How MDSD improves software quality

... as well as a little bit of advertising for openArchitectureWare ☺

Markus Völter
voelter@acm.org
www.voelter.de

About me

- Independent Consultant
- Based out of Heidenheim, Germany
- Focus on
  - Model-Driven Software Development
  - Software Architecture
  - Middleware

Markus Völter

voelter@acm.org

www.voelter.de

Advantages of MDSD

- Using MDSD can result in a **variety of advantages**, such as
  - Better integration of domain experts
  - Better testability
  - More efficient development
  - Architecture management and enforcement
  - Improved code quality & consistency

- In this talk I want to **focus on the latter two**, subsumed by the term „improved software quality"

Refining the Architecture

Building a Domain Architecture improves the architectural quality of the target system

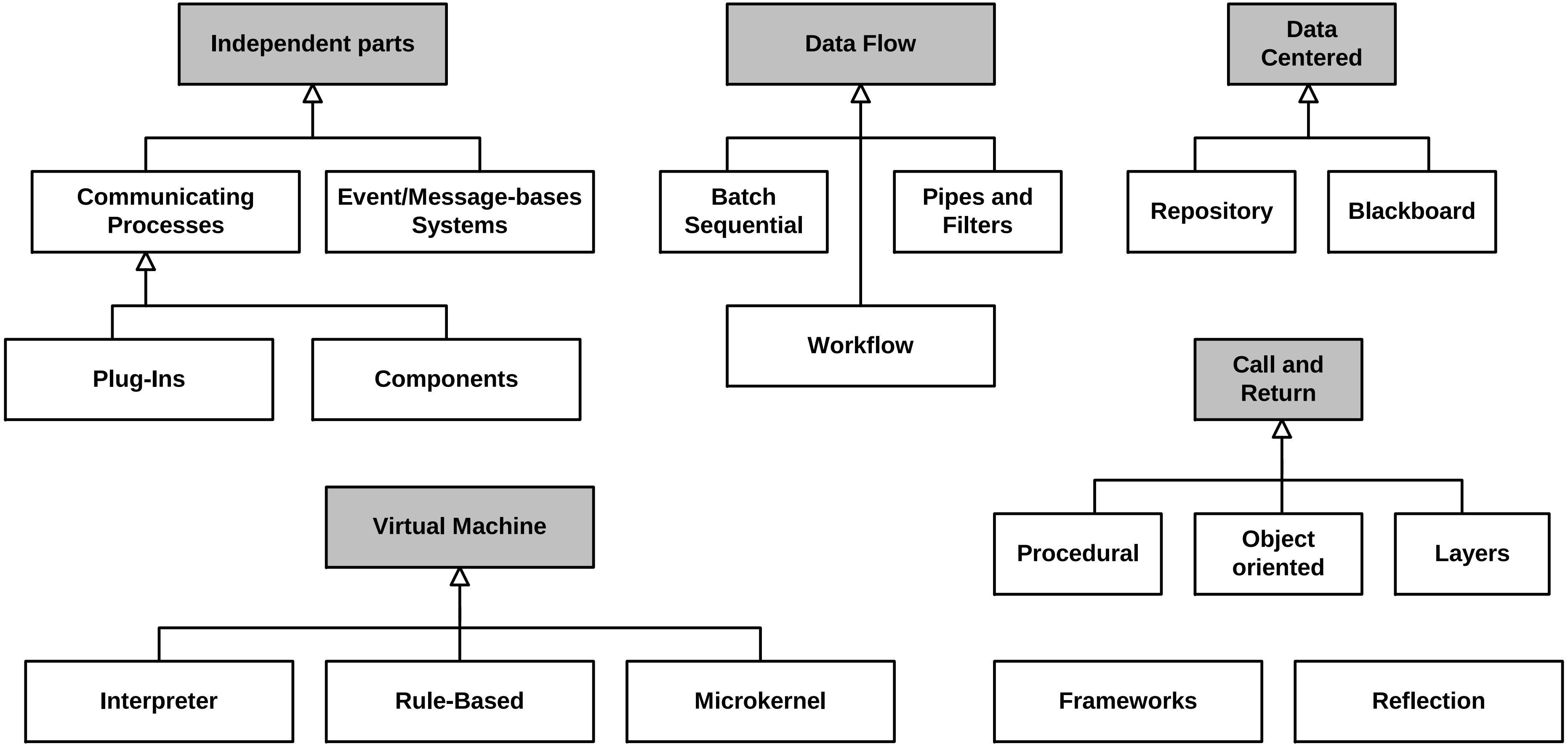
Three kinds of Architecture

- **Conceptual Architecture**
  Definition of the artifacts available for building systems as well as their properties, characteristics and interactions
  -> Metamodels

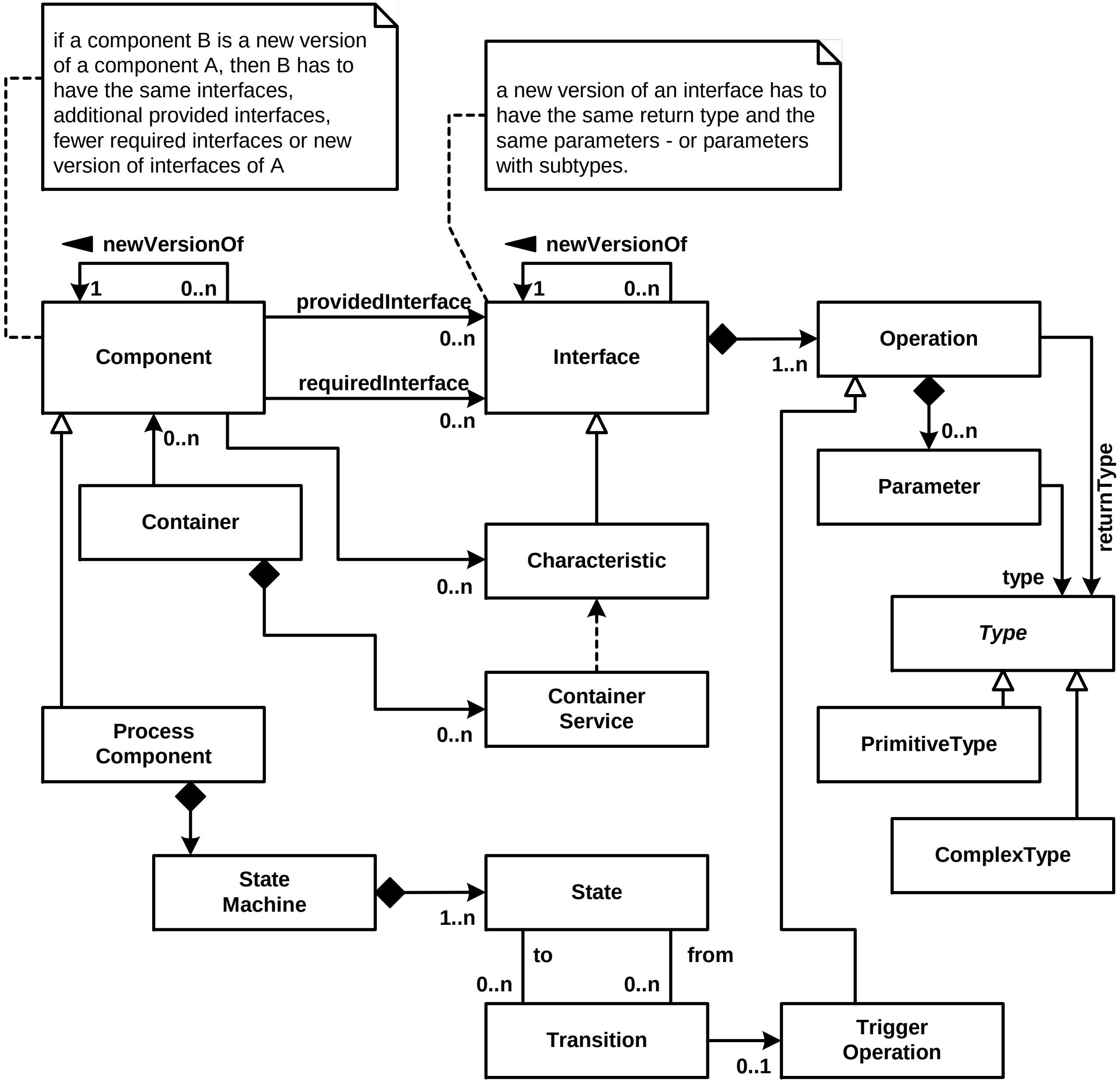
- **Technical Architecture**
  Mapping of the Conceptual Architecture to one or more technology platforms, taking into account the non-functional requirements
  -> Automatic Mapping Code Generation

- **Functional Architecture**
  Definitions of a system (as instances of the conceptual artifacts) that implements the functional requirements
  -> Easier to describe based on the metamodels

Conceptual Architecture: Starting Points

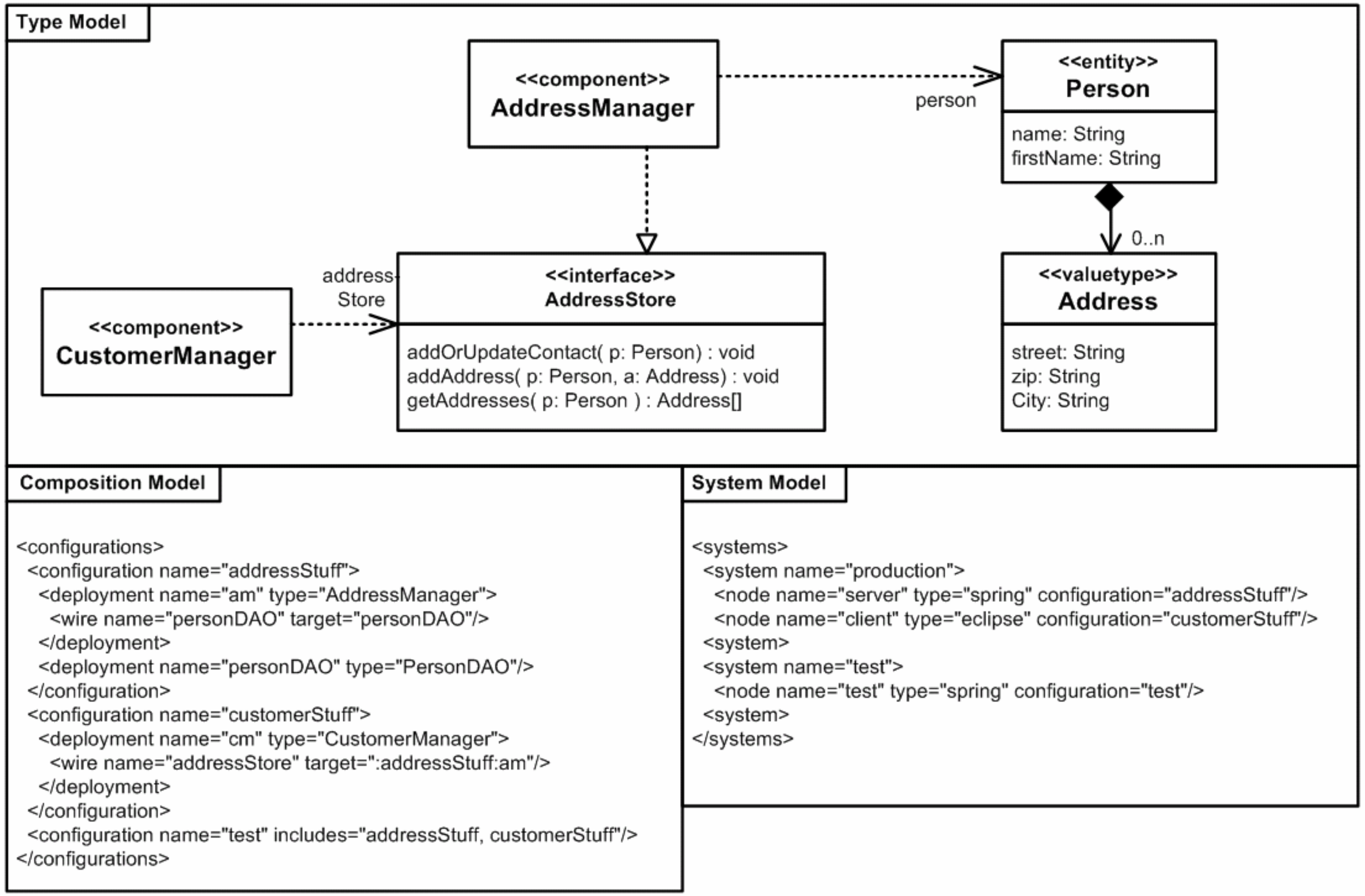


Formaliziation of Architecture in MDSD using Metamodels

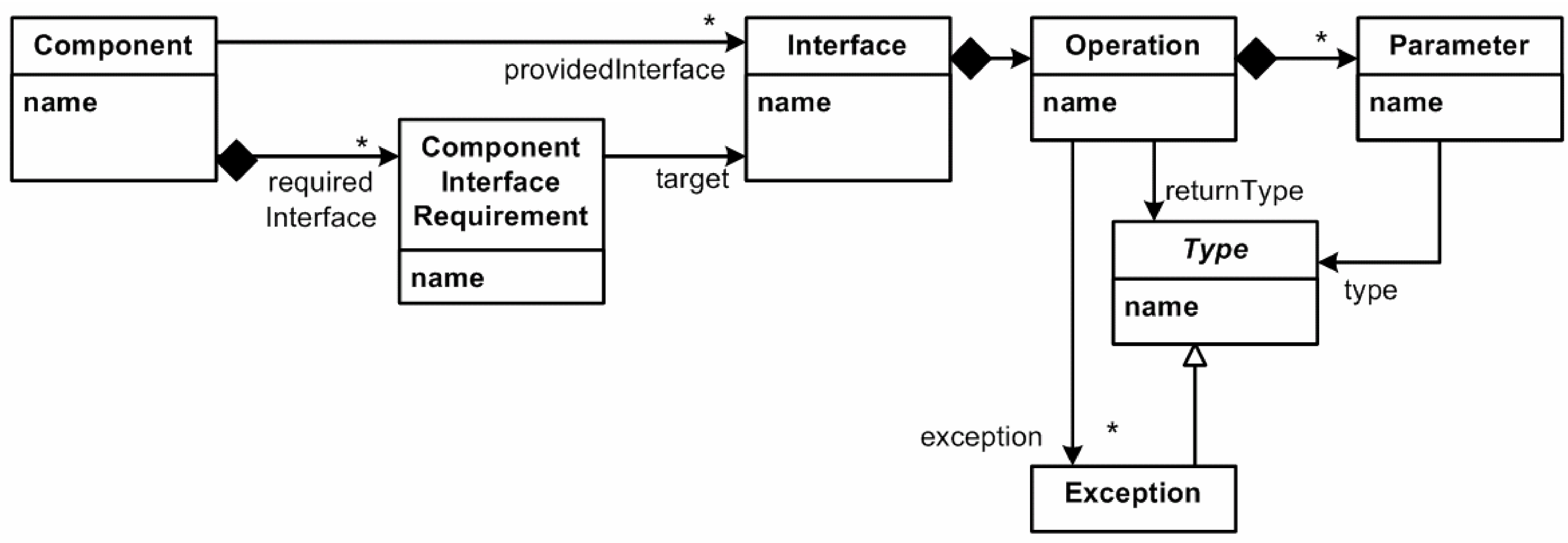


Multi-Viewpoint models

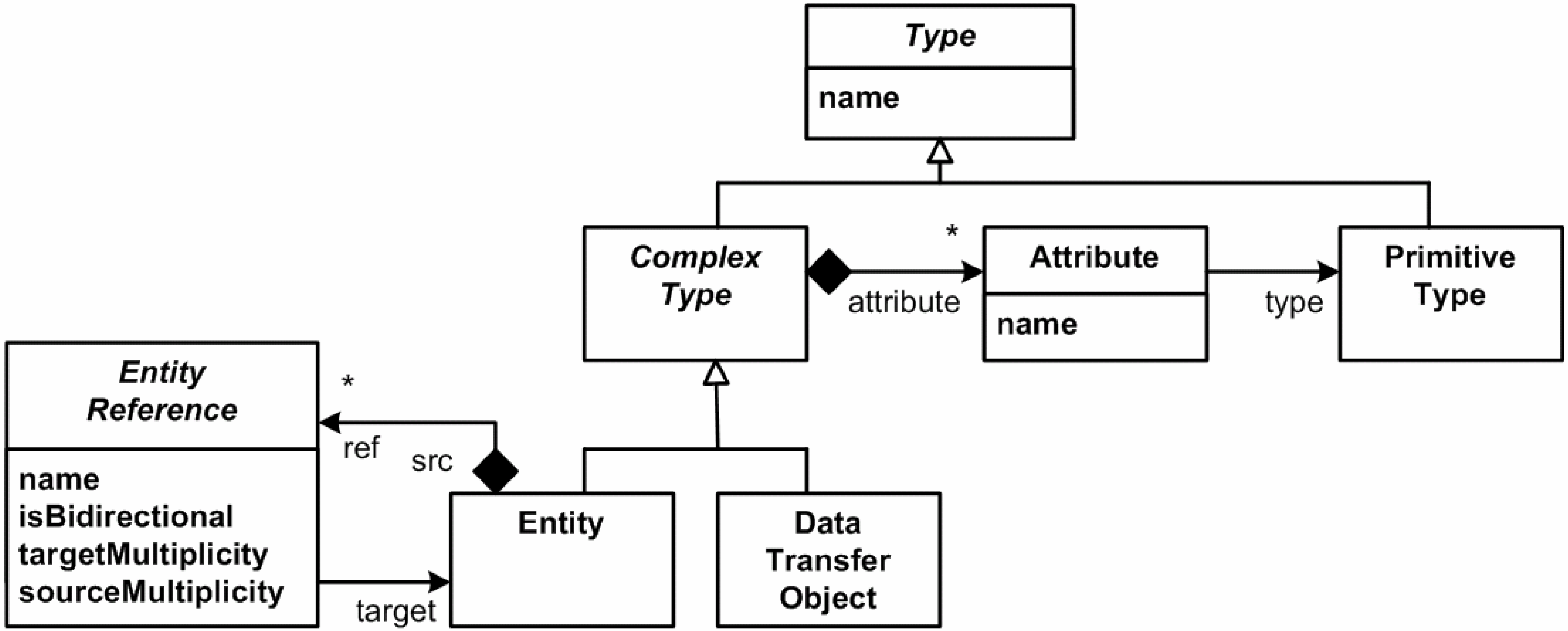
- **Type Model**: Components, Interfaces, Data Types
- **Composition Model**: Instances, “Wirings”
- **System Model**: Nodes, Channels, Deployments



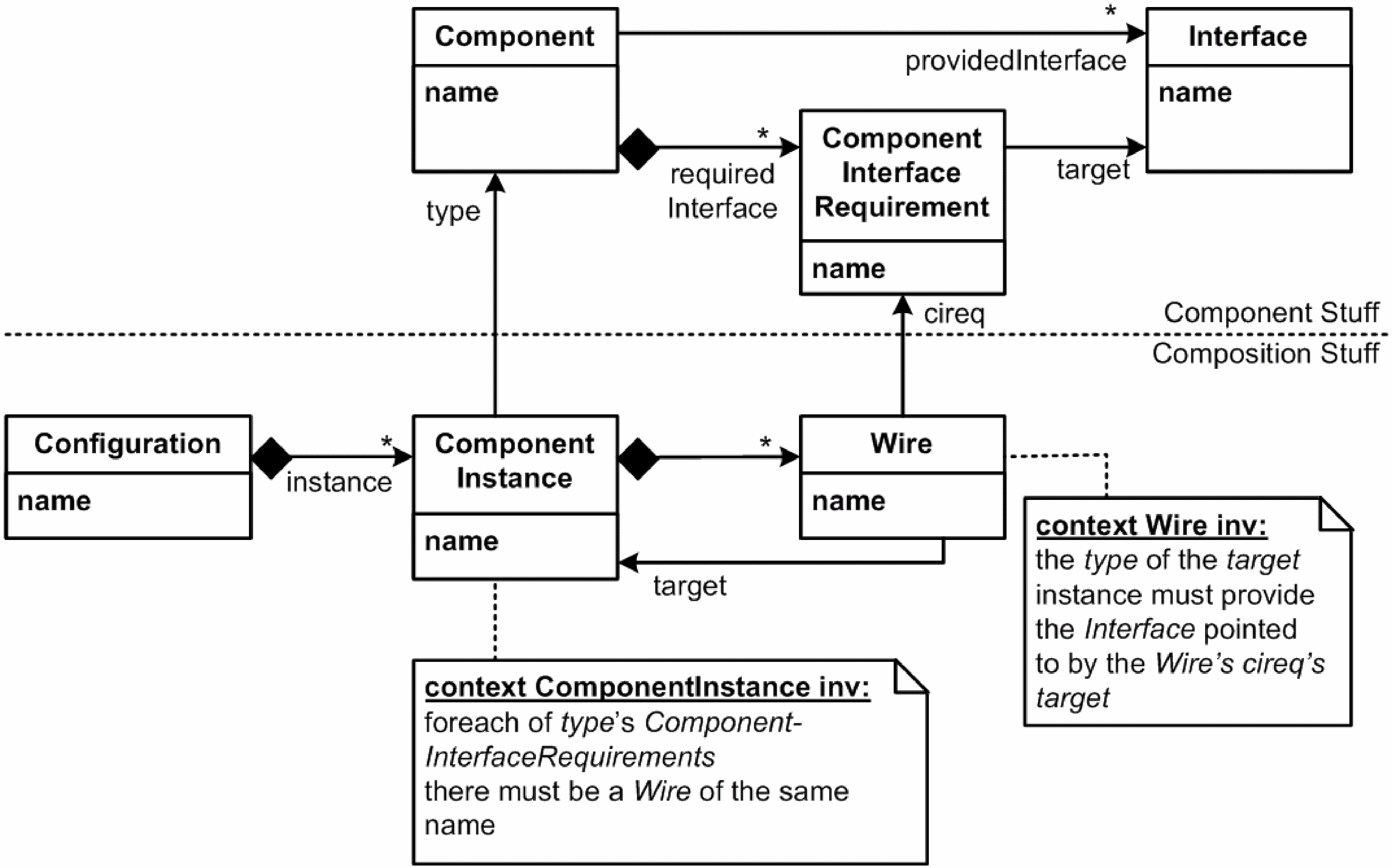
Type Metamodel



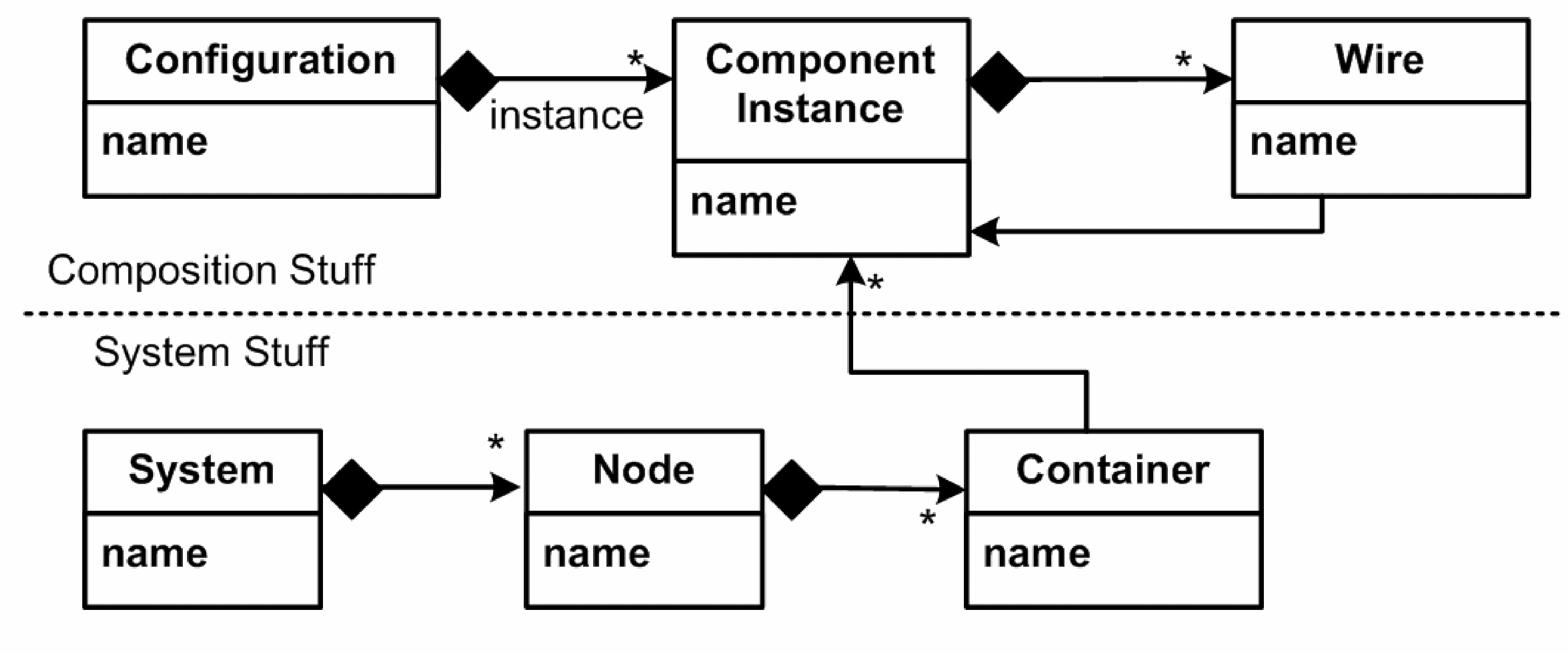
Type Metamodel II (Data)



Composition Metamodel

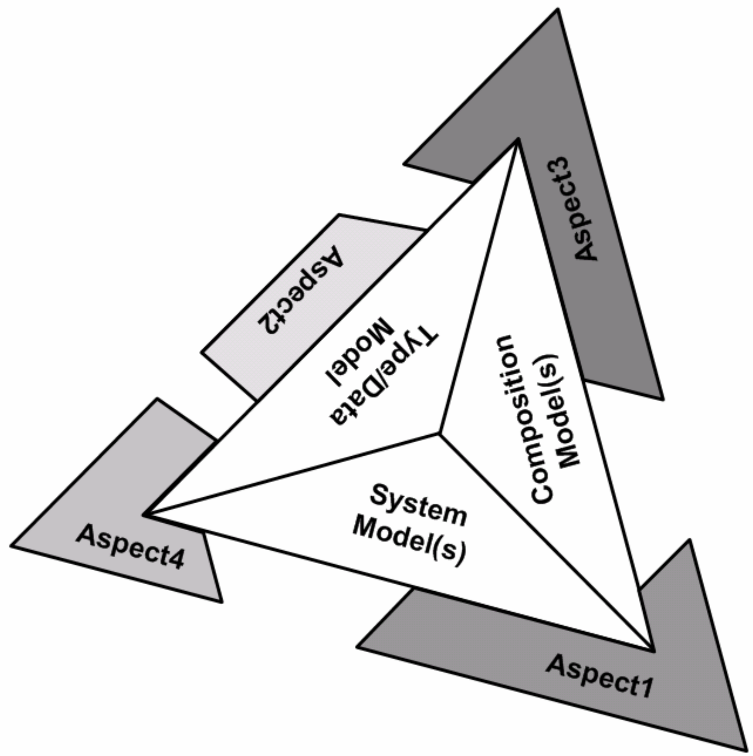


System Metamodel



Aspect Models

- Often, the described three viewpoints are not enough, **additional aspects** need to be described.
- These go into **separate aspect models**, each describing a well-defined aspect of the system.
  - Each of them uses a suitable DSL/syntax
  - The generator acts as a weaver
- Typical **Examples** are
  - Persistence
  - Security
  - Forms, Layout, Pageflow
  - Timing, QoS in General
  - Packaging and Deployment
  - Diagnostics and Monitoring

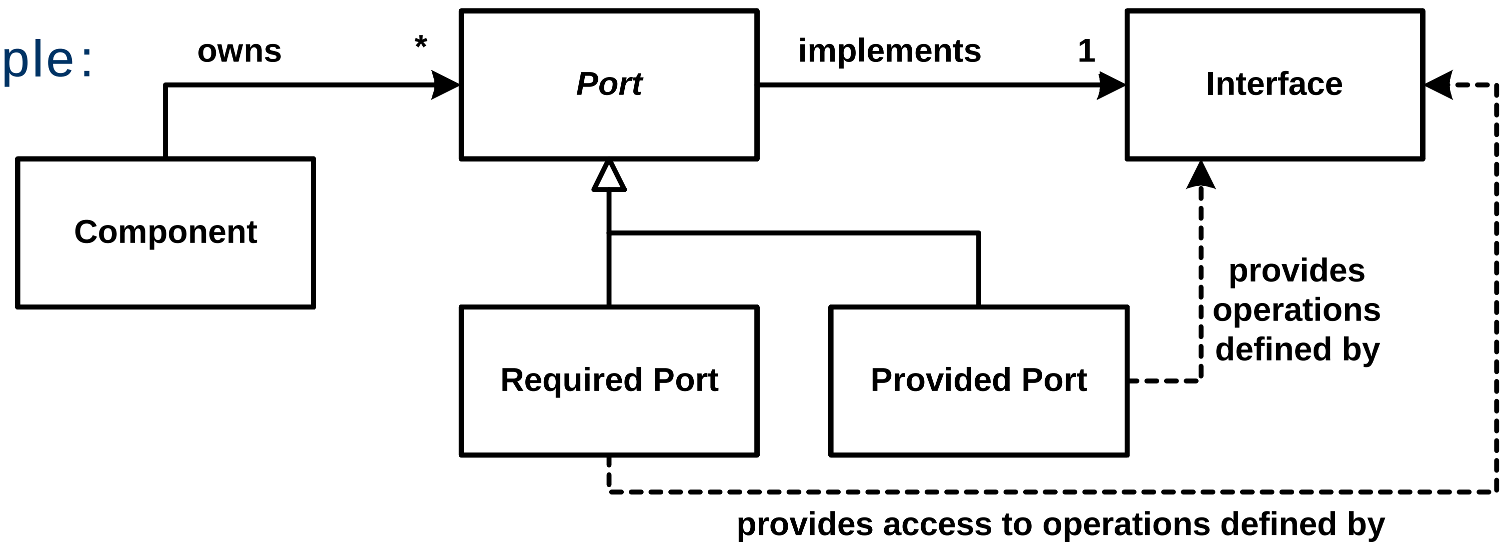


Talk Metamodel

- In order to **continuously improve and validate** the FORMAL META MODEL for a domain, it has to be **exercised** with domain experts as well as by the development team.
- In order to achieve this, it is a good idea to use it during discussions with stakeholders by **formulating sentences** using the concepts in the meta model.
- As soon as you find that you **cannot express something using sentences** based on the meta model,
  - you have to reformulate the sentence
  - the sentence's statement is just wrong
  - you have to update the meta model.

Talk Metamodel II

- Example:

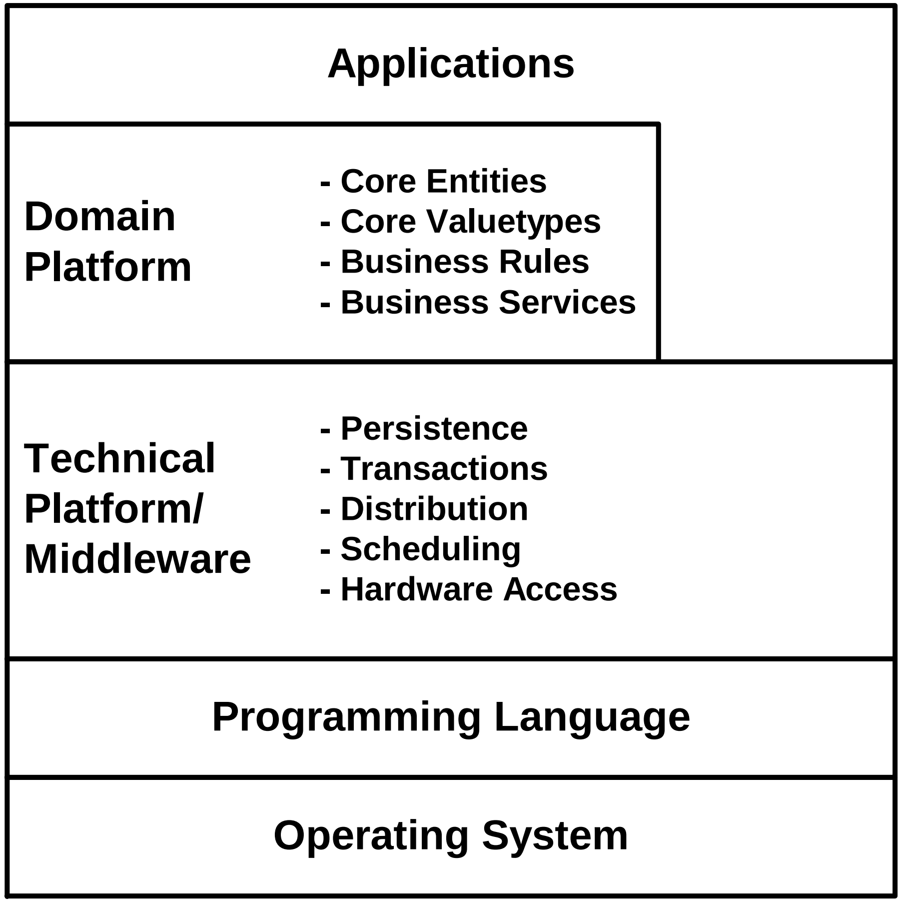


- A component owns any number of ports.
- Each port implements exactly one interface.
- There are two kinds of ports: required ports and provided ports.
- A provided port provides the operations defined by its interface.
- A required port provides access to operations defined by its interface.

Technical Architecture

You can generate all the „adaption code“ to run the system on a given platform – you don‘t need to care about these things when implementing business logic

Technical Architecture - Blueprint

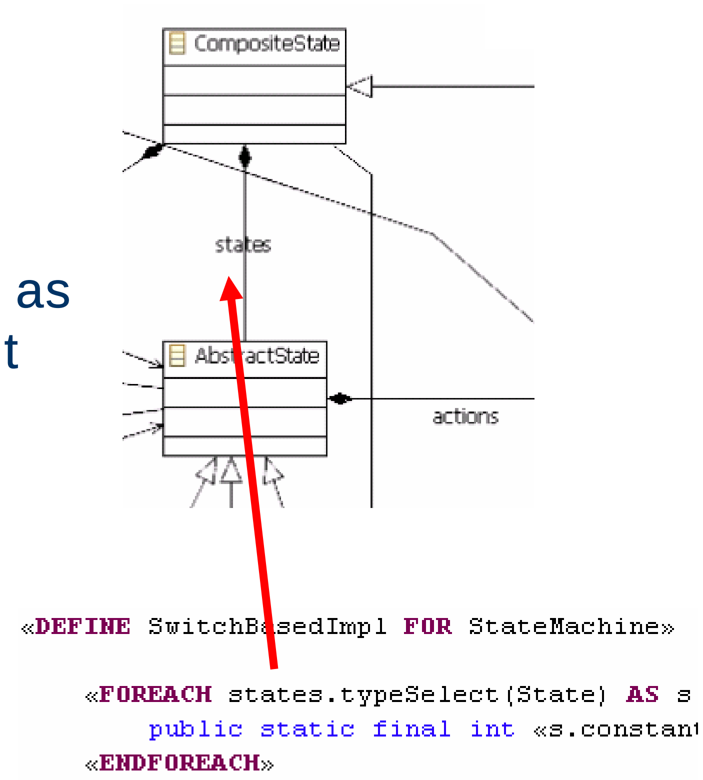


Three Basic Viewpoints – Generated Stuff

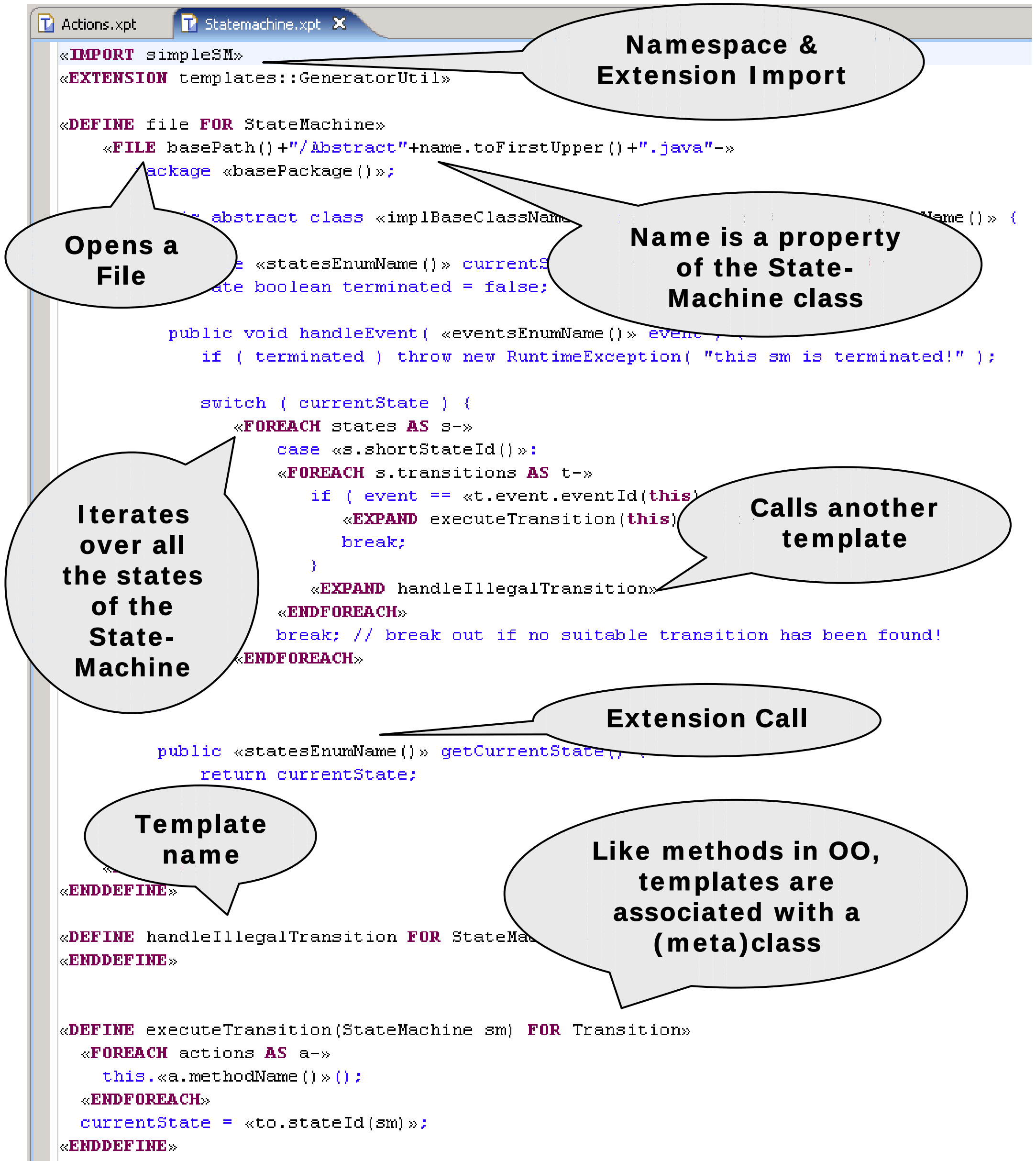
- What can be generated?
  - Base classes for component implementation
  - Build-Scripts
  - Descriptors
  - Remoting Infrastructure
  - Persistence
  - ...

Code Generation

- Code Generation is used to **generate executable code** from models.
- Code Generation is **based on the metamodel** & uses **templates** to attach to-be-generated source code.
- In openArchitectureWare, we use a **template language** called **xPand**.
- It provides a number of **advanced features** such as polymorphism, AO support and a powerful integrated expression language.
- Templates can access **metamodel properties** seamlessly



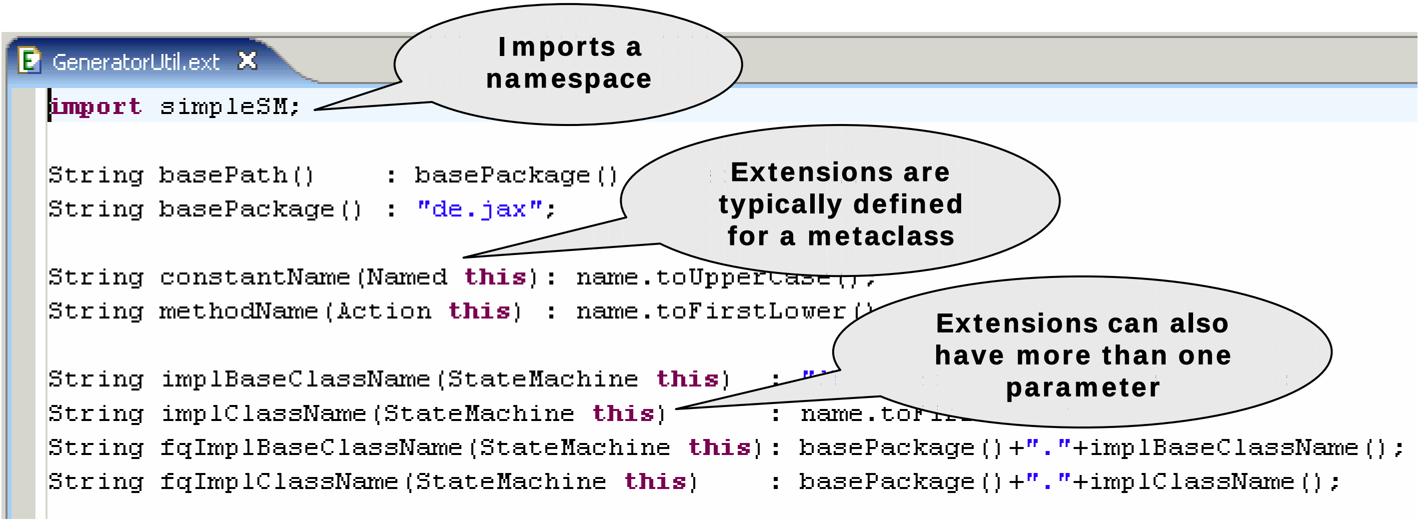
Code Generation II



- The **blue text** is generated into the target file.
- The **capitalized words** are xPand keywords
- **Black text** are metamodel properties
- DEFINE...END-DEFINE blocks are called **templates**.
- The whole thing is called a **template file**.

Code Generation III

- One can **add behaviour to existing metaclasses** using oAW's **Xtend** language.



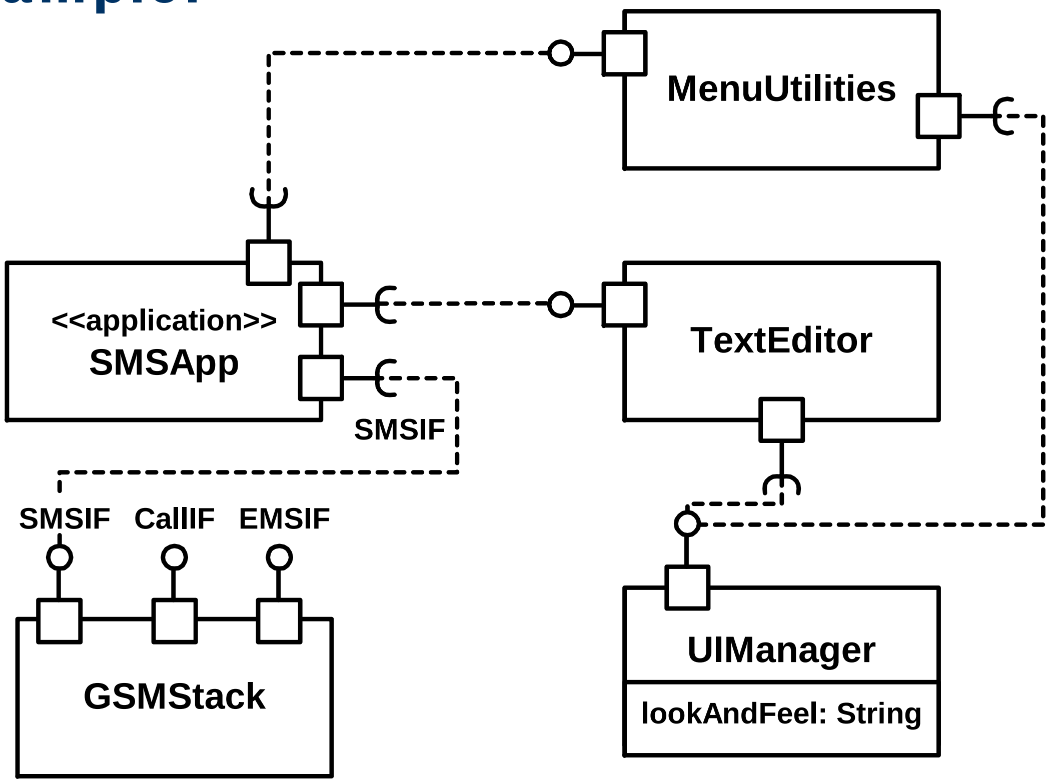
- Extensions can be called using **member-style syntax**: *myAction.methodName()*
- Extensions can be used in **Xpand templates, Check files** as well as in other **Extension files**.
- They are imported into template files using the **EXTENSION** keyword

Managing Architecture

MDSD can help to make sure an architecture is used consistently and „correctly“ in larger teams

Architecture „Enforcement“ using MDSD

- **Example:**



- **Problem:** How do you **ensure** that developers can actually only reference (use) those components, which are declared as being used in the model?

Typical Solution, without MDSD

```
public class SMSAppImpl {
  public void tueWas() {
    TextEditor editor =
           Factory.getComponent(“TextEditor”);
    editor.setText( someText );
    editor.show();
  }
}
```

- **Problems:**
  - Developers can lookup, use, and thus, depend on whatever they like
  - Developers are not guided (by IDE, compiler, etc.) what they are allowed to access and what is prohibited

Improved Solution, with MDSD

```
public interface SMSAppContext extends ComponentContext {
  public TextEditorIF getTextEditorIF();
  public SMSIF getSMSIF();
  public MenuIF getMenuIF();
}
```

```
public class SMSAppImpl implements Component {
  private SMSAppContext context = null;
  public void init( ComponentContext ctx) {
    this.context = (SMSAppContext)ctx;
  }
  public void tueWas() {
    TextEditor editor = context.getTextEditorIF();
    editor.setText( someText ); editor.show();
} }
```

- **Better, because:**
  - Developers can only access what they are allowed to...
  - ... and this is always in sync with the model
  - IDE can help developer (ctrl+space in eclipse)
  - Architecture (here: Dependencies) are enforced and controlled

The Programming Model

**You can restrict the freedom of developers …
making the code more consistent and structured**

Problem

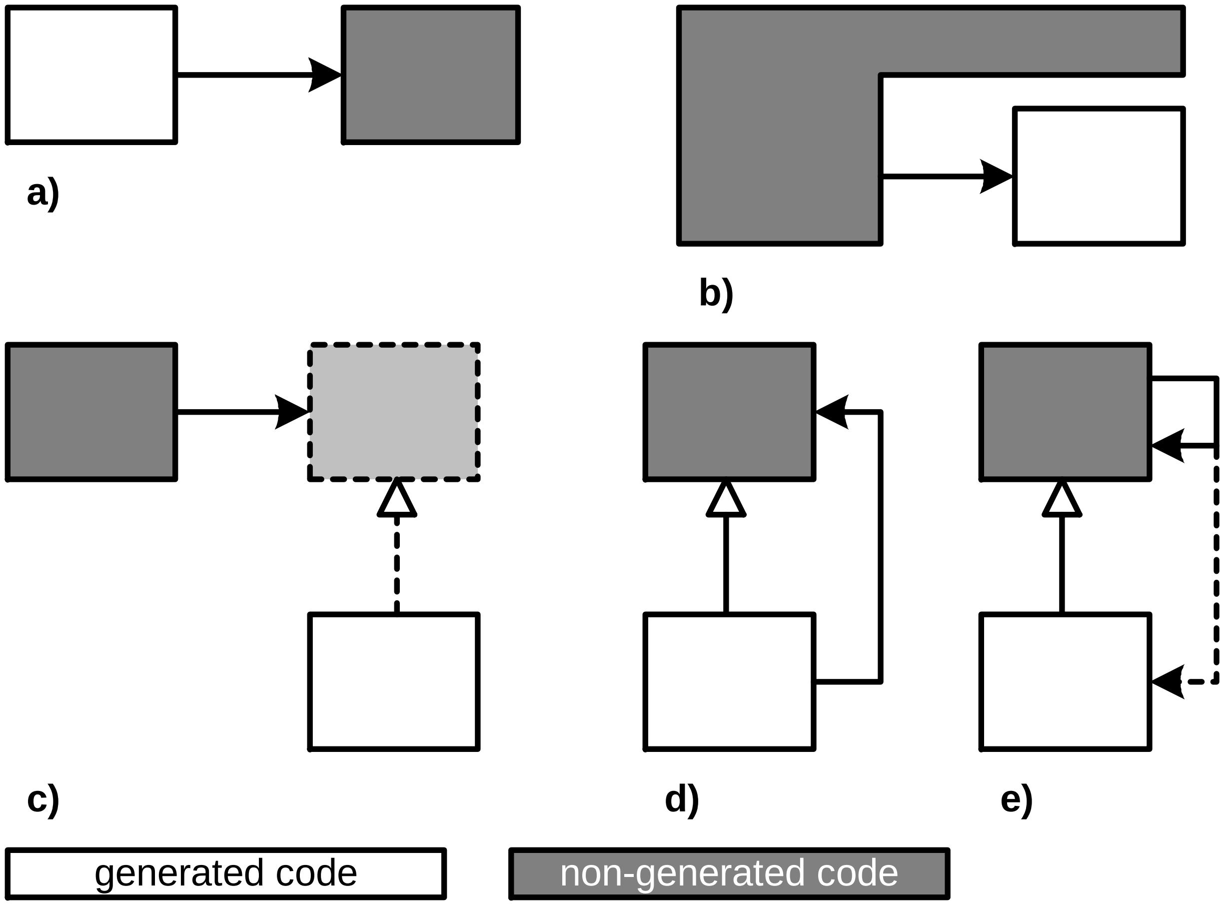
- You want to make sure developers have only **limited freedom** when implementing those aspects of the code that are not generated.
  -> well structured system
  -> keeps the promises made by the architecture

- An important challenge is thus: How do we combine **generated** code and **manually written** code in a controlled manner (and without using protected regions)?

- **Solution**: Patterns, Recipe Framework

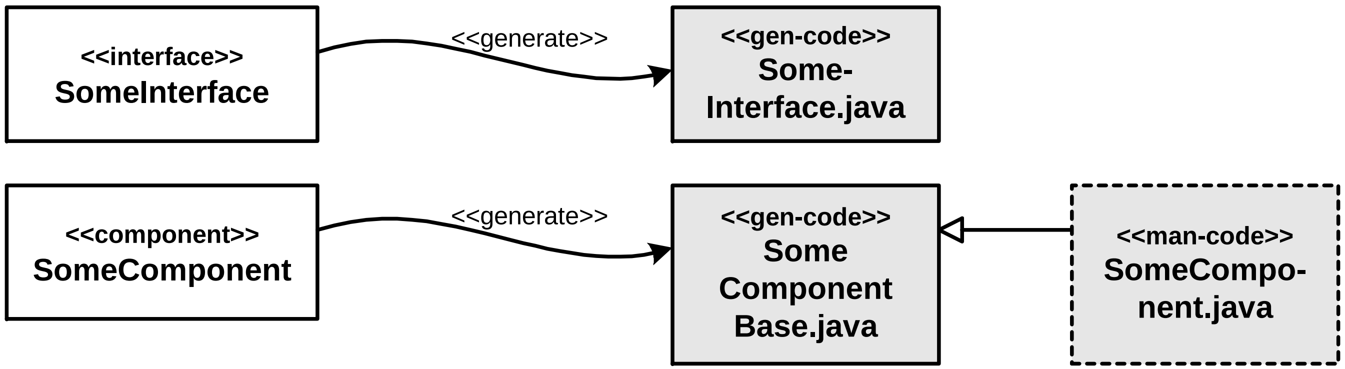
Integration Patterns

- There are various ways of integrating generated code with non-generated code



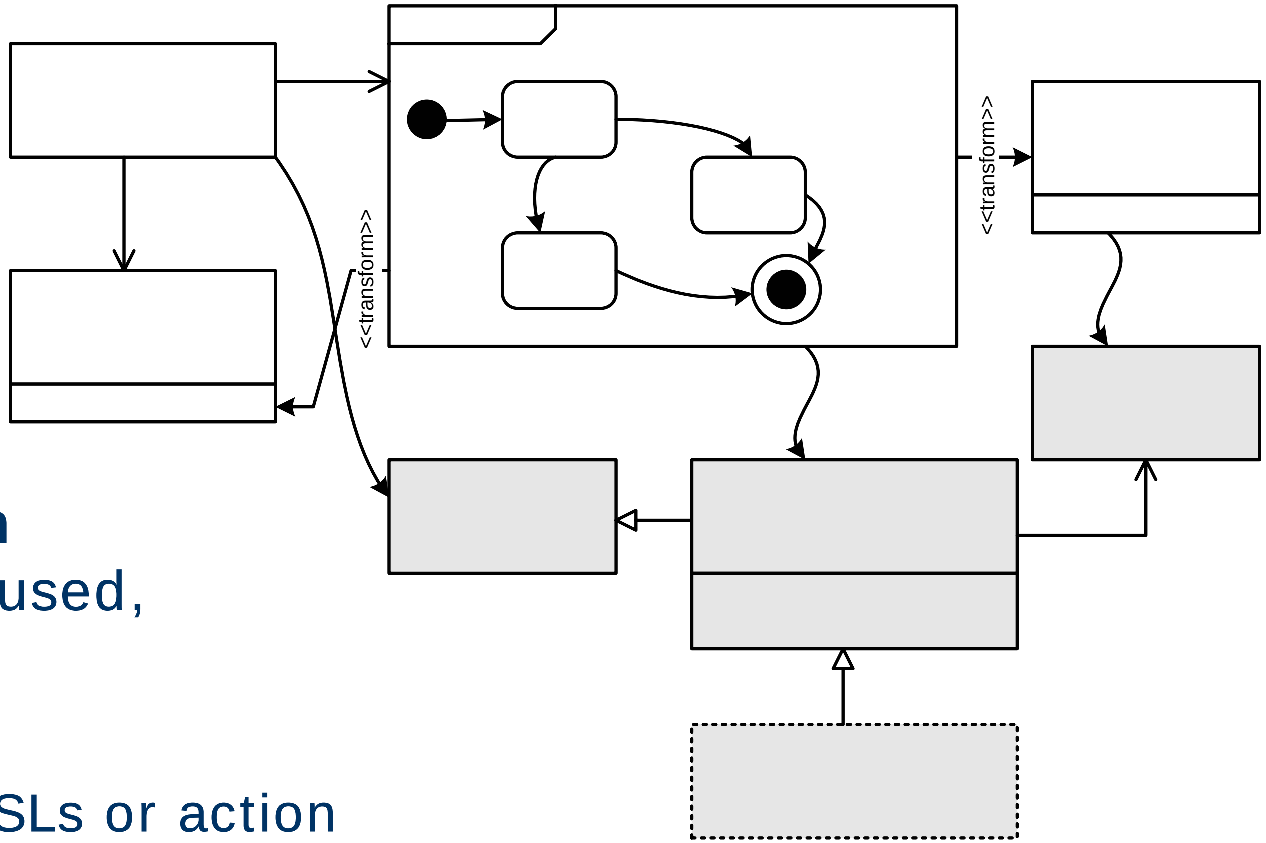
Component Implementation

- We have not yet talked about the **implementation code** that needs to go along with components.
  - As a default, you will provide the implementation by a **manually written subclass**



- However, for **special kinds of components** ("component kind" will be defined later) can use different implementation strategies -> **Cascading!**

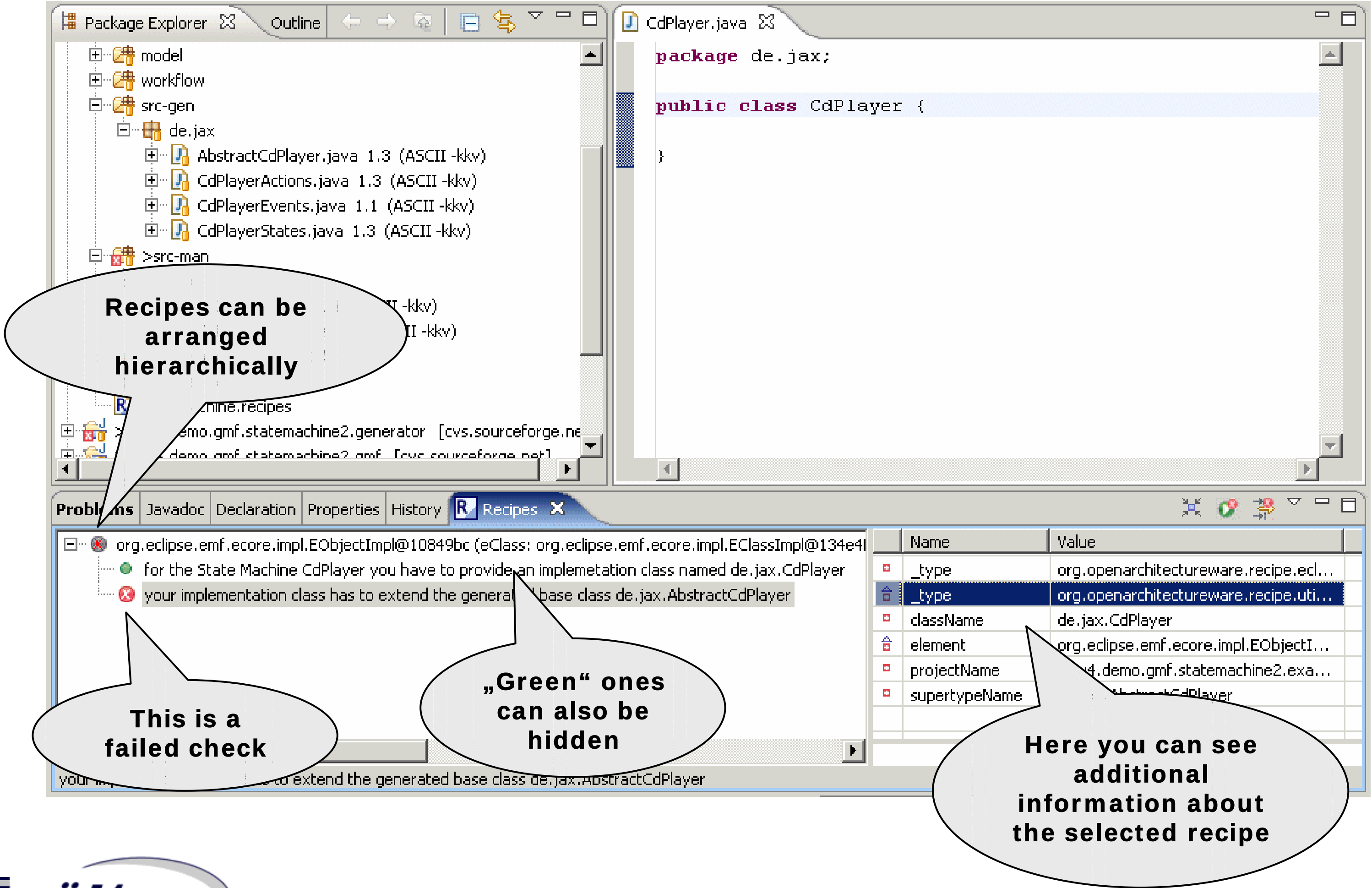
Component Implementation II



- Remember the **example of the process components** from before:
- Various other **implementation stragies** can be used, such as:
  - Rule-Engines
  - “Procedural” DSLs or action semantics
- Note that, here, **interpreters** can often be used sensibly instead of generating code!

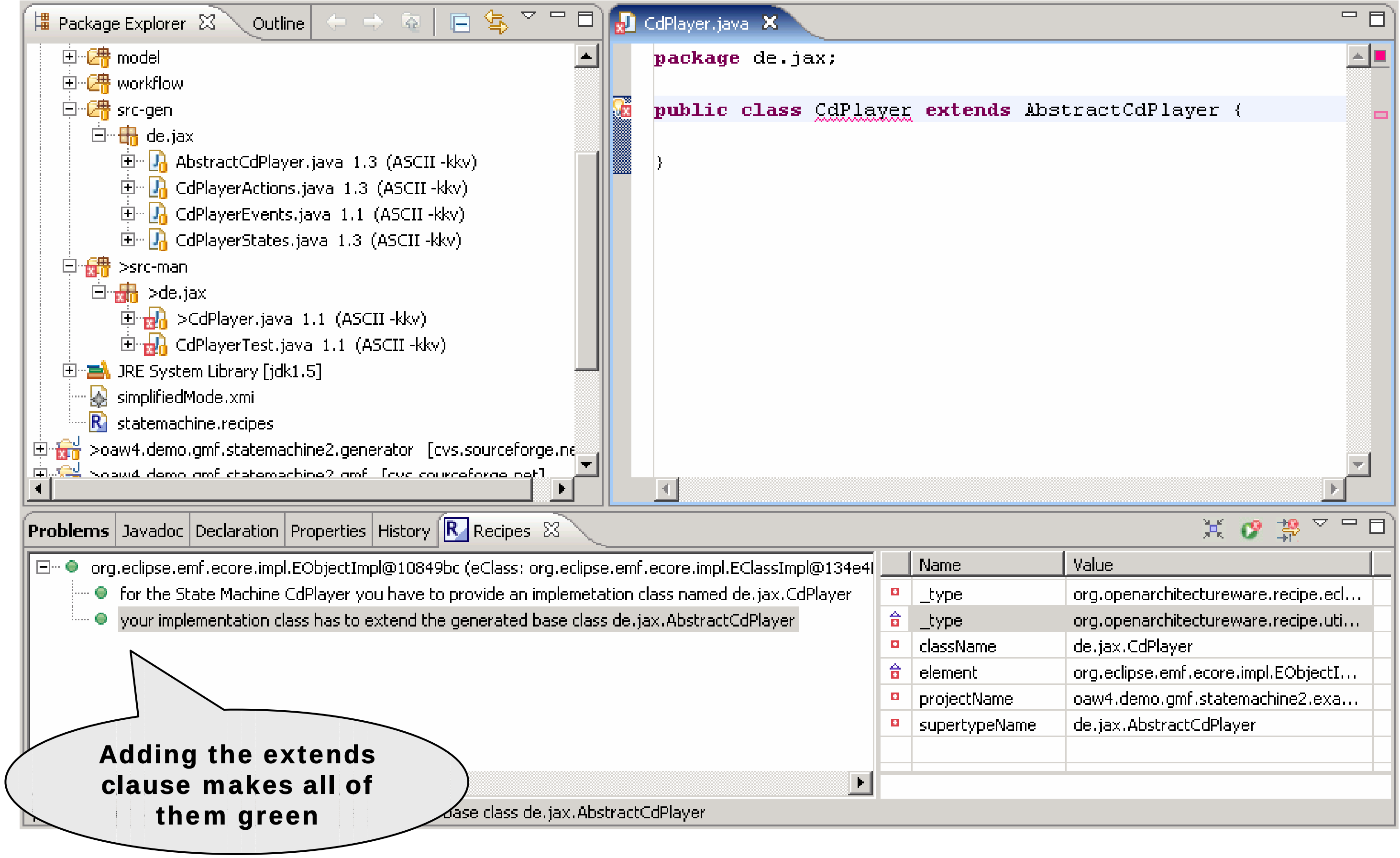
Recipes I

- Here's an error that suggests that I **extend** my manually written class **from the generated base class:**



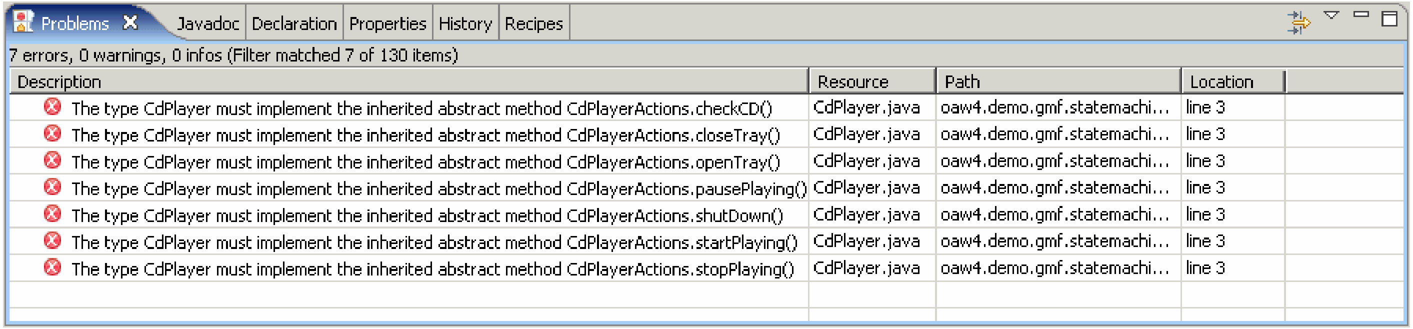
Recipes II

- I now **add the respective *extends* clause**, & the message goes away – automatically.



Recipes III

- Now I get a number of compile errors because I have to **implement the abstract methods** defined in the super class:



Problems | Javadoc | Declaration | Properties | History | Recipes

7 errors, 0 warnings, 0 infos (Filter matched 7 of 130 items)

Description	Resource	Path	Location
The type CdPlayer must implement the inherited abstract method CdPlayerActions.checkCD()	CdPlayer.java	oaw4.demo.gmf.statemachi...	line 3
The type CdPlayer must implement the inherited abstract method CdPlayerActions.closeTray()	CdPlayer.java	oaw4.demo.gmf.statemachi...	line 3
The type CdPlayer must implement the inherited abstract method CdPlayerActions.openTray()	CdPlayer.java	oaw4.demo.gmf.statemachi...	line 3
The type CdPlayer must implement the inherited abstract method CdPlayerActions.pausePlaying()	CdPlayer.java	oaw4.demo.gmf.statemachi...	line 3
The type CdPlayer must implement the inherited abstract method CdPlayerActions.shutDown()	CdPlayer.java	oaw4.demo.gmf.statemachi...	line 3
The type CdPlayer must implement the inherited abstract method CdPlayerActions.startPlaying()	CdPlayer.java	oaw4.demo.gmf.statemachi...	line 3
The type CdPlayer must implement the inherited abstract method CdPlayerActions.stopPlaying()	CdPlayer.java	oaw4.demo.gmf.statemachi...	line 3

- I finally implement them sensibly, & everything is ok.
- The Recipe Framework & the Compiler have **guided me through the manual implementation steps.**
  - If I didn't like the compiler errors, we could also add recipe tasks for the individual operations.
  - oAW comes with a number of **predefined recipe checks for Java**. But you can also define your own checks, e.g. to verify C++ code.

Model Verification

Model Verification is an additional way of „testing“ a system, on a very „semantical“ level

Additional Tests: Model Verification

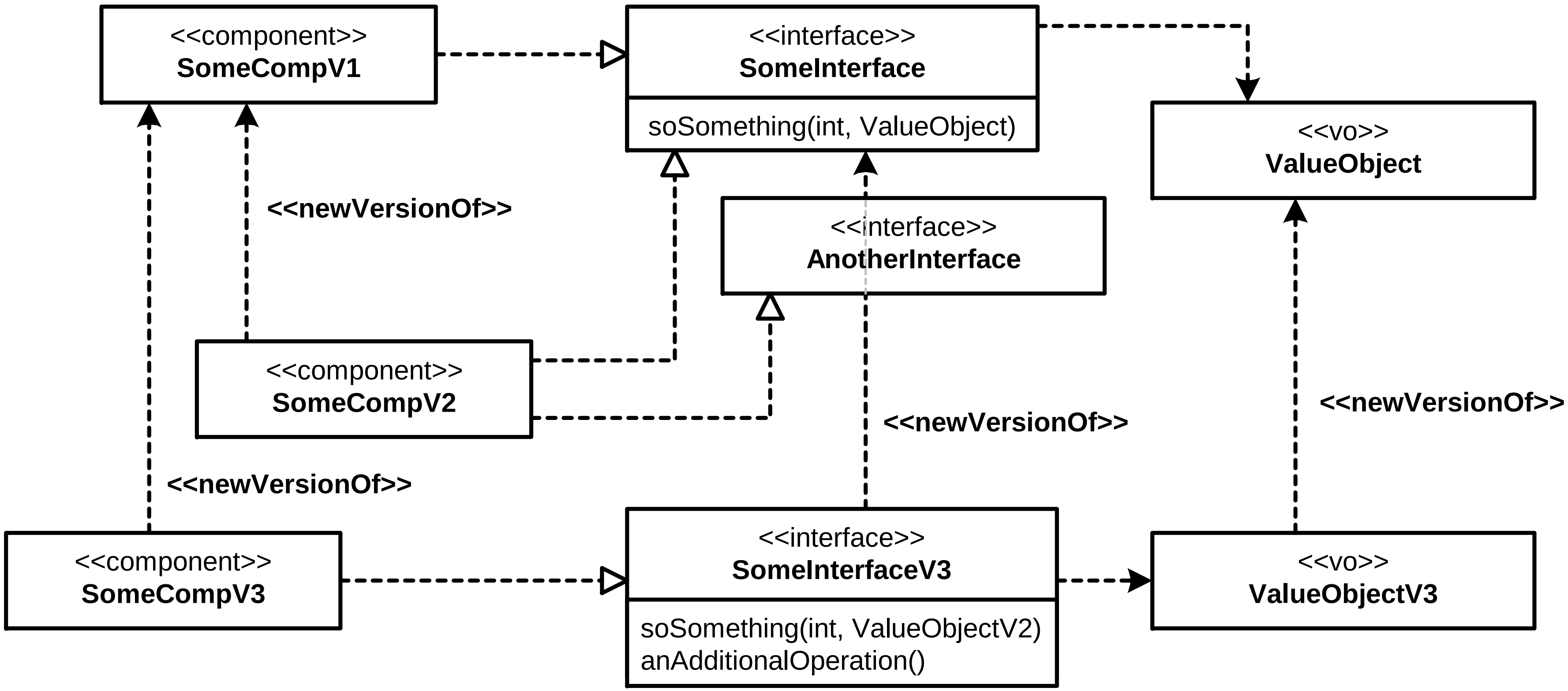
- In many cases it is possible to **detect design errors already in the models**. This step is called **model verification**.

- The most „extreme" form is to **interpret and simulate the whole model**; this is however, not simple to achieve, although there are „UML VMs".

- However, it is easily possible to **verify design constraints** in the model **before** model transformation or code generation steps are done.

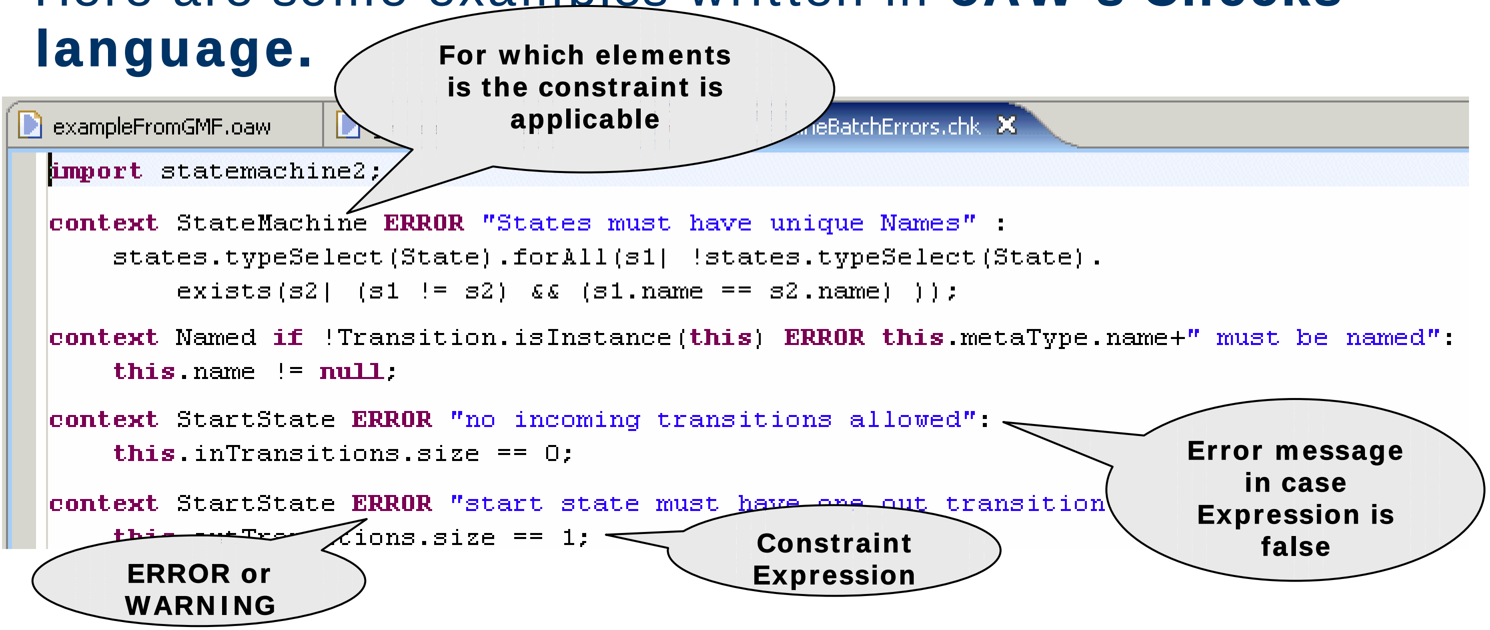
Additional Tests: Model Verification

- A really important aspect in our example system is **evolution of interfaces**:

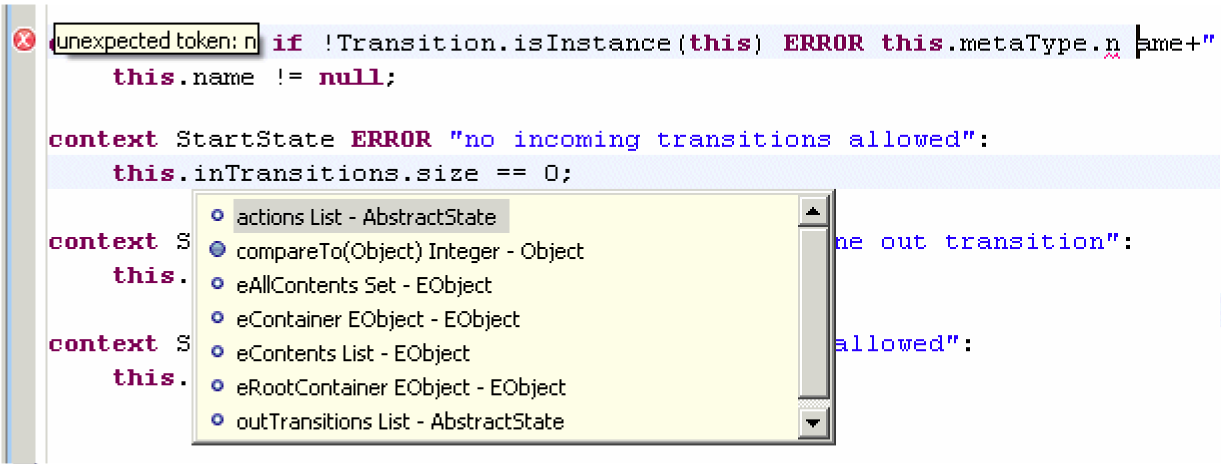


Additional Tests: Model Verification

- Here are some examples written in **oAW's Checks language.**



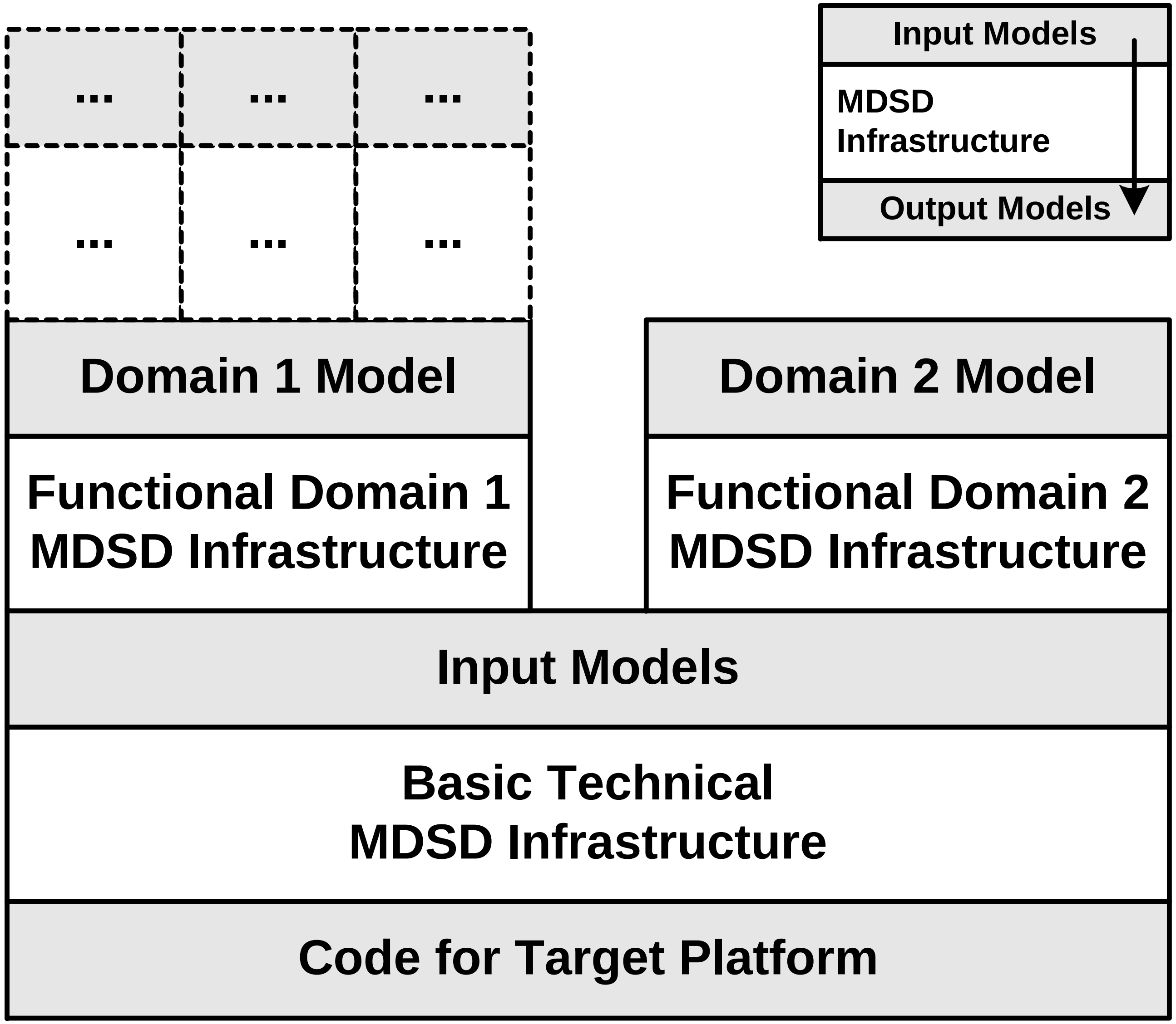
- Note the **code completion** & **error highlighting** ☺



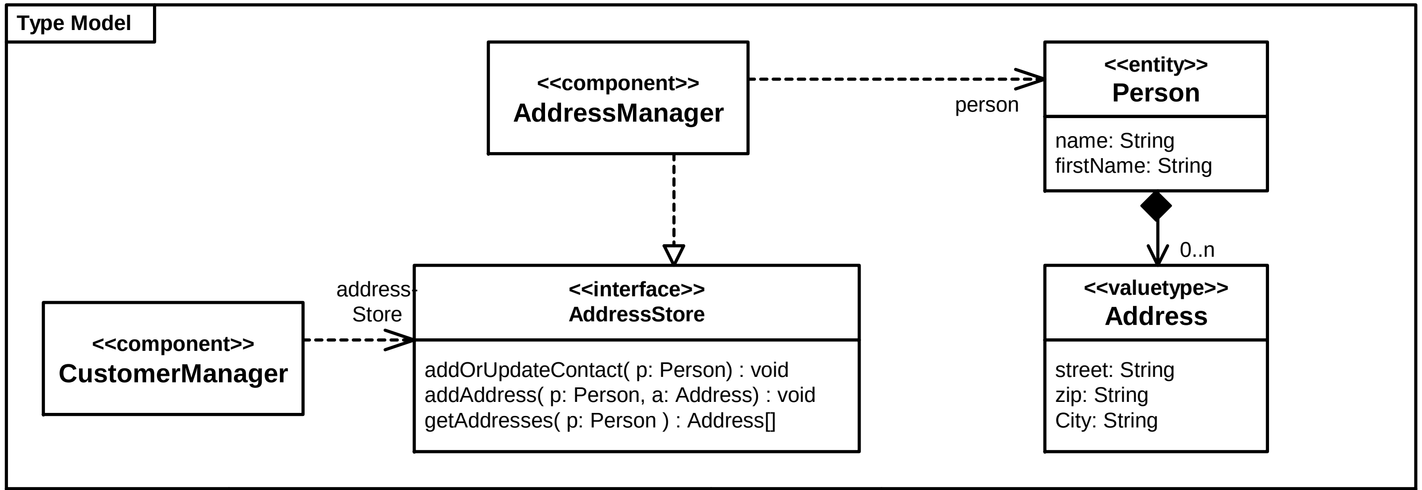
Partitions / Layers / Cascading

Architecture can be nicely layered and architected to be as small an consistent as possible

Levels of MDSD



Levels of MDSD III – M2M Transformations

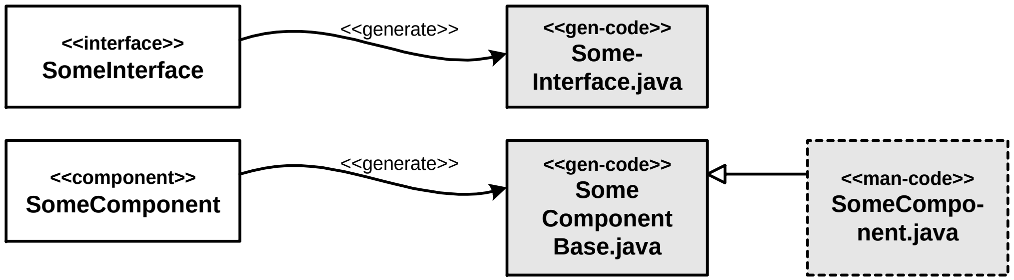


Composition Model

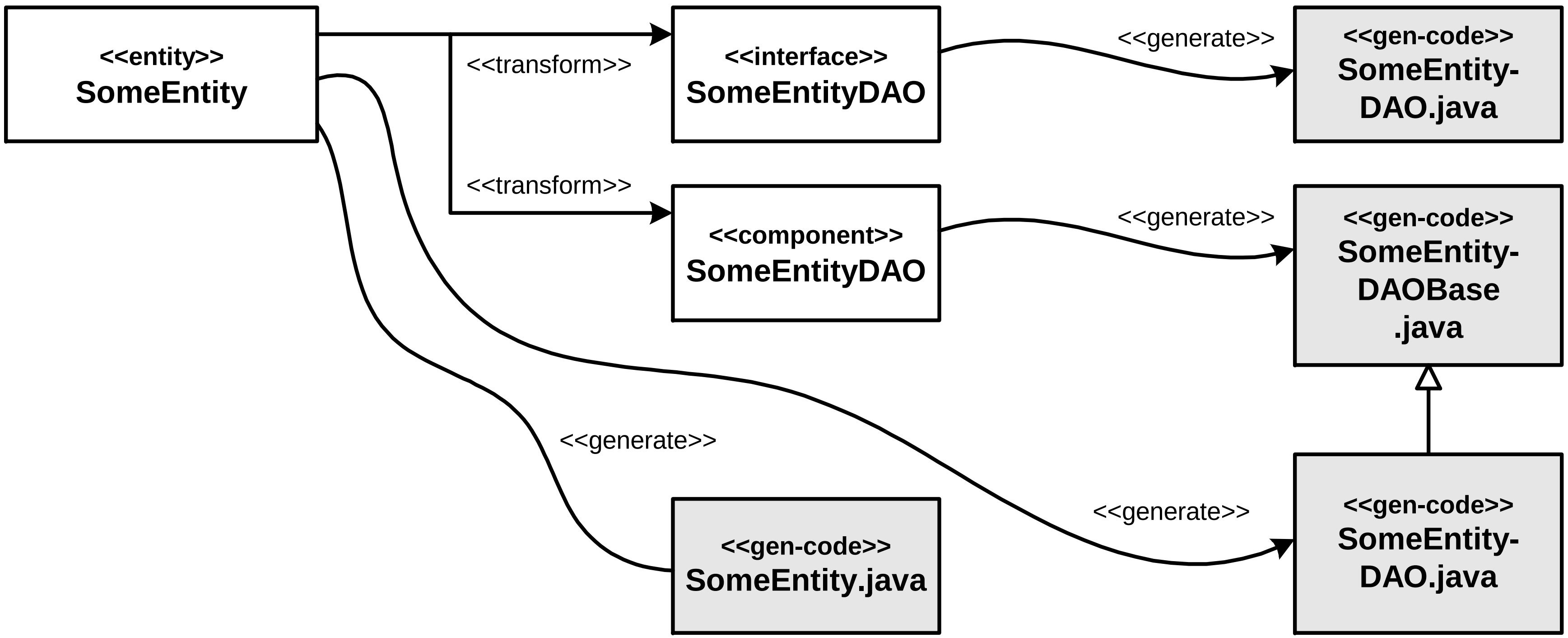
```
<configurations>
  <configuration name="addressStuff">
    <deployment name="am" type="AddressManager">
      <wire name="personDAO" target="personDAO"/>
    </deployment>
    <deployment name="personDAO" type="PersonDAO"/>
  </configuration>
  <configuration name="customerStuff">
    <deployment name="cm" type="CustomerManager">
      <wire name="addressStore" target=":addressStuff:am"/>
    </deployment>
  </configuration>
  <configuration name="test" includes="addressStuff, customerStuff"/>
</configurations>
```

System Model

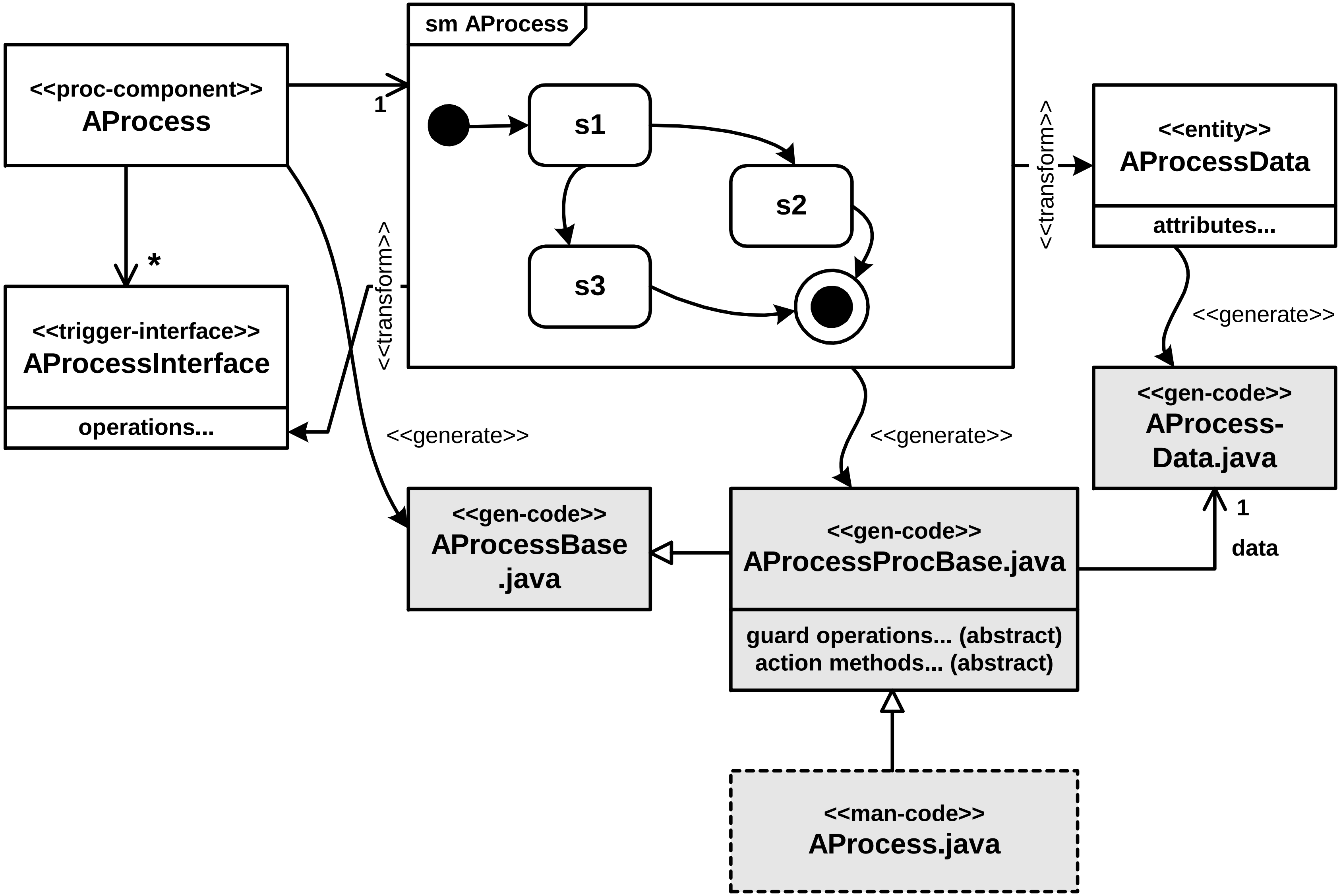
```
<systems>
  <system name="production">
    <node name="server" type="spring" configuration="addressStuff"/>
    <node name="client" type="eclipse" configuration="customerStuff"/>
  <system>
  <system name="test">
    <node name="test" type="spring" configuration="test"/>
  <system>
</systems>
```



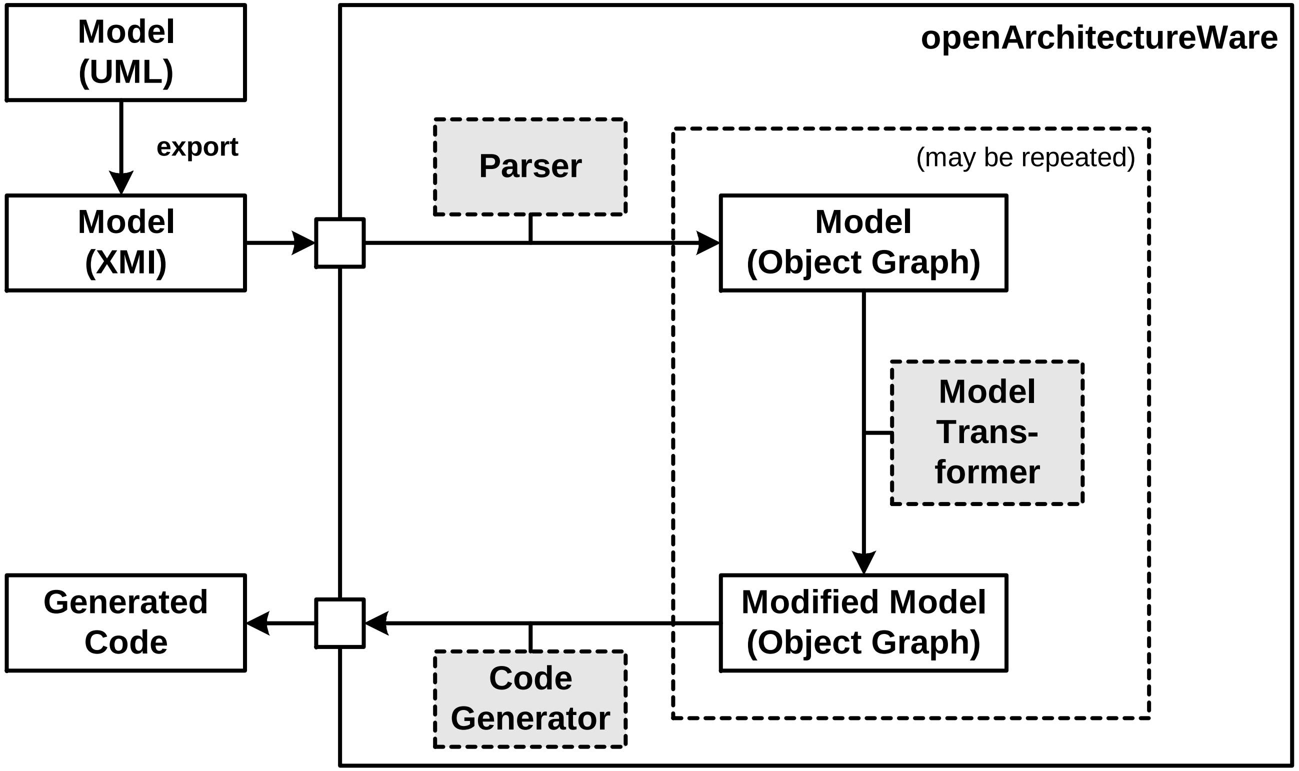
Levels of MDSD III – M2M Transformations II



Levels of MDSD III – M2M Transformations IV



Levels of MDSD III – M2M Transformations III



M2M Transformations

- The **model modification** shows how to add an additional state & some transitions to an existing state machine (emergency shutdown)

AddEmergencyShutdown.ext

```
import statemachine2;

extension statemachine2::constraints::Statemachine;

StateMachine modify(StateMachine sm) :
    sm.transitions.addAll(sm.allConcreteStates().createTransition()) ->
    sm.states.add(createShutDown()) ->
    sm;

private create State this createShutDown() :
    setName("EmergencyShutDown");

private create Transition this createTransition(State s) :
    setEvent("Error")->
    setName("Aborting") ->
    setFrom(s) ->
    setTo(createShutDown());
```

Extensions can import other extensions

The main function

„create extensions“ guarantee that for each set of parameters the *identical* result will be returned.

Therefore createShutDown() will always return the same element.

Thanks!

Please ask questions!

Some advertisement ☺

- For those, who speak (or rather, read) german:

  Völter, Stahl:

  Modellgetriebene Softwareentwicklung
  Technik, Engineering, Management

  dPunkt, 2005

  www.mdsd-buch.de

- An **very much updated** translation is under way:
  Model-Driven Software Development,
  Wiley, Q2 2006

  www.mdsd-book.org