Model Driven Architecture
Metamodeling — Applications

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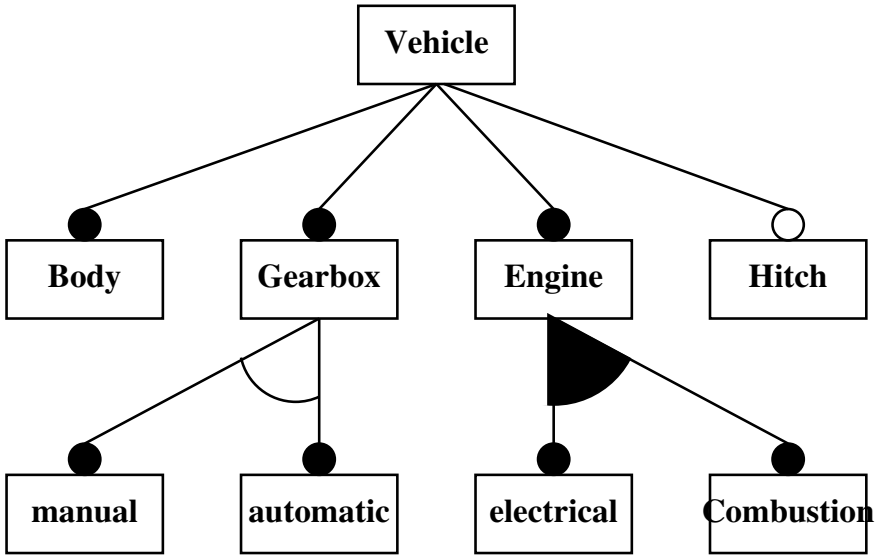
Applications of Metamodeling
Feature Modeling

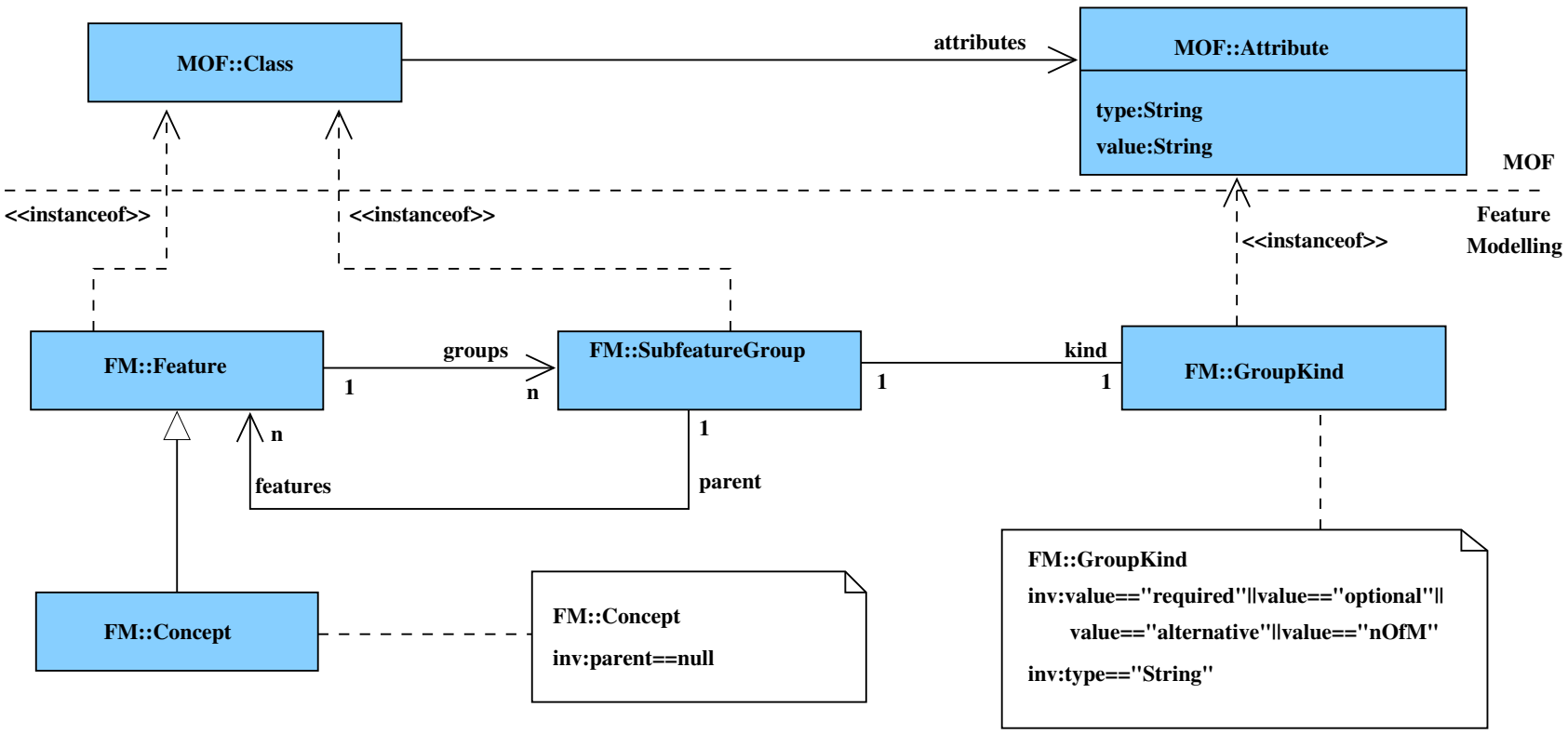
- Feature models are a tool for domain analysis
  - Provide a hierarchical view of features and their dependencies
  - Establish an ontology for categorization
- Visualized by feature diagrams
- Conceived for software domain analysis: Kang, Cohen, Hess, Novak, Peterson. Feature-Oriented Domain Analysis (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



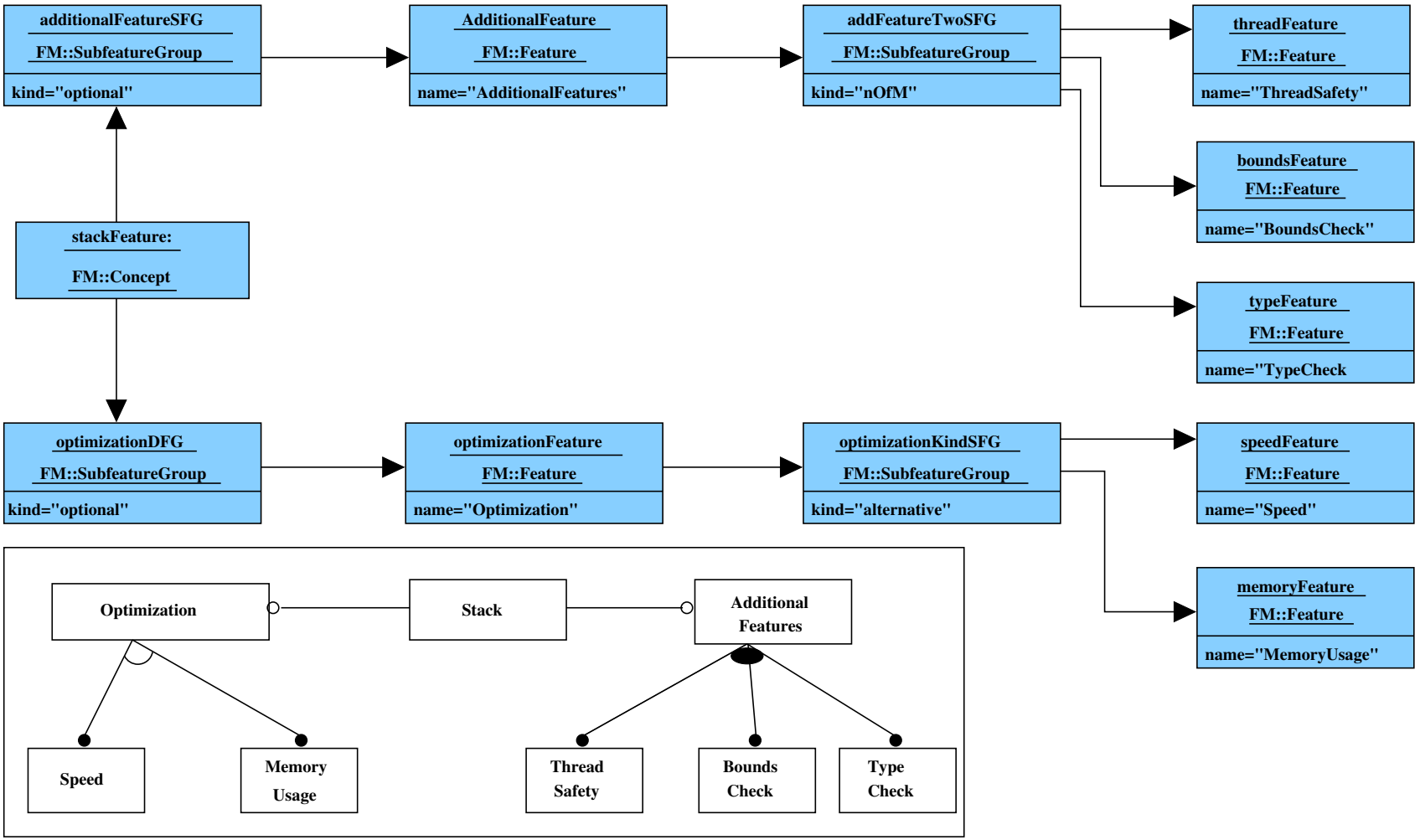
- Hierarchical, but **not** is-a relation (as in a class diagram)
- Features may be qualified as
  required, optional, alternative, or *n*-of-*m* (selection)

Feature Modeling
MOF-based Metamodel

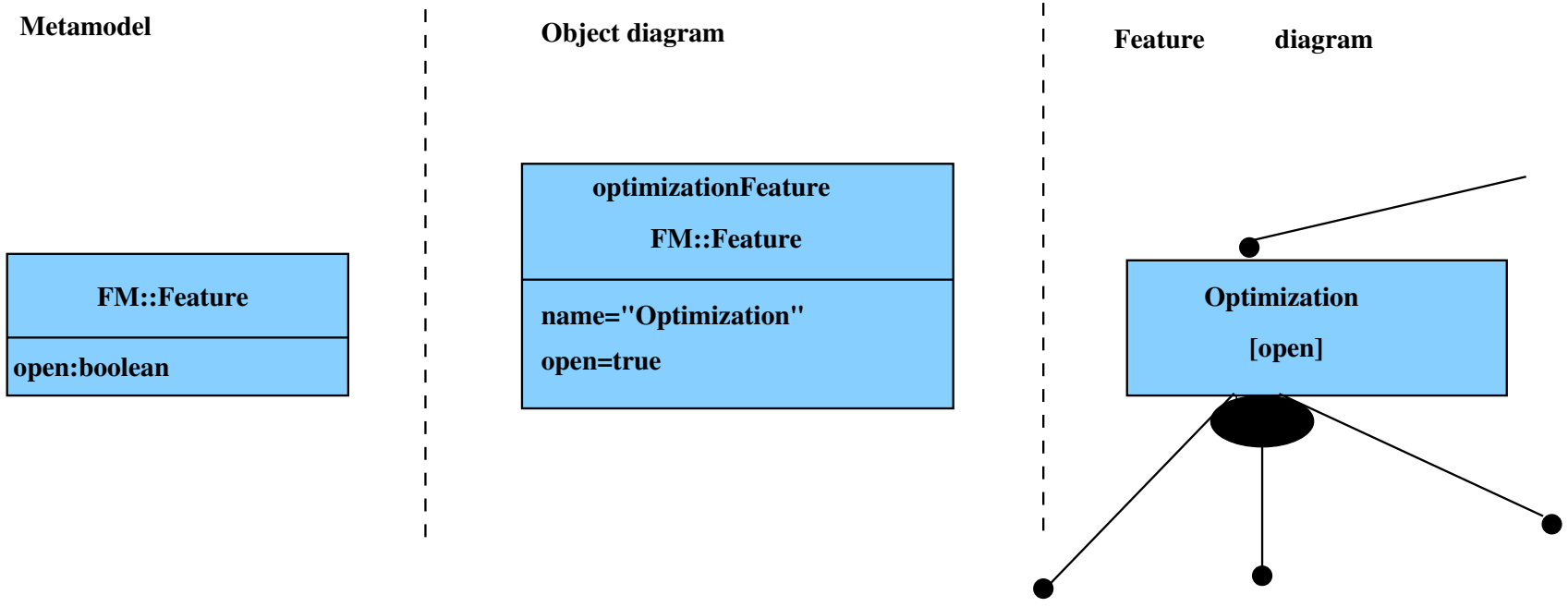


Feature Modeling

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

Feature Modeling
Further Features

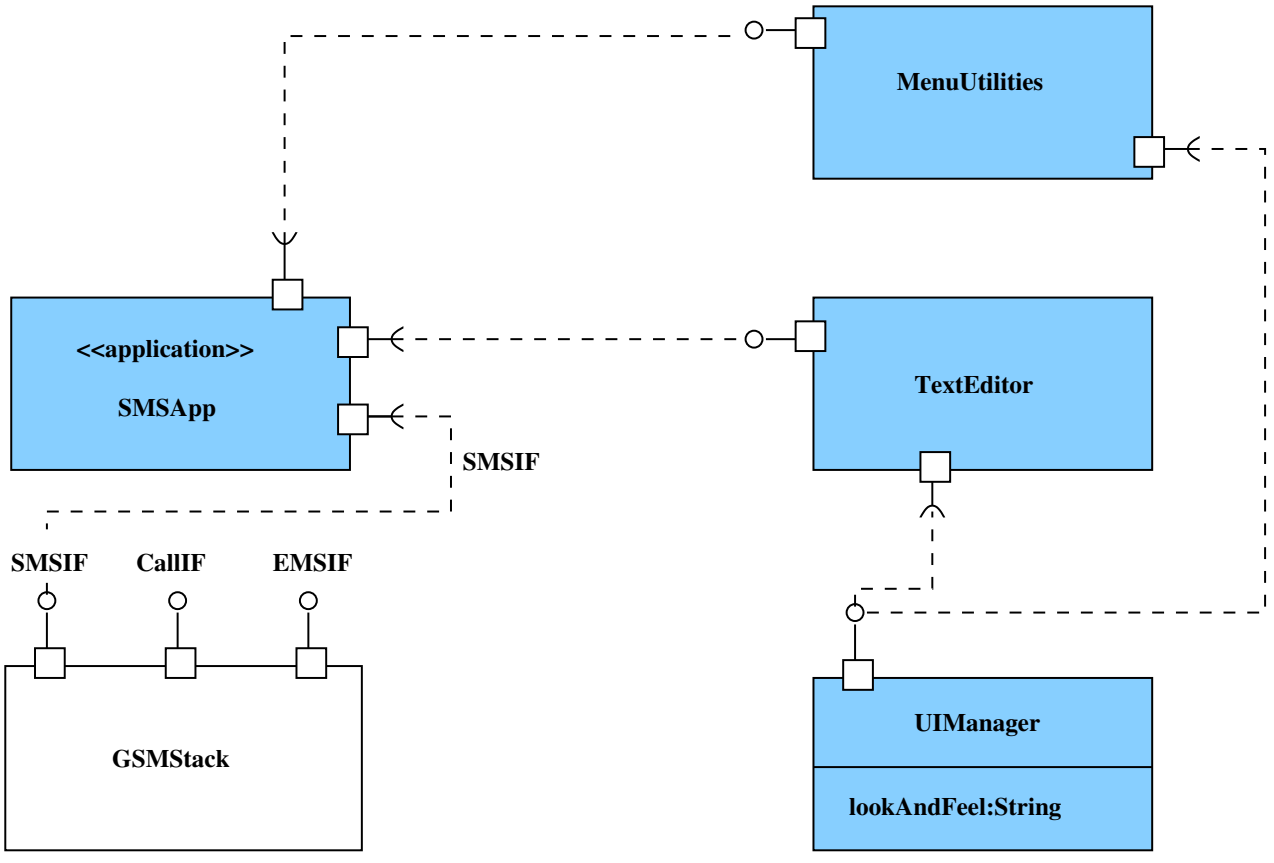
- Macros for combinations of features
- Multiplicity of subfeatures
- Priority of features; stakeholders
- Open / closed
- Additional constraints (without graphical notation)
  - *requires*: feature dependency
  - *excludes*: feature anti-dependency
  - *recommends*: soft dependency
  - *discourages*: soft anti-dependency

  Example: Optimization for speed *discourages* thread safety, *discourages* bounds check

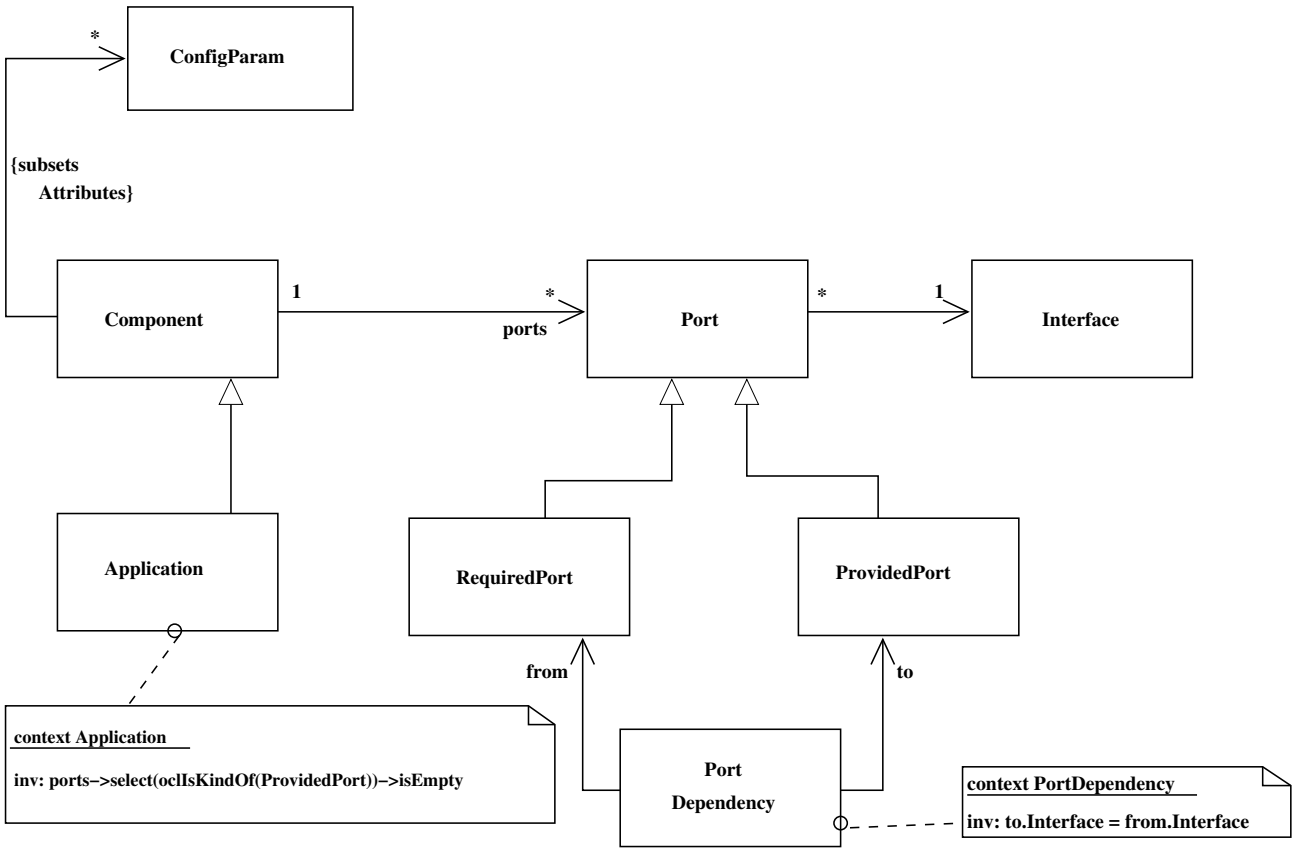
Applications of Metamodeling
Component Modeling

- 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)

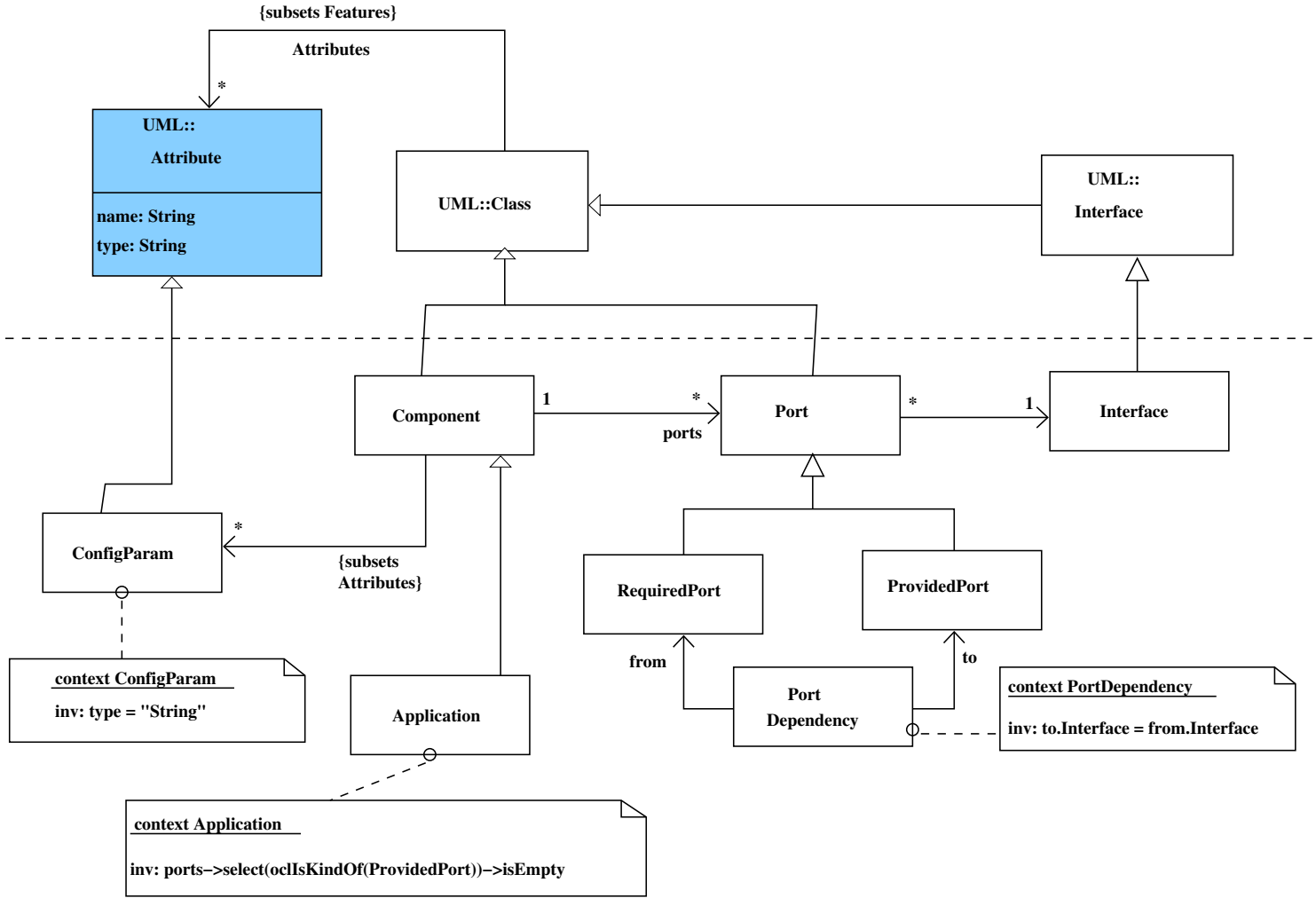
Component Modeling
Example



Component Modeling
Simple Component Metamodel



Component Modeling
MOF-based Simple Component Metamodel



Pitfalls in Metamodeling

How to avoid

- confusion with UML notation
- mixing metalevels

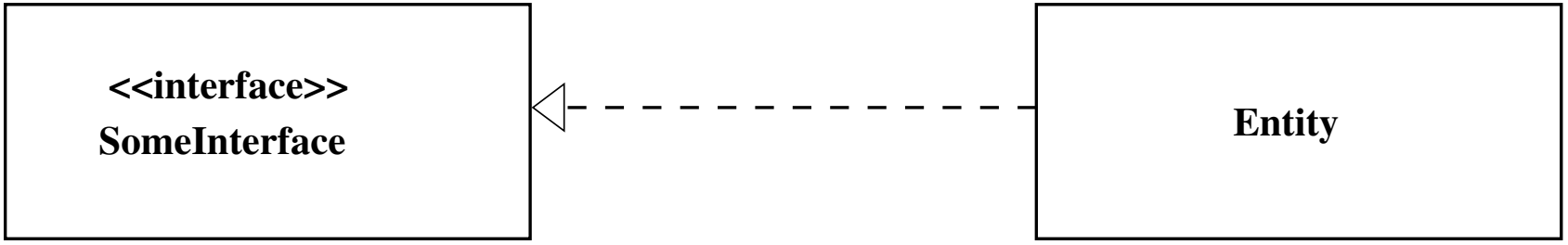
Central question

- what is the mapping to a programming language?

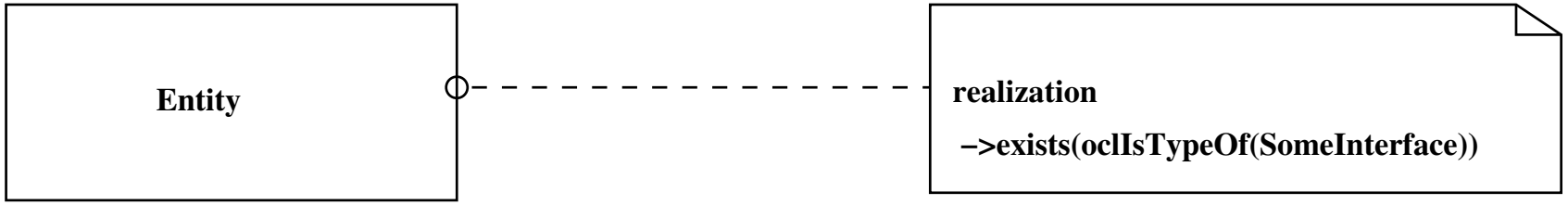
Interfaces

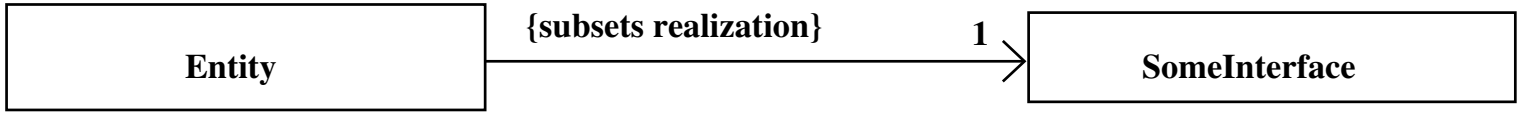
Every instance of **Entity** should implement **SomeInterface**

- wrong approach



- book solution use OCL or subsetting of metaassociation

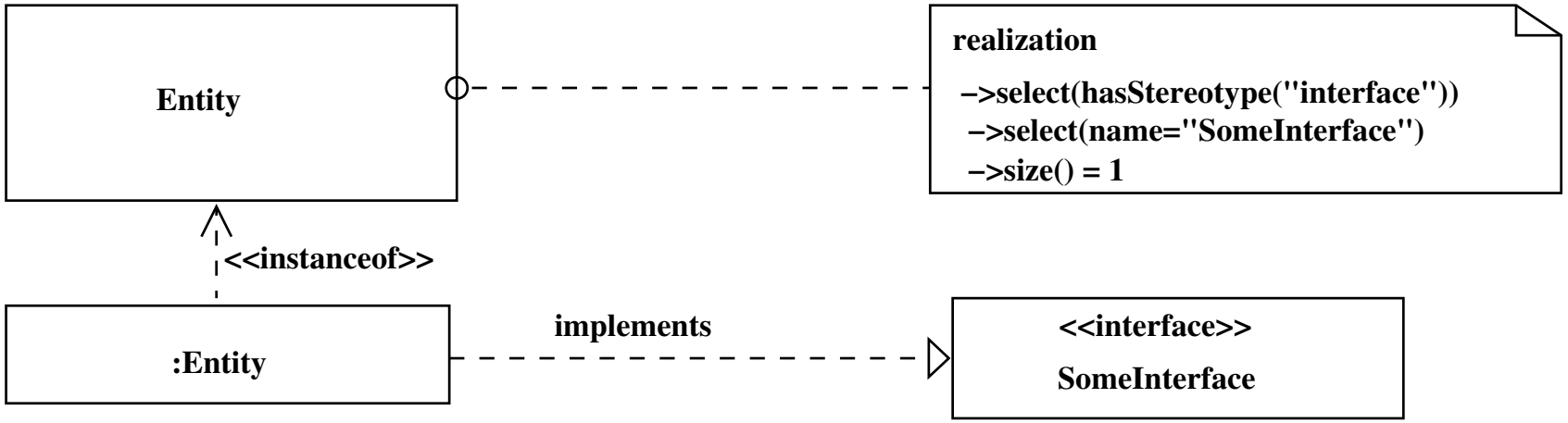




Interfaces/2

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

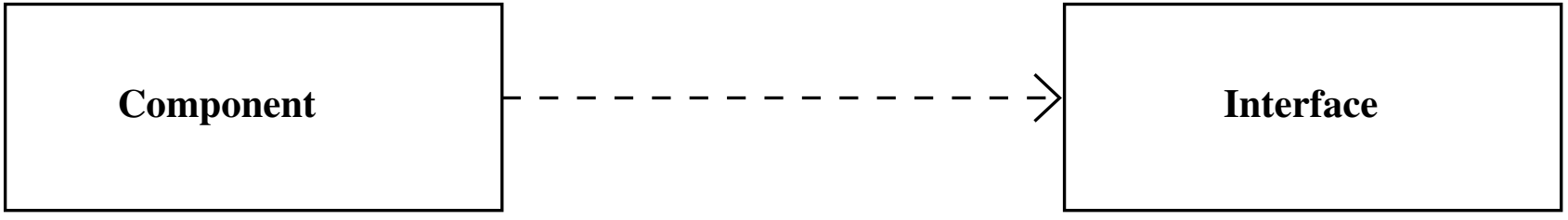
- correct solution use OCL



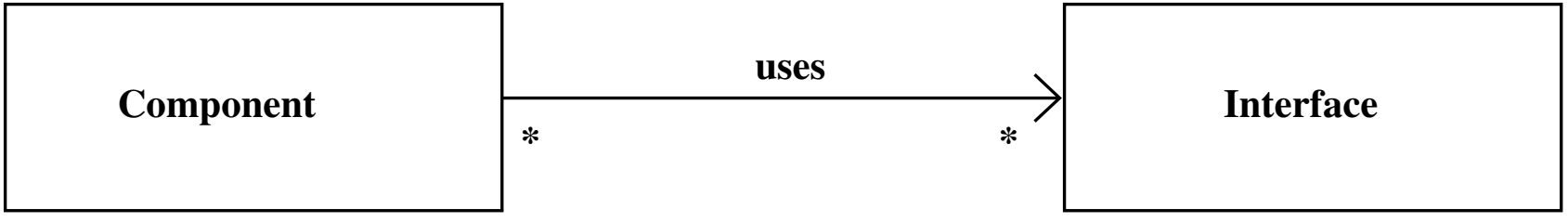
- solution with metaassociation and OCL is also possible

Dependency

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



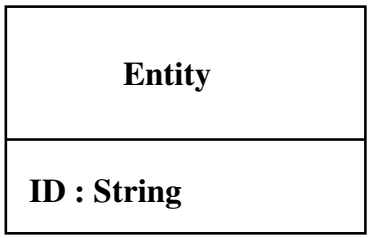
- correct solution a metaassociation “uses”



Identifying Attribute

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

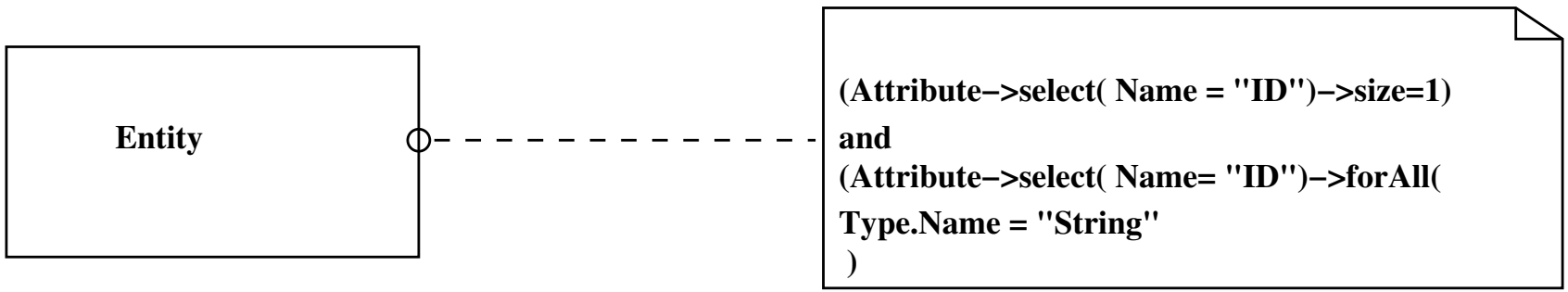
- wrong approach



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

Identifying Attribute

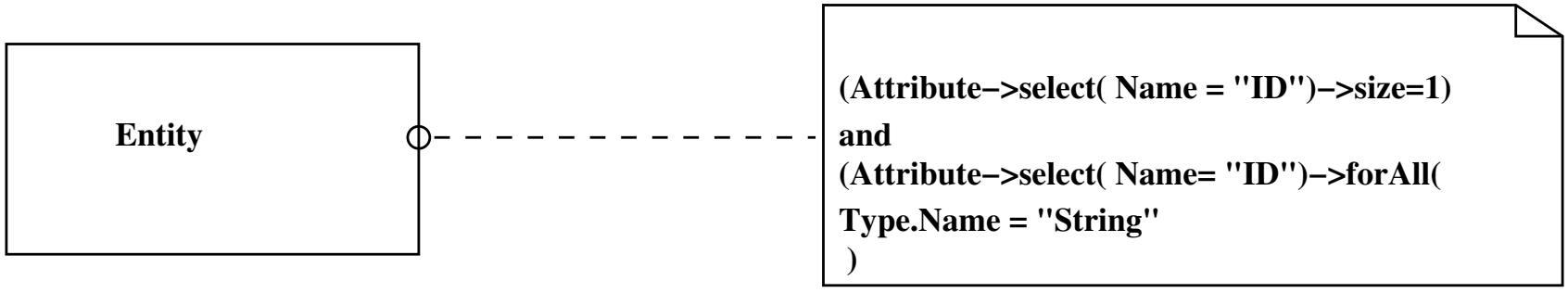
- correct solution



  - 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`

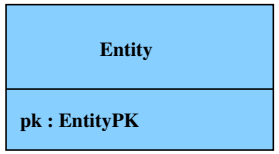
- incorrect attempt

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

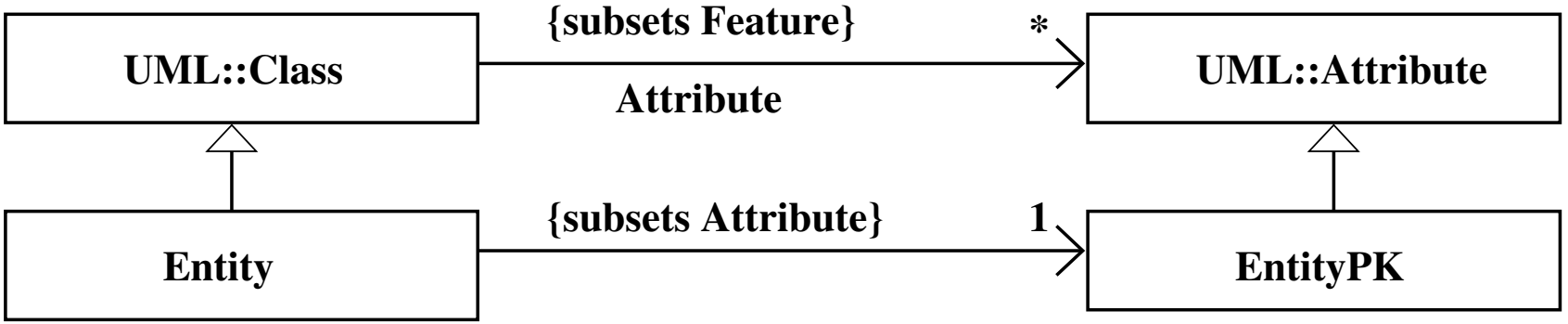
Primary Key Attribute

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

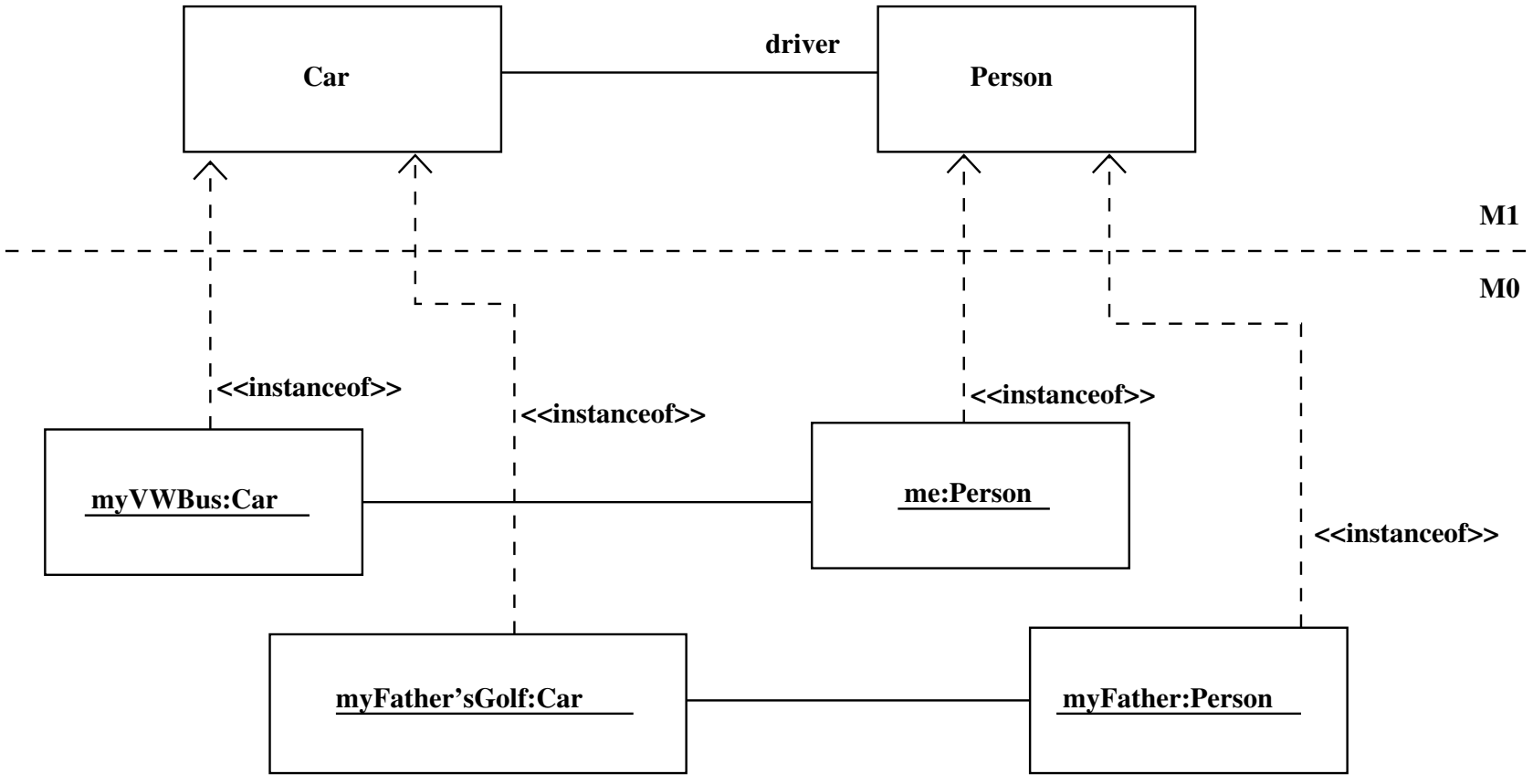
- wrong approach



- correct solution



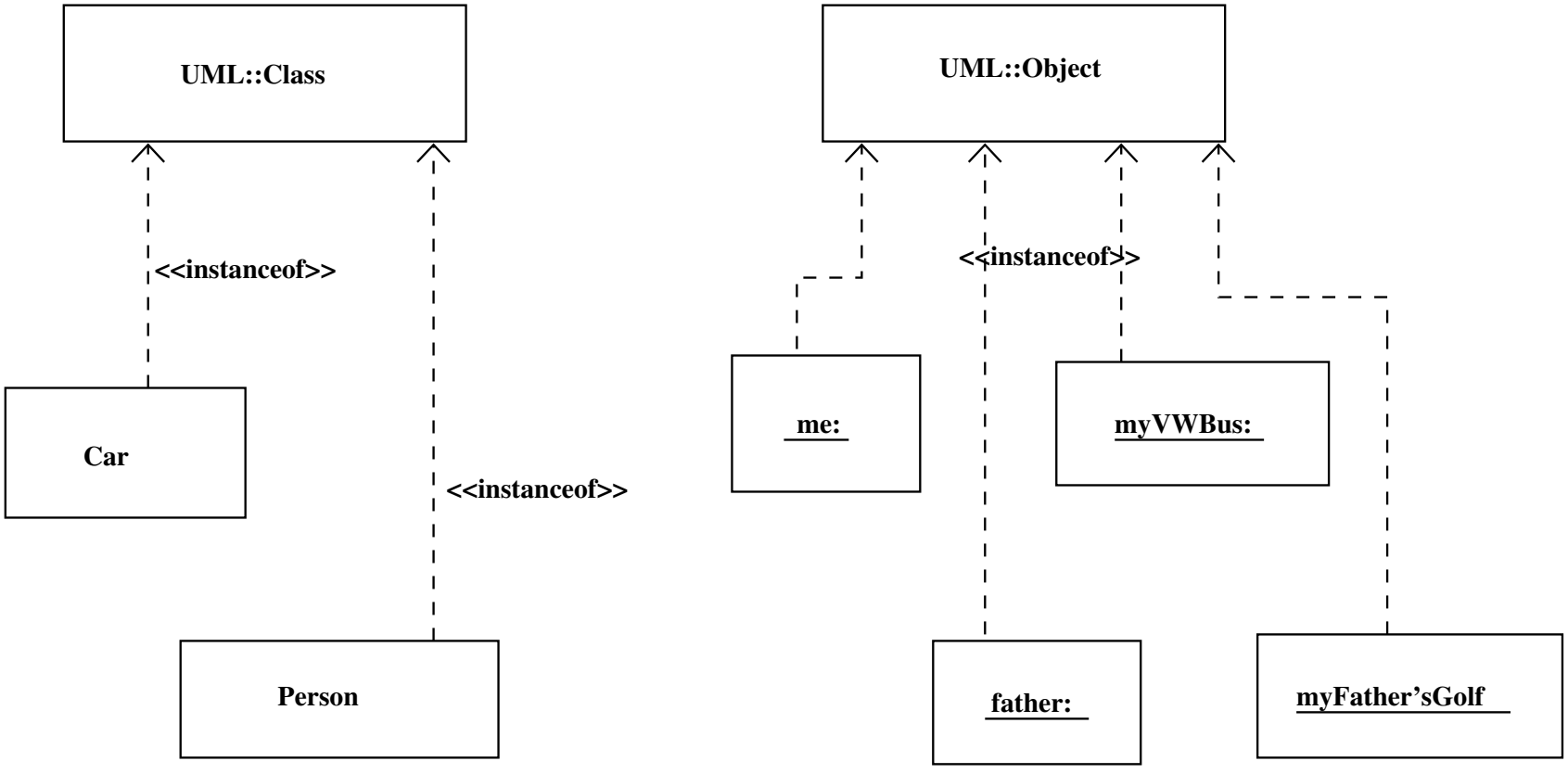
Metalevels and Instanceof



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

Metalevels and Instanceof

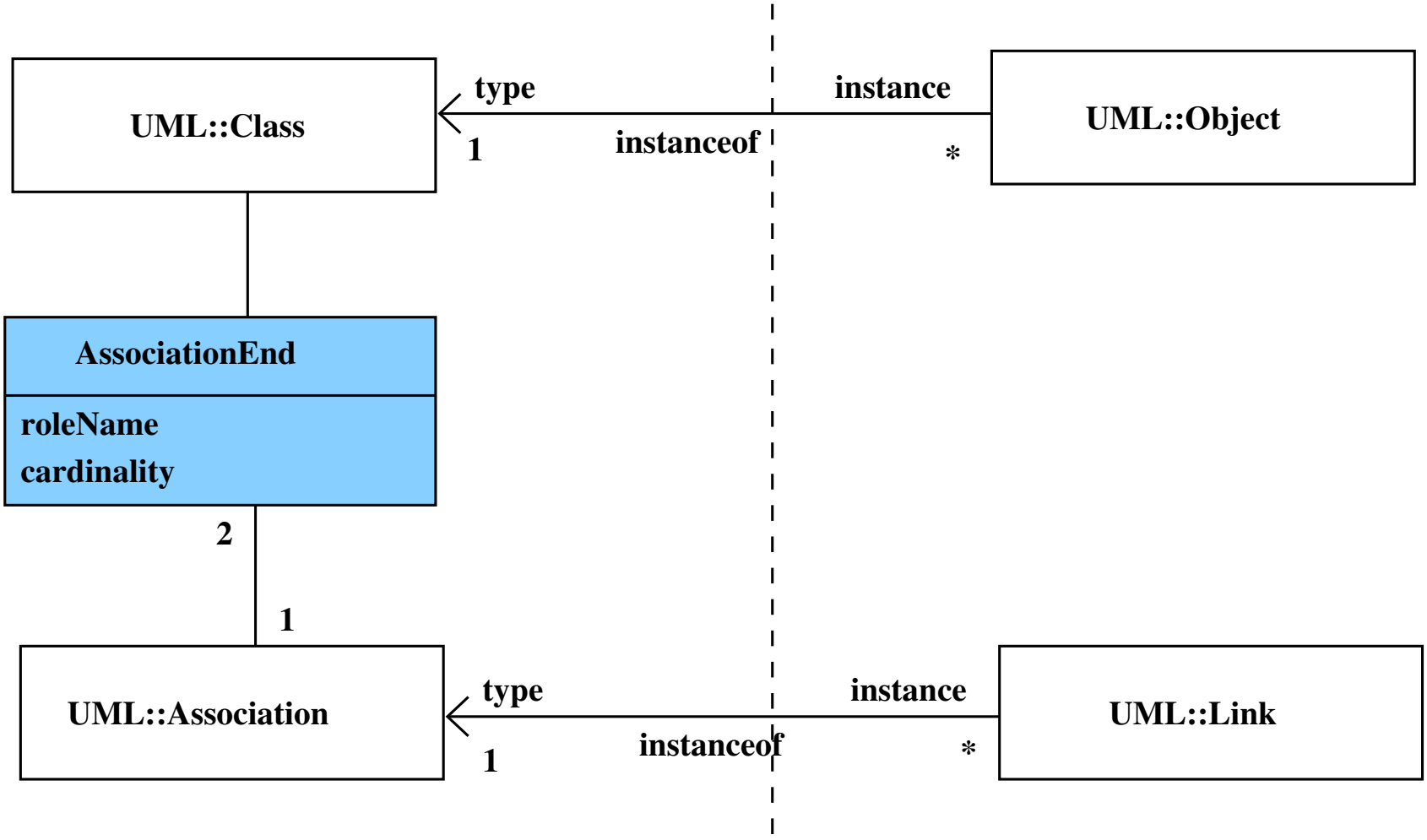
Model Elements as Instances of Metamodel Elements



- 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**

Metalevels and Instanceof

A Look at the Metamodel



- $\Rightarrow$ two different instanceof relations