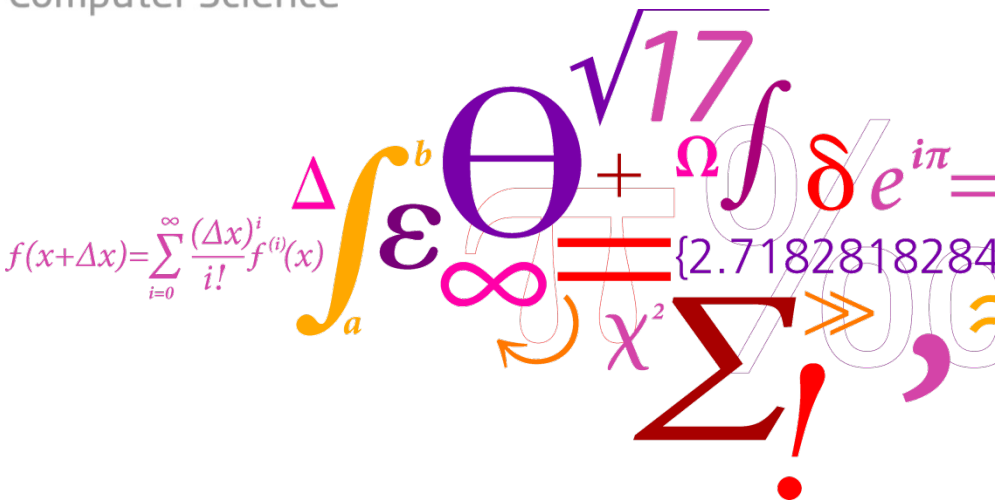
Model-based Software Engineering for/with Petri nets

From models to code

Ekkart Kindler

DTU Compute
Department of Applied Mathematics and Computer Science



Motivation (cf. Vision)

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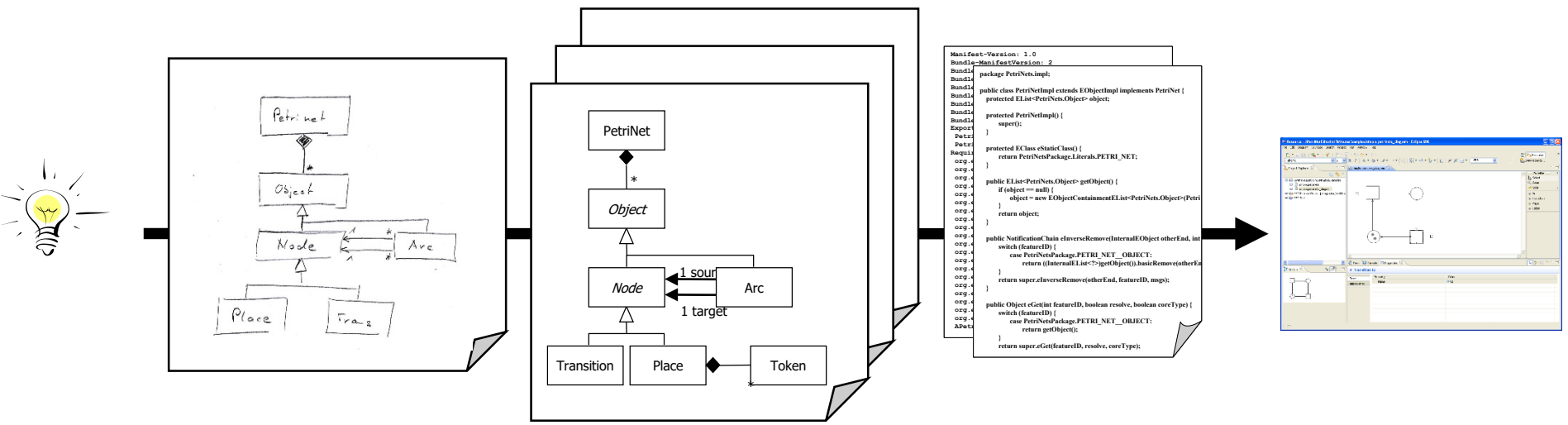

Analysis

Design

Implementation

~~Coding~~

Code is generated

Motivation

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- If we want to get software automatically from models, we need to have a technology for transforming models into code
- Programming this transformation manually is very error prone (and not in the spirit of our endeavour)
- In essence, we need a technology for transforming Models to Text: M2T-transformation

Templates: Idea

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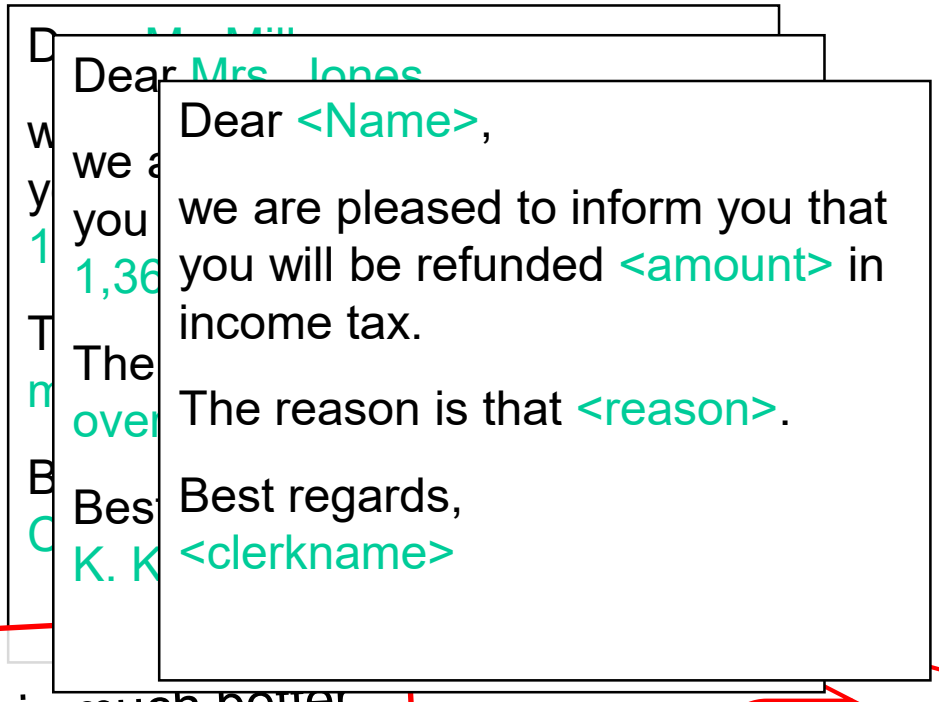

Today, this is much better known from web programming: PHP or JSP, ASP, …

Standard text in which some “specifics” will be filled in (attributes/parameters/fields).

Java Emitter Templates (JET)

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- There are different concrete template technologies (JET, XPand) that are made for transforming models into some form of text

- The ideas will be presented based on the Java Emitter Templates (JET)

JET is very similar to JSP and the control language is Java: we do not need to learn much new stuff!

1. Example: Overview report

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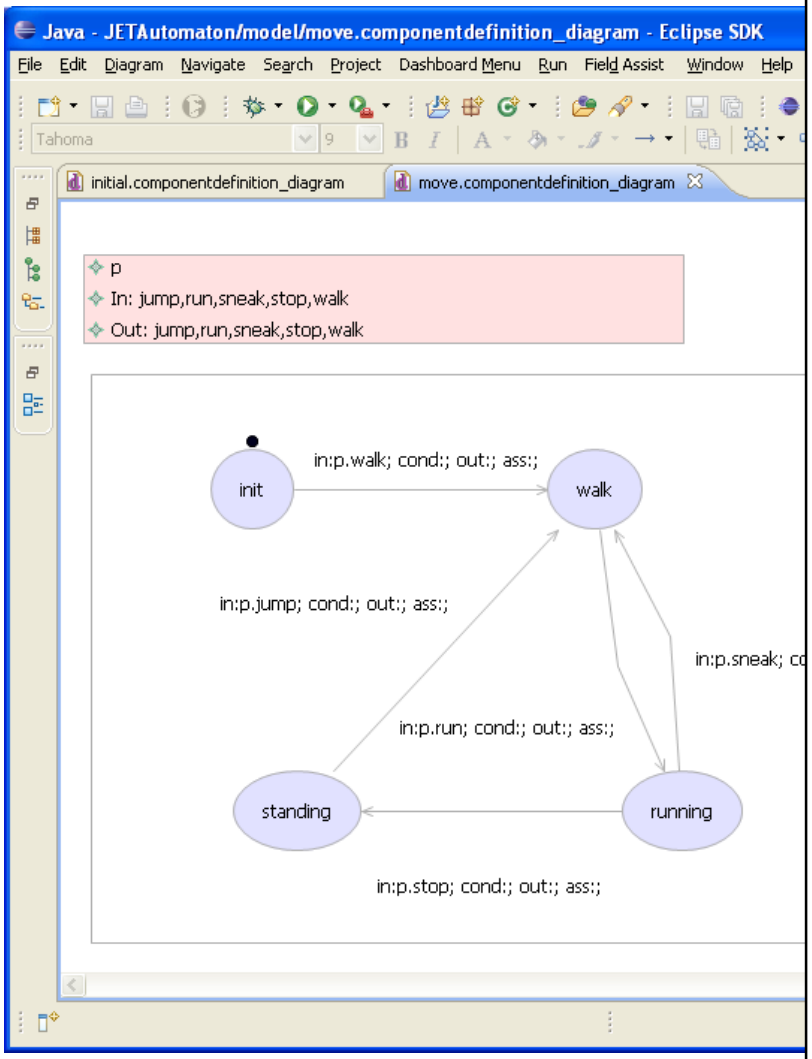


```
%--------------------------------
Overview of component definition
%--------------------------------

The components name is "Move".

The automaton has 4 states:
    init (initial)
    walk
    running
    standing

%--------------------------------
```

Example: ”template” it

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```
%-----------------------------------
Overview of component definition
%-----------------------------------

The components name is "Move".

The automaton has 4 states:
   init (initial)
   walk
   running
   standing

%-----------------------------------
```

Example: ”template” it more

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```
%--------------------------------
Overview of component definition
%--------------------------------

The components name is "<name>".

The automaton has <no of states>
states:
<foreach state>
   <state.name> <initial>
<hcaerof>

%--------------------------------
```

```
---------------------------
ew of component definition
---------------------------

mponents name is "Move".

tomaton has 4 states:
t (initial)
k
ning
nding

---------------------------
```

Example: Java it

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```
%--------------------------------
Overview of component definition
%--------------------------------

The components name is "< c.getName() >".

The automaton has
< c.getAutomaton().getState().size() > states:
< for (State s:c.getAutomaton().getState() ) { >
   < s.getName() > < s.isInitial() ? "(initial)" : "" >
< } >

%--------------------------------
```

Example: JET it

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```
<%@ jet package="translated" class="SimpleAutomaton"
    imports="dk.dtu.imm.se2e09.casetool.componentdefinition.*"
%>
%-------------------------------
Overview of component definition
%-------------------------------
<%
   ComponentDefinition c = (ComponentDefinition) argument;
   Automaton a = c.getAutomaton();
%>

The components name is "<%= c.getName() %>".

The automaton has <%= a.getState().size() %> states:
<% for (State s:a.getState()) { %>
   <%= s.getName() %> <%= s.isInitial() ? "(initial)" : "" %>
<% } %>

%-------------------------------
```

Not very readable anymore, but does what we want!

Example: Lessons learned

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- Idea behind JET is simple
- It is not restricted to any synax concerning the final output

- The final JET-template is not very readable
- But it is not difficult to ”work through” it (see later: class that does transformation)

- Always start from a concrete example, that you turn into a template

As long as you do not know where you are heading it, DON’T even try to make a template.

2. Concepts

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```
<%@ jet package="translated" class="SimpleAutomaton"
    imports="dk.dtu.imm.se2e09.casetool.componentdefinition.*"
%>
%-------------------------------
Overvie          ponent definition
%---
<%
%>
Th                                >".
Th                                %> states:
<%                                ? "(initial)" : "" %>
<% } %>

%-------------------------------
```

JET-directive.

Actually from this JET-template, a Java class will be generated that does the actual transformation.

These directives tell the name, package and imports for this class.

If you want to see this class, go to your runtime workbench and have a look into the hidden JET-project (class SimplePN2Java in the .JETEmitters project) in the navigator view.

Concepts

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```
<%@ jet package="translated" class="SimpleAutomaton"
    imports="dk.dtu.imm.se2e09.casetool.componentdefinition.*"
%>
%---------------------------------
Overview of component definition
%---------------------------------
<%
   ComponentDefinition c = (Componen
   Automaton a = c.getAutomaton();
%>

The components name is "<%= c.getName
The automaton has <%= a.getState().size() %> states:
<% for (State s:a.getState()) { %>
   <%= s.getName() %> <%= s.isInitial() ? "(initial)" : "" %>
<% } %>

%---------------------------------
```

Text snippet directly going to the text-output (including all spaces, tabs, and line feeds!)

Concepts

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JET Scriptlet: Must altogether give a legal Java method body!

```
<%@ jet packag                                    mpleAutomaton"
    imports="d                                    l.componentdefinition.*"
%>
%-------------------------------
Overview    component definition
%-------------------------------
<%
    ComponentDefinition c = (ComponentDefinition) argument;
    Automaton a = c.getAut maton();
%>

T                                          %= c.getName

T                                          etState().si
<                                          e()) { %>
                                                s.isInitial
<% } %>

%-------------------------------
```

In principle, we can use all Java commands and all classes we want; don't forget to import them!

The Object passed to the template as an argument when the template is started.

We also need to configure the class-path of the generated class! This is done when the template is called (see later).

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```
<%@ jet package="translated" class="SimpleAutomaton"
    imports="dk.dtu.imm.se2e09.casetool.componentdefinition.*"
%>
%-------------------------------
Over                                    n
%---                                    --
<%
    C                                   t
    A                                   ();
%>

The components name is "<%= c.getName() %>".

The automaton has <%= a.getState().size() %> states:
<% for (State s:a.getState()) { %>
   <%= s.getName() %> <%= s.isInitial() ? "(initial)" : "" %>
<% } %>

%-------------------------------
```

JET/Java expression: must return a String (or something that can be “used” as a String).

More technically, it must be possible to append the returned value to a StringBuffer (see later).

More details

Note: Scriptlets, and expressions in this template will also be resolved!

Other JET-directives:

- include:
  `<%@ include file="anotherTemplate.jet" %>`

- skeleton:
  Defines the skeleton class to be used (later)

- startTag, endTag:
  used to replace `<%` and `%>` as start and end tags.

- nlString:
  defines the String serving as a newline

3. Applying the template

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Up to now:

- What is a template
- What does it do/mean

For more details, have a look into the code of the generator project in our basic project.

In particular, have a look into the automatically generated project .JETEmitters in your runtime workbench.

Question now:

- How do we start (and configure) a transformation for such a template?
- What happens behind the scenes?

Some code snippets

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```
import org.eclipse.emf.codegen.jet.JETEmitter;
import org.eclipse.emf.codegen.jet.JETException;
...

ComponentDefinition c = ...

JETEmitter emitter = new JETEmitter(uriOfTemplate,
   getClass().getClassLoader());

emitter.addVariable(
   "CASETOOL", "dk.dtu.imm.se2e09.caseto
emitter.addVariable(
   "EMF_COMMON", "org.eclipse.emf.common");

String result = emitter.generate(
   monitor, new Object[] { c });
```

Generate and initialize generator class from JET-template.

Configures the class path (and project dependencies) for the automatically generated JET emitter project!

If you use classes in the template from some plugIns, these plugIns need to be added here.

Don’t worry! You can typically copy that from other projects (we can look at some practical details later on).

Generated Class (snippets)

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```
package translated;

import dk.dtu.imm.se2e09.casetool.componentdefinition.*;

public class SimpleAutomaton {
...

  protected final String TEXT_1 =
    "%-----…" + NL +
    "  Overview of component  definition" + NL + "%-----…";
  protected final String TEXT_2 =
    NL + NL + "The components name is \"";
  protected final String TEXT_3 =
    "\"." + NL + "" + NL + "The automaton has ";
  protected final String TEXT_4 = " state(s):";
  protected final String TEXT_5 = NL + "   ";
  protected final String TEXT_6 = " ";
  protected final String TEXT_7 = NL + " …" + NL + "%-----…";
```

Generated Class (ctnd.)

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```
public String generate(Object argument)
 {
   final StringBuffer stringBuffer = new StringBuffer();
   stringBuffer.append(TEXT_1);

  ComponentDefinition component = (ComponentDefinition) argument;
  Automaton automaton = component.getAutomaton();

   stringBuffer.append(TEXT_2);
   stringBuffer.append( component.getName() );
   stringBuffer.append(TEXT_3);
   stringBuffer.append( automaton.getState().size() );
   stringBuffer.append(TEXT_4);
    for (State state : automaton.getState()) {
   stringBuffer.append(TEXT_5);
   stringBuffer.append( state.getName() );
   stringBuffer.append(TEXT_6);
   stringBuffer.append( state.isInitial() ? "(initial)" : "" );
    }
   stringBuffer.append(TEXT_7);
   return stringBuffer.toString();
 }
```

Note

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- Here, we used a setting, where the generator code is generated dynamically, which allows to change the JET templates while the software is running!
- This is very convenient for development.

- The generator code can also be generated once and for all at development time; which is faster and less prone to setup errors in deployed code.

4. Skeleton

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Now:

- We know how to use the generator
- We know how the generated generator class looks (which defines a JET-template's semantics)

Question now:

- Can we adapt change the generation of the generator class?
  This is interesting, once we call generators from other templates or to implement some helper functionality which should not be in the JET-template

The answer: Skeletons

Standard skeleton

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```
public class CLASS
{
  public String generate(Object argument)
  {
    return "";
  }
}
```

Change skeleton

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```
public class CLASS extends MyClass
{
  private WhatEverType attribute;

  public OtherType myMethod()
  {... }

  // Some comment.
  public String generate(Object argument)
  {
    return "";
  }
}
```

See skeleton in our basic project with many “helper”.

Attention: This part must be last!

If you want your template to use another skeleton, use the JET-directive:

```
<%@ jet package="translated" …
    skeleton="my.skeleton" %>
```

Concepts

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```
<%@ jet package="translated" class="SimpleAutomaton"
    skeleton="my.skeleton"
    imports="dk.dtu.imm.se2e09.casetool.componentdefinition.*"
%>
%-------------------------------
Overview of component definition
%-------------------------------
<%
   ComponentDefinition c = (ComponentDefinition) argument;
   Automaton a = c.getAutomaton();
%>
<%= myMethod().toString %>
The components name is "<%= c.getName() %>".

The automaton has <%= a.getState().size() %> states:
<% for (State s:a.getState()) { %>
   <%= s.getName() %> <%= s.isInitial() ? "(initial)" : "" %>
<% } %>

%-------------------------------
```

5.Summary

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- JET is a simple way to define transformations
- Creating JETs is a bit tedious
- To ease working with JET (and getting them right)
  - start from an example
  - be disciplined
  - use helpers (in skeleton)
  - check them after changes
  - run runtime workbench in debug mode, so you do not need to restart runtime workbench after JET changes

Conclusion & Perspective

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- Working with JET in practice is a bit tedious to work with (only limited syntactical support by IDE)
- But, I used it for larger generation projects (including Petri nets). When working backwards from an example, this is doable.

We have a look on how templates (and skeletons) are developed in practice in the hands-on slot.

- Also important in MBSE: Bidirectional transformations between models (e.g. Triple Graph Grammars / TGGs): M2M

If there is interest, we could have a look into some of the details

Appendix

JET Example

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```
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```