Software Engineering
Model Driven Architecture
Applications of Metamodeling

Prof. Dr. Peter Thiemann

Universität Freiburg

25.06.2009

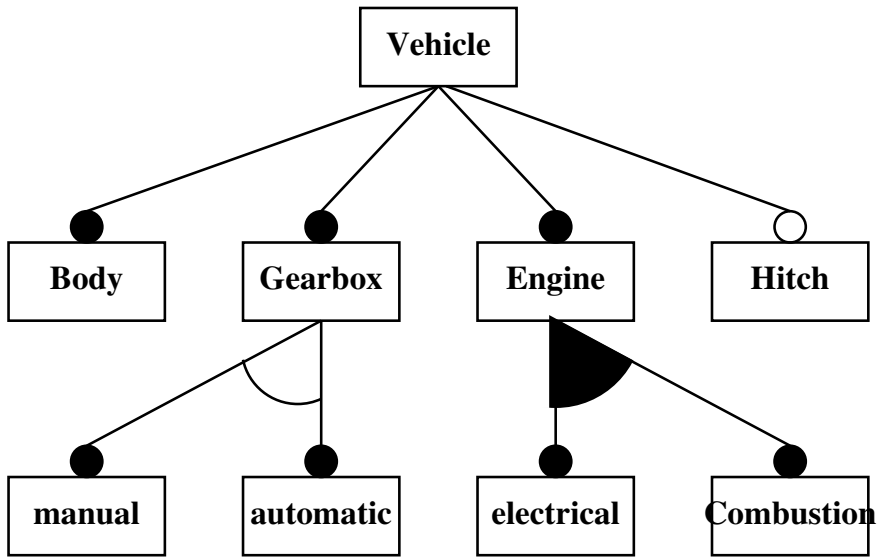
Applications of Metamodeling

Feature Modeling

- Feature models are a tool for domain analysis
  - Provide a hierarchical view of features and their dependencies
  - Establish an ontology for categorization
- Visualized by feature diagrams
- Conceived for software domain analysis: Kang, Cohen, Hess, Novak, Peterson. Feature-Oriented Domain Analysis (FODA) Feasibility Study. Technical report CMU/SEI-90-TR-21. 1990.
- Popularized for Generative Programming by Czarnecki and Eisenäcker
- Also for analyzing other domains

Feature Modeling

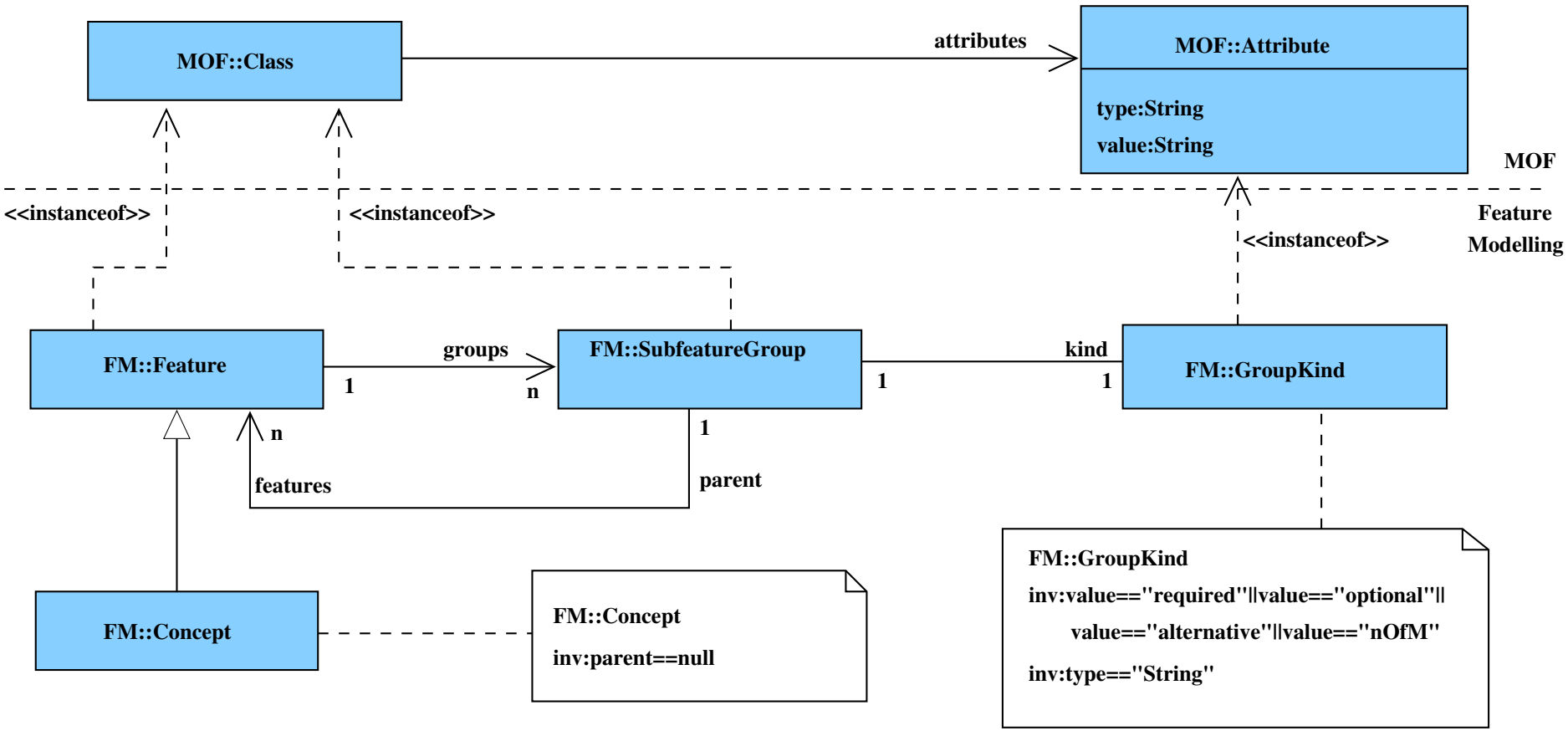
Example



- Hierarchical, but **not** is-a relation (as in a class diagram)
- Features may be qualified as
  required, optional, alternative, or *n*-of-*m* (selection)

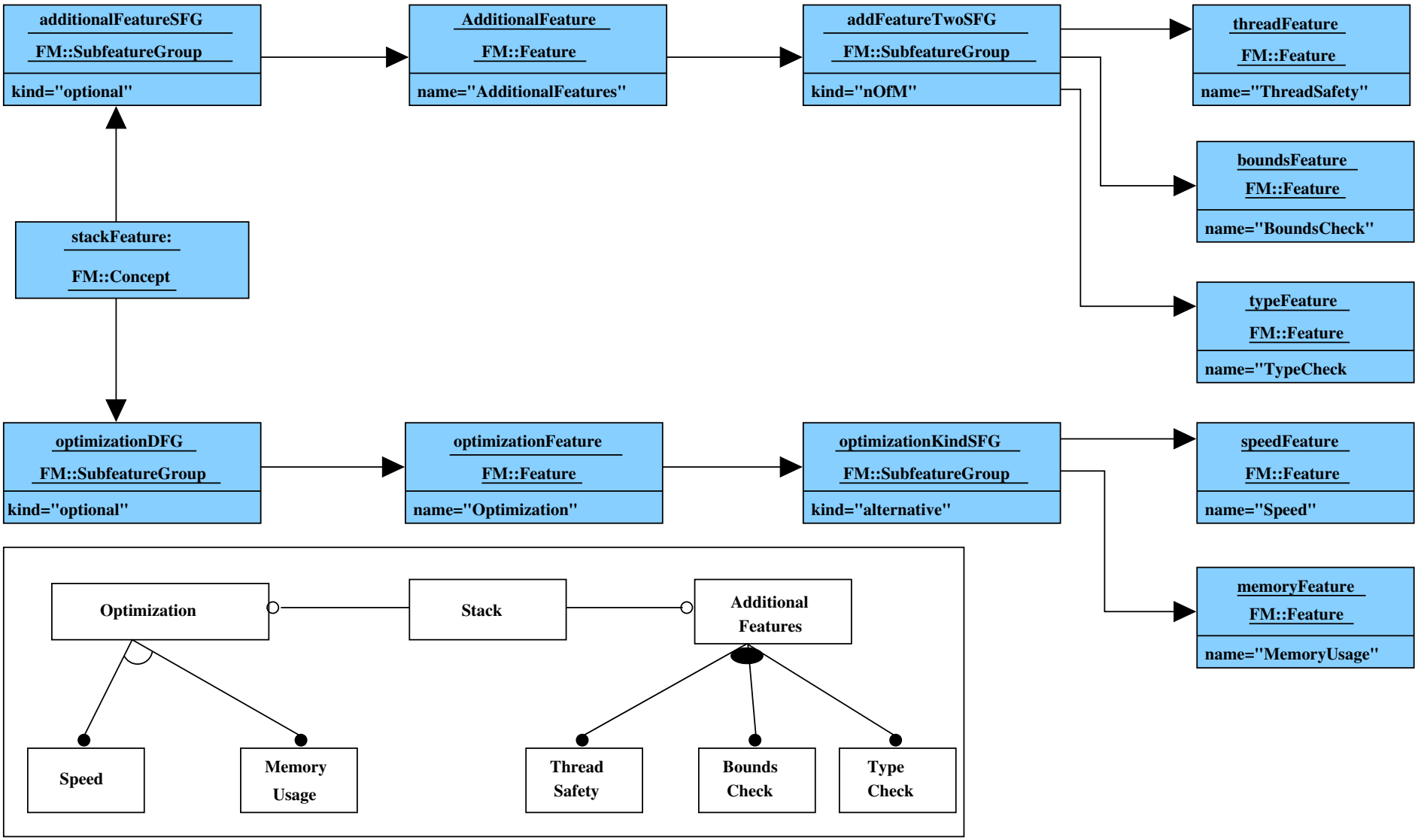
Feature Modeling

MOF-based Metamodel



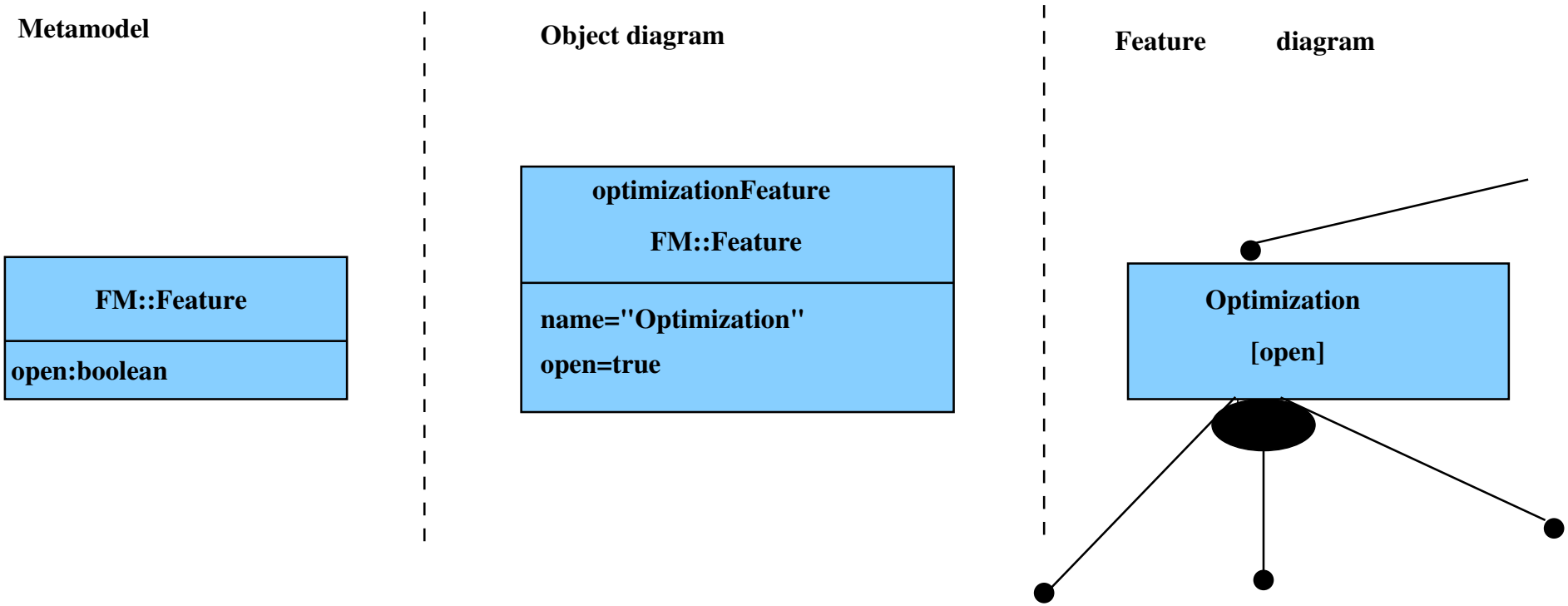
Feature Modeling

Feature Model in Abstract Syntax



Feature Modeling

Extended Metamodel and Concrete Syntax



New feature $\Rightarrow$

- new attribute in metamodel
- new slot in model
- extension of concrete syntax

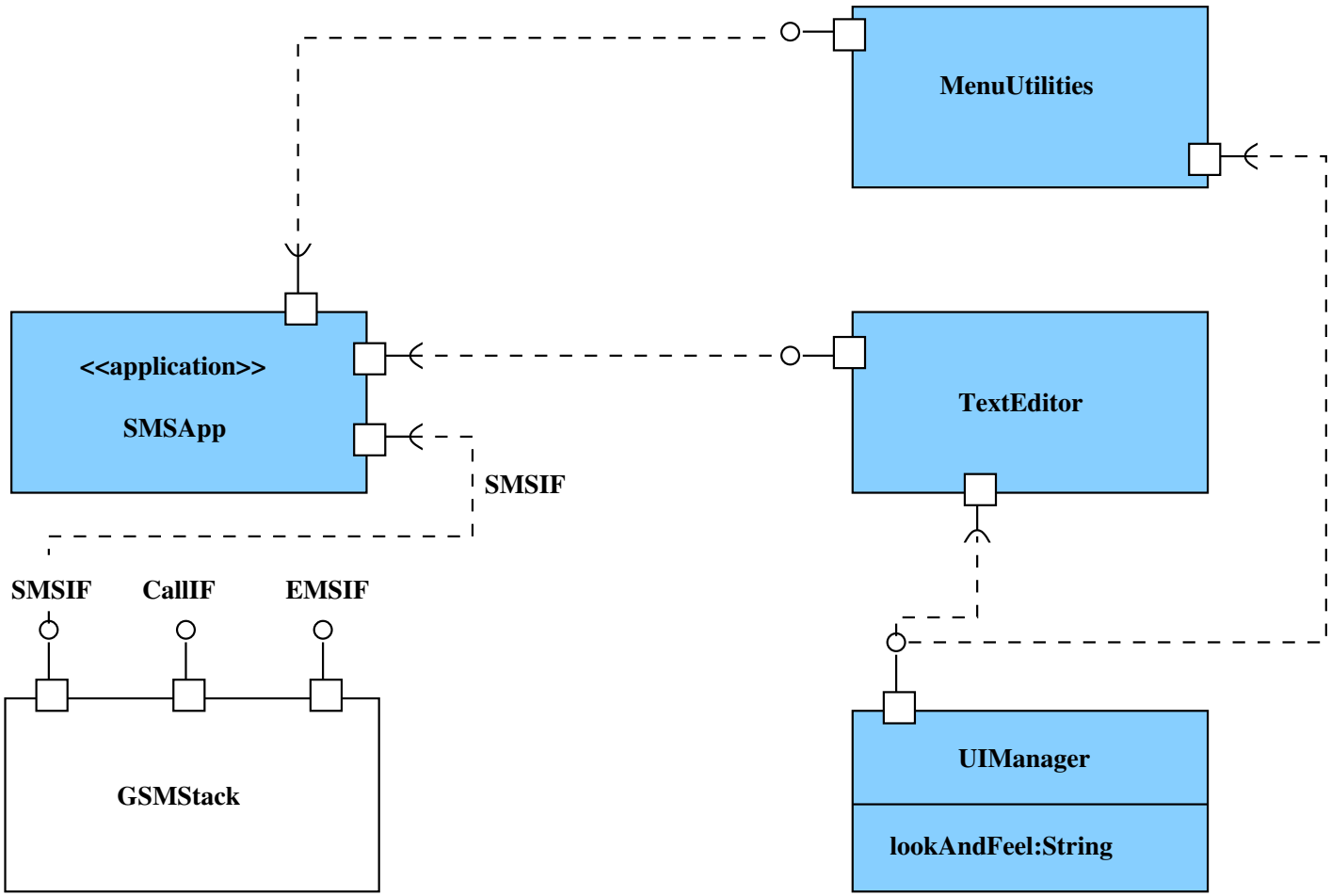
Applications of Metamodeling

Component Modeling

- Domain specific modeling language for small and embedded systems
- Main abstraction: component
- A component may
  - *provide* services via *interfaces*
  - *require* services via *interfaces*
  - have *configuration* parameters
  - be an application (does not provide services)

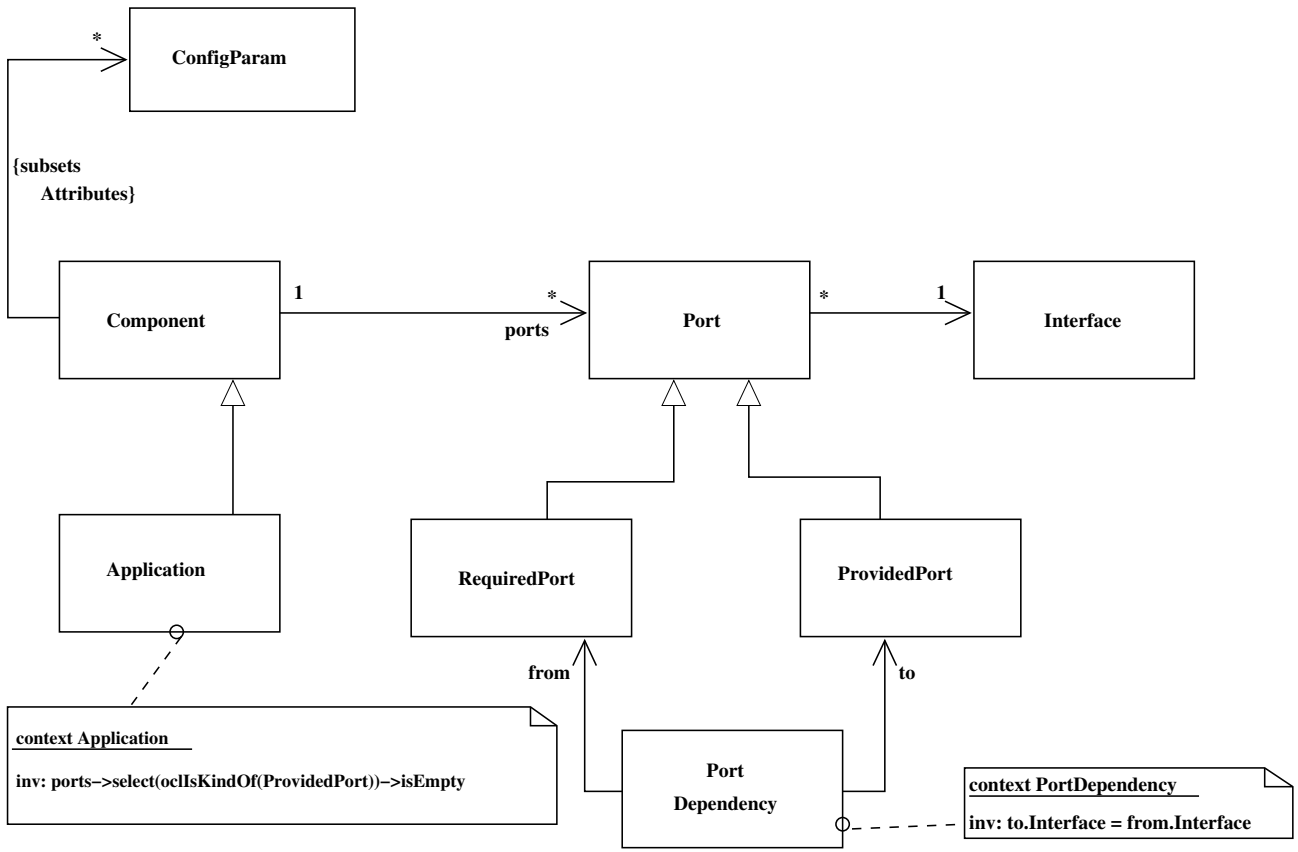
Component Modeling

Example



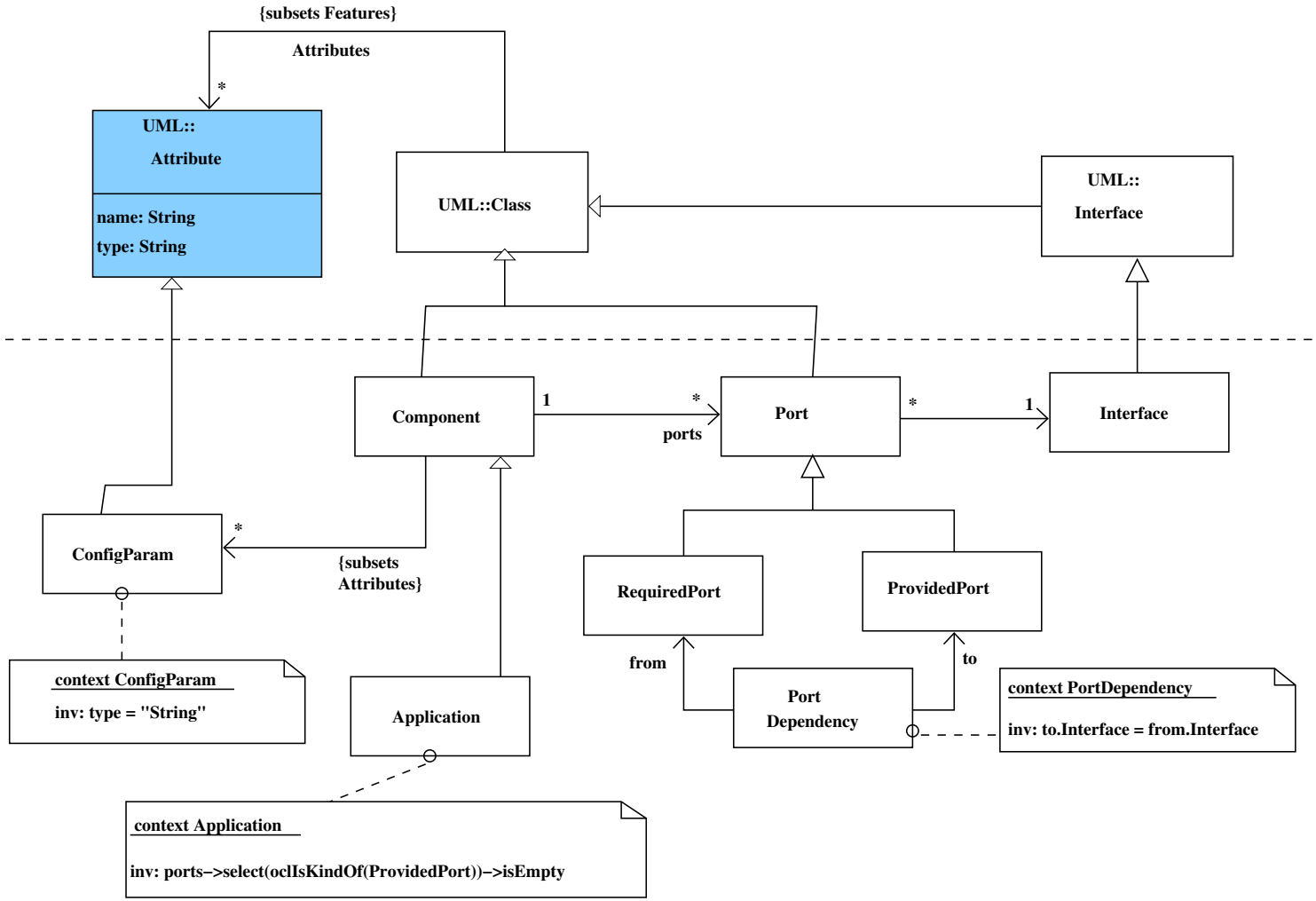
Component Modeling

Simple Component Metamodel



Component Modeling

MOF-based Simple Component Metamodel



Pitfalls in Metamodeling

How to avoid

- confusion with UML notation
- mixing metalevels

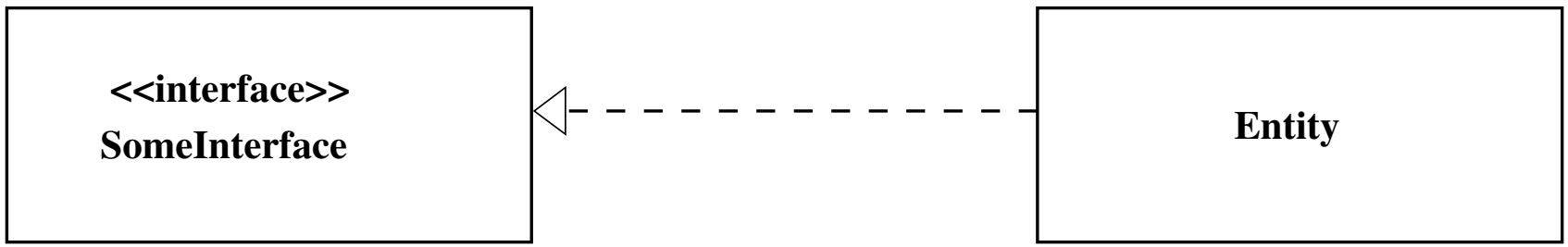
Central question

- what is the mapping to a programming language?

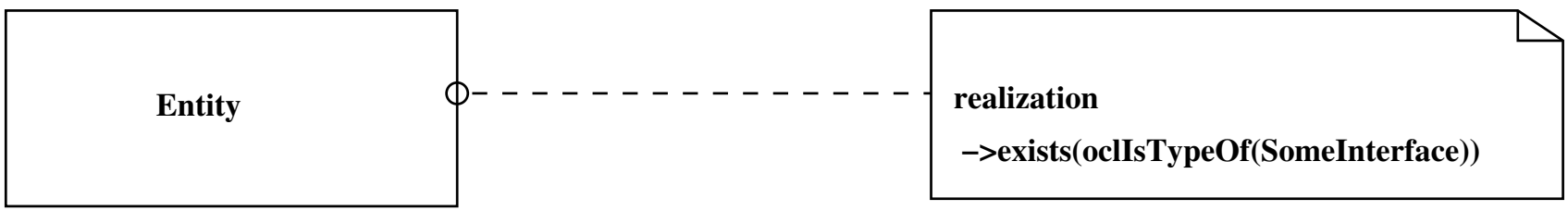
Interfaces

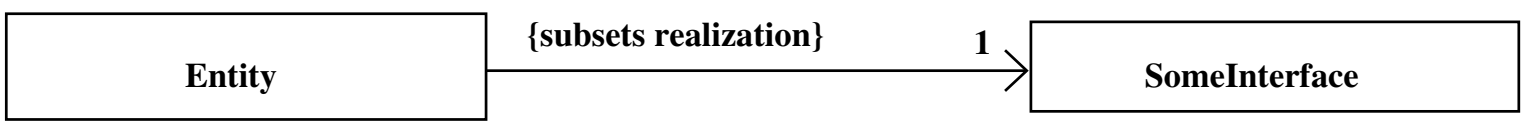
Every instance of **Entity** should implement **SomeInterface**

- *wrong approach*



- book solution use OCL or subsetting of metaassociation

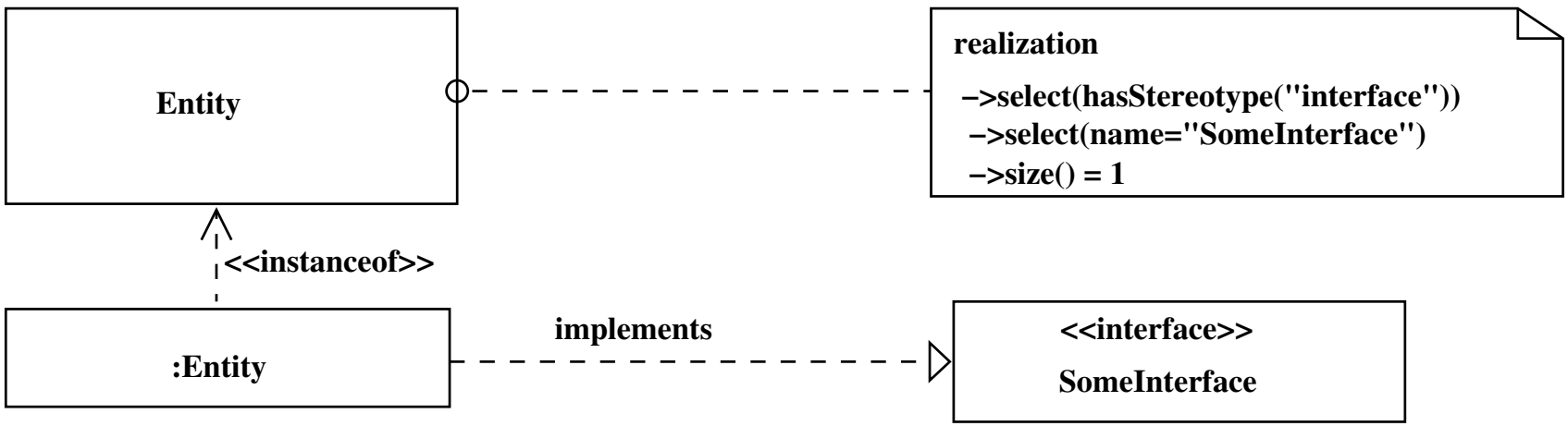




Interfaces/2

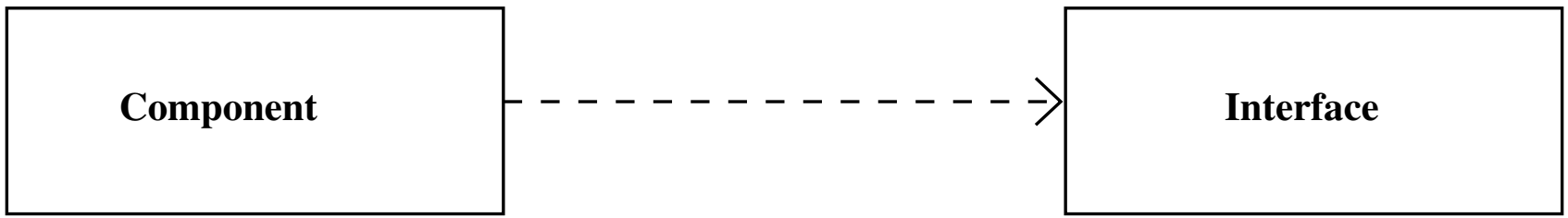
Every instance of **Entity** should implement **SomeInterface**

- correct solution use OCL

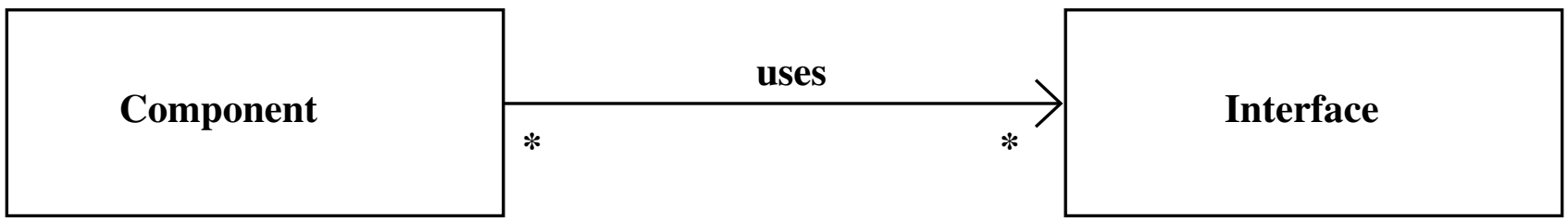


Dependency

- **Problem:** A **Component** may depend from multiple **Interfaces** because the **Component** may invoke operations of the **Interfaces**.
- *wrong approach* "metaclass **Component** depends on metaclass **Interface**"



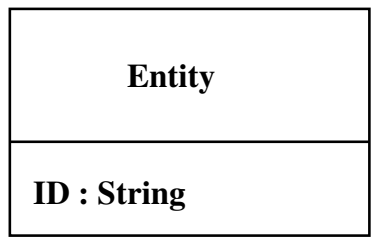
- correct solution a metaassociation "uses"



Identifying Attribute

An **Entity** *must have an identifying attribute with name* `ID` *and type* `String`. **Entity** *is a subclass of* **UML::Class**.

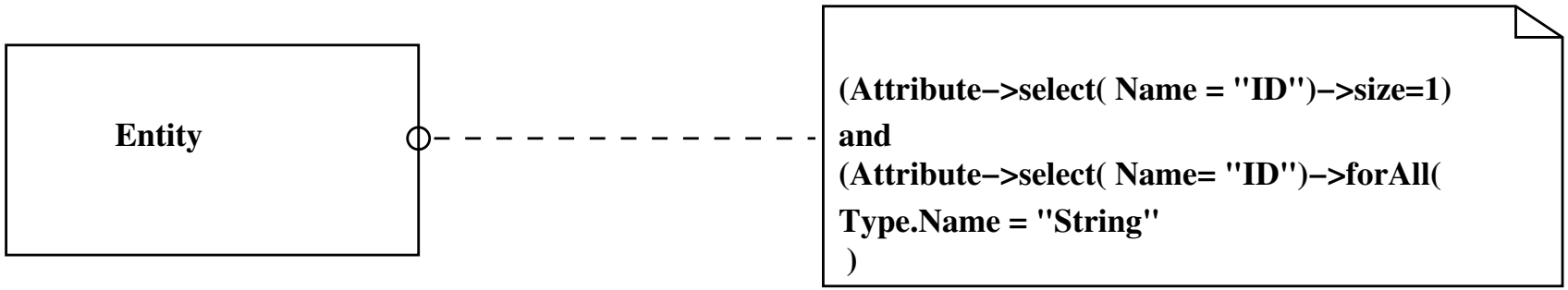
- *wrong approach*



defines a tagged value `ID` for all **Entity** instances in the model

Identifying Attribute

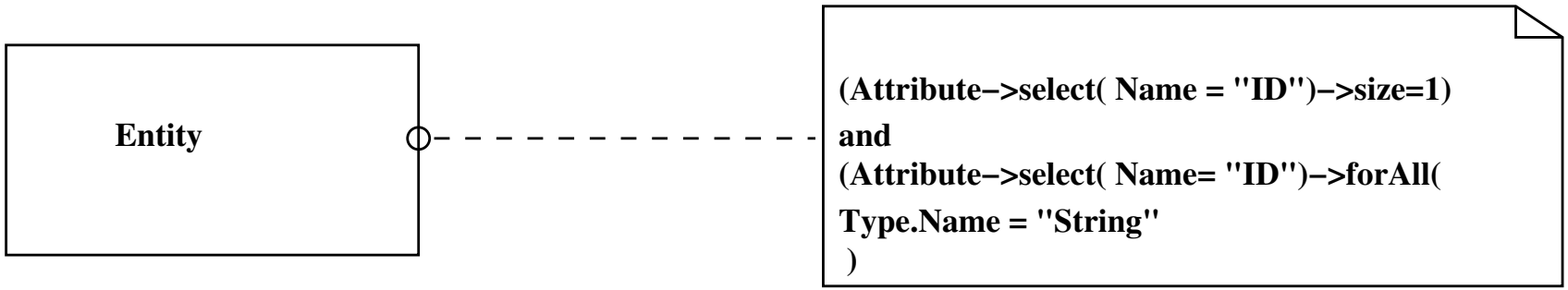
- correct solution



  - there must be exactly one attribute with name `ID`
  - all attributes named `ID` must have type `String`

Identifying Attribute

- correct solution



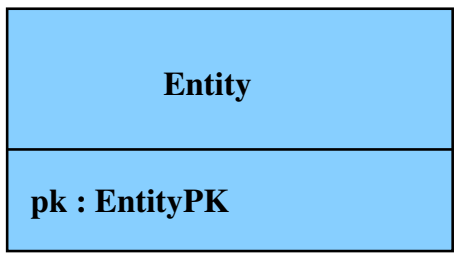
  - there must be exactly one attribute with name `ID`
  - all attributes named `ID` must have type `String`

- *incorrect attempt*

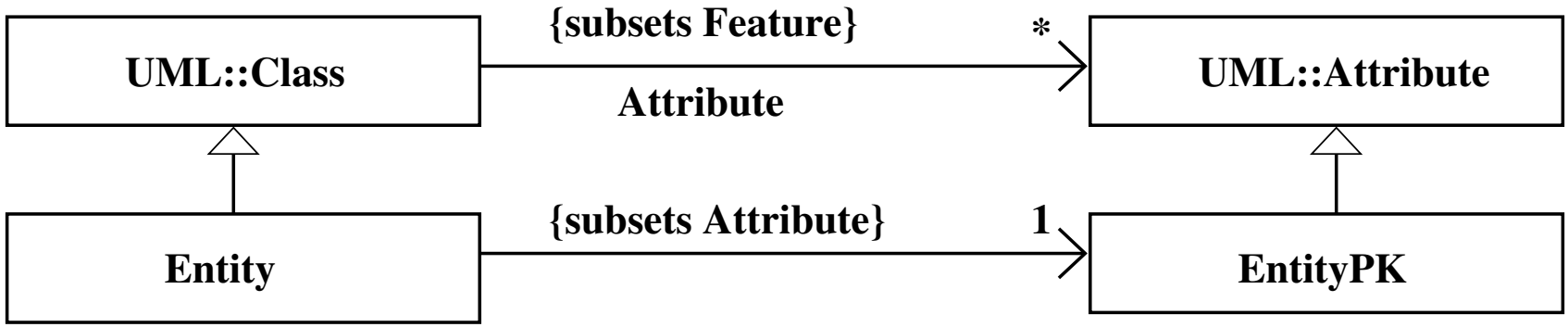
```
context Entity inv:
  Attribute
    ->select (Name="ID" and Type.Name="String")
    ->size() = 1
```

Primary Key Attribute

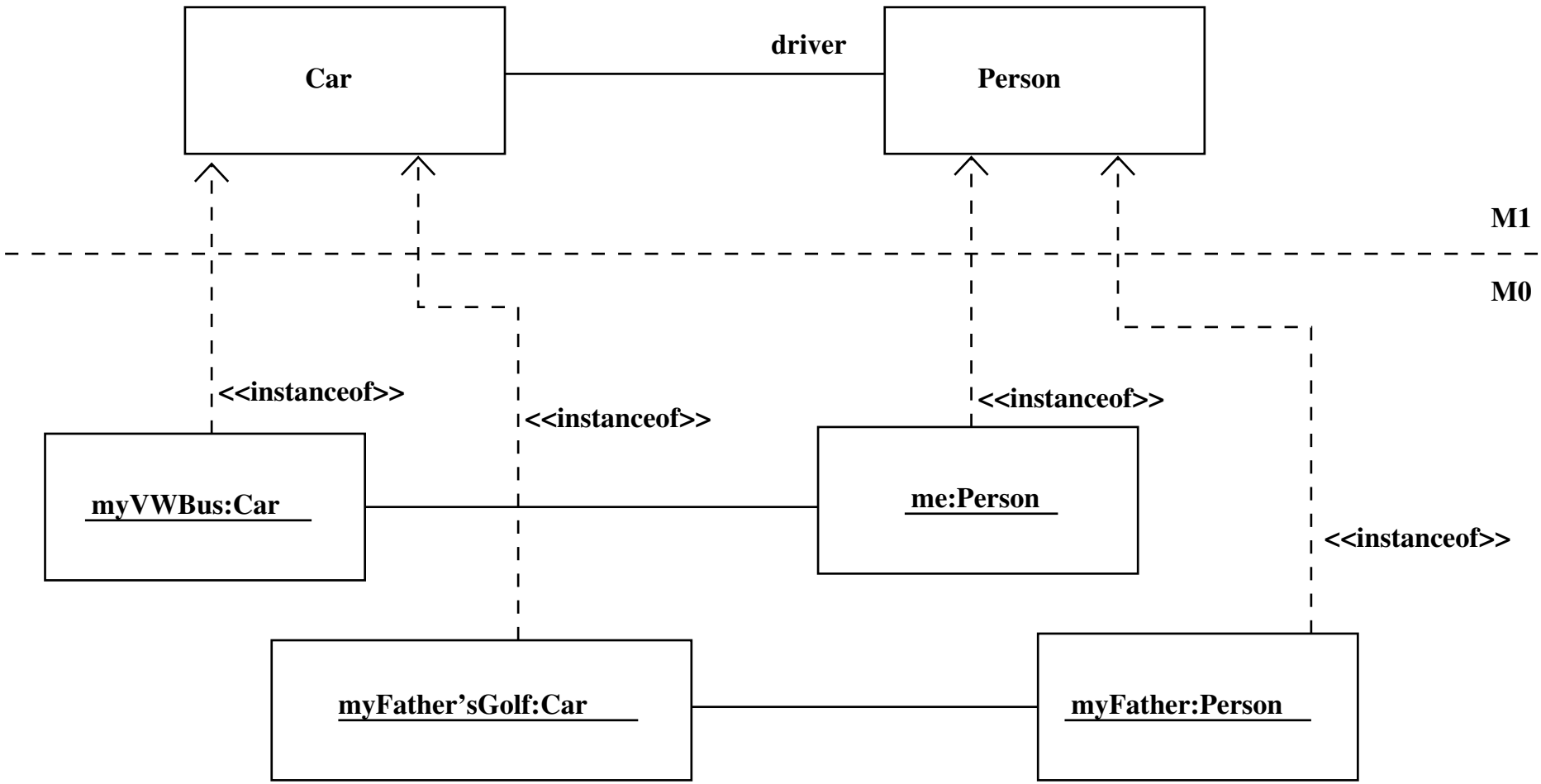
Each instance of **Entity** *must have exactly one attribute of type* **EntityPK**, *where* **EntityPK** *is a subclass of* **Attribute**.



- *wrong approach*
- correct solution



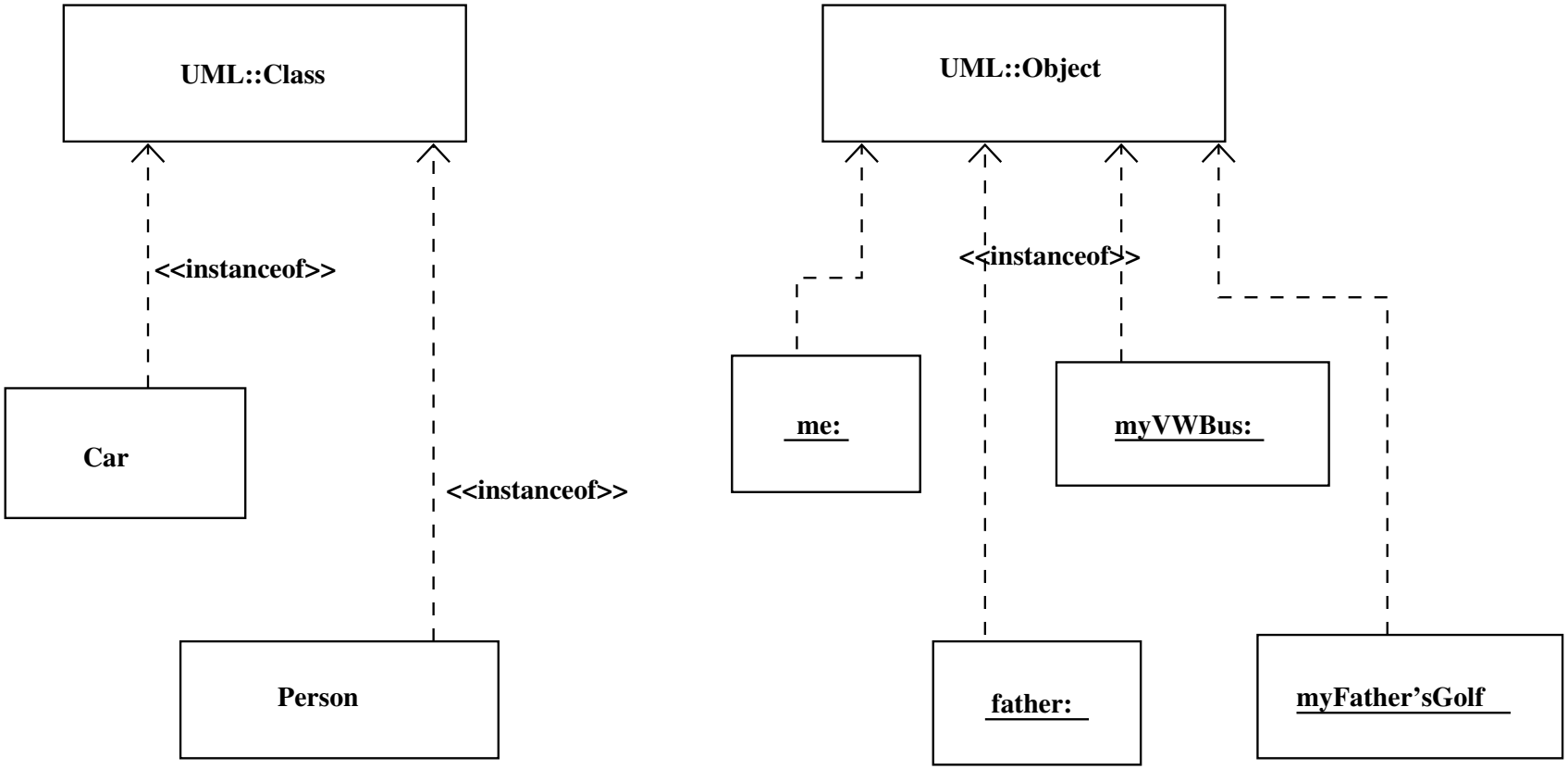
Metalevels and Instanceof



- Objects are instances of classes
- Links are instances of associations

Metalevels and Instanceof

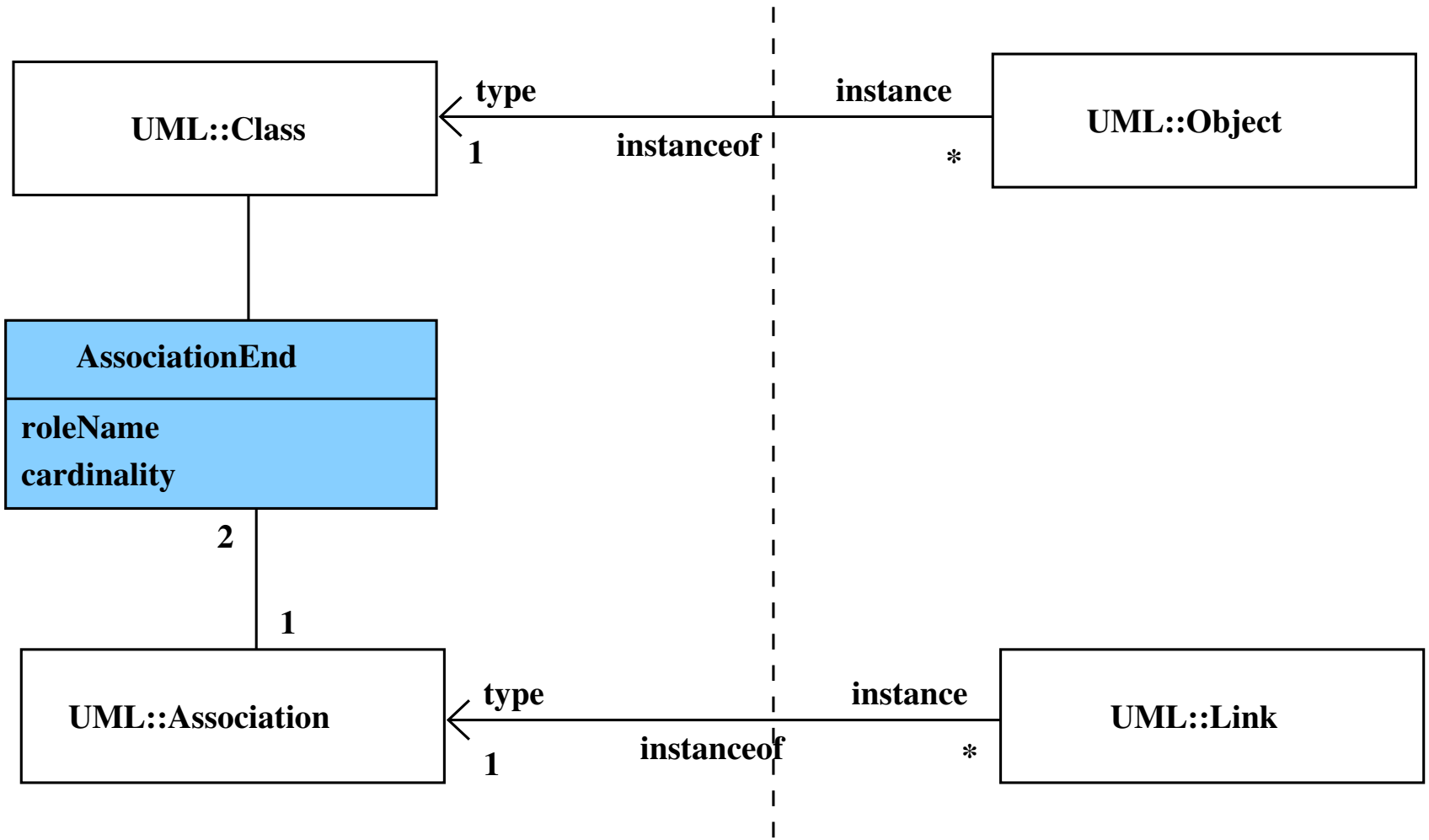
Model Elements as Instances of Metamodel Elements



- The **Auto** and **Person** classes are instances of the MOF metaclass **UML::Class**
- The objects **me:** and **myFather:** are instances of the MOF metaclass **UML::Object**
- How can that be?

Metalevels and Instanceof

A Look at the Metamodel



- $\Rightarrow$ two different instanceof relations

Summary

- Metamodeling required for customizing UML
- OMG relies on MOF to define profiles
- OCL defines static semantics of models
- Metalevels should not be confused