TECHNISCHE UNIVERSITÄT DRESDEN

Metamodelling and Language Engineering

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Hauptseminar Metamodelling

02.02.2006

Agenda

- Concepts
- Motivations
- Meta Modelling Framework
- Example: Small Modelling Language
- Language Composition
- Summary

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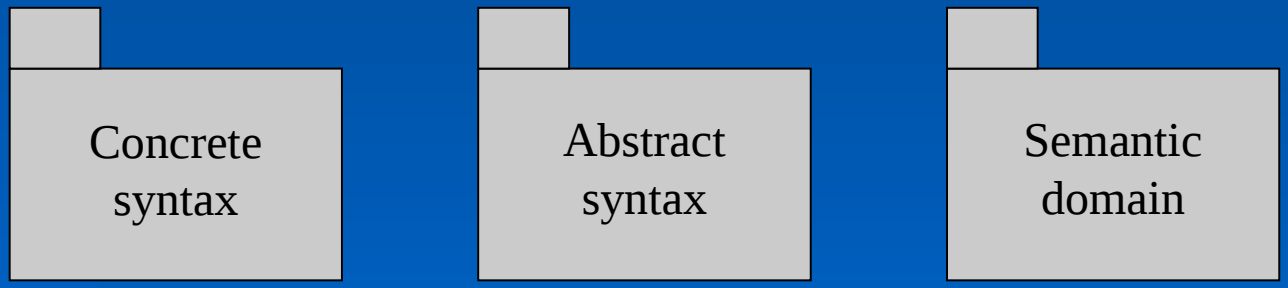
- **Concepts**
- **Motivations**
- **Meta Modelling Framework**
- **Example: Small Modelling Language**
- **Language Composition**
- **Summary**

Concepts: Language

- **Definition (Wikipedia)**
  - A [formal] language can be thought of as a set of formal specifications concerning syntax, vocabulary, and meaning.
- **Definition (Clark, Evan, Kent)**
  - A language consists of models for concrete syntax, abstract syntax and for the semantic domain.



Concepts: Language Engineering

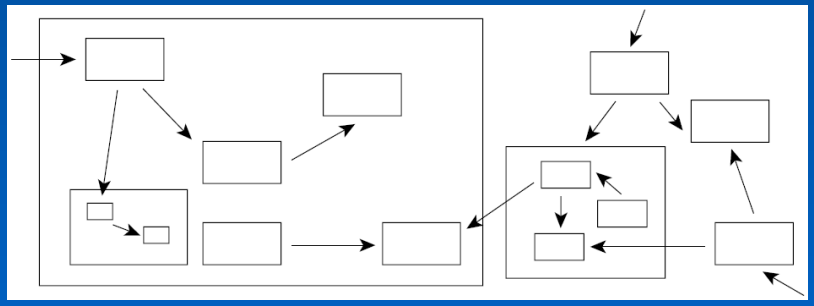
- **Definition (Wikipedia)**
  - Creation of [natural] language processing systems whose cost and outputs are measurable and predictable
- **Goals (Bézivin, Heckel)**
  - Definition of abstract syntax and well-formedness rules, operational and denotational semantics, consistency and refinement relations, and model transformations

Concepts: Domain Specific Languages

- **Definition (Wikipedia)**
  - Language designed to be useful for a specific set of tasks
  - DSLs tend to be focused on doing one sort of task well
- **Goal**
  - Enhancement of quality, maintainability, portability and reusability
- **Disadvantages**
  - Expensive to design, implement, and maintain!
- **Examples**
  - GraphViz to define directed graphs
  - Csound to create audio files
  - YACC for parsing and compilers
  - SQL for databases

Concepts: Catalysis Method

- **Presentation**
  - Started 1992 by D'Souza D. and Wills A.
  - Object-Oriented method based on UML 1.0
- **Concepts**
  - Action as important as object
  - Modelling frameworks as templates
  - Package import mechanism
  - Refinements: objects and actions at different scales



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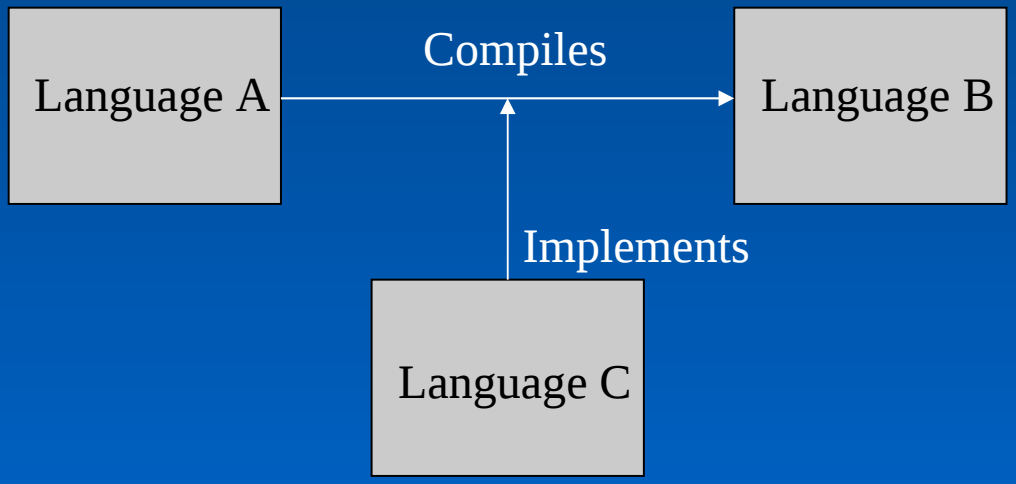
Motivations

- **Language engineering:**
  - Required to support the design, implementation, and validation of languages with the goal to deliver languages at low cost with high quality
  - Reusability of parts of languages
  - Example: compilers



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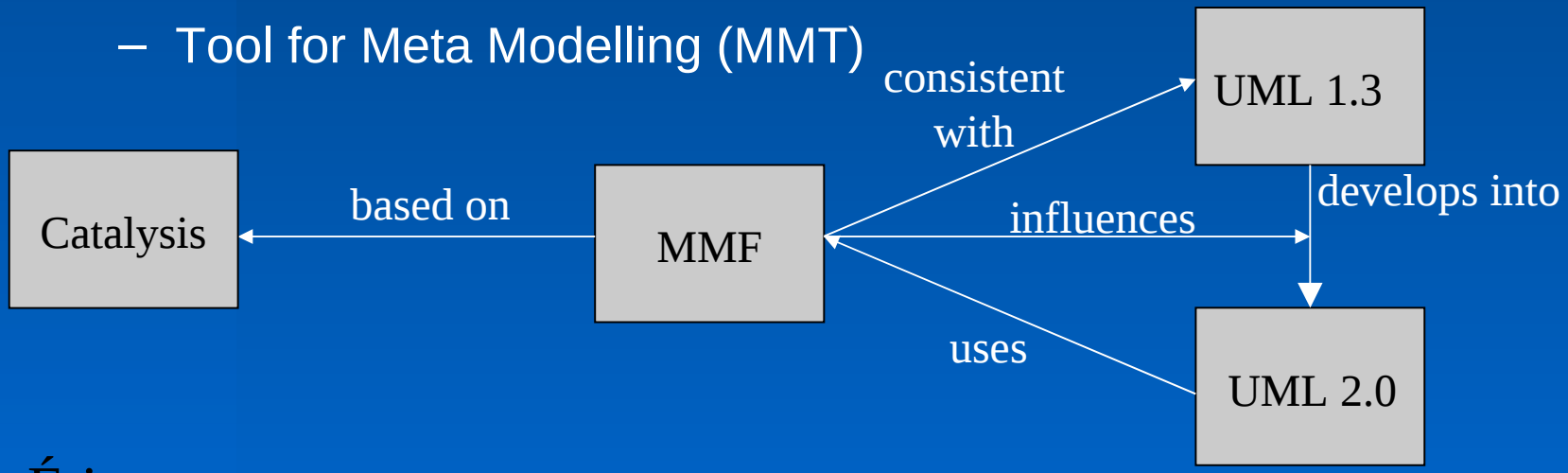
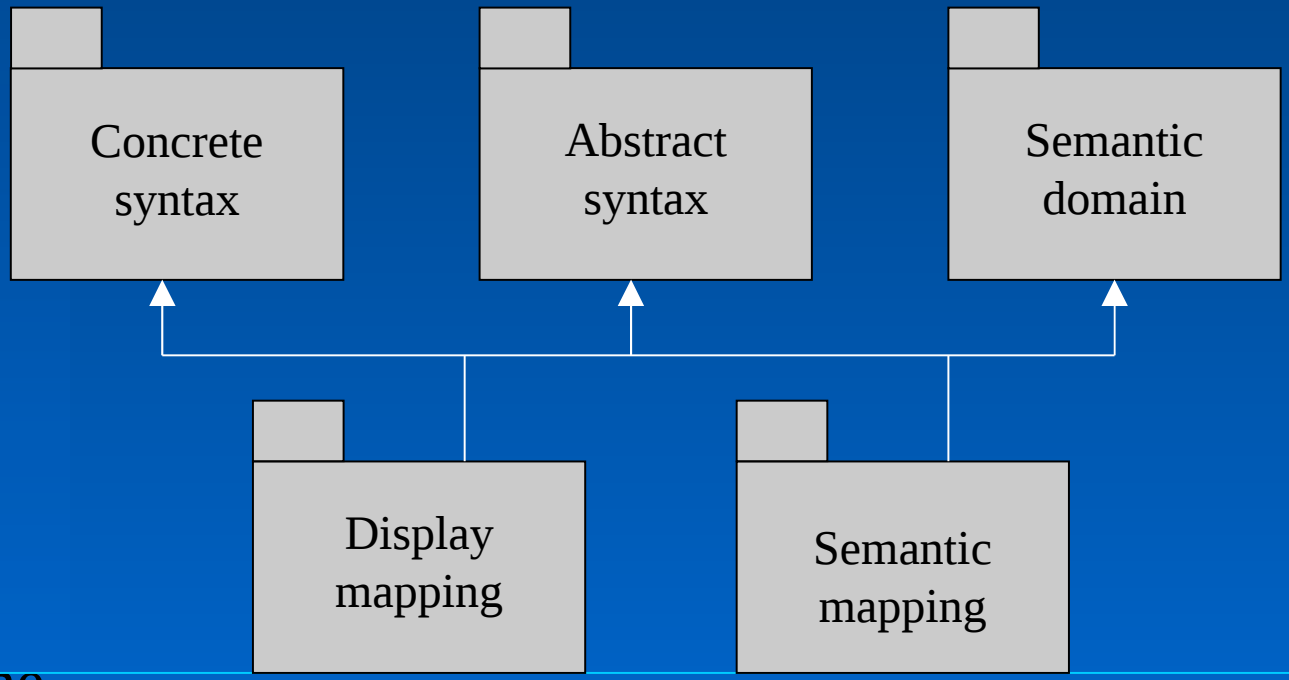
Meta Modelling Framework: Overview

- **Presented 2002 by Clark, Evans, Kent**
- **Motivations**
  - Deficiencies in the definition of UML 1.3
  - Support MDA
- **Overview**
  - Method for Meta Modelling (MMM)
  - Language for Meta Modelling (MML)
  - Tool for Meta Modelling (MMT)



Meta Modelling Framework: MMM

- **Method for Meta Modelling (MMM)**
  - This approach applies OO modelling to the definition of languages, especially OO modelling languages
  - OCL used to define well-formedness constraints on the language components
  - “UML needs to become a precisely defined family of languages”



Meta Modelling Framework: MMM

- **MMM Key features**
  - Package specialization
    - Partial definitions of model elements in a super package to be consistently specialized in a sub-package
  - Templates
    - Parametric model elements
    - Means of representing reusable modelling patterns
    - Provide a framework for defining language families

Meta Modelling Framework: MML

- **Language for Meta Modelling (MML)**
  - Static OO modelling language:
    - Small
    - Meta-circular, describes itself
  - Basic expression language based on OCL
    - Supports sets and sequences

Meta Modelling Framework: MML

- **MML class definition**
  - MML definition = name + expression

```
class Person
  name : String
  age : Integer
  married : Boolean
  children : Set(Person);
  parents : Set(Person);
  init(s:Seq(Instance)):Person
    self.name := s->at(0)[]
    self.age := s->at(1)[]
    self;
  averageChildAge():Integer
    self.children->iterate(c, a = 0 | a + c.age) / self.children->size;
  inv
    IfMarriedThenOver15
      self.married implies self.age >=16;
    OnlyTwoParents
      self.parents->size = 2
end
```

- **MML association definitions**
  - Only binary associations

```
association Family
  parents : Person mult: 2
  children : Person mult : *
end
```

Meta Modelling Framework: MML

- **MML package definition**
  - Group definitions of model elements

```
package People
  class Person
    // as given above...
  end;
  association Family
    // as given above
  end
end
```

  - Powerful package specialization mechanism

```
package Employment extends People
  class Person
    yearsInService : Integer
  end;
  class Company
    name : String
  end
  association Works
    company : Company mult : 1
    employees : Person mult : *
  end
end
```

Meta Modelling Framework: MML

- **MML templates definition**
  - Template: parametric model element

```
package Contains(Container,n1,m1,Contained,n2,m2)
  class <<Container>>
    <<n2>>():Set(<<Contained>>)
      self.<<n2>>
    inv
      UniqueNames
        self.<<n2>>->forAll(c1 c2 |
          c1.name = c2.name implies c1 = c2)
  end;
  association <<Container + Contains>>
    <<n1>> : <<Container>> mult: <<m1>>
    <<n2>> : <<Contained>> mult: <<m2>>
  end
end
```

```
package People
 class Person
   parents():Set(Person)
     self.parents
   inv
     UniqueNames
       self.parents->forAll(c1 c2 |
         c1.name = c2.name implies c1 = c2)
  end;
  association PersonContains
    children : Person mult: *
    parents : Person mult: 2
  end
end
```

```
package People extends Container(“Person”,”children”,*,”Person”,”parents”,2)
  class Person
    // atribute and method definitions
  end
end
```

Meta Modelling Framework: MMT

- **Tool for Meta-Modelling (MMT)**
  - Apparently not available!
  - Prototype tool written in Java
  - Supports MMF Approach
  - Several checks
    - Well-formedness
    - OCL constraints

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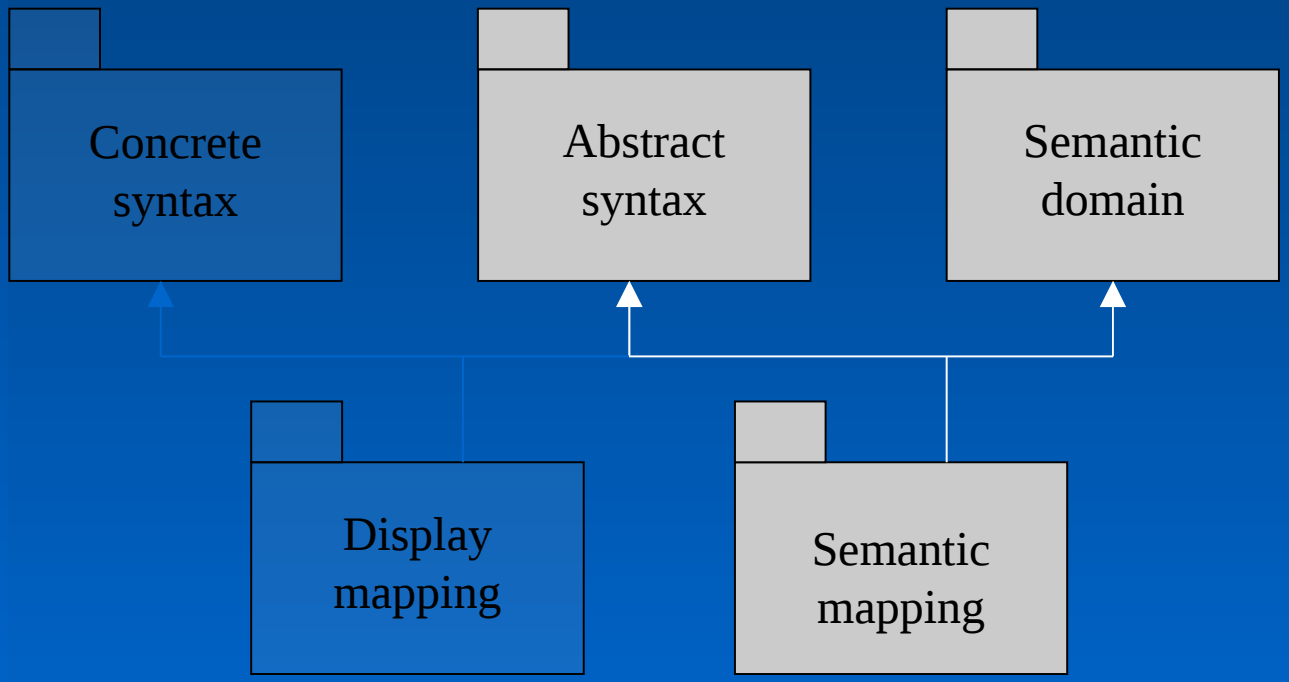
Example: SML

- **Example of a Small Modelling Language**
  - Static modelling language consisting of packages and class with attributes
  - Only abstract syntax, semantic domain and mapping between them



Example: SML

- **Templates libraries definitions**
  - Named model elements

```
package Named(Model)
  class <<Model>>
    name : String;
    toString():String
      "<" + self.of.name + self.name + ">"
  end
end
```

  - …and more templates definitions

```
package NameSpace(Container, Contained)

package Contains(Container, Contained)

package Specializable(Model)

package SpecializableContainer(Container, Contained)
  extends Specializable(Container), Specializable(Contained)

package Relation(Name, Domain, Range)

package RelateAtt(R, Domain, Range, DomainAtt, RangeAtt, Pred)
  extends Relation(R, Domain, Range)

package TypeCorrect(R, Domain, Range)
  extends RelateAtt(R, Domain, Range, “type”, “value”, check)
```

Example: SML

- **Abstract Syntax**

```
package AbstractSyntax
  extends
    SelfContains("Package"),
    SpecializableContainer("Package","Package"),
    SpecializableContainer("Package","Class"),
    SpecializableContainer("Class","Attribute"),
    Specializable("Attribute"),
    Contains("Package","Class"),
    Contains("Class","Attribute"),
    Clonable("Package","Class"),
    Clonable("Package","Package"),
    Clonable("Class","Attribute"),
    Named("Package"),
    Named("Class"),
    Named("Attribute"),
    NameSpace("Package","Package"),
    NameSpace("Package","Class"),
    NameSpace("Class","Attribute")

  class Attribute
    // some definition
  end
end
```

Example: SML

- **Semantic domain**

```
package SemanticDomain
  extends
    SelfContains("Snapshot"),
    Contains("Snapshot","Object"),
    Contains("Object","Slot"),
    Named("Snapshot"),
    Named("Slot")

  class Slot value : Object end
end
```

- **Semantic mapping**

```
package SemanticMapping
  extends
    AbstractSyntax,
    SemanticDomain,
    ContainsInstances1(
      "PackXSnap","Package","Class",
      "ClassXObj","Snapshot","Object"),
    ContainsInstances(
      "ClassXObj","Class","Attribute",
      "AttXSlot","Object","Slot"),
    SameName("AttXSlot","Attribute","Slot")
    TypeCorrect("AttXSlot","Attribute","Slot")
end
```

Example: SML

- **Conclusion on this example**
  - Definition of templates libraries
    - Reusability
  - Simple definition

- **MMF applicable to more complex languages**

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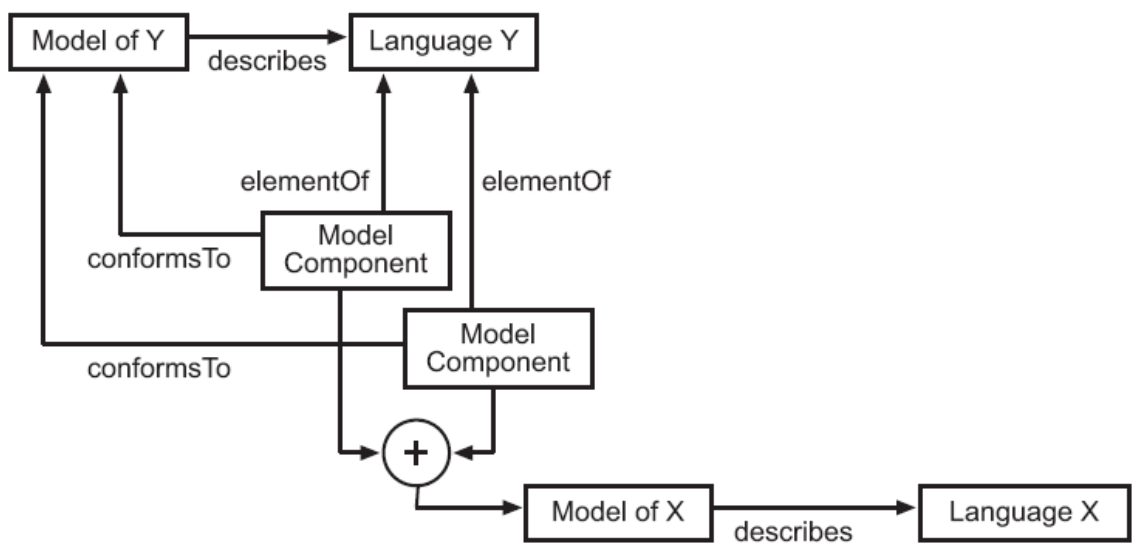
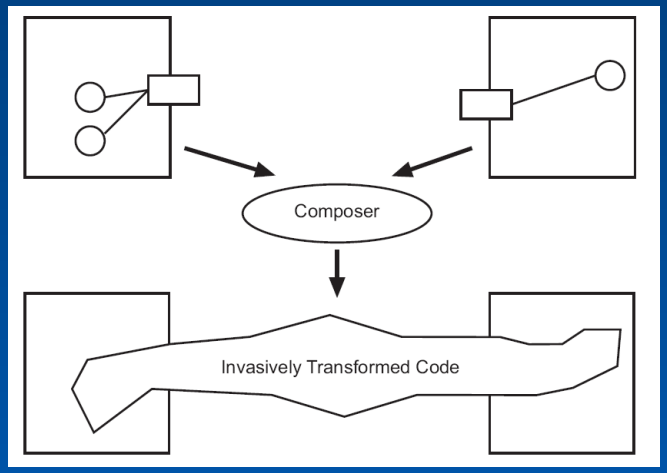
Language Composition

- **Motivation**
  - Reusability
  - Lower costs
- **Structure**
  - Composing model components result in a model that describes a language



Language Composition

- **Parallel with Software Engineering**
  - Invasive language composition: Composition through fragment boxes



- **Achieved through package extension**
  - Not so easy!
  - Metamodel defined by Clark, Evans and Kent

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Summary

- **Why language engineering?**
  - Reusability of parts of languages (packages, templates)
  - Lower costs
- **Key features**
  - Templates
  - Package extension
  - Language composition

References

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The end

- **Thanks for your attention ☺**

- **Any questions…?**