CASE Tool Integration mit XMI

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Inhaltsübersicht

Motivation:

Herausforderungen in Methoden- und Werkzeugeinsatz

Zusammenspiel: Werkzeug – Modellierungssprache

Ziele von SMIF/XMI

Technische Umsetzung
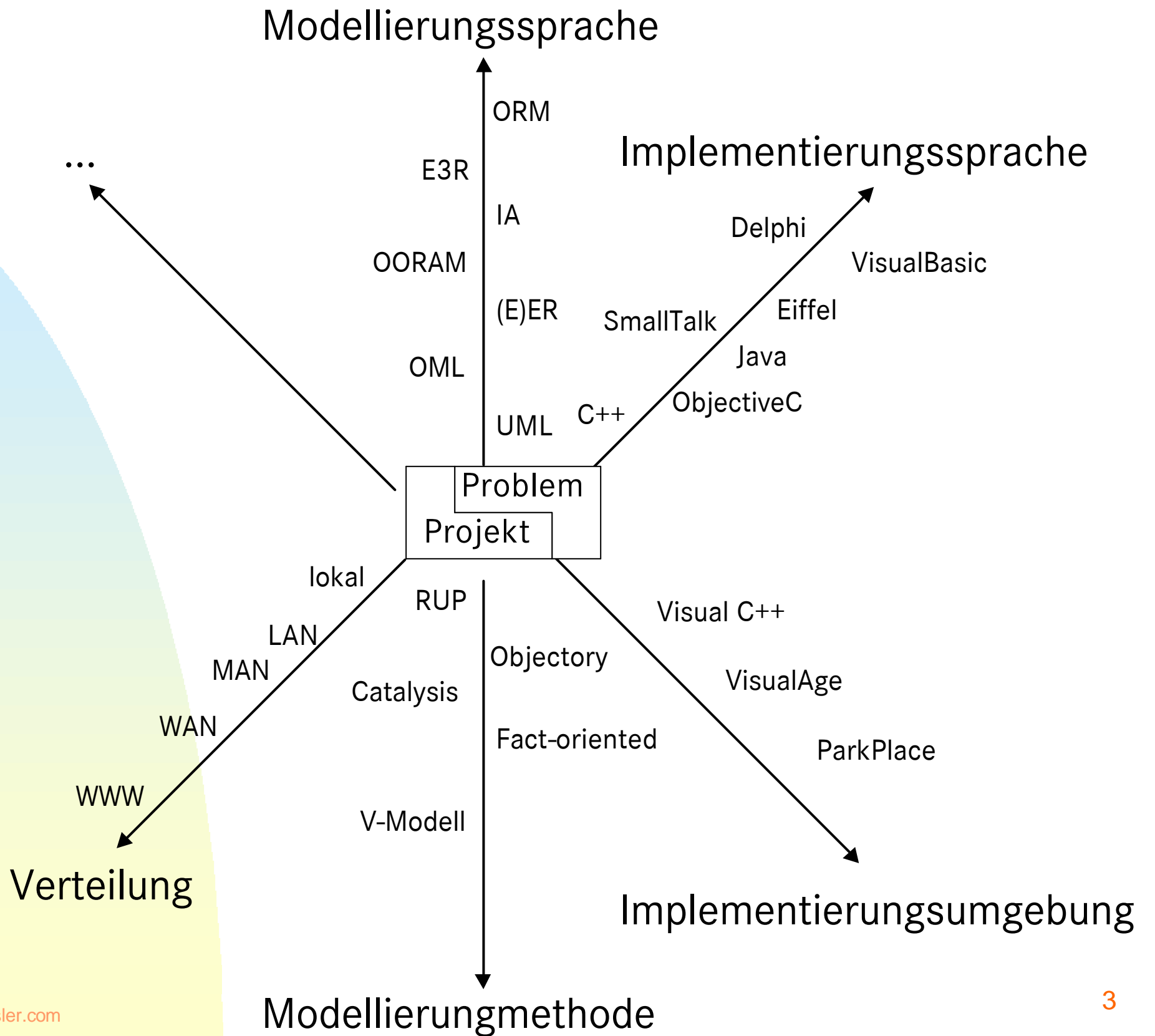
Metamodellierung

eXtensible Markup Language

Beispiel

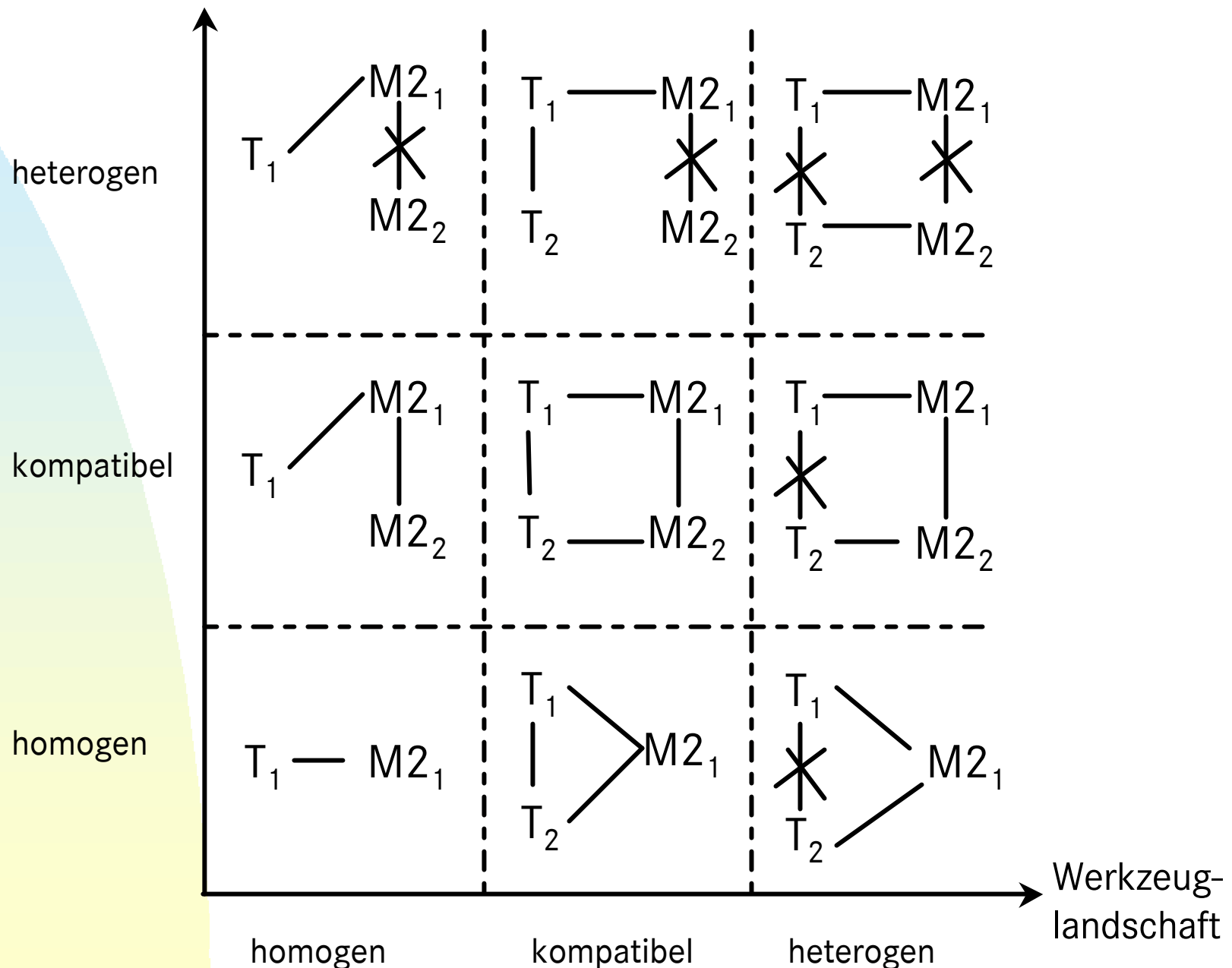**Existierende Anwendungen (proof of concept)**

Einsatzspektrum von XMI

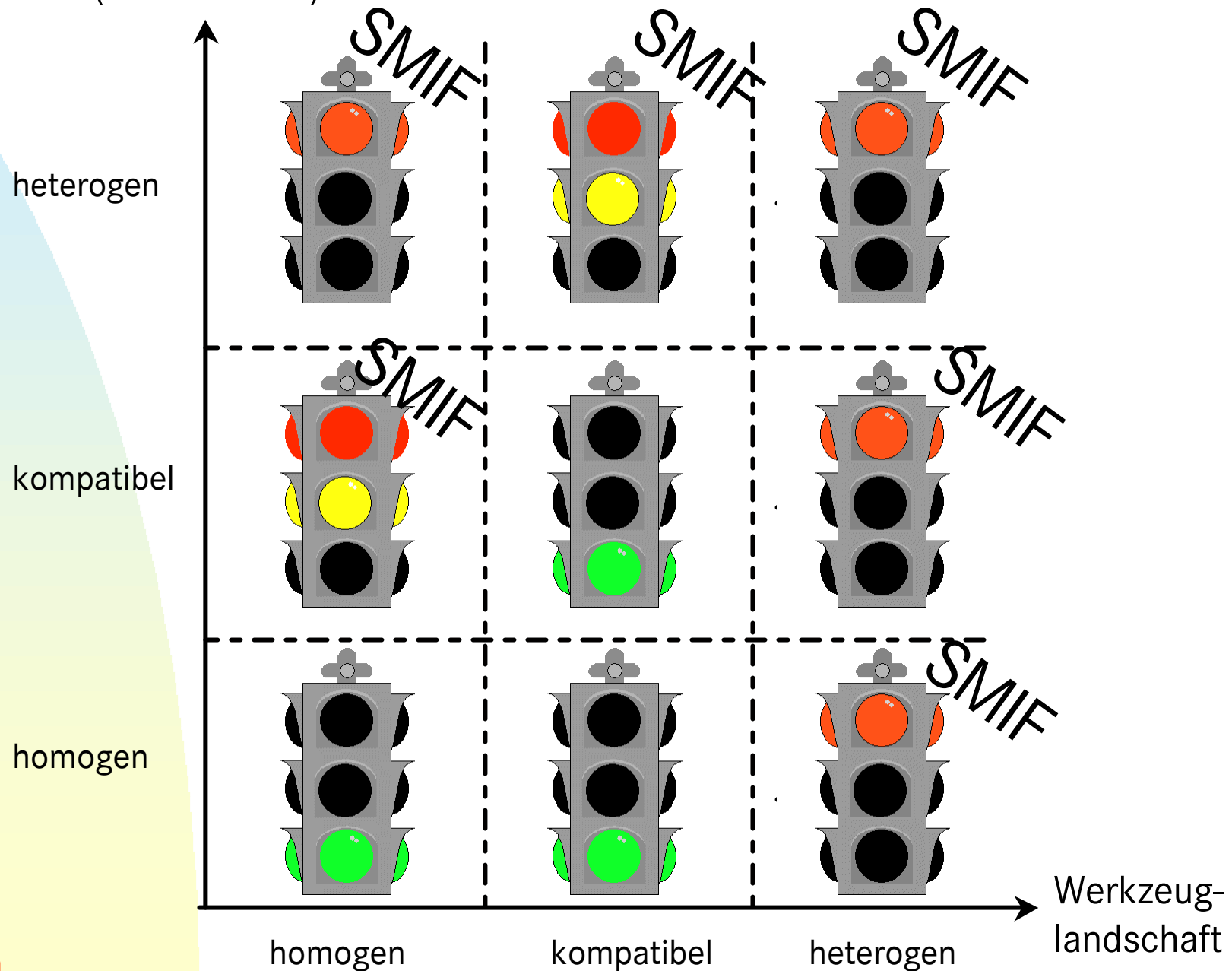**XMI in der Praxis**

XMI heute (verfügbare Werkzeuge)

Zusammenspiel: Werkzeug – Sprache

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Zusammenspiel: Werkzeug – Sprache

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SMIF/XMI

Ziele
- Herstellerunabhängiges Transferformat
- Instriestandard-Formatfestlegung
- generisches Format
- Modellaustausch
  - MOF-basierter Modelle
    - UML
    - Work-Flow Management Facility
    - Business Objects Facility

Lösung für
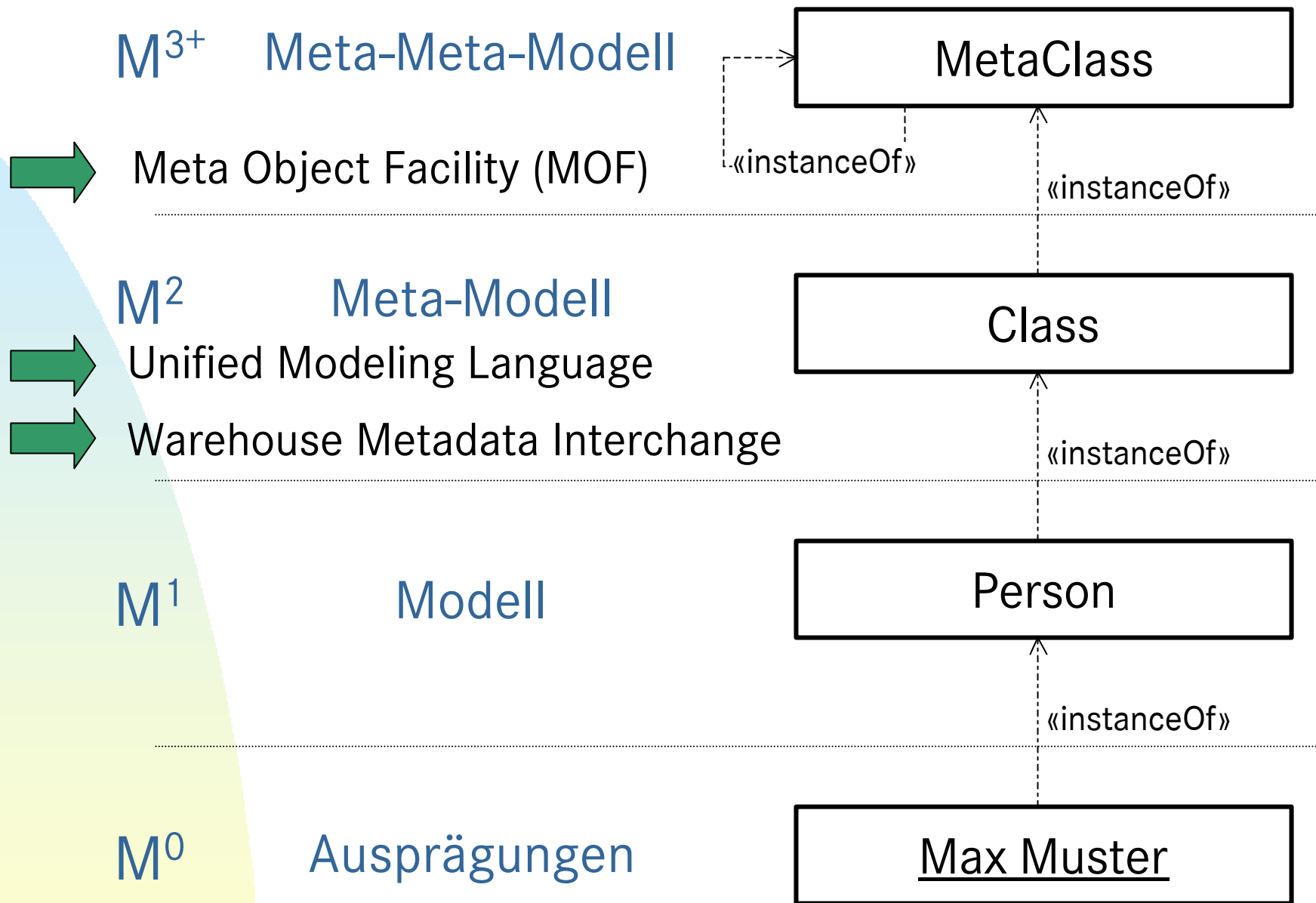- Transferspezifikation
  - MOF basierter Modelle
  - CDIF codierter Modelle
  - STEP/EXPRESS Modelle
- Metamodell-Versionierung

Umsetzung:
- Web-Technologien (W3-Standards)
  - XML liefert Syntax und Encoding Standard
- MOF liefert Metadaten Definition

XMI ist eine Sprache der XML-Familie

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Metamodellhierarchie der OMG

M^{3+} Meta-Meta-Modell

→ Meta Object Facility (MOF)

M^2 Meta-Modell

→ Unified Modeling Language

→ Warehouse Metadata Interchange

M^1 Modell

M^0 Ausprägungen

MetaClass

«instanceOf»

«instanceOf»

Class

«instanceOf»

Person

«instanceOf»

Max Muster

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Umsetzung mit XML
Die Struktur von XMI

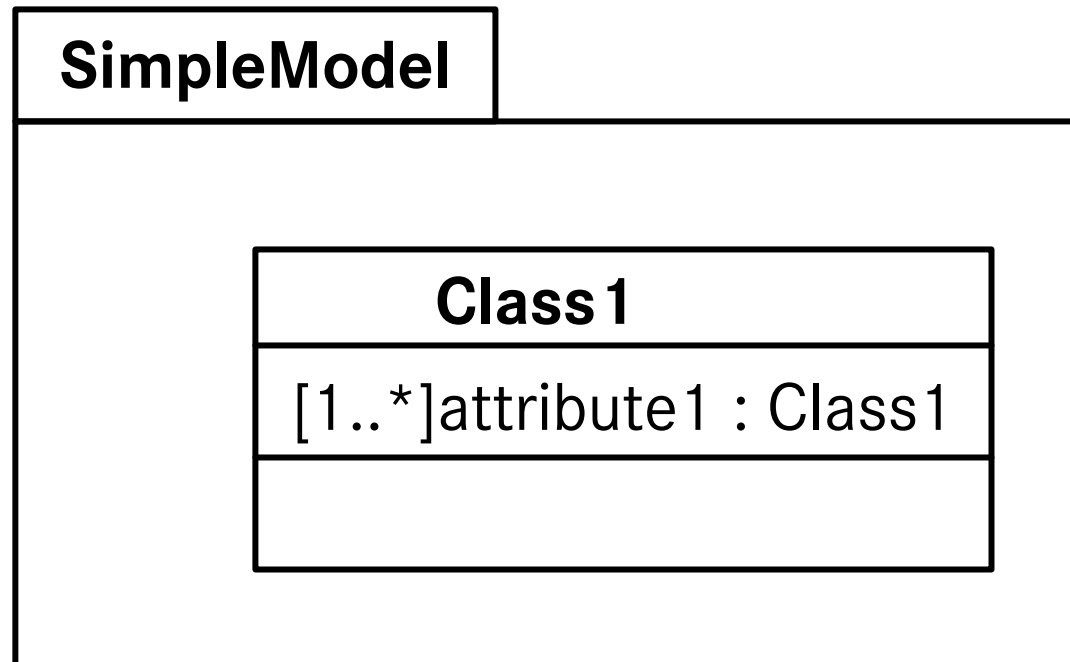|			
M^{3+}	Meta Object Facilities Meta Meta Model	MOF as XML DTD	
M^2	UML & other Meta Models	UML & others as XML DTDs	MOF MetaModels as XML Documents
M^1	Model		UML & other Models as XML Documents
M^0	Instances		

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Beispiel

...Umsetzung in MOF

SimpleModel: Model

name = SimpleModel
visibility = public
...

ownedElement

Class1 : Class

name = Class1
...

feature

attribute1 : Attribute

name = attribute1
multiplicity = ({1, 1})
...

type

Class1 : DataType

name = Class1
...

SimpleModel

Class1

[1..*]attribute1 : Class1

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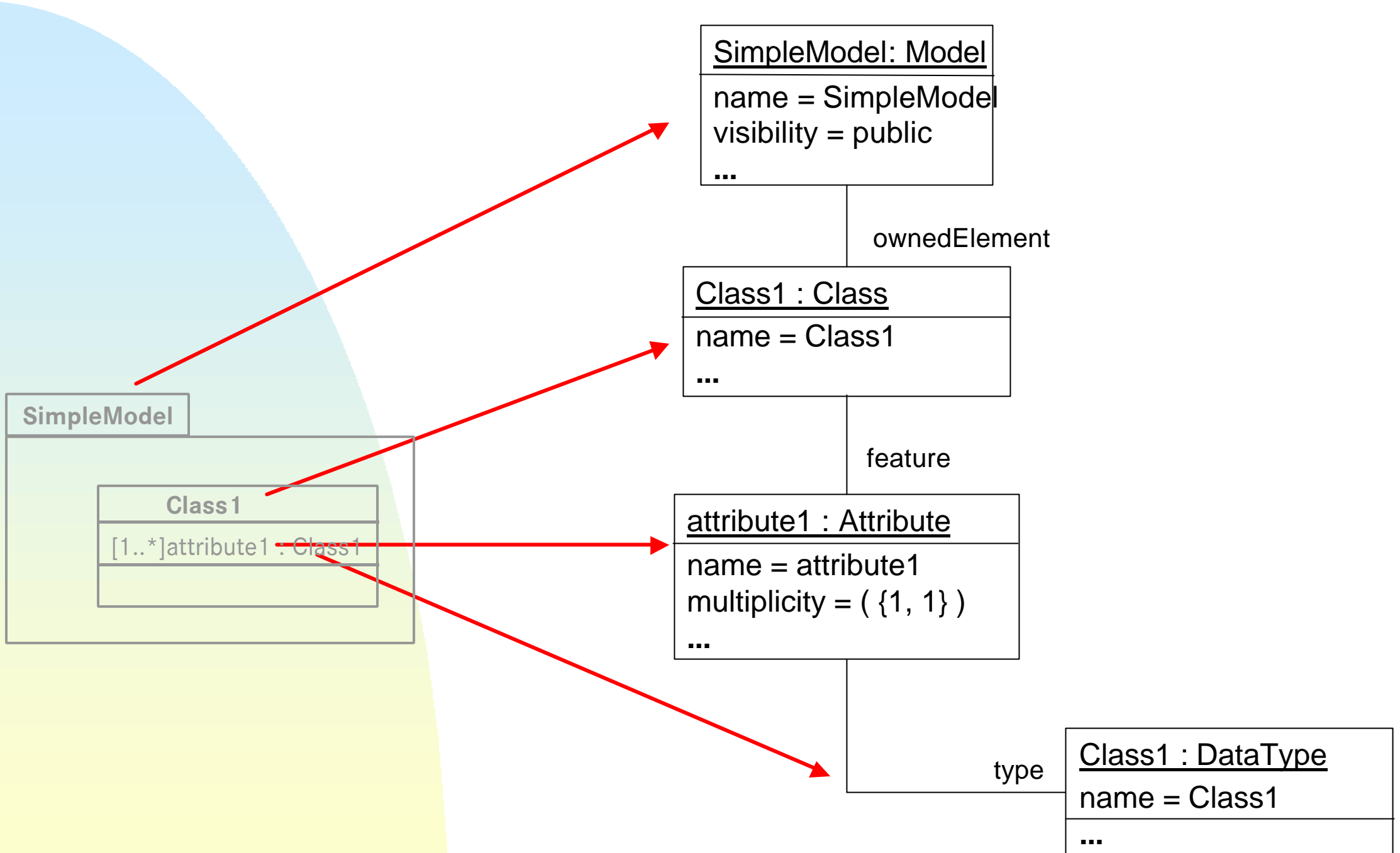# ...Generierung der XMI-Darstellung

- XMI-Header

```
<?xml version = "1.0"?>
<!DOCTYPE XMI SYSTEM "uml.dtd">
<XMI xmi.version="1.0">
  <XMI.header>
    <XMI.metamodel xmi.name="uml" xmi.version="1.1"/>
  </XMI.header>
  <XMI.content>
   <Model_Management.Model xmi.id="i00000001">
    <Foundation.Core.ModelElement.name>
      SimpleModel
    </Foundation.Core.ModelElement.name>
    <Foundation.Core.ModelElement.visibility xmi.value="public"/>
    <Foundation.Core.GeneralizableElement.isRoot xmi.value="true"/>
    <Foundation.Core.GeneralizableElement.isLeaf xmi.value="true"/>
    <Foundation.Core.GeneralizableElement.isAbstract xmi.value="false"/>
    <Foundation.Core.Namespace.ownedElement>
     <Foundation.Core.Class xmi.id="i00000002">
      <Foundation.Core.ModelElement.name>
        class1
      </Foundation.Core.ModelElement.name>
      <Foundation.Core.ModelElement.visibility xmi.value="public"/>
      <Foundation.Core.GeneralizableElement.isRoot xmi.value="true"/>
      <Foundation.Core.GeneralizableElement.isLeaf xmi.value="true"/>
      <Foundation.Core.GeneralizableElement.isAbstract xmi.value="false"/>
      <Foundation.Core.Class.isActive xmi.value="true"/>
      <Foundation.Core.Classifier.feature>
       <Foundation.Core.Attribute xmi.id="i00000003">
        <Foundation.Core.ModelElement.name>
          attribute1
        </Foundation.Core.ModelElement.name>
```
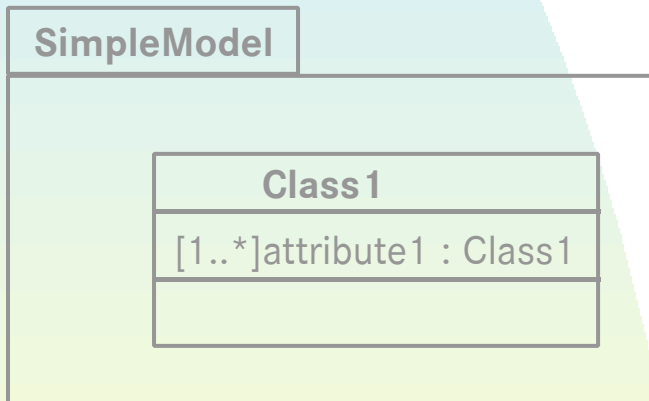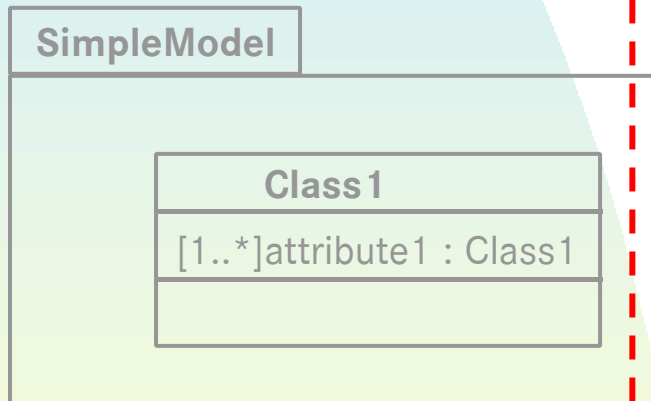
SimpleModel

Class1

[1..*]attribute1 : Class1

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...Generierung der XMI-Darstellung

- XMI-Body

SimpleModel

Class1

[1..*]attribute1 : Class1

```
<?xml version = "1.0"?>
<!DOCTYPE XMI SYSTEM "uml.dtd">
<XMI xmi.version="1.0">
  <XMI.header>
    <XMI.metamodel xmi.name="uml" xmi.version="1.1"/>
  </XMI.header>
  <XMI.content>
    <Model_Management.Model xmi.id="i00000001">
      <Foundation.Core.ModelElement.name>
        SimpleModel
      </Foundation.Core.ModelElement.name>
      <Foundation.Core.ModelElement.visibility xmi.value="public"/>
      <Foundation.Core.GeneralizableElement.isRoot xmi.value="true"/>
      <Foundation.Core.GeneralizableElement.isLeaf xmi.value="true"/>
      <Foundation.Core.GeneralizableElement.isAbstract xmi.value="false"/>
      <Foundation.Core.Namespace.ownedElement>
        <Foundation.Core.Class xmi.id="i00000002">
          <Foundation.Core.ModelElement.name>
            class1
          </Foundation.Core.ModelElement.name>
          <Foundation.Core.ModelElement.visibility xmi.value="public"/>
          <Foundation.Core.GeneralizableElement.isRoot xmi.value="true"/>
          <Foundation.Core.GeneralizableElement.isLeaf xmi.value="true"/>
          <Foundation.Core.GeneralizableElement.isAbstract xmi.value="false"/>
          <Foundation.Core.Class.isActive xmi.value="true"/>
          <Foundation.Core.Classifier.feature>
            <Foundation.Core.Attribute xmi.id="i00000003">
              <Foundation.Core.ModelElement.name>
                attribute1
              </Foundation.Core.ModelElement.name>
```
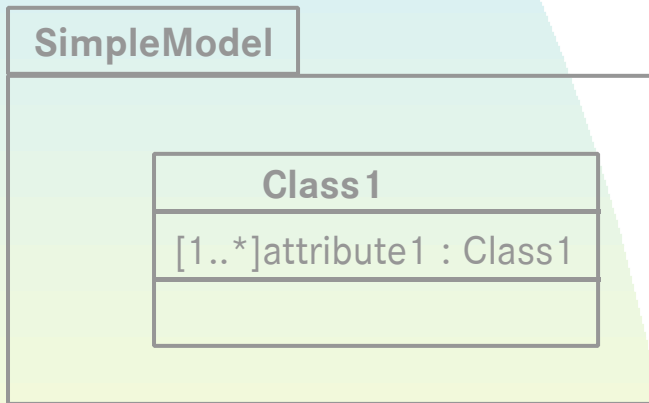
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...Generierung der XMI-Darstellung

- DTD-Verweis

SimpleModel

Class 1
[1..*]attribute1 : Class1

```
<?xml version = "1.0"?>
<!DOCTYPE XMI SYSTEM "uml.dtd">
<XMI xmi.version="1.0">
  <XMI.header>
    <XMI.metamodel xmi.name="uml" xmi.version="1.1"/>
  </XMI.header>
  <XMI.content>
    <Model_Management.Model xmi.id="i00000001">
      <Foundation.Core.ModelElement.name>
        SimpleModel
      </Foundation.Core.ModelElement.name>
      <Foundation.Core.ModelElement.visibility xmi.value="public"/>
      <Foundation.Core.GeneralizableElement.isRoot xmi.value="true"/>
      <Foundation.Core.GeneralizableElement.isLeaf xmi.value="true"/>
      <Foundation.Core.GeneralizableElement.isAbstract xmi.value="false"/>
      <Foundation.Core.Namespace.ownedElement>
        <Foundation.Core.Class xmi.id="i00000002">
          <Foundation.Core.ModelElement.name>
            class1
          </Foundation.Core.ModelElement.name>
          <Foundation.Core.ModelElement.visibility xmi.value="public"/>
          <Foundation.Core.GeneralizableElement.isRoot xmi.value="true"/>
          <Foundation.Core.GeneralizableElement.isLeaf xmi.value="true"/>
          <Foundation.Core.GeneralizableElement.isAbstract xmi.value="false"/>
          <Foundation.Core.Class.isActive xmi.value="true"/>
          <Foundation.Core.Classifier.feature>
            <Foundation.Core.Attribute xmi.id="i00000003">
              <Foundation.Core.ModelElement.name>
                attribute1
              </Foundation.Core.ModelElement.name>
```
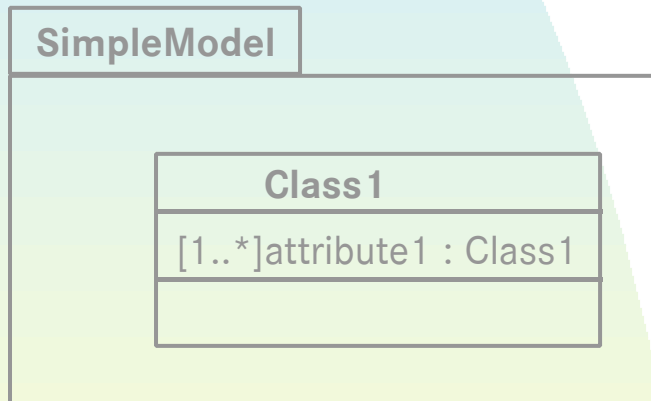
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...Generierung der XMI-Darstellung

- Metamodell-Identifikation

SimpleModel

Class1
[1..*]attribute1 : Class1

```
<?xml version = "1.0"?>
<!DOCTYPE XMI SYSTEM "uml.dtd">
<XMI xmi.version="1.0">
<XMI.header>
  <XMI.metamodel xmi.name="uml" xmi.version="1.1"/>
</XMI.header>
<XMI.content>
  <Model_Management.Model xmi.id="i00000001">
   <Foundation.Core.ModelElement.name>
     SimpleModel
   </Foundation.Core.ModelElement.name>
   <Foundation.Core.ModelElement.visibility xmi.value="public"/>
   <Foundation.Core.GeneralizableElement.isRoot xmi.value="true"/>
   <Foundation.Core.GeneralizableElement.isLeaf xmi.value="true"/>
   <Foundation.Core.GeneralizableElement.isAbstract xmi.value="false"/>
   <Foundation.Core.Namespace.ownedElement>
    <Foundation.Core.Class xmi.id="i00000002">
      <Foundation.Core.ModelElement.name>
        class1
      </Foundation.Core.ModelElement.name>
      <Foundation.Core.ModelElement.visibility xmi.value="public"/>
      <Foundation.Core.GeneralizableElement.isRoot xmi.value="true"/>
      <Foundation.Core.GeneralizableElement.isLeaf xmi.value="true"/>
      <Foundation.Core.GeneralizableElement.isAbstract xmi.value="false"/>
      <Foundation.Core.Class.isActive xmi.value="true"/>
      <Foundation.Core.Classifier.feature>
       <Foundation.Core.Attribute xmi.id="i00000003">
         <Foundation.Core.ModelElement.name>
           attribute1
         </Foundation.Core.ModelElement.name>
```
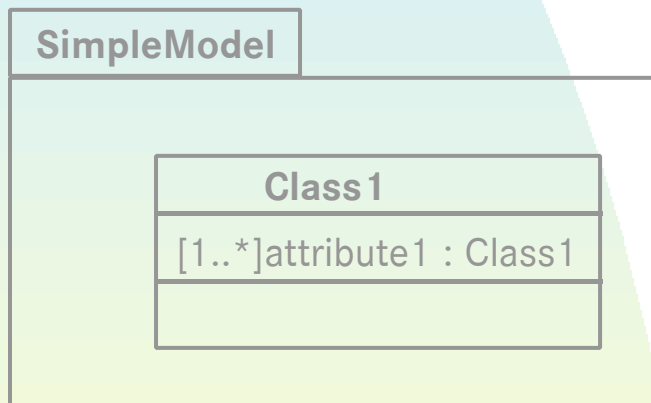
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...Generierung der XMI-Darstellung

- **Implizite Modellinformation**

SimpleModel
```
Class 1
[1..*]attribute1 : Class1
```

```xml
<?xml version = "1.0"?>
<!DOCTYPE XMI SYSTEM "uml.dtd">
<XMI xmi.version="1.0">
  <XMI.header>
    <XMI.metamodel xmi.name="uml" xmi.version="1.1"/>
  </XMI.header>
  <XMI.content>
    <Model_Management.Model xmi.id="i00000001">
      <Foundation.Core.ModelElement.name>
        SimpleModel
      </Foundation.Core.ModelElement.name>
      <Foundation.Core.ModelElement.visibility xmi.value="public"/>
      <Foundation.Core.GeneralizableElement.isRoot xmi.value="true"/>
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      <Foundation.Core.GeneralizableElement.isAbstract xmi.value="false"/>
      <Foundation.Core.Namespace.ownedElement>
        <Foundation.Core.Class xmi.id="i00000002">
          <Foundation.Core.ModelElement.name>
            class1
          </Foundation.Core.ModelElement.name>
          <Foundation.Core.ModelElement.visibility xmi.value="public"/>
          <Foundation.Core.GeneralizableElement.isRoot xmi.value="true"/>
          <Foundation.Core.GeneralizableElement.isLeaf xmi.value="true"/>
          <Foundation.Core.GeneralizableElement.isAbstract xmi.value="false"/>
          <Foundation.Core.Class.isActive xmi.value="true"/>
          <Foundation.Core.Classifier.feature>
            <Foundation.Core.Attribute xmi.id="i00000003">
              <Foundation.Core.ModelElement.name>
                attribute1
              </Foundation.Core.ModelElement.name>
```
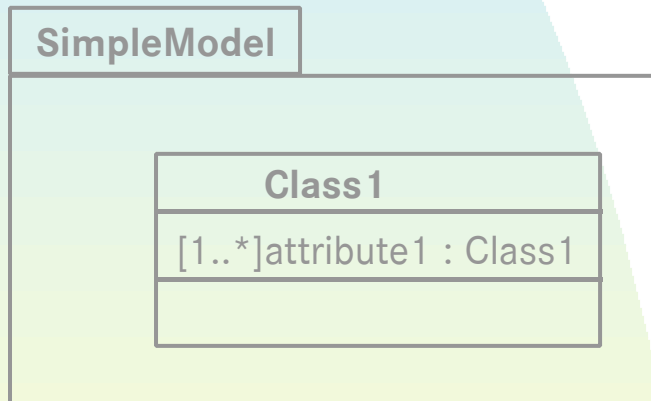
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- Nicht in UML
  dargestellte
  Vorgabewerte

SimpleModel

Class1
[1..*]attribute1 : Class1

```
<?xml version = "1.0"?>
<!DOCTYPE XMI SYSTEM "uml.dtd">
<XMI xmi.version="1.0">
  <XMI.header>
    <XMI.metamodel xmi.name="uml" xmi.version="1.1"/>
  </XMI.header>
  <XMI.content>
    <Model_Management.Model xmi.id="i00000001">
      <Foundation.Core.ModelElement.name>
        SimpleModel
      </Foundation.Core.ModelElement.name>
      <Foundation.Core.ModelElement.visibility xmi.value="public"/>
      <Foundation.Core.GeneralizableElement.isRoot xmi.value="true"/>
      <Foundation.Core.GeneralizableElement.isLeaf xmi.value="true"/>
      <Foundation.Core.GeneralizableElement.isAbstract xmi.value="false"/>
      <Foundation.Core.Namespace.ownedElement>
        <Foundation.Core.Class xmi.id="i00000002">
          <Foundation.Core.ModelElement.name>
            class1
          </Foundation.Core.ModelElement.name>
          <Foundation.Core.ModelElement.visibility xmi.value="public"/>
          <Foundation.Core.GeneralizableElement.isRoot xmi.value="true"/>
          <Foundation.Core.GeneralizableElement.isLeaf xmi.value="true"/>
          <Foundation.Core.GeneralizableElement.isAbstract xmi.value="false"/>
          <Foundation.Core.Class.isActive xmi.value="true"/>
          <Foundation.Core.Classifier.feature>
            <Foundation.Core.Attribute xmi.id="i00000003">
              <Foundation.Core.ModelElement.name>
                attribute1
              </Foundation.Core.ModelElement.name>
```
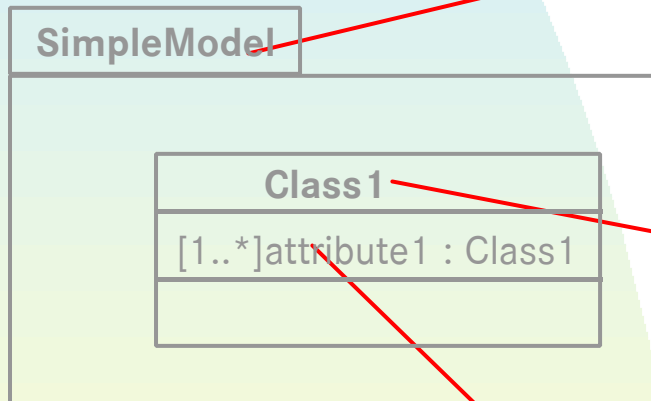
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...Generierung der XMI-Darstellung

- Umsetzung der UML-Konstrukte

```xml
<?xml version = "1.0"?>
<!DOCTYPE XMI SYSTEM "uml.dtd">
<XMI xmi.version="1.0">
  <XMI.header>
    <XMI.metamodel xmi.name="uml" xmi.version="1.1"/>
  </XMI.header>
  <XMI.content>
    <Model_Management.Model xmi.id="i00000001">
    <Foundation.Core.ModelElement.name>
      SimpleModel
    </Foundation.Core.ModelElement.name>
    <Foundation.Core.ModelElement.visibility xmi.value="public"/>
    <Foundation.Core.GeneralizableElement.isRoot xmi.value="true"/>
    <Foundation.Core.GeneralizableElement.isLeaf xmi.value="true"/>
    <Foundation.Core.GeneralizableElement.isAbstract xmi.value="false"/>
    <Foundation.Core.Namespace.ownedElement>
      <Foundation.Core.Class xmi.id="i00000002">
      <Foundation.Core.ModelElement.name>
        class1
      </Foundation.Core.ModelElement.name>
      <Foundation.Core.ModelElement.visibility xmi.value="public"/>
      <Foundation.Core.GeneralizableElement.isRoot xmi.value="true"/>
      <Foundation.Core.GeneralizableElement.isLeaf xmi.value="true"/>
      <Foundation.Core.GeneralizableElement.isAbstract xmi.value="false"/>
      <Foundation.Core.Class.isActive xmi.value="true"/>
      <Foundation.Core.Classifier.feature>
        <Foundation.Core.Attribute xmi.id="i00000003">
        <Foundation.Core.ModelElement.name>
          attribute1
        </Foundation.Core.ModelElement.name>
```
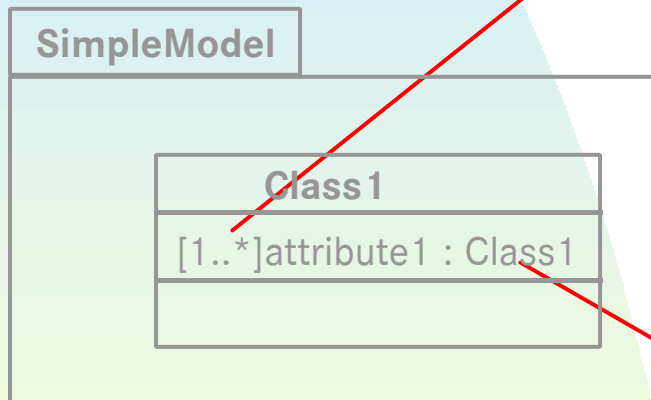
SimpleModel

Class1

[1..*]attribute1 : Class1

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...Fortsetzung

- Umsetzung der UML-Konstrukte

SimpleModel

Class1

[1..*]attribute1 : Class1

```
<Foundation.Core.ModelElement.visibility xmi.value="public"/>
    <Foundation.Core.Feature.ownerScope xmi.value="instance"/>
    <Foundation.Core.StructuralFeature.multiplicity>
      1..*
    </Foundation.Core.StructuralFeature.multiplicity>
    <Foundation.Core.StructuralFeature.changeable xmi.value="none"/>
    <Foundation.Core.StructuralFeature.targetScope xmi.value="instance"/>
    <Foundation.Core.Attribute.initialValue>
      <Foundation.Data_Types.Expression>
        <Foundation.Data_Types.Expression.language>
        </Foundation.Data_Types.Expression.language>
        <Foundation.Data_Types.Expression.body>
          0
        </Foundation.Data_Types.Expression.body>
      </Foundation.Data_Types.Expression>
    </Foundation.Core.Attribute.initialValue>
    <Foundation.Core.StructuralFeature.type>
      <Foundation.Core.DataType xmi.idref = "i00000004"/>
    </Foundation.Core.StructuralFeature.type>
    </Foundation.Core.Attribute>
  </Foundation.Core.Classifier.feature>
 </Foundation.Core.Class>
 <Foundation.Core.DataType xmi.id="i00000004">
  <Foundation.Core.ModelElement.name>
    Class1
  </Foundation.Core.ModelElement.name>
  <Foundation.Core.ModelElement.visibility xmi.value="public"/>
  <Foundation.Core.GeneralizableElement.isRoot xmi.value="true"/>
  <Foundation.Core.GeneralizableElement.isLeaf xmi.value="true"/>
  <Foundation.Core.GeneralizableElement.isAbstract xmi.value="false"/>
 </Foundation.Core.DataType>
 </Foundation.Core.Namespace.ownedElement>
 </Model_Management.Model>
 </XMI.content>
</XMI>
```
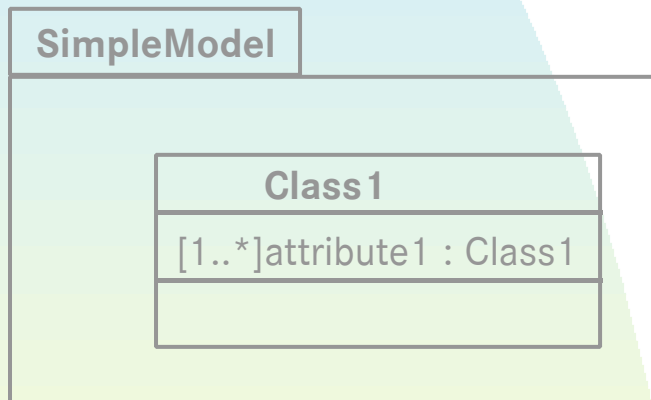
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...Fortsetzung

- Nicht in UML dargestellte Vorgabewerte

```
SimpleModel
  ┌─────────────────────┐
  │      Class1          │
  ├─────────────────────┤
  │ [1..*]attribute1 : Class1 │
  ├─────────────────────┤
  │                     │
  └─────────────────────┘
```

```
<Foundation.Core.ModelElement.visibility xmi.value="public"/>
        <Foundation.Core.Feature.ownerScope xmi.value="instance"/>
        <Foundation.Core.StructuralFeature.multiplicity>
          1..*
        </Foundation.Core.StructuralFeature.multiplicity>
        <Foundation.Core.StructuralFeature.changeable xmi.value="none"/>
        <Foundation.Core.StructuralFeature.targetScope xmi.value="instance"/>
        <Foundation.Core.Attribute.initialValue>
          <Foundation.Data_Types.Expression>
            <Foundation.Data_Types.Expression.language>
            </Foundation.Data_Types.Expression.language>
            <Foundation.Data_Types.Expression.body>
              0
            </Foundation.Data_Types.Expression.body>
          </Foundation.Data_Types.Expression>
        </Foundation.Core.Attribute.initialValue>
        <Foundation.Core.StructuralFeature.type>
          <Foundation.Core.DataType xmi.idref = "i00000004"/>
        </Foundation.Core.StructuralFeature.type>
      </Foundation.Core.Attribute>
    </Foundation.Core.Classifier.feature>
  </Foundation.Core.Class>
  <Foundation.Core.DataType xmi.id="i00000004">
    <Foundation.Core.ModelElement.name>
      Class1
    </Foundation.Core.ModelElement.name>
    <Foundation.Core.ModelElement.visibility xmi.value="public"/>
    <Foundation.Core.GeneralizableElement.isRoot xmi.value="true"/>
    <Foundation.Core.GeneralizableElement.isLeaf xmi.value="true"/>
    <Foundation.Core.GeneralizableElement.isAbstract xmi.value="false"/>
  </Foundation.Core.DataType>
  </Foundation.Core.Namespace.ownedElement>
  </Model_Management.Model>
 </XMI.content>
</XMI>
```
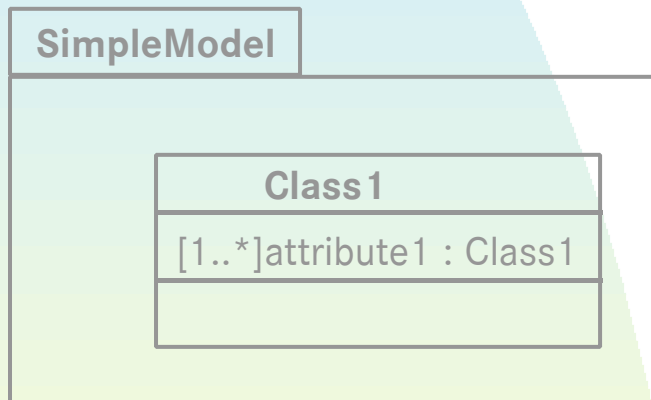
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...Fortsetzung

- Automatische Generierung notwendiger Zusatzinformation

SimpleModel

Class1

[1..*]attribute1 : Class1

```
        <Foundation.Core.ModelElement.visibility xmi.value="public"/>
            <Foundation.Core.Feature.ownerScope xmi.value="instance"/>
            <Foundation.Core.StructuralFeature.multiplicity>
              1..*
            </Foundation.Core.StructuralFeature.multiplicity>
            <Foundation.Core.StructuralFeature.changeable xmi.value="none"/>
            <Foundation.Core.StructuralFeature.targetScope xmi.value="instance"/>
            <Foundation.Core.Attribute.initialValue>
              <Foundation.Data_Types.Expression>
                <Foundation.Data_Types.Expression.language>
                </Foundation.Data_Types.Expression.language>
                <Foundation.Data_Types.Expression.body>
                  0
                </Foundation.Data_Types.Expression.body>
              </Foundation.Data_Types.Expression>
            </Foundation.Core.Attribute.initialValue>
            <Foundation.Core.StructuralFeature.type>
              <Foundation.Core.DataType xmi.idref = "i00000004"/>
            </Foundation.Core.StructuralFeature.type>
          </Foundation.Core.Attribute>
        </Foundation.Core.Classifier.feature>
      </Foundation.Core.Class>
      <Foundation.Core.DataType xmi.id="i00000004">
        <Foundation.Core.ModelElement.name>
          Class1
        </Foundation.Core.ModelElement.name>
        <Foundation.Core.ModelElement.visibility xmi.value="public"/>
        <Foundation.Core.GeneralizableElement.isRoot xmi.value="true"/>
        <Foundation.Core.GeneralizableElement.isLeaf xmi.value="true"/>
        <Foundation.Core.GeneralizableElement.isAbstract xmi.value="false"/>
      </Foundation.Core.DataType>
    </Foundation.Core.Namespace.ownedElement>
  </Model_Management.Model>
 </XMI.content>
</XMI>
```
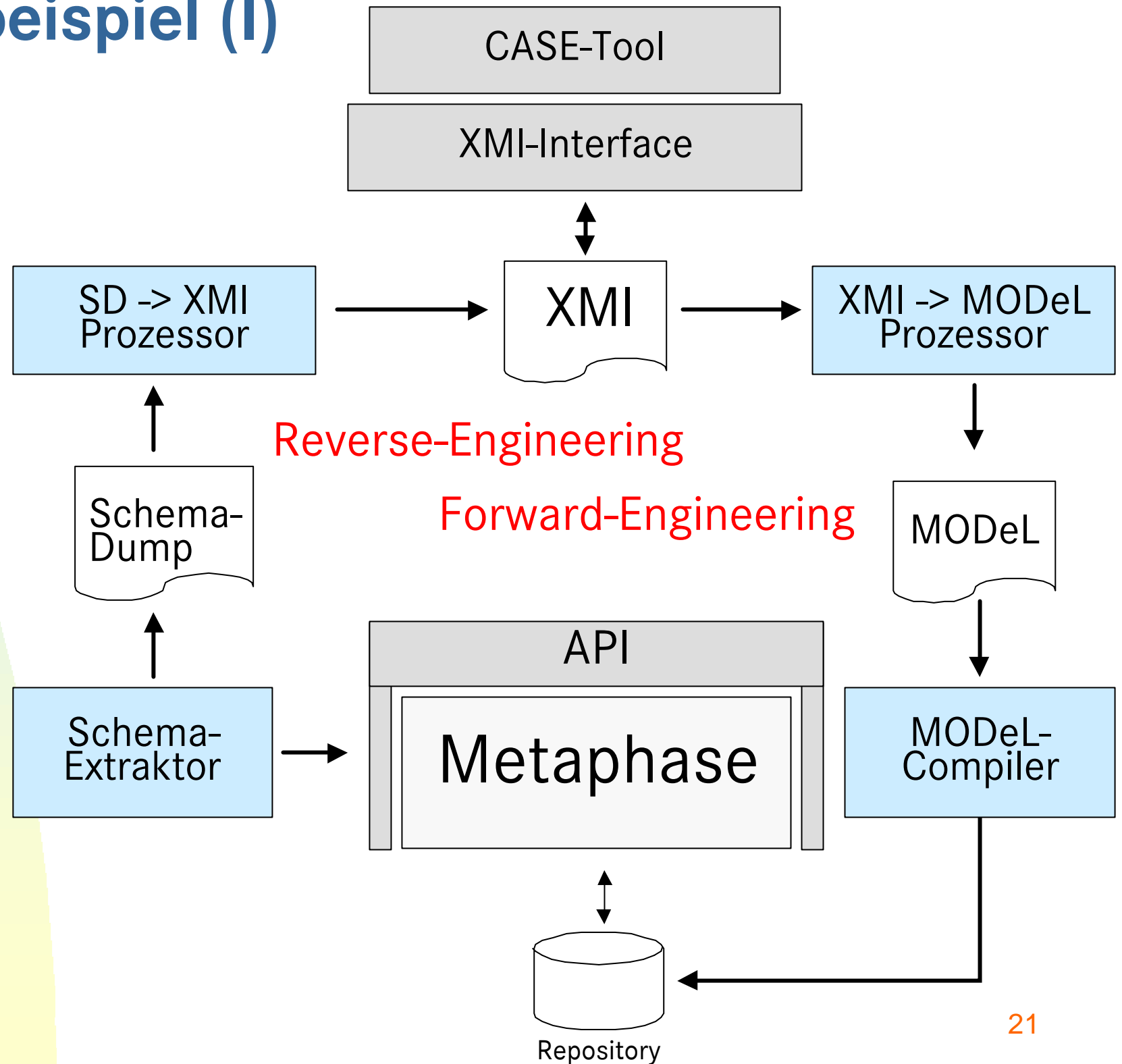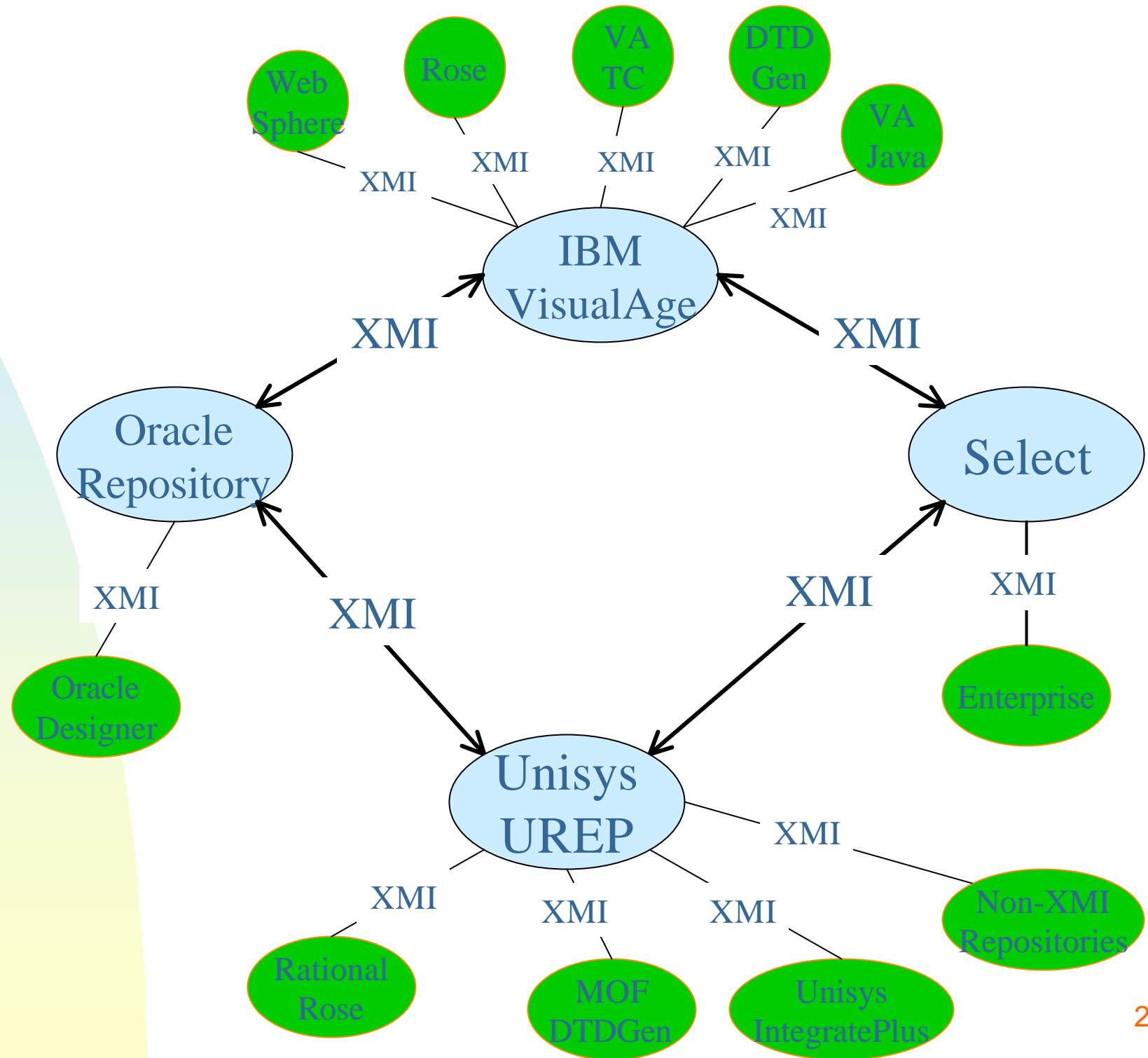
Anwendungsbeispiel (I)

CASE-Tool

XMI-Interface

SD -> XMI Prozessor

XMI

XMI -> MODeL Prozessor

Reverse-Engineering

Forward-Engineering

Schema-Dump

MODeL

API

Schema-Extraktor

Metaphase

MODeL-Compiler

Repository

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Anwendungsbeispiel (II)

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XMI – mehr als „nur" Modellaustausch

- Einsatz als Modellaustauschformat
- Transferformat für Data-Warehouse Applikationen
- Eindeutige textuelle Beschreibung von (Meta-)Modellen
- Toolunabhängige Code-Generierung
- Metriken
- Pattern Libraries
- Modellvalidierung
- Modellierungssprachen-unabhängige Modellbeschreibung
- ...

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Warum XMI?!

+ Breite Industrieunterstützung

Unisys
IBM
DSTC
Oracle
Platinum Technology
Fujitsu
Softeam
Recerca Informatica
DaimlerChrysler

Cayenne Software
Genesis Development
Inline Software
Rational Software
Select Software
Sprint Communications
Sybase
Xerox
MCI Systemhouse
Boeing
Ardent
Aviatis
ICONIX
Integrated Systems
Verilog
Telefonica I+D
Universitat Politecnica de Catalunya
NCR
Nihon
NTT

Warum XMI?!

+ Breite Industrieunterstützung

+ Web-Technologie (W3-Standardfamilie)

+ Weiterführende Ansätze:

     Delta-Interchange

     Metamodellversionierung

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– mangelnde Lesbarkeit (HUTN-RFP ad/99-03-12)

– Größe des XMI-Streams

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XMI heute...

CASE-Tools mit XMI-Unterstützung
(Stand: 12. Sept. 1999)

- ArgoUML
- Rational Rose (IBM's XMI-Toolkit)
- Together/J
- Software through Pictures (StP) v7.x

sonstige Werkzeuge:
- IBMs XMI-Tookit
- <u>alle</u> XML-Werkzeuge(!)

Weitere Informationen

Meta Object Facility (MOF): OMG Document ad/99-07-03

Bruce McLean: *Evaluation Report OMG OA&DTF RFP3
Stream-based Model Interchange Format (SMIF),* OMG A&D-TF

Revised Joint-Submission:

XMI Partners: *XML Metadata Interchange,*
OMG-Dokument ad/98-10-05

WWW:

- http://www.software.ibm.com/ad/features/xmi.html
- http://www.alphaworks.ibm.com/tech/xmitoolkit
- http://www.omg.org
- http://www.krumbach.de/home/jeckle

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