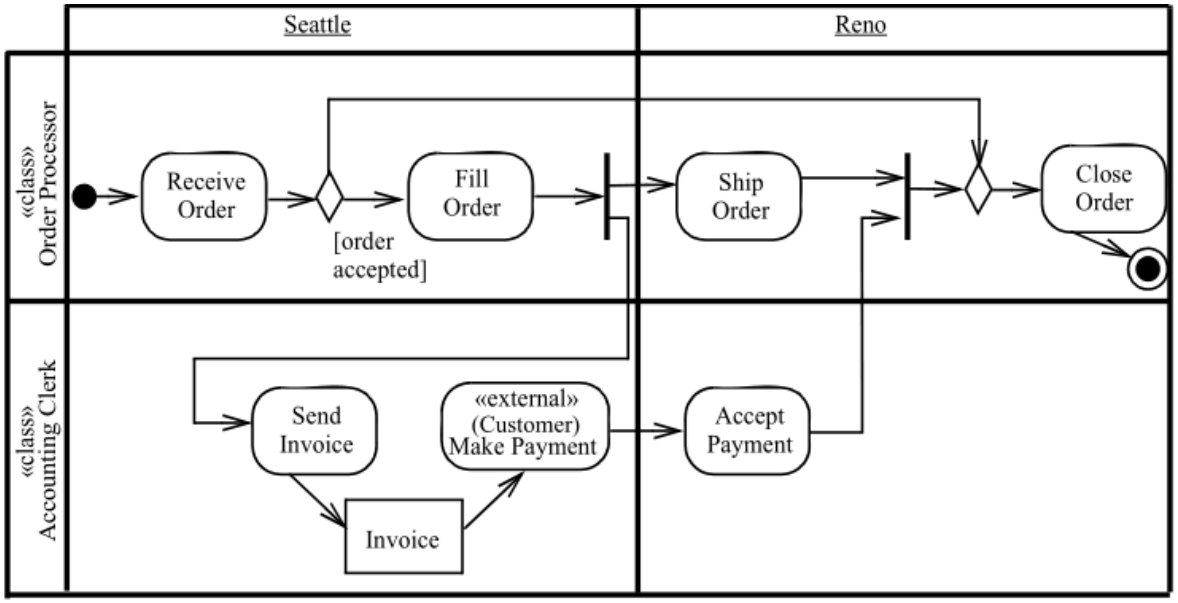
- **Advantages** of **graphical** syntax (vs. textual syntax):
  - Models that capture **spatial aspects** are best understood graphically
    - (street) maps, floor plans, fire escape route plans
    - even 3D syntax, for example for CAD





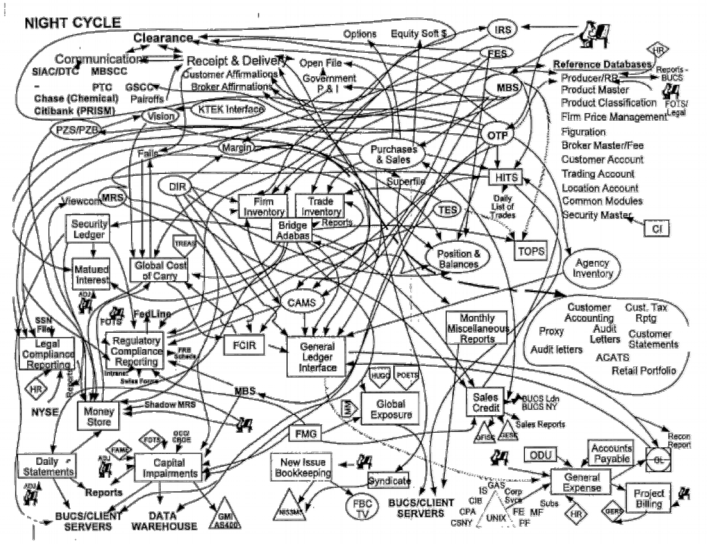
Textual vs. Graphical Syntax

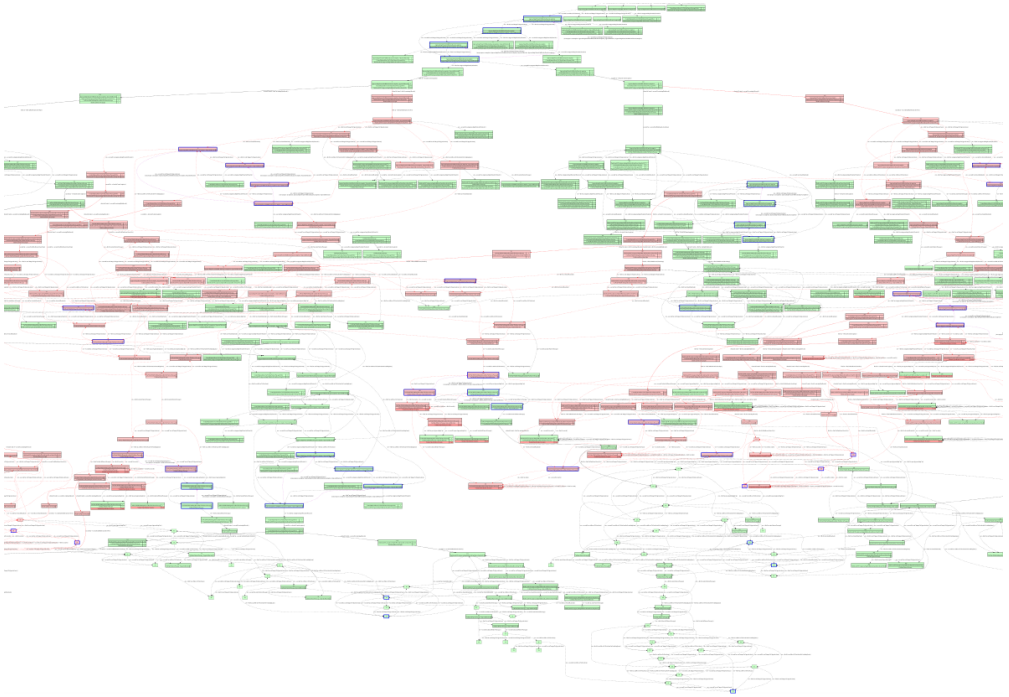
- **Advantages** of **graphical** syntax (vs. textual syntax):
  - use of **colors or shapes** to highlight different concepts
  - use of **two** dimensions to express different aspects
    - example: UML Activity Diagram with multidimensional swimlanes



Textual vs. Graphical Syntax

- **Advantages** of **graphical** syntax (vs. textual syntax):
  - may become **confusing** for displaying **large models**
  - it may become **hard to maintain a nice layout**
    - there exist automatic layout algorithms, but often they do not yield the desired result





Textual vs. Graphical Syntax

- **Advantages** of **graphical** syntax (vs. textual syntax):
  - **graphical editors** usually take more effort to build
  - especially, good **usability** for **graphical editors** is more challenging to achieve
    - for example: editing graphical elements with text often requires switching between mouse and keyboard
  - also, **graphical editors** may not have good **performance**
    - when editing, loading/saving
  - versioning (diff/merge) is more difficult for graphical models

- Do you see other advantages/disadvantages?

Textual vs. Graphical Syntax

- **Advantages** of **textual** syntax (vs. graphical syntax):
  - easy cut/copy/paste
  - easy versioning (diff/merge)
  - clear information flow (reading direction)
  - fast editing “straight on typing”
- **Disadvantages** of **textual** syntax (vs. graphical syntax):
  - complex dependencies are not easy to see (because of indirect references)

```
class Department extends NamedElement{
    property employee : Person[*] { ordered composes };
}
...
class Person extends NamedElement{
    attribute age : ecore::EInt[?];
}
```

SOFTWARE ENGINEERING

4.1. Graphical syntax

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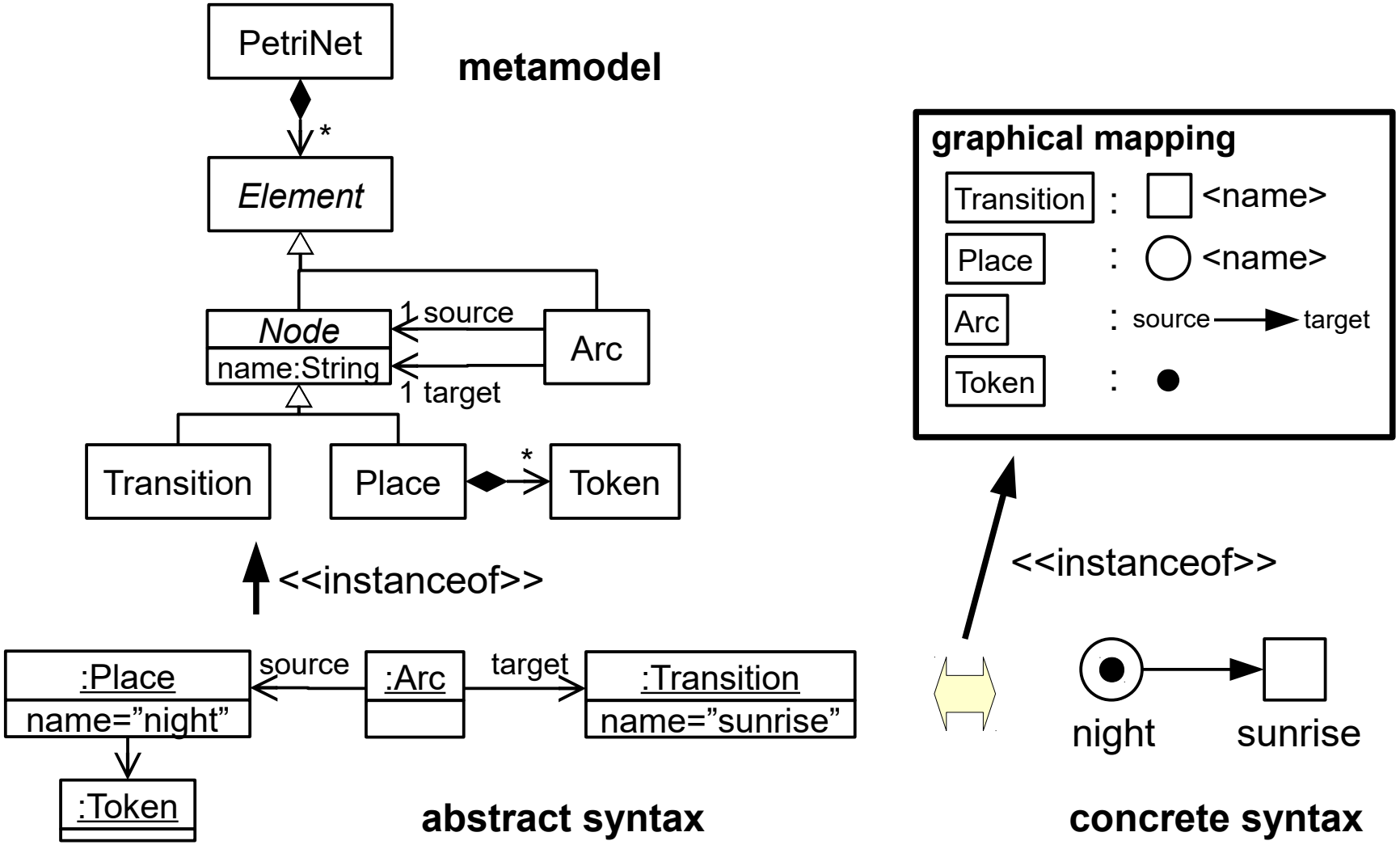
Building a Graphical Language – General Steps

1) Specify a metamodel (that defines the language's abstract syntax)
2) Define how abstract syntax elements should be represented visually
3) Implement or generate the graphical editor

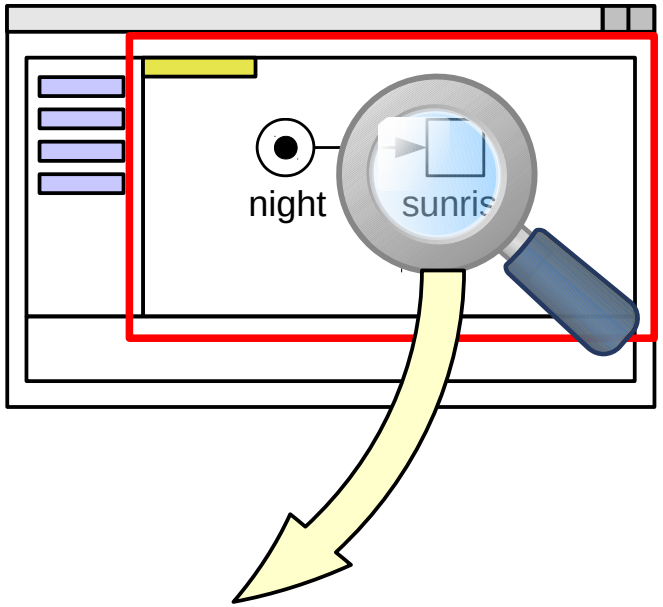
Build a Graphical Petri Net Language

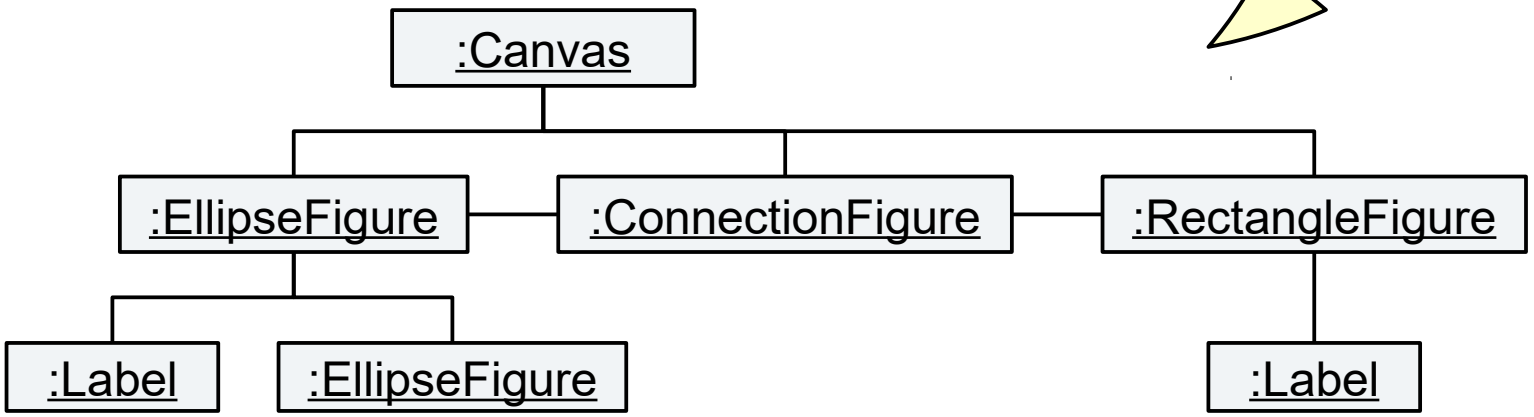
- Metamodel and mapping of abstract to concrete syntax



Implementing a Graphical Editor Manually

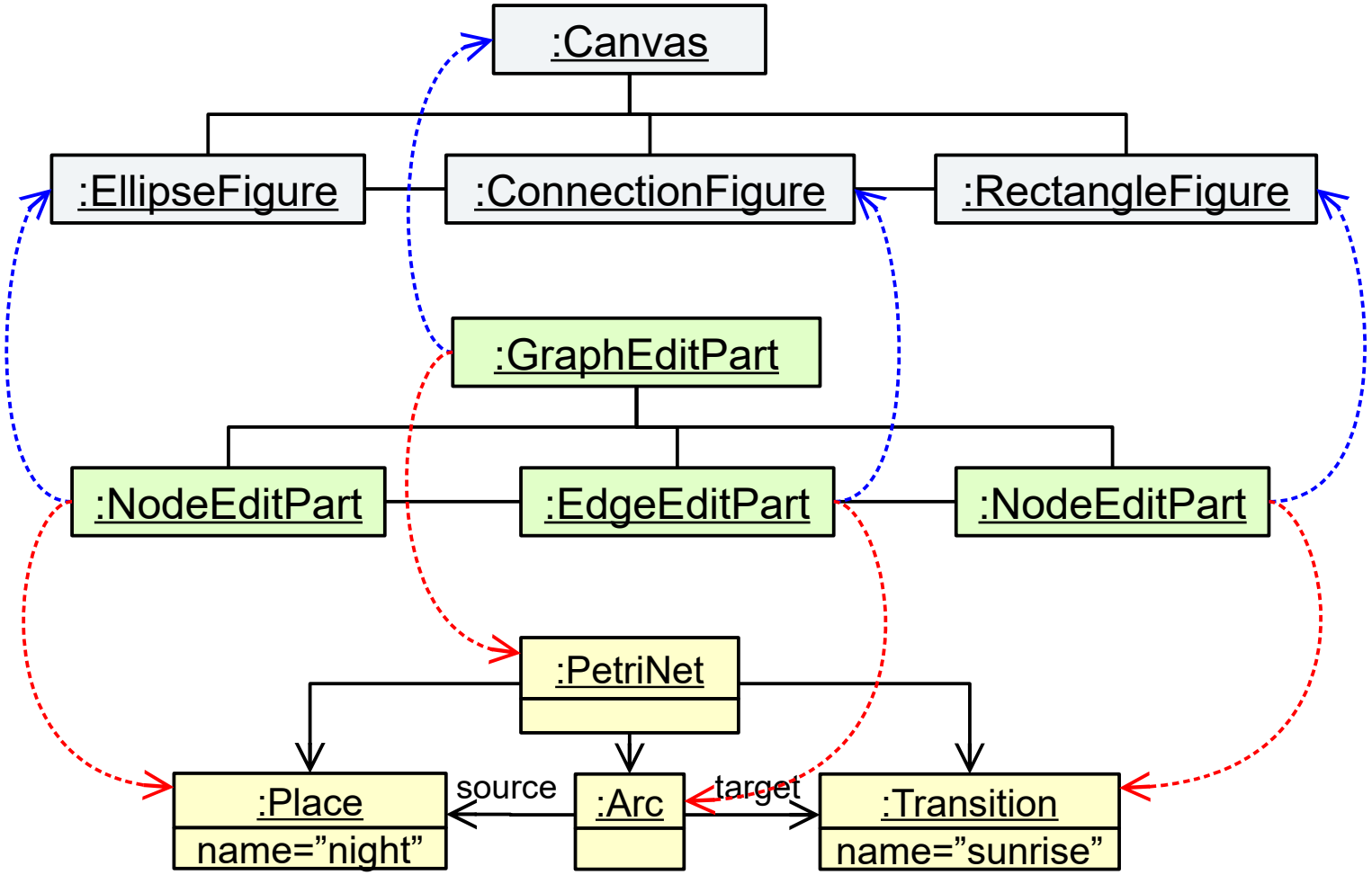
- Implementing the graphics
  - for example using Eclipse GEF (Graphical Editing Framework)





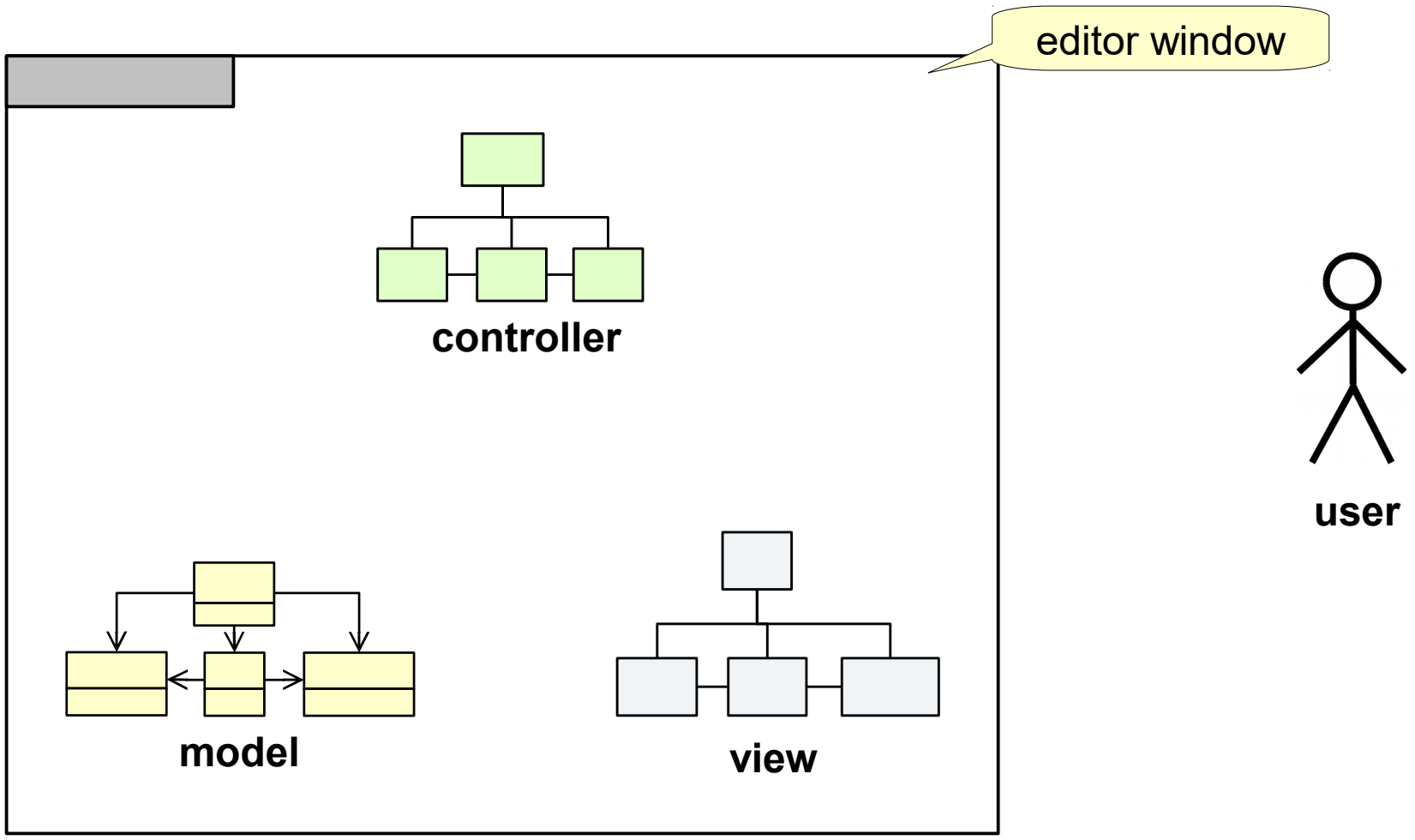
Implementing a Graphical Editor Manually

- How are graphical elements and model elements connected?
  - typically using the **Model-View-Controller (MVC)** pattern



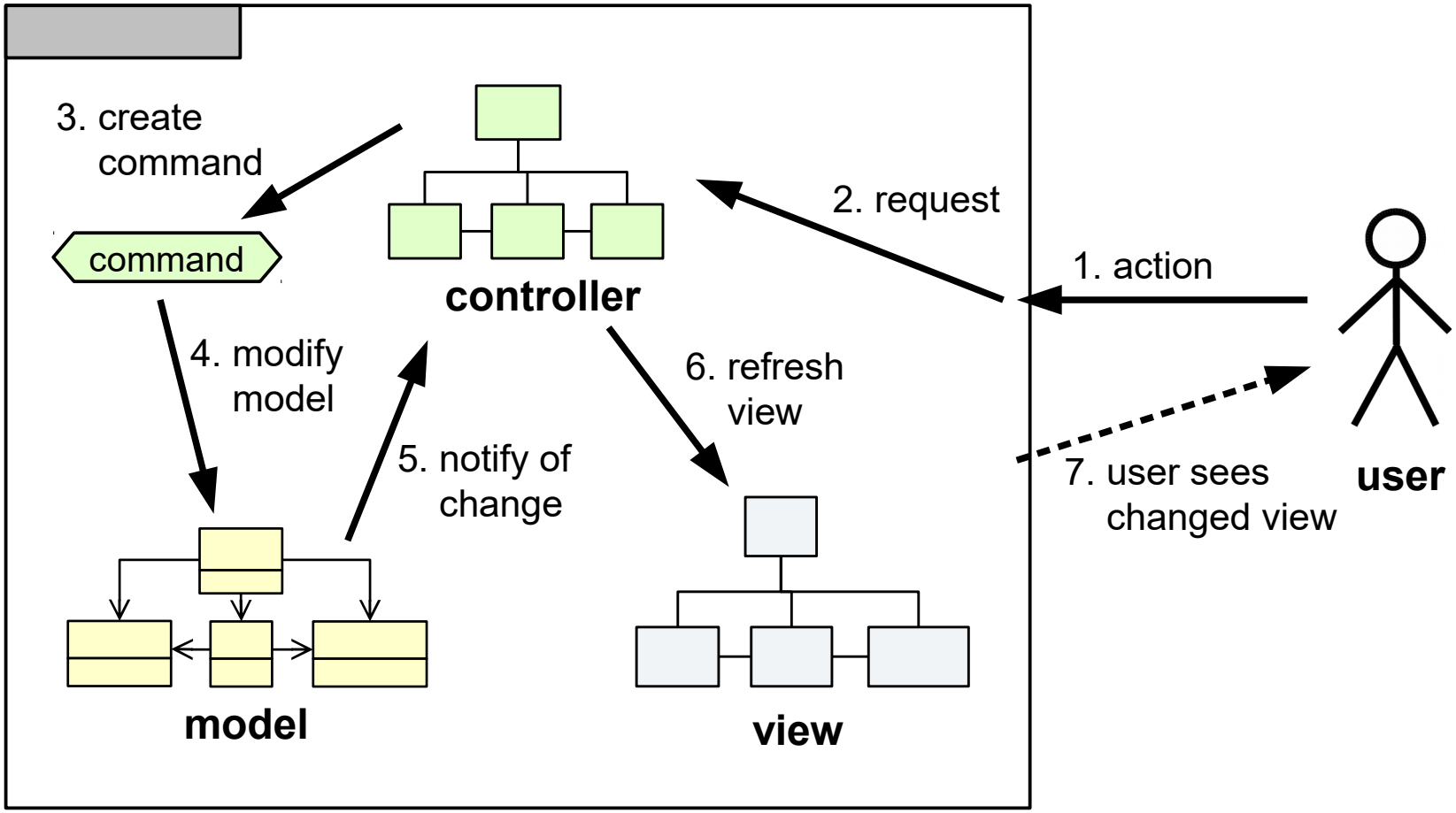
Implementing a Graphical Editor Manually

- MVC pattern as implemented with GEF



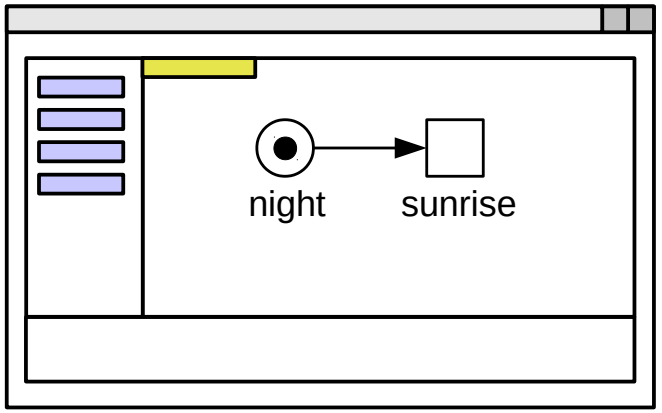
Implementing a Graphical Editor Manually

- MVC pattern as implemented with GEF



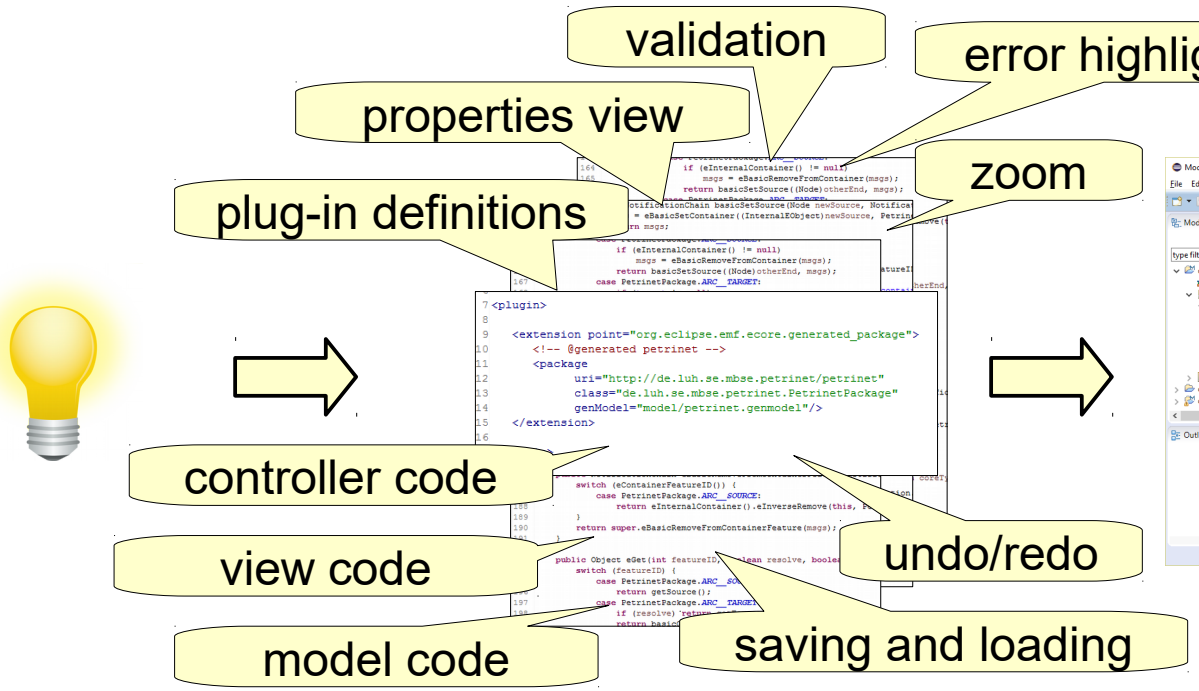
Implementing a Graphical Editor Manually

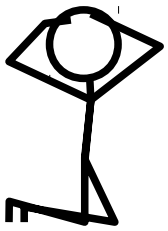
- What else must be implemented?
  - undo/redo logic
  - tool bar
  - zoom
  - grid
  - properties view
  - error highlighting
  - ...



Generating a Graphical Editor Automatically

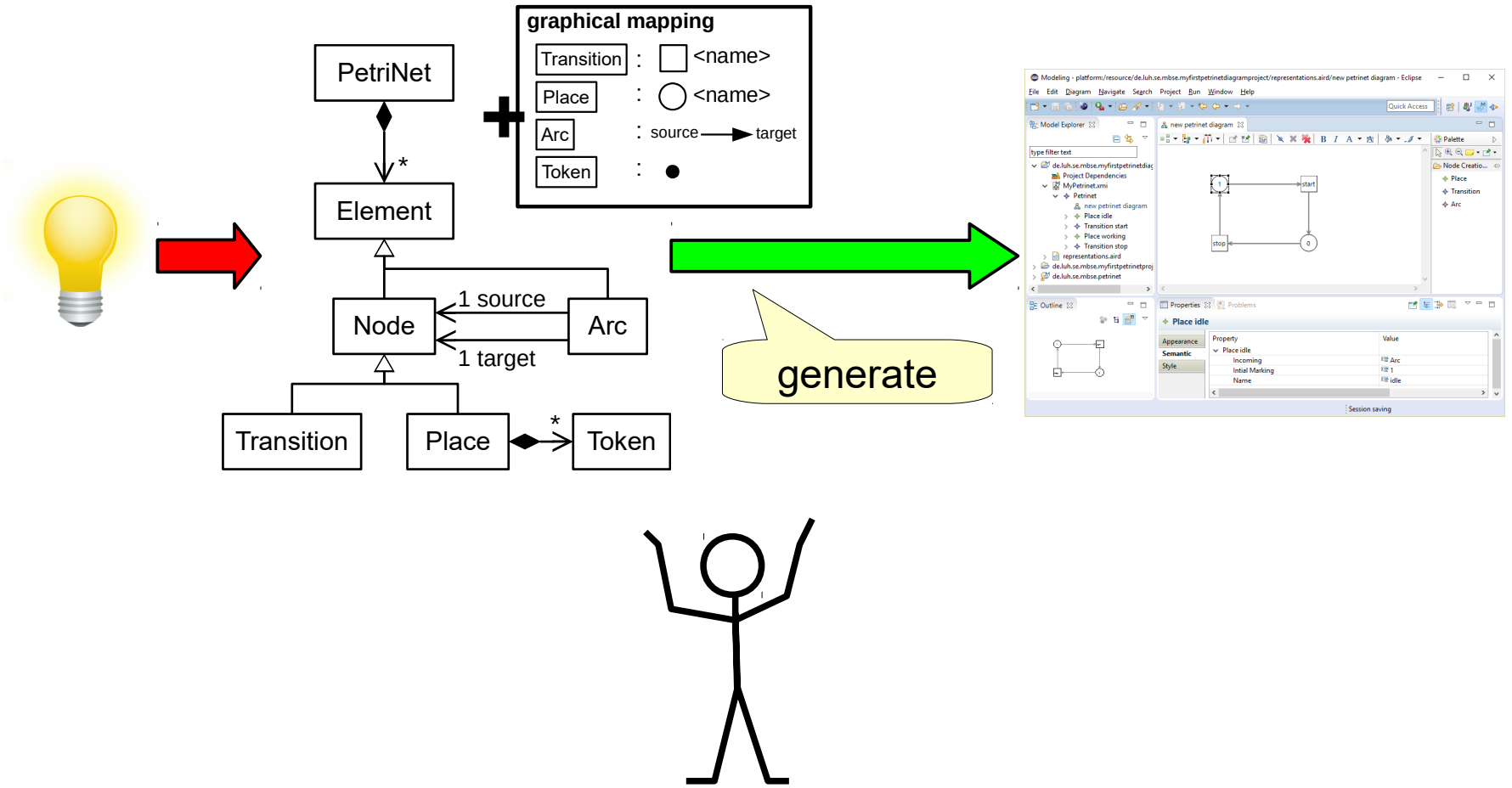
- Instead of doing all the work manually...





Generating a Graphical Editor Automatically

- … we would like to do as much as possible automatically



Eclipse Frameworks for the Automatic Generation/Creation of Graphical Editors

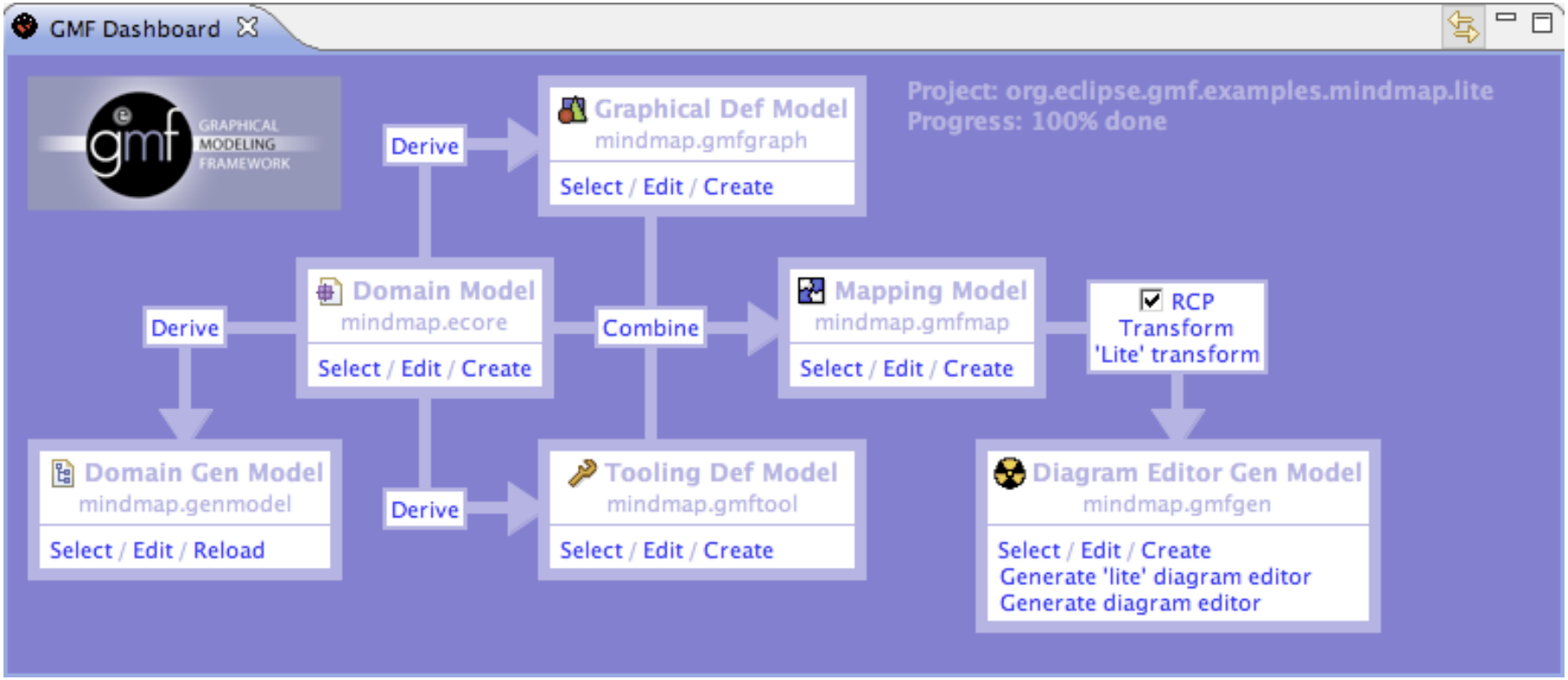
- Graphical Modeling Framework (GMF)

- Graphiti

- Sirius

Graphical Modeling Framework (GMF)

- Model graphical elements, graphical mapping, tools, …
- Then generate editor code from the combined models

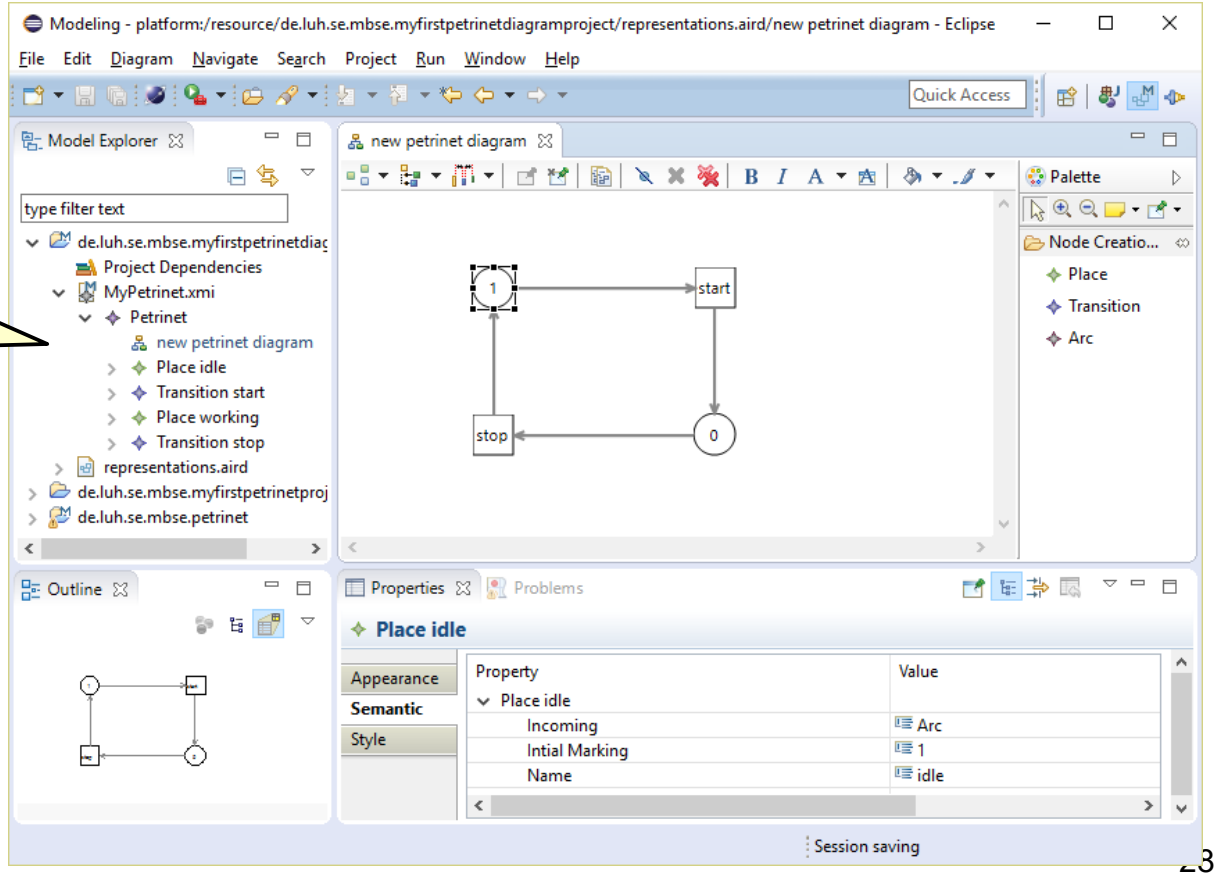


see http://www.eclipse.org/modeling/gmp/
and https://wiki.eclipse.org/Graphical_Modeling_Framework/Tutorial/Part_1

Eclipse Sirius

- Eclipse **Sirius** works by *interpreting* a graphical mapping of the model
  - no code generation required

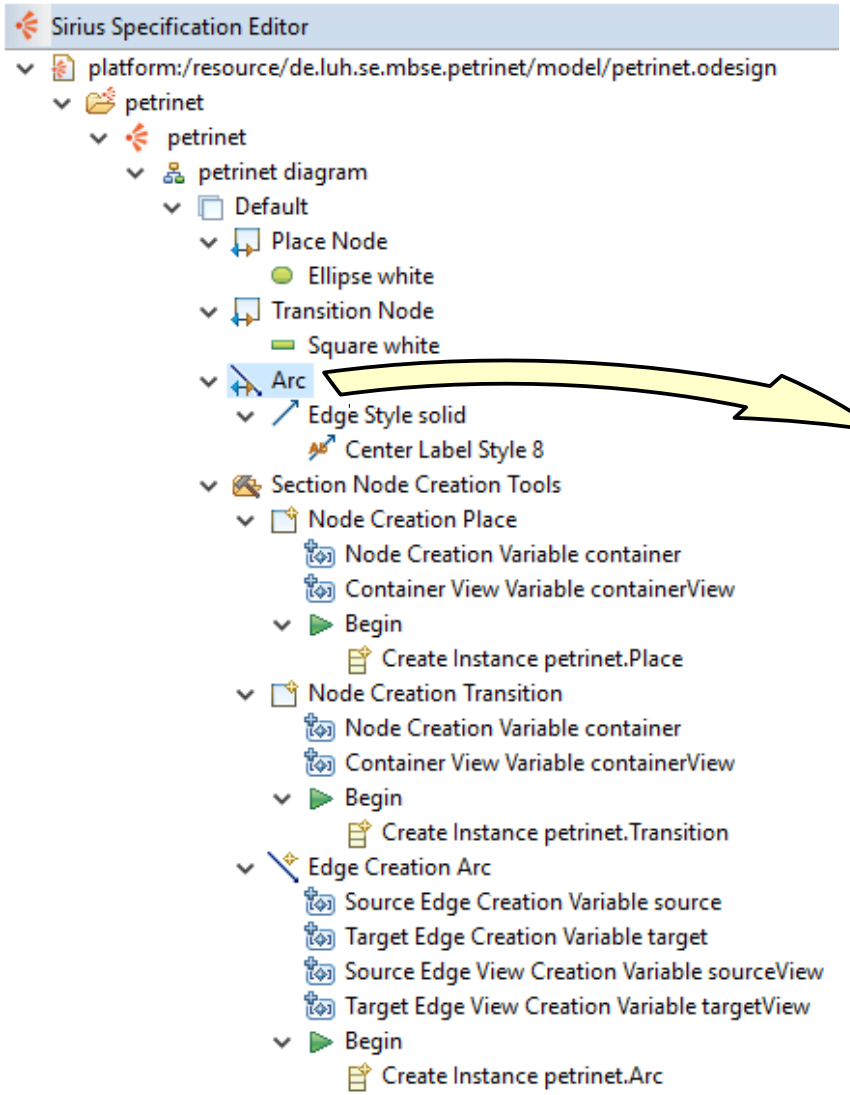
example: Petri net editor created in 15 Minutes!



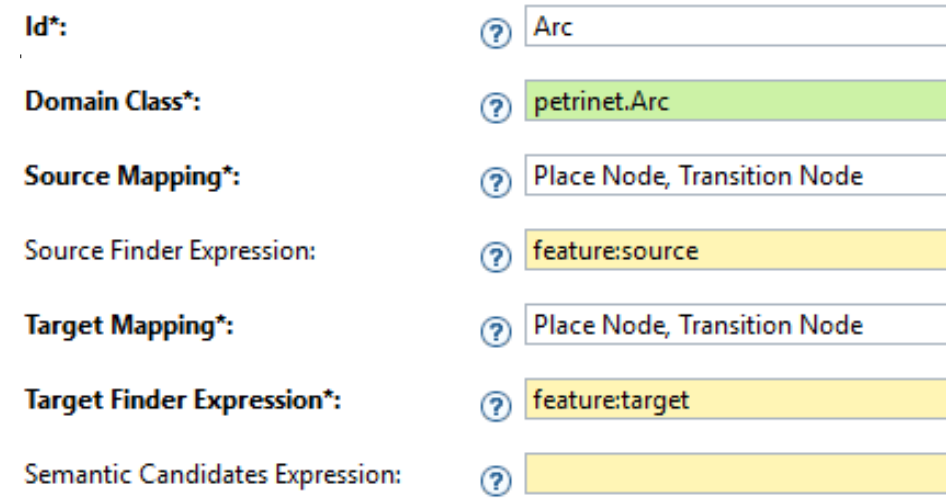
see https://eclipse.org/sirius/
and https://eclipse.org/sirius/getstarted.html

Eclipse Sirius

- Sirius graphical mapping:



defining how an arc connector should connect source and target elements (via its features “source” and “target”)



SOFTWARE ENGINEERING

4.2. Textual syntax

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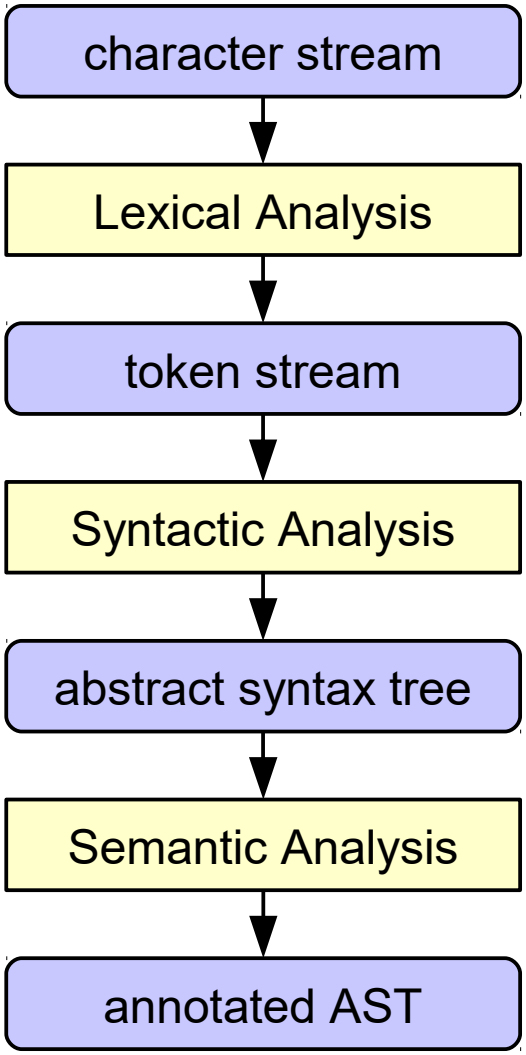
Excursion on Compilers – Syntax Analysis

- Steps in the textual syntax analysis:
  - Lexical Analysis
    - partitions character stream into tokens (removes whitespaces, identifies keywords, identifiers, ...)
  - Syntax Analysis
    - context-free analysis identifies abstract syntax tree (AST) structure
  - Semantic Analysis
    - analyze cross-references of AST elements (variable scoping, type conformance, ...)



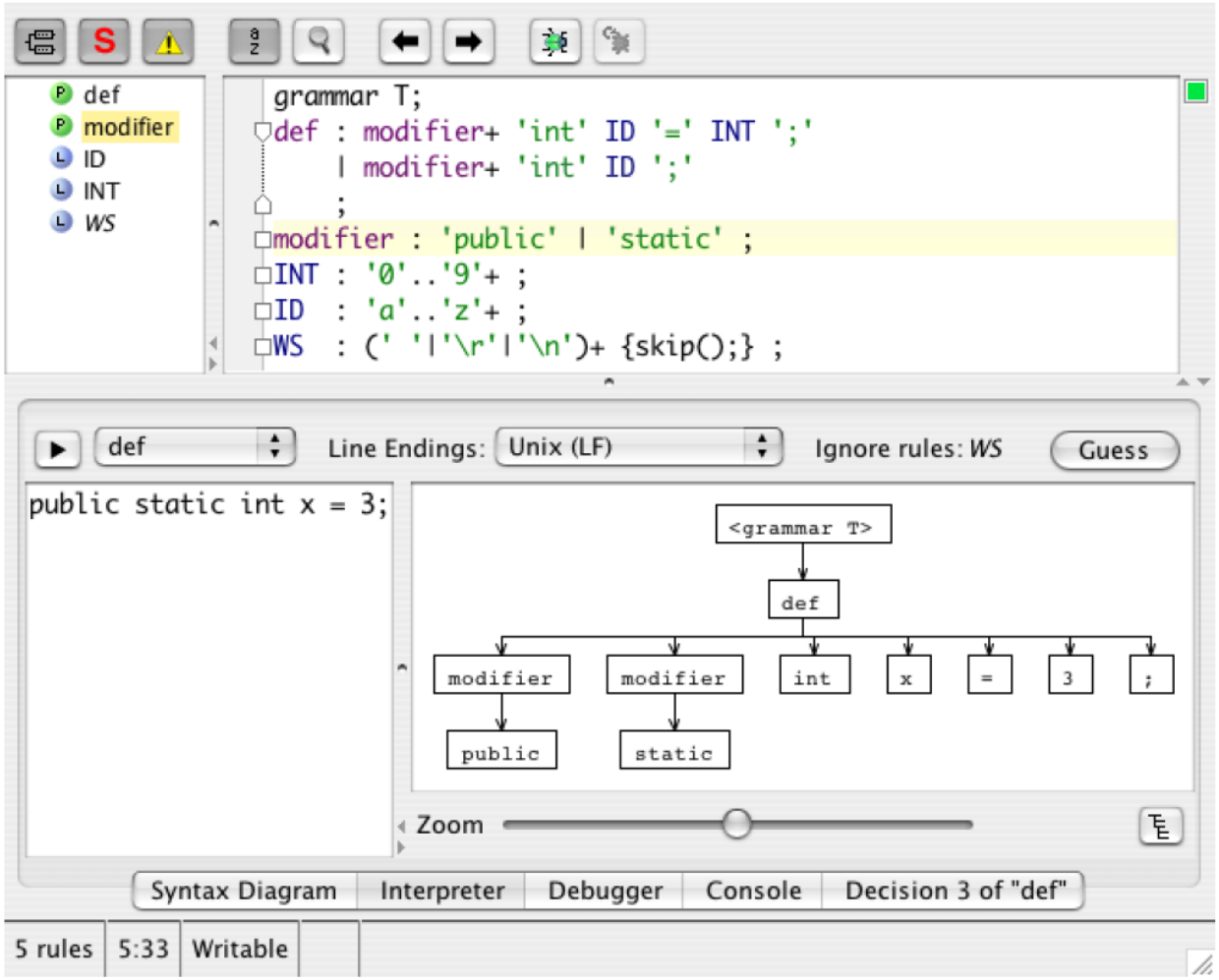
Parser generators – Example: ANTLR

- There exist **frameworks for constructing compilers** that can generate lexer and parser components (and other things) from a language definition in the form of a grammar

- a popular example: **ANTLR**
  - takes as input a context-free grammar in Extended Backus–Naur Form (EBNF)

Parser generators – Example: ANTLR

- ANTLRWorks Interpreter visualizes the result of the syntactic analysis:



see http://www.antlr.org/papers/antlrworks-draft.pdf

Xtext – a Framework for Building Textual Languages in Eclipse

- **Xtext** is a framework for building textual languages and editors within Eclipse (also IntelliJ IDEA and web browser)
- The language is built based on a grammar definition similar to EBNF
  - but with extra features for referencing a corresponding Ecore metamodel
  - Generation of an Ecore metamodel from a grammar is also supported
- Xtext can create the Ecore metamodel, lexer/parser, and editor from the grammar definition
  - The editor supports syntax checking, highlighting, and code completion, renaming/refactoring, and has extensions for implementing quick-fixes, and other functionality

Xtext – Simple Example: Company

```
// automatically generated by Xtext
grammar de.luh.se.mbse.company.cml.CML with org.eclipse.xtext.common.Terminals

import "platform:/resource/de.luh.se.mbse.company/model/company.ecore"
import "http://www.eclipse.org/emf/2002/Ecore" as ecore

Company returns Company:
    {Company}
    'Company'
    name=EString
    '{'
        ('department' '{' department+=Department ( "," department+=Department)* '}' )?
    '}';

EString returns ecore::EString:
    STRING | ID;

Department returns Department:
    {Department}
    'Department'
    name=EString
    '{'
        ('employee' '{' employee+=Person ( "," employee+=Person)* '}' )?
    '}';

Person returns Person:
    {Person}
    'Person'
    name=EString
    '{'
        ('age' age=EInt)?
    '}';

EInt returns ecore::EInt:
    '-'? INT;
```

mycompany.cml

```
Company MyCompany{
    department {
        Department Finance{
            employee{
                Person Alison {age 21},
                Person Beverly {age 34}
            }
        },
        Department Marketing{
            employee{
                Person Charlie {age 43},
                Person Dave {age 39}
            }
        }
    }
}
```