Software Engineering I: Software Technology

WS 2008/09

The UML 2.0 meta model

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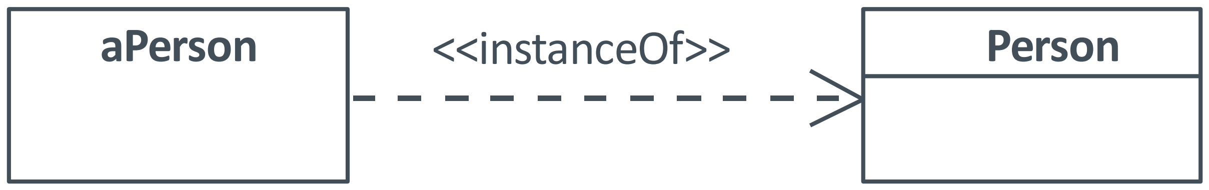
Outline for today

- From model instances to meta models
- MOF meta model hierarchy
- How UML relates to MOF
  - Example: Use case diagram meta model
  - Example: Class diagram meta model
- Different notations for the UML meta model describe the same language
- UML Profiles: Adding new members to the family

From model instances to meta models



From model instances to meta models

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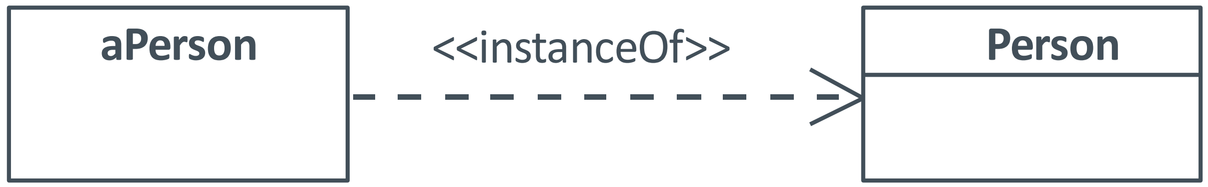

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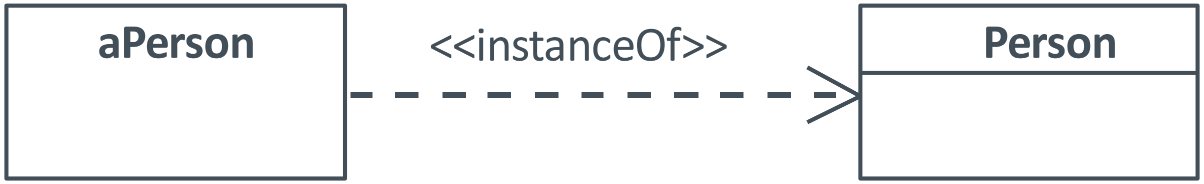

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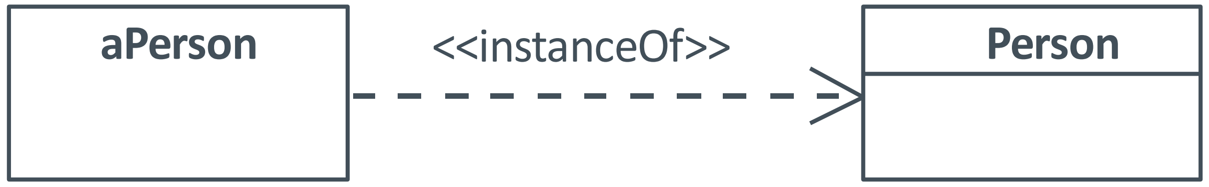

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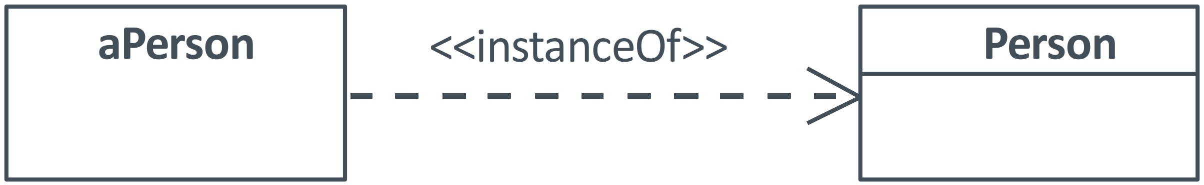

aPerson is an instance of the class Person.

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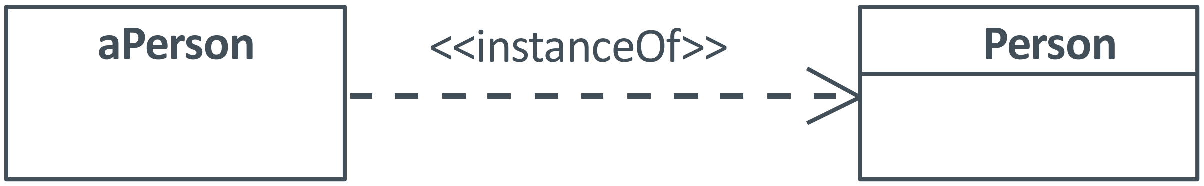

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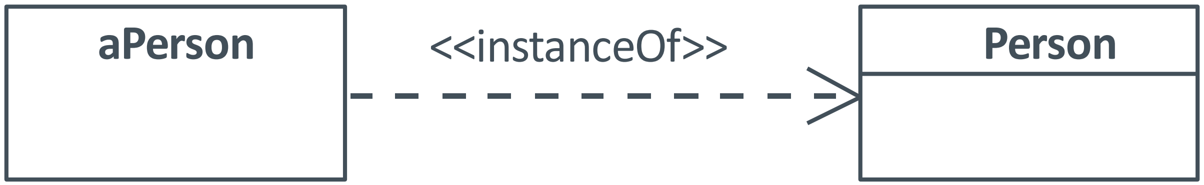

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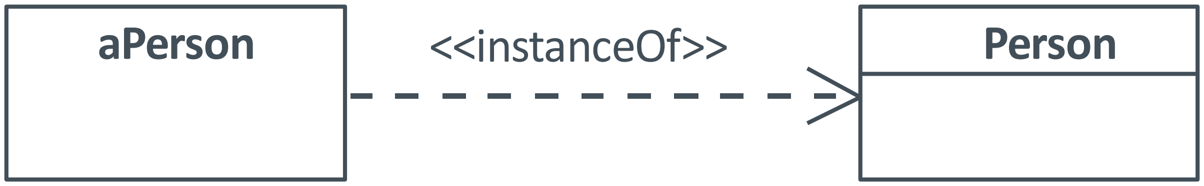

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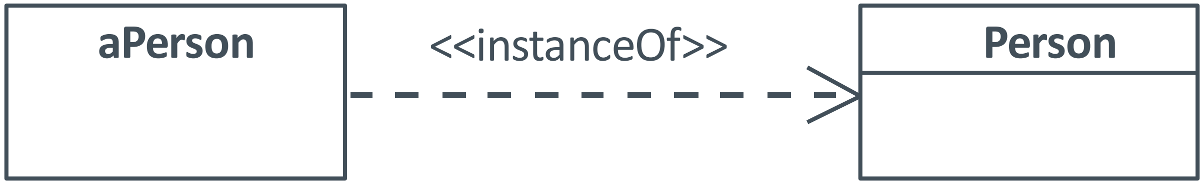


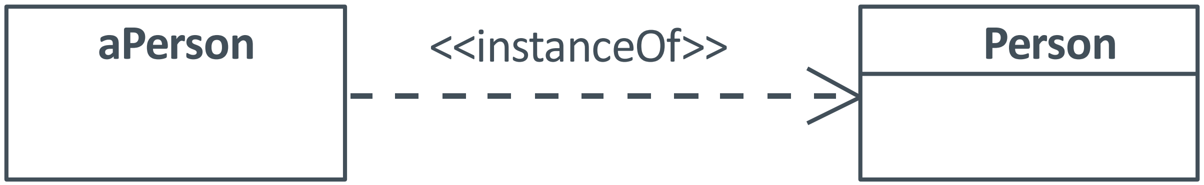
aPerson is an instance of the class Person.

Thus the class Person is a model for aPerson.

- Can we generalize this relationship?

  ➔ What is the model for the class Person?

From model instances to meta models



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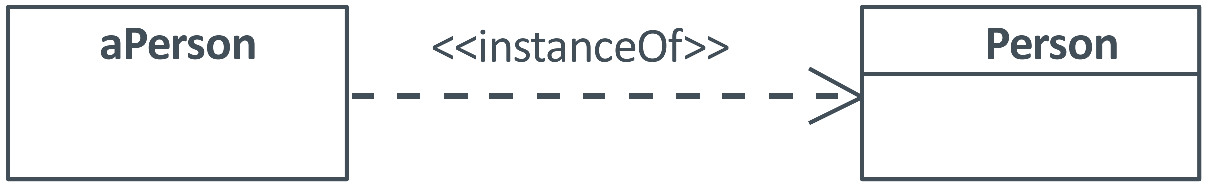

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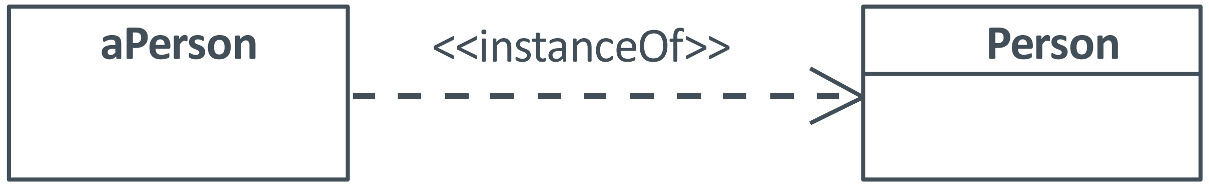

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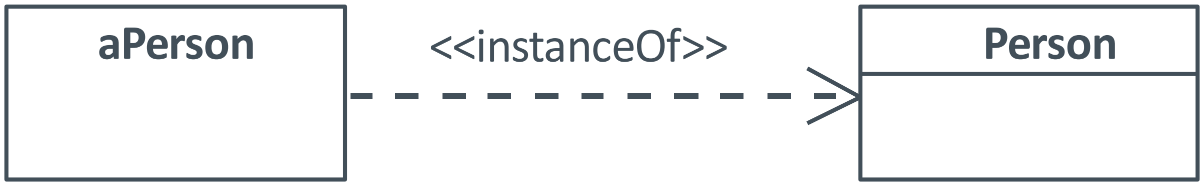

  – The instance aPerson and the class Person are on different levels of abstraction
  – The class Person specifies features that characterize the structure and behavior of *Persons*

  ➔The model for the class Person must characterize the structure and behavior of *classes*

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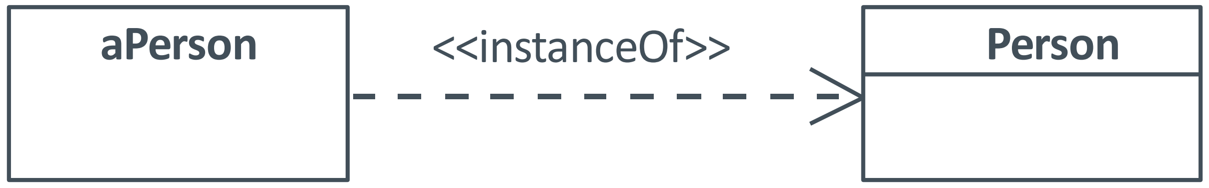

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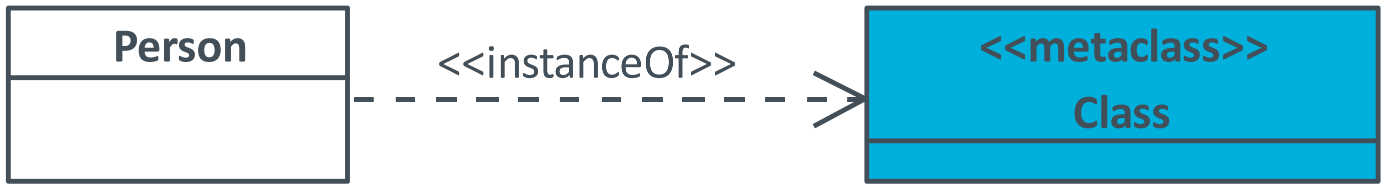

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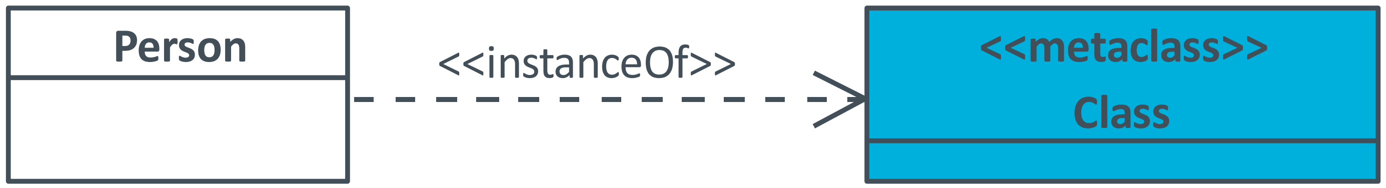

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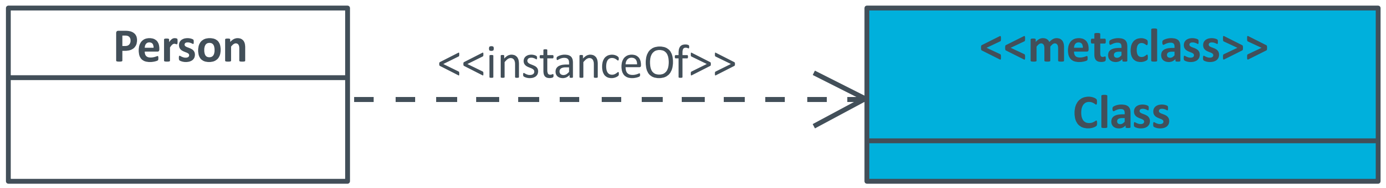

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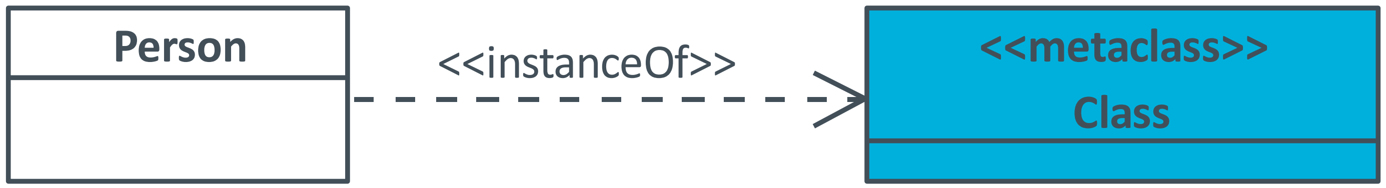

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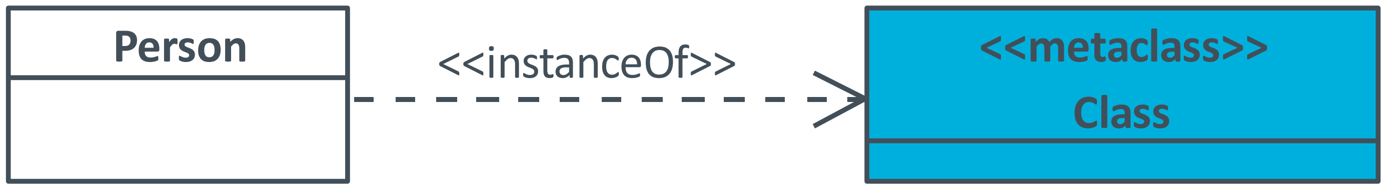

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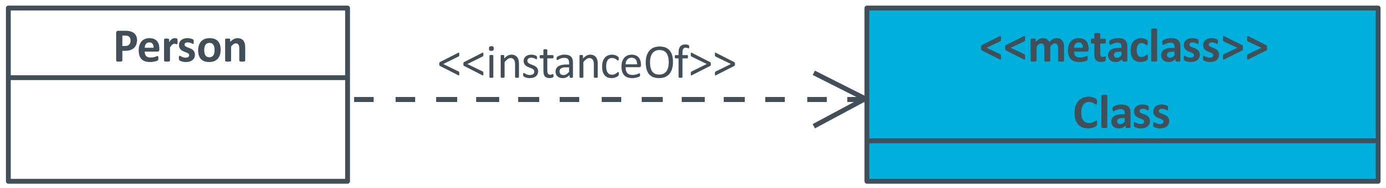

  - The meta class Class is a model for the class Person
  - Since Person is a model (for the instance aPerson), Class is a meta model (model for models)

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- Think of the different layers of abstraction:
  - Instances are concrete
  - Models are an abstract description of the instances
  - Meta models are an abstract description of models
  - …

Meta models

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- Meta models can be used for instance to formalize UML notations:
  - The UML is a Language, meta models are used to describe the grammar
  - The UML meta model describes all models one can create using UML
  - The meta model allows to talk about semantics

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To approach this problem, we will look at the history of UML's meta model first.

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➔ To describe any meta model, we can use the UML class diagram notation!

Meta Object Facility (MOF)

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- A meta model which is defined using MOF is called “MOF compliant”

Advantages of MOF compliant meta models

- They can easily be compared
- Their instances (models) can be exchanged in a standardized way (XML Metadata Interchange)
- Their instances can live in the same metadata repository (data warehousing)

Meta Object Facility (MOF) - Facts

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In general, the sequence

instance → *model* → *meta model* → *meta-meta model* →…

could be continued infinitely.

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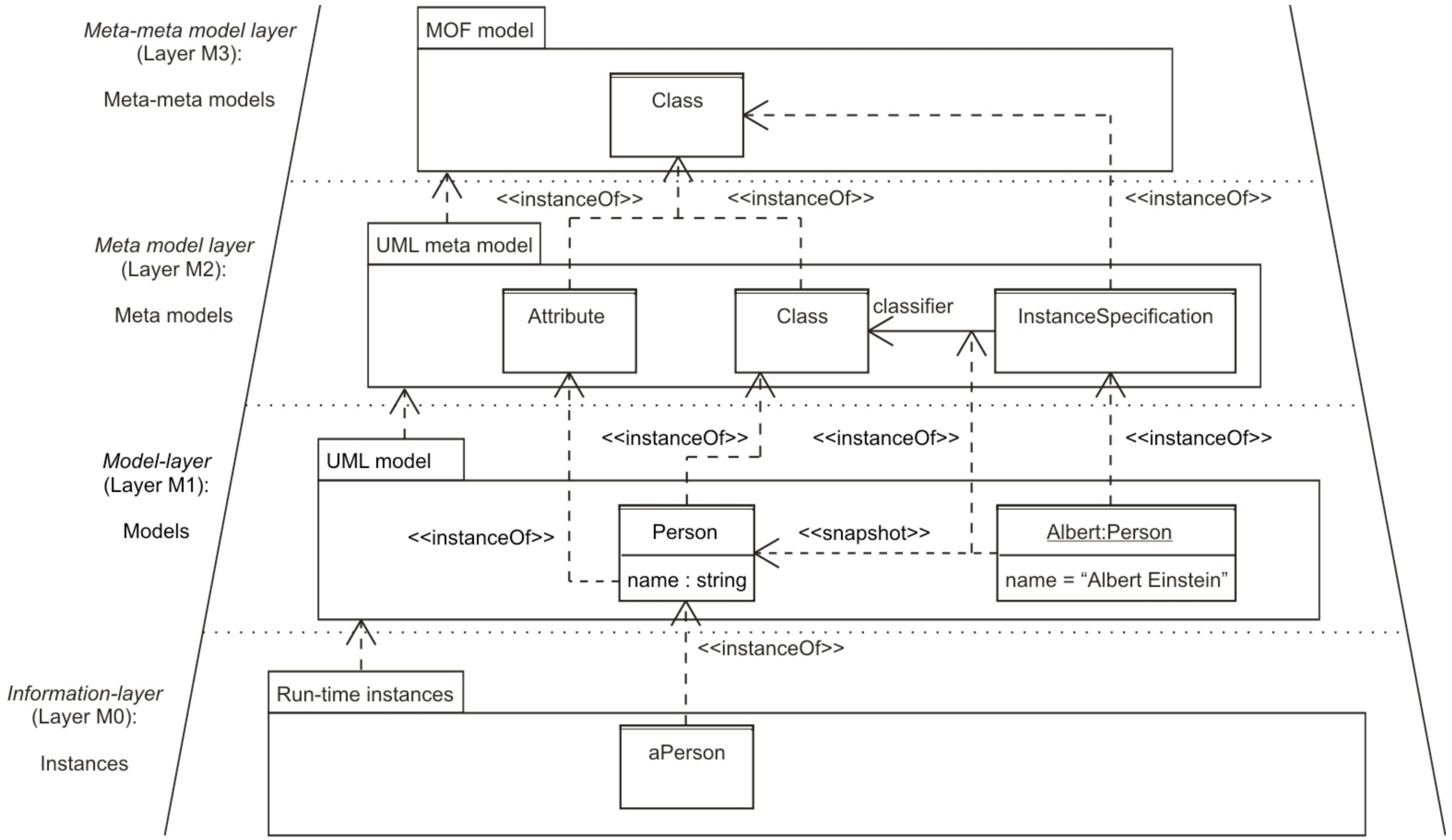
- MOF defines a four-layer meta model hierarchy
  - four layers suffice for most practical applications
- MOF and UML are aligned
  - UML infrastructure contains concepts for UML *and* MOF

Meta model hierarchy of the MOF (UML-specific)



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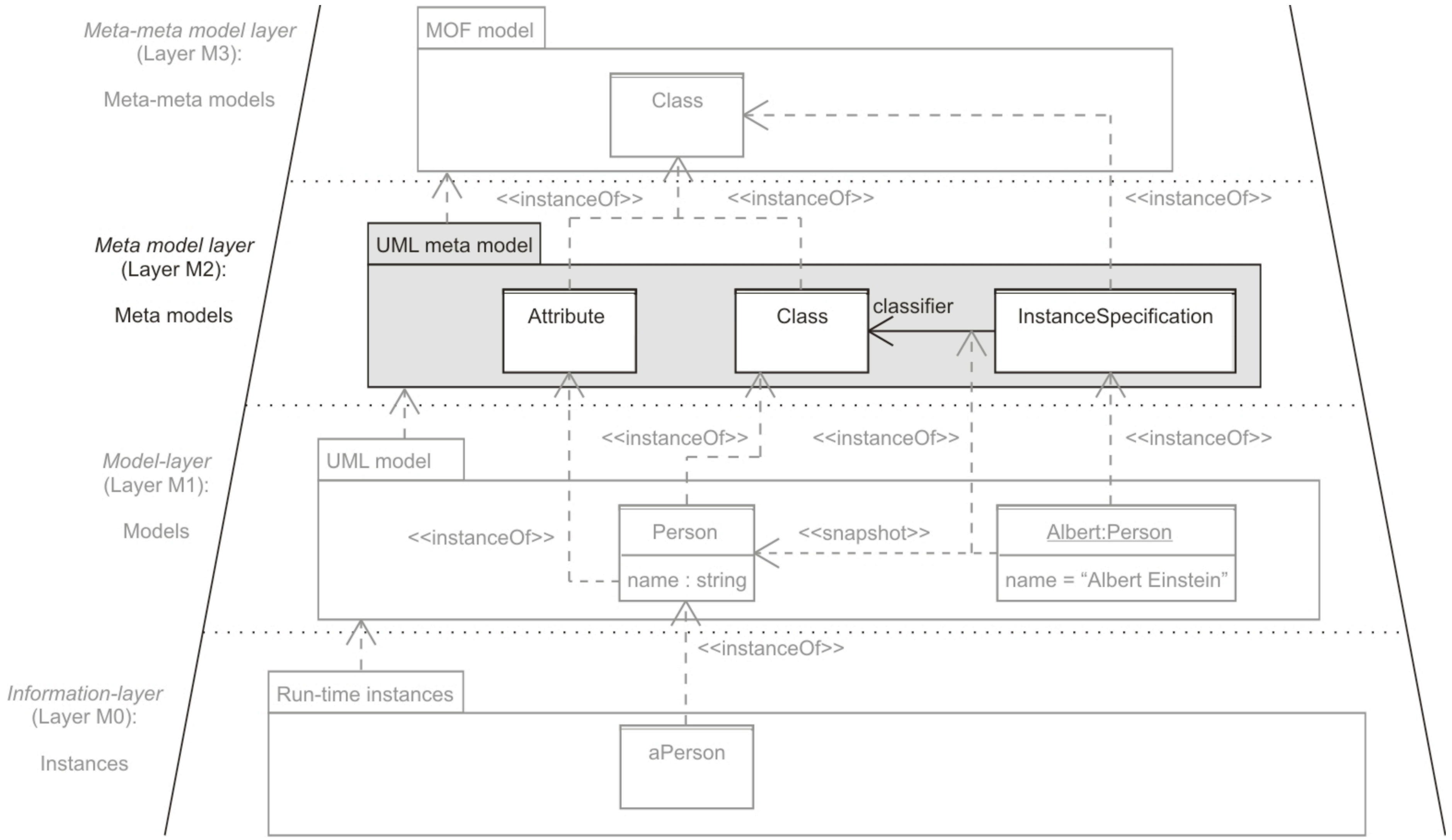

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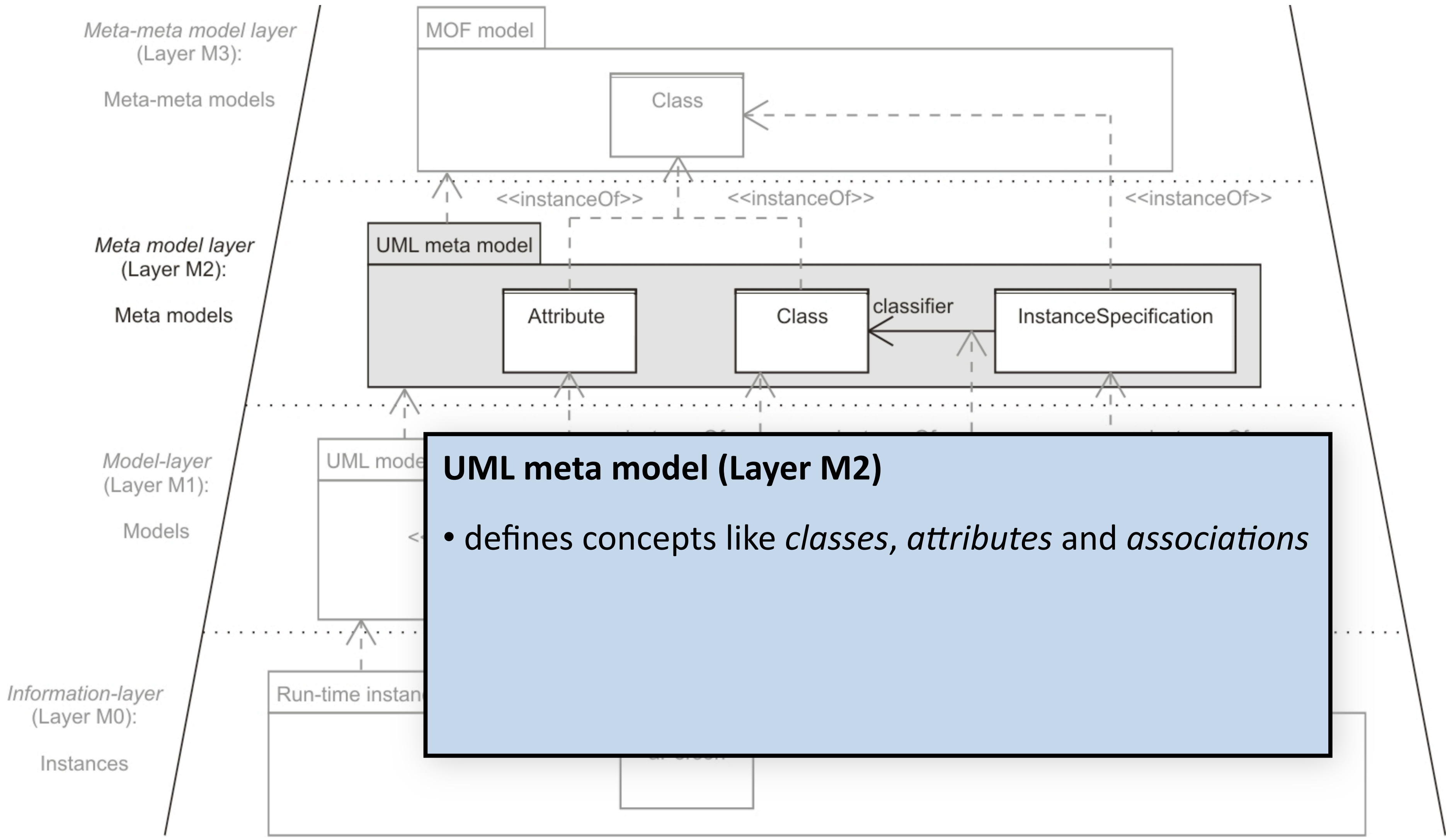

UML meta model (Layer M2)

• defines concepts like *classes*, *attributes* and *associations*

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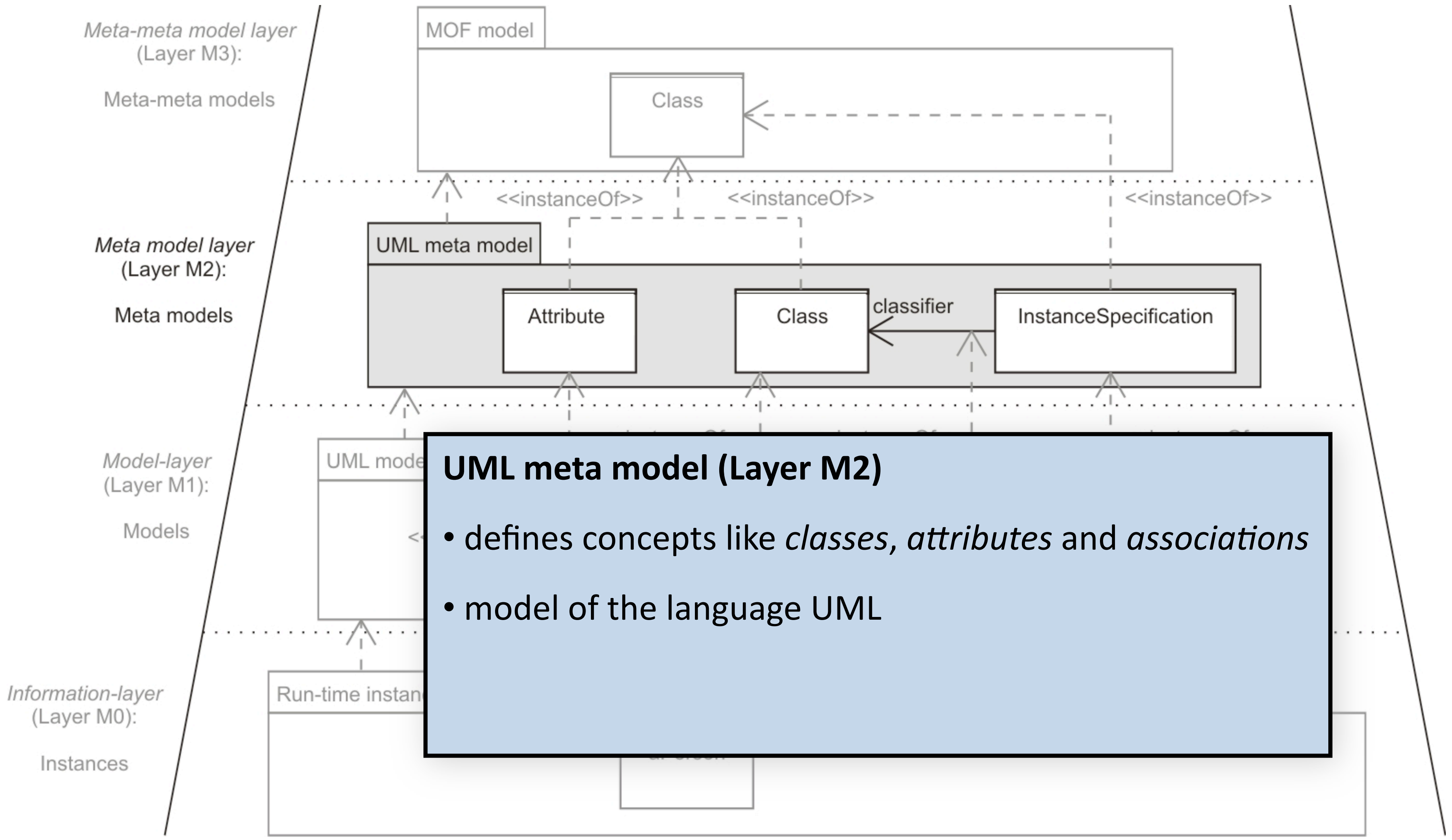

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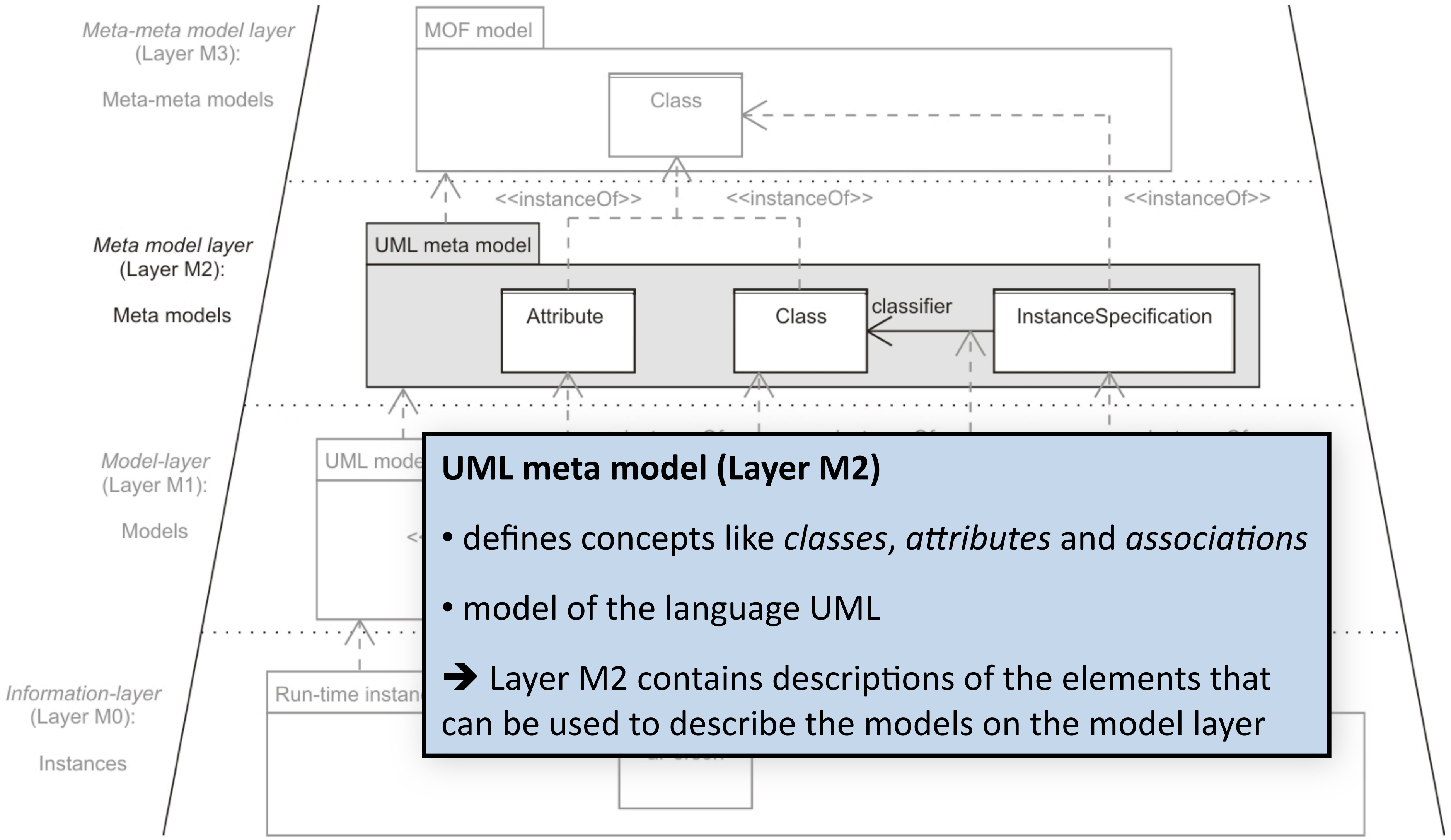

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➔ Layer M2 contains descriptions of the elements that can be used to describe the models on the model layer

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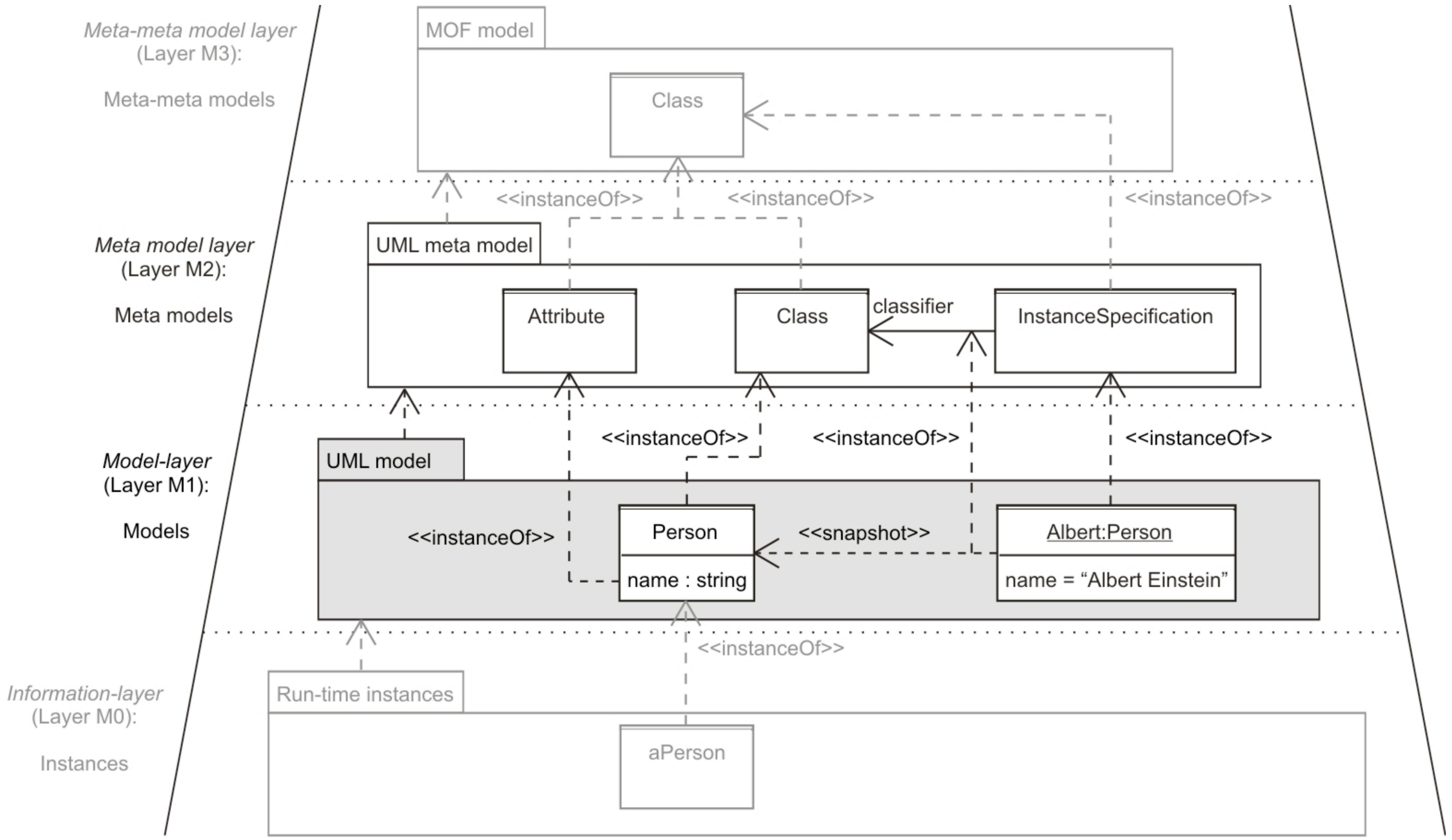

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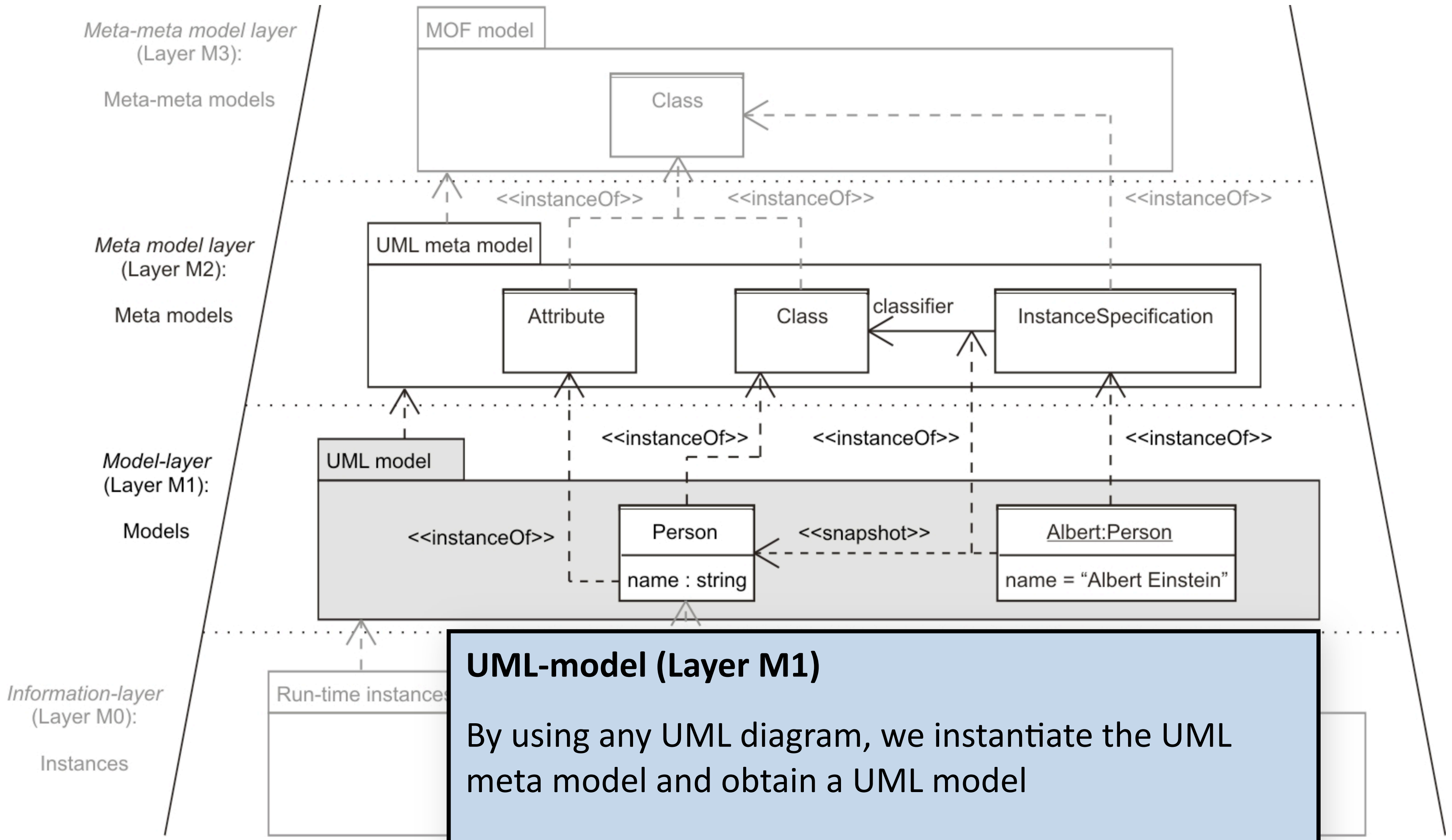

UML-model (Layer M1)

By using any UML diagram, we instantiate the UML meta model and obtain a UML model

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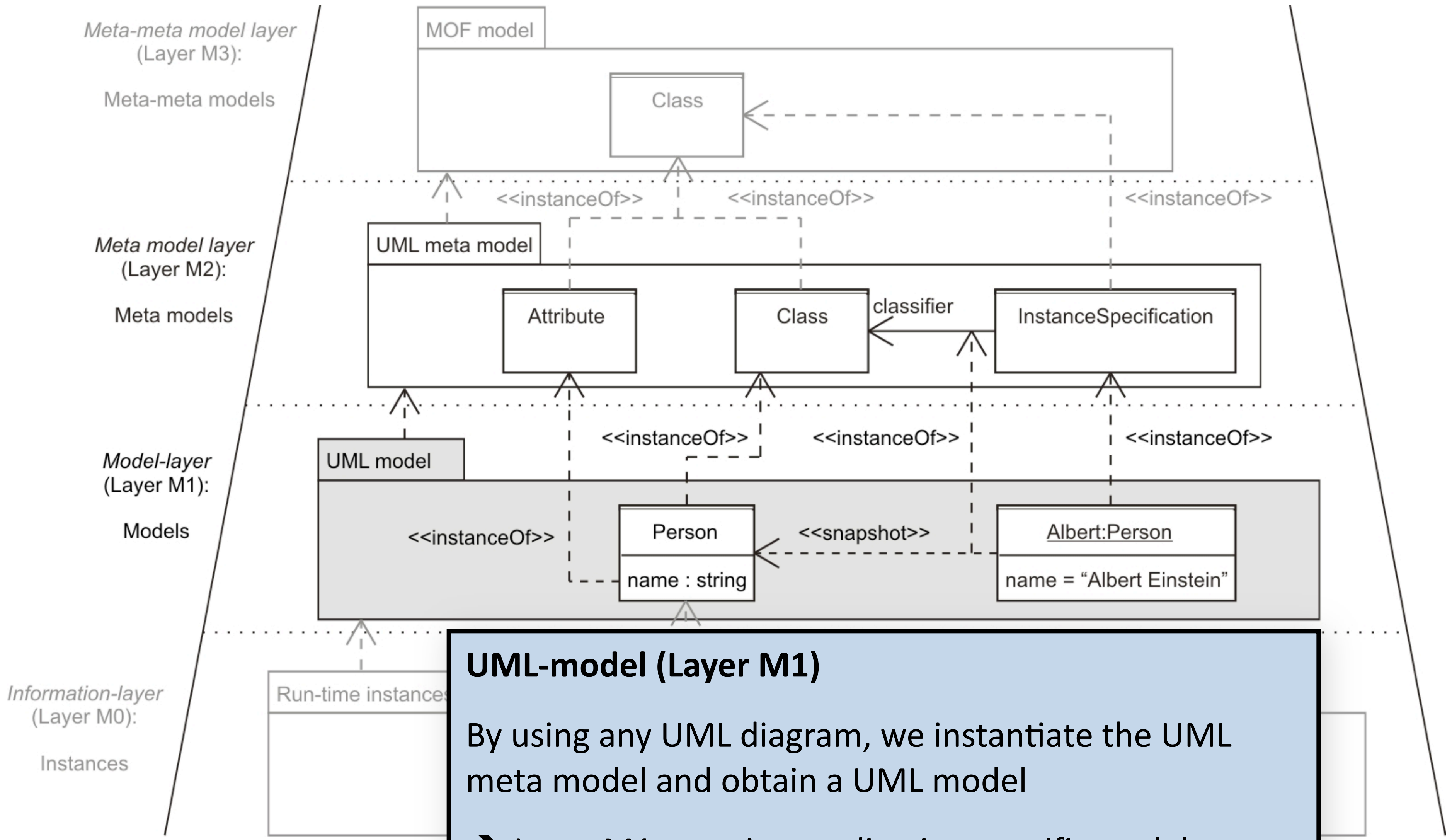

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➔ Layer M1 contains *application-specific* models

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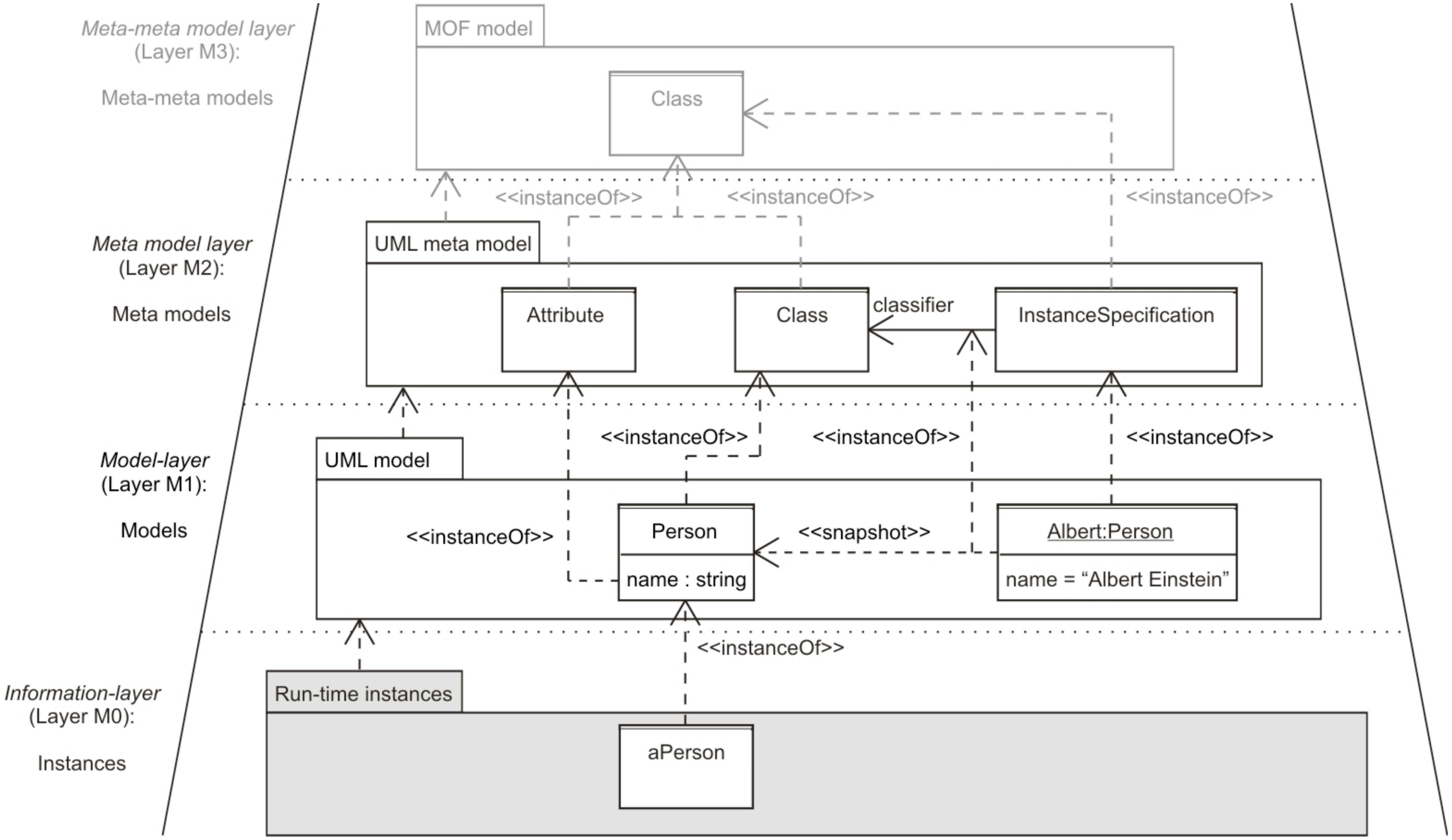

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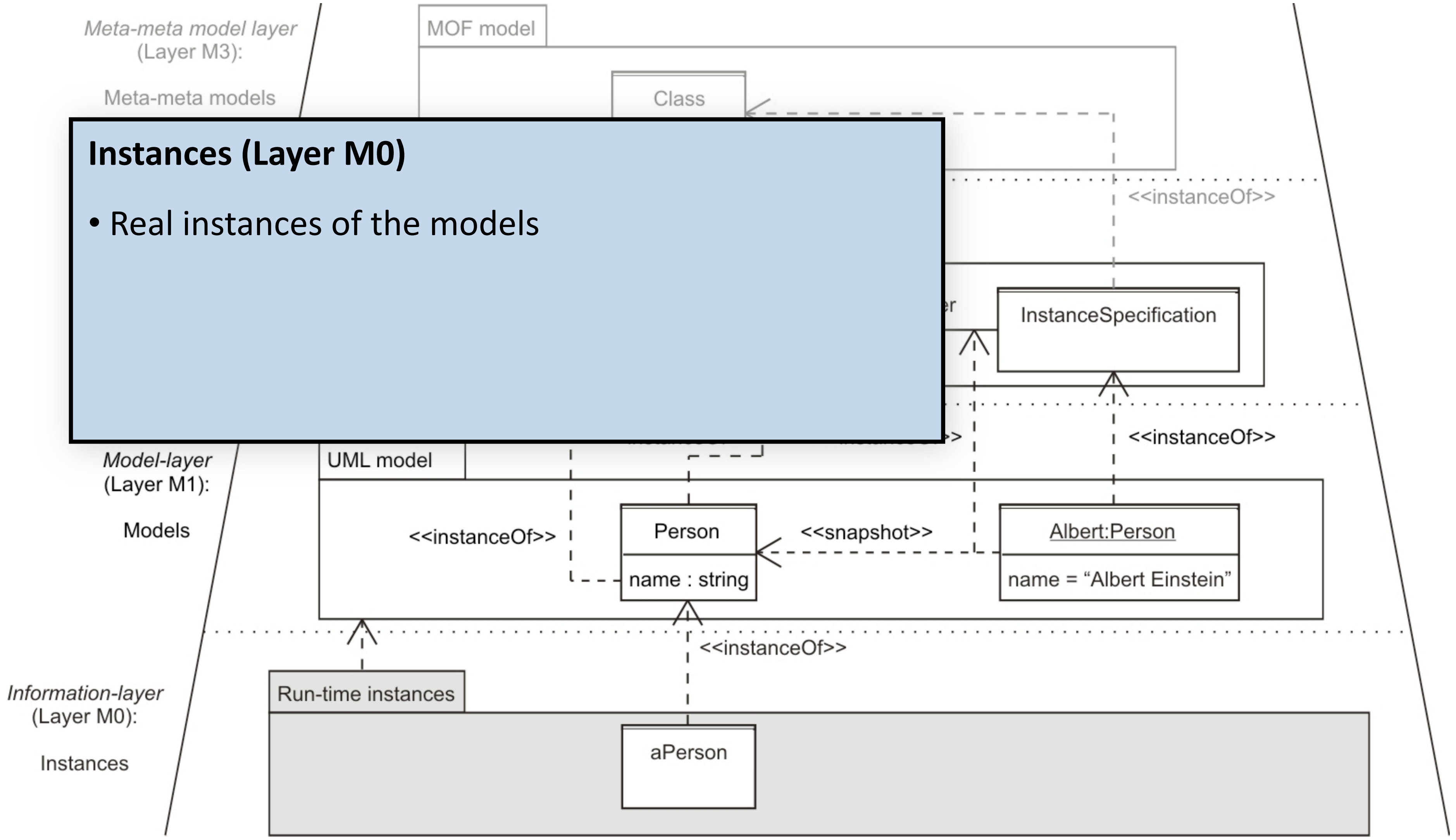

Instances (Layer M0)

- Real instances of the models

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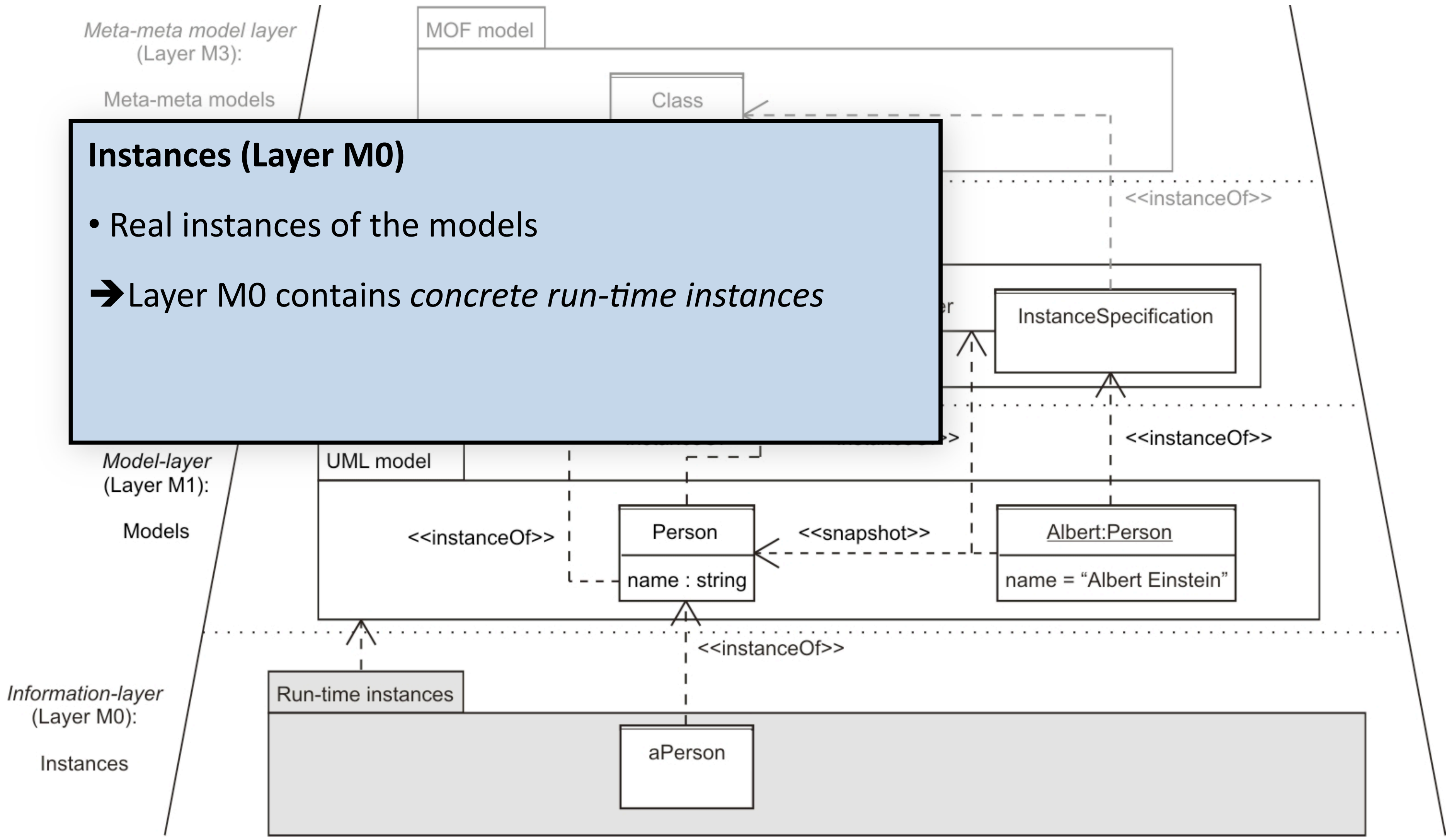

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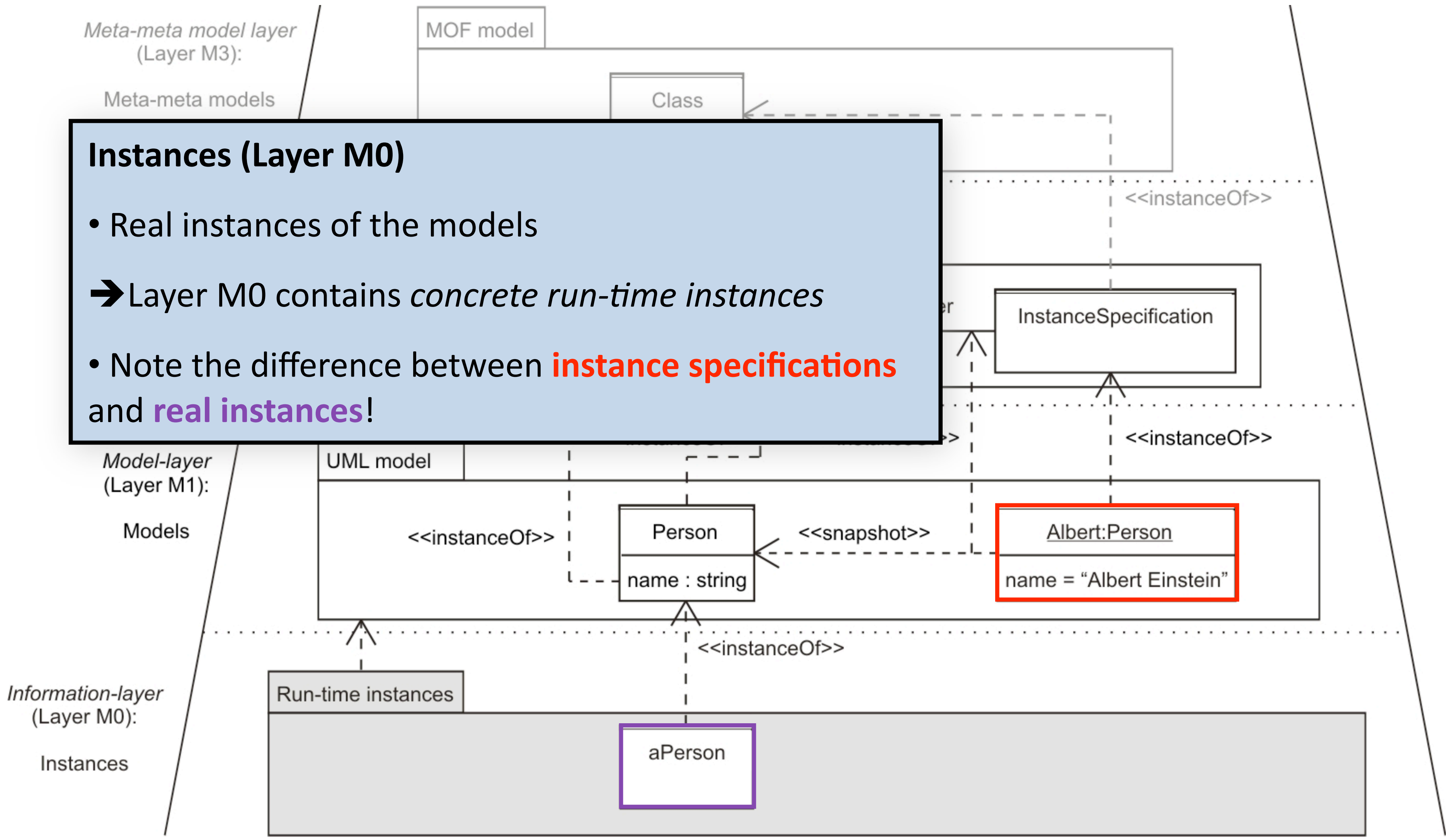

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- Note the difference between **instance specifications** and **real instances**!

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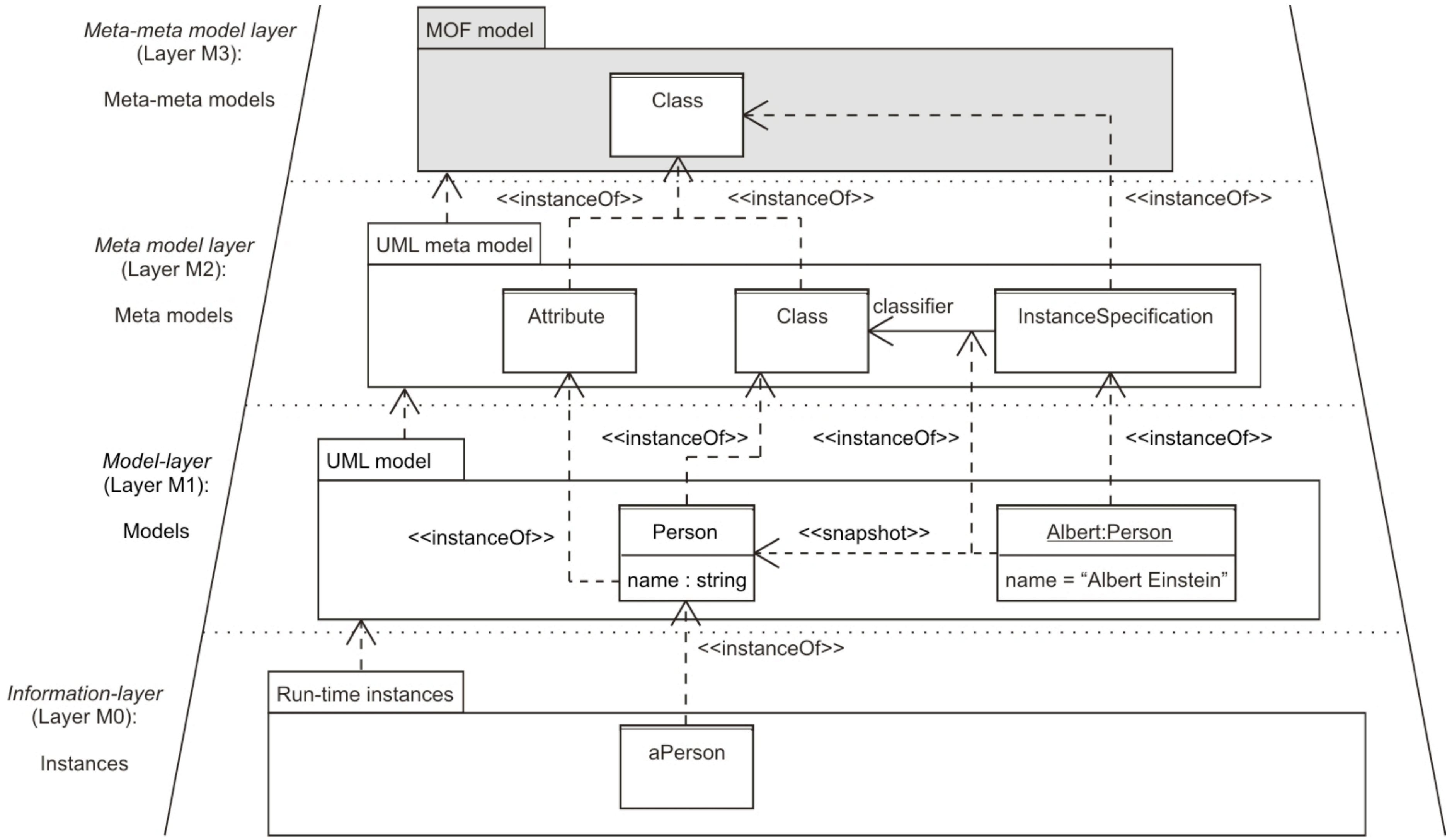

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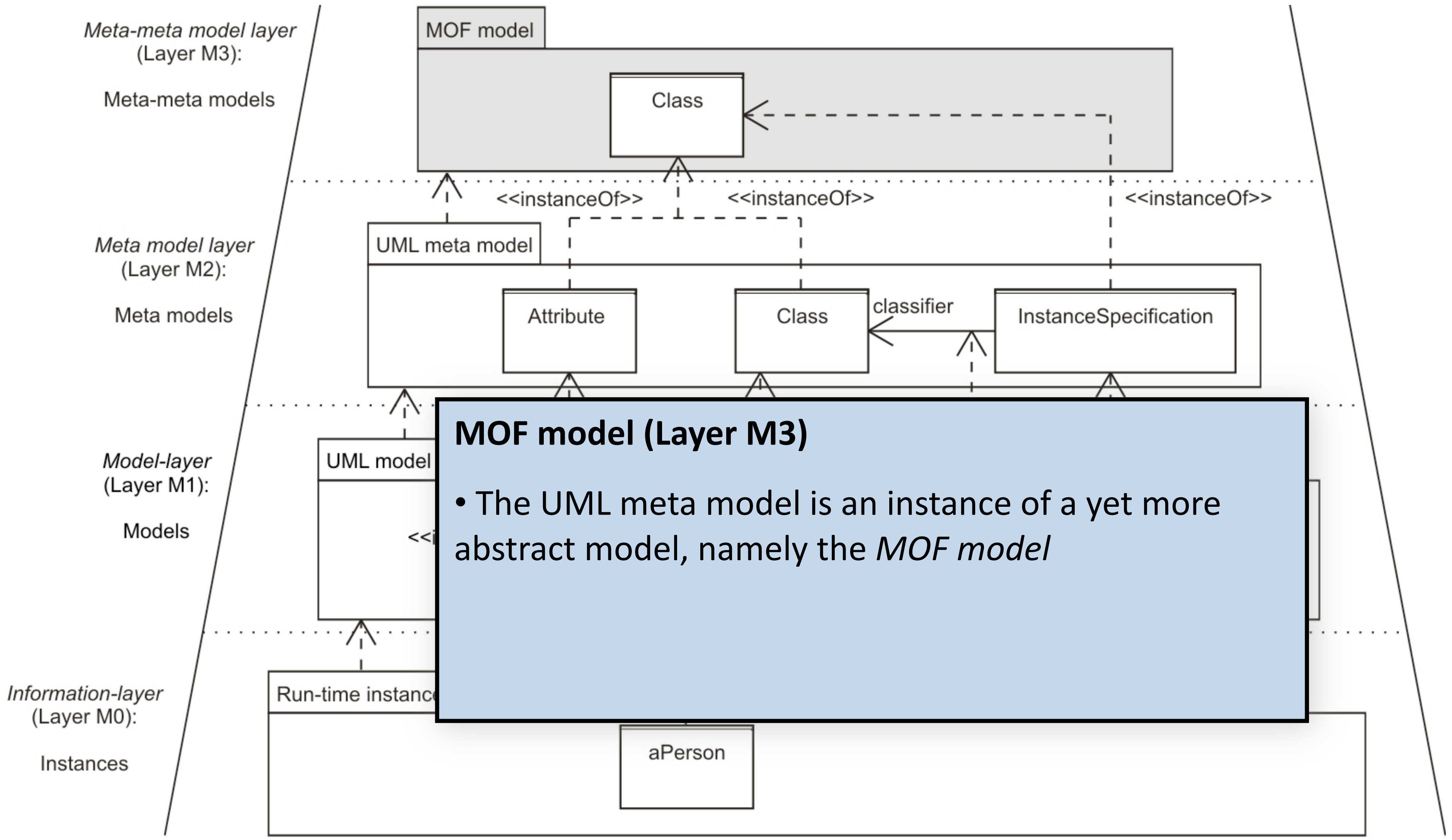

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• The UML meta model is an instance of a yet more abstract model, namely the *MOF model*

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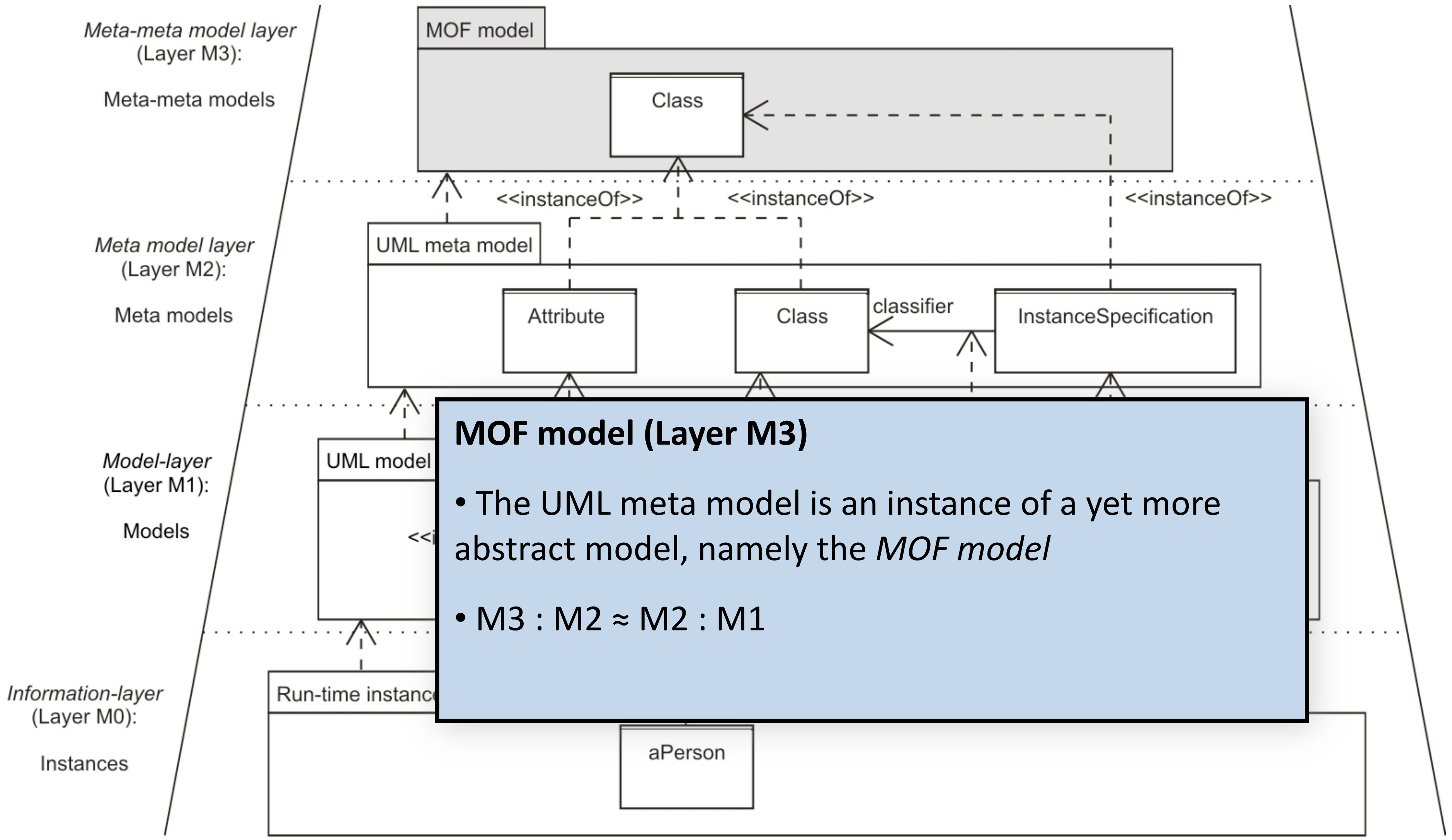

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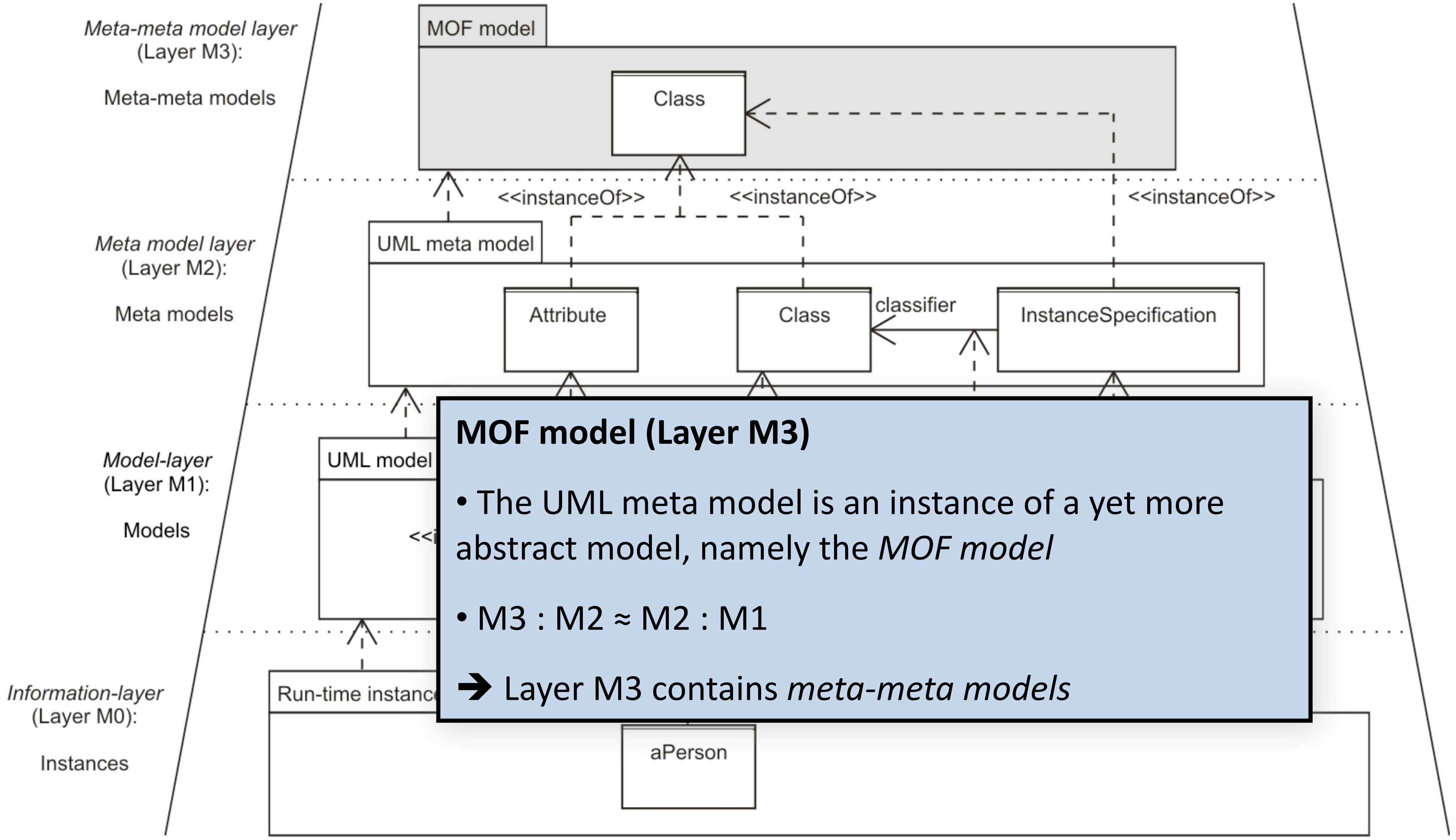

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➔ Layer M3 contains *meta-meta models*

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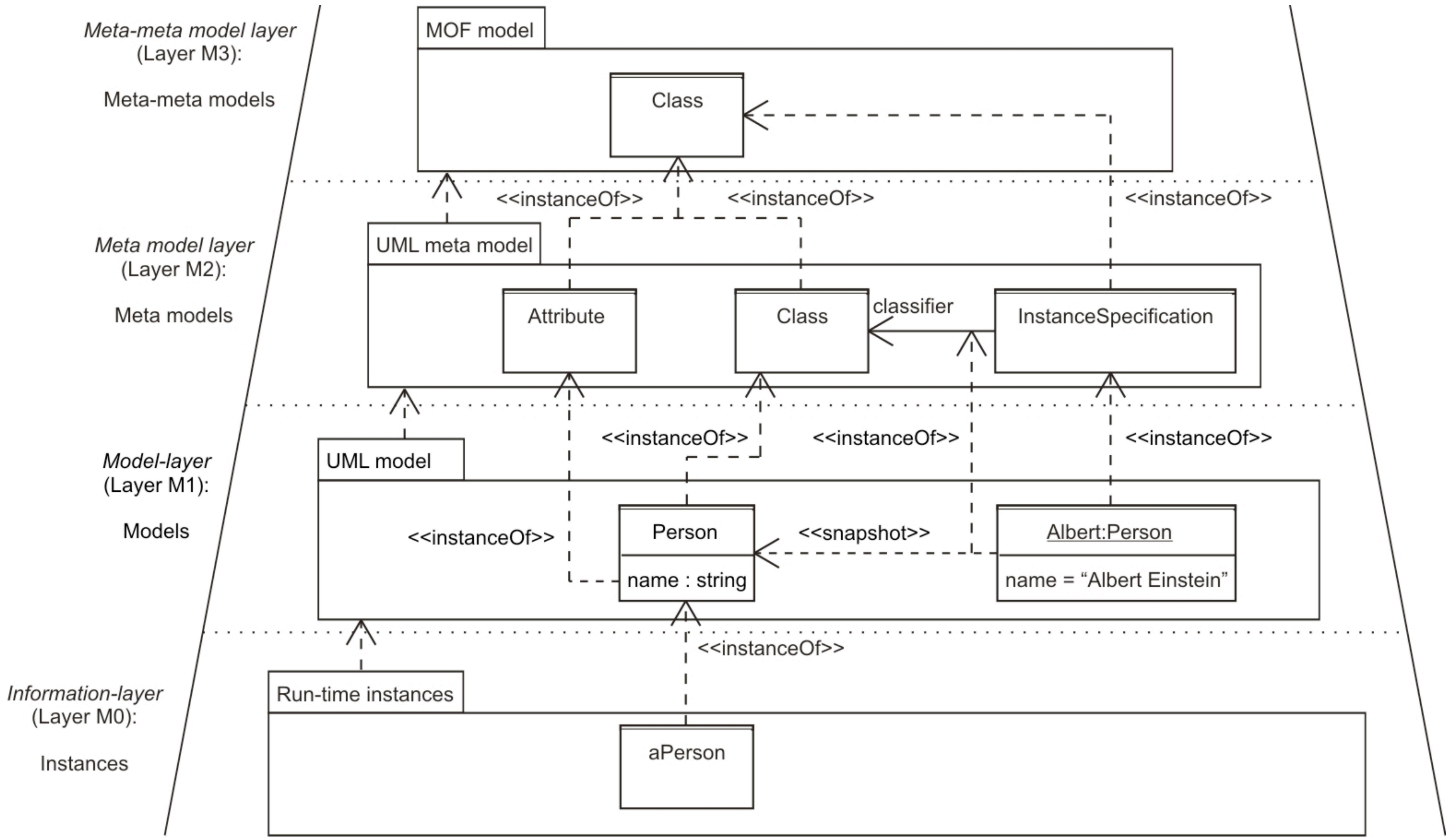

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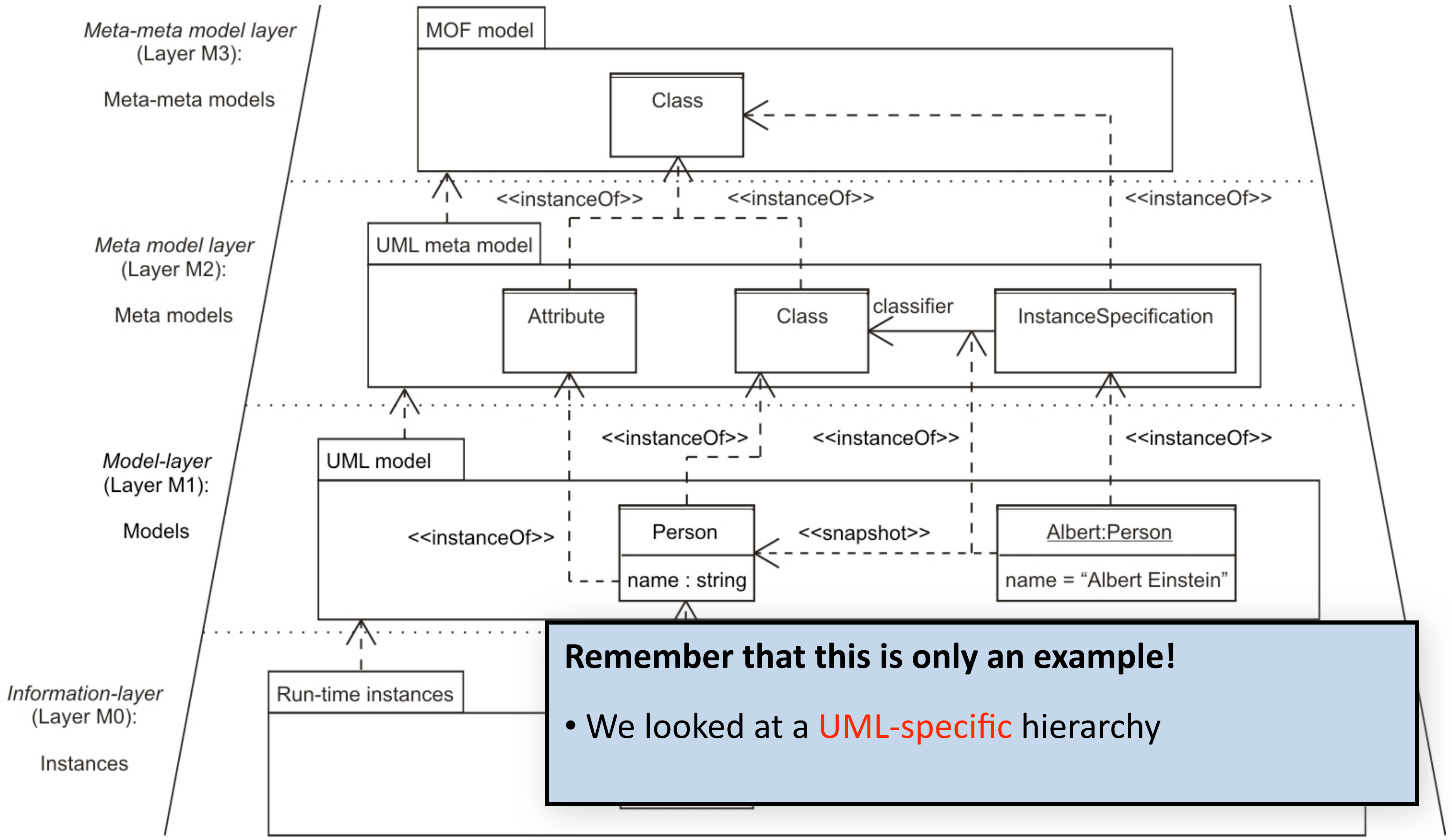

Remember that this is only an example!

- We looked at a UML-specific hierarchy

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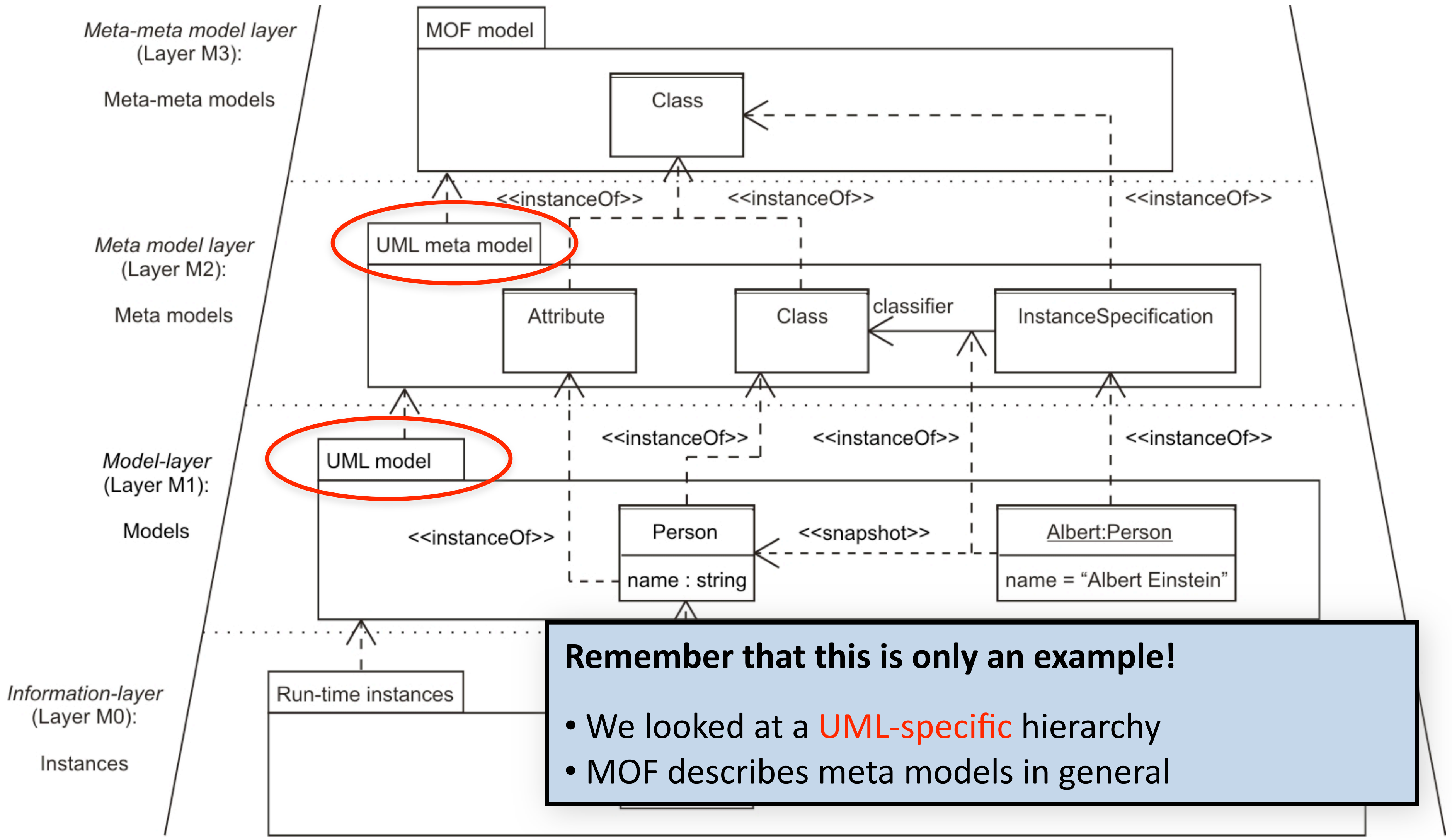

Remember that this is only an example!

- We looked at a UML-specific hierarchy
- MOF describes meta models in general

Where are we?

- ✓ From model instances to meta models
- ✓ MOF meta model hierarchy
- ➢ How UML relates to MOF
  - – Example: Use case diagram meta model
  - – Example: Class diagram meta model
- • Different notations for the UML meta model describe the same language
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How UML relates to MOF

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- UML is MOF-compliant:

  The UML meta model is an instance of the MOF model

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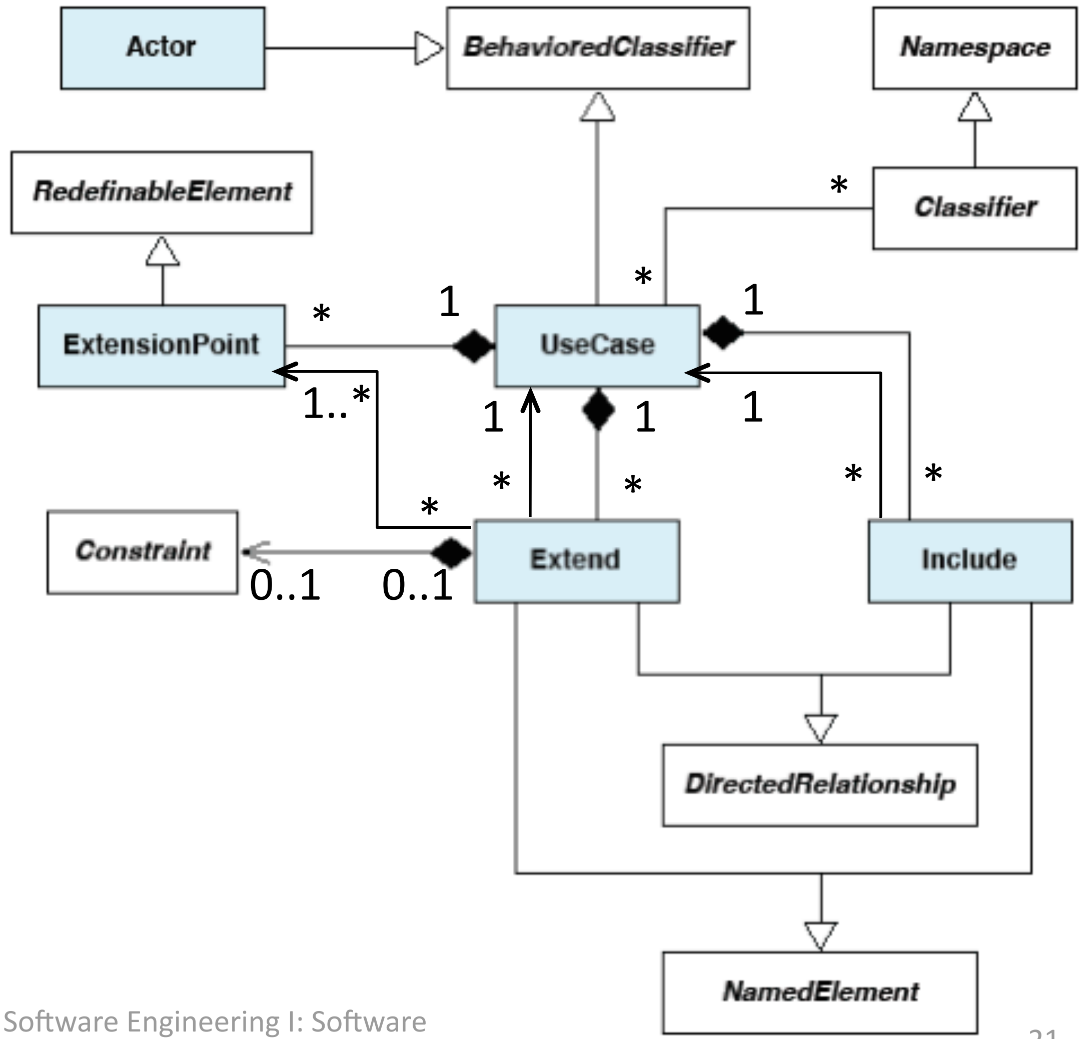
- Let’s see the UML meta model in action!

Use Case Diagram Meta Model (simplified)



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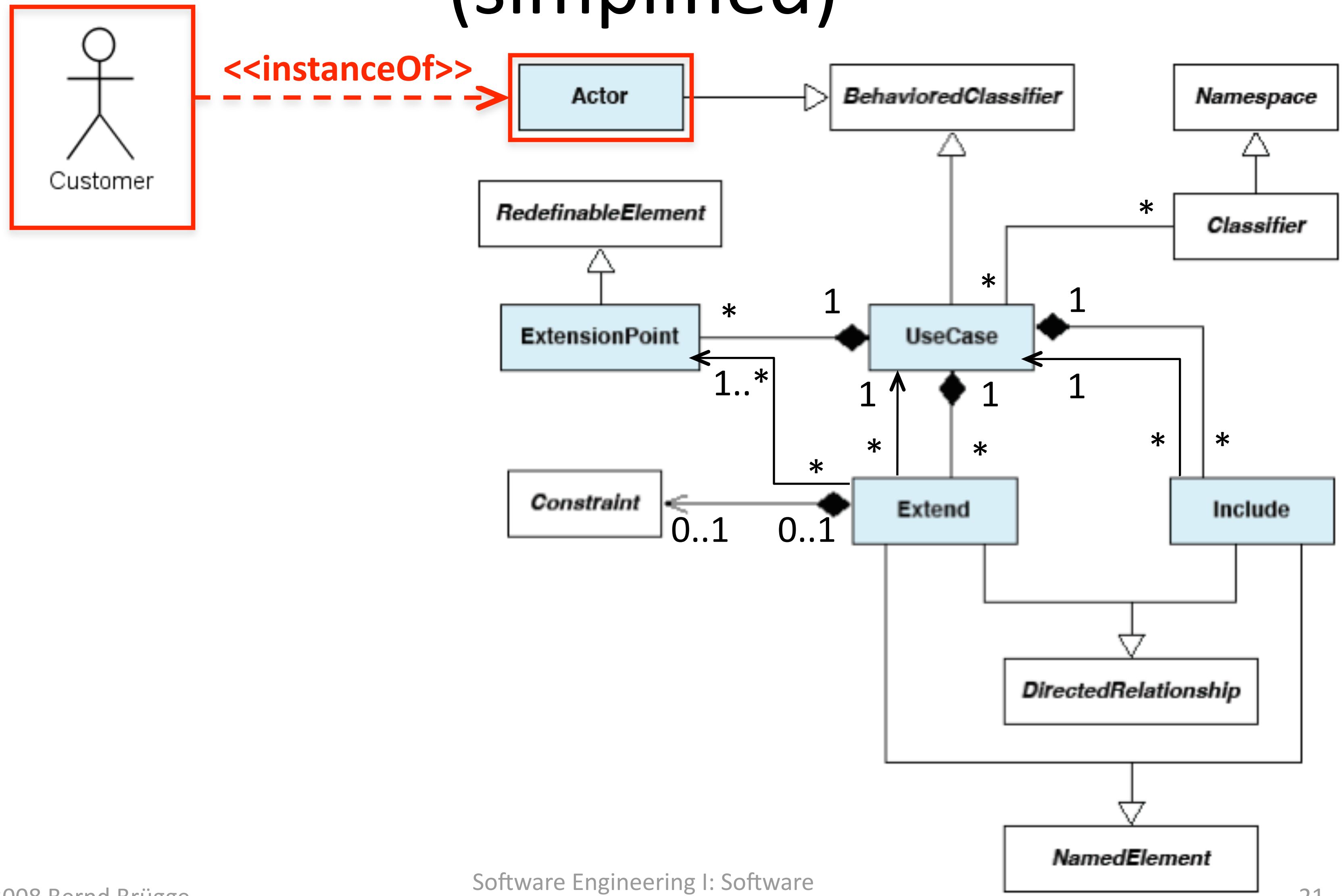

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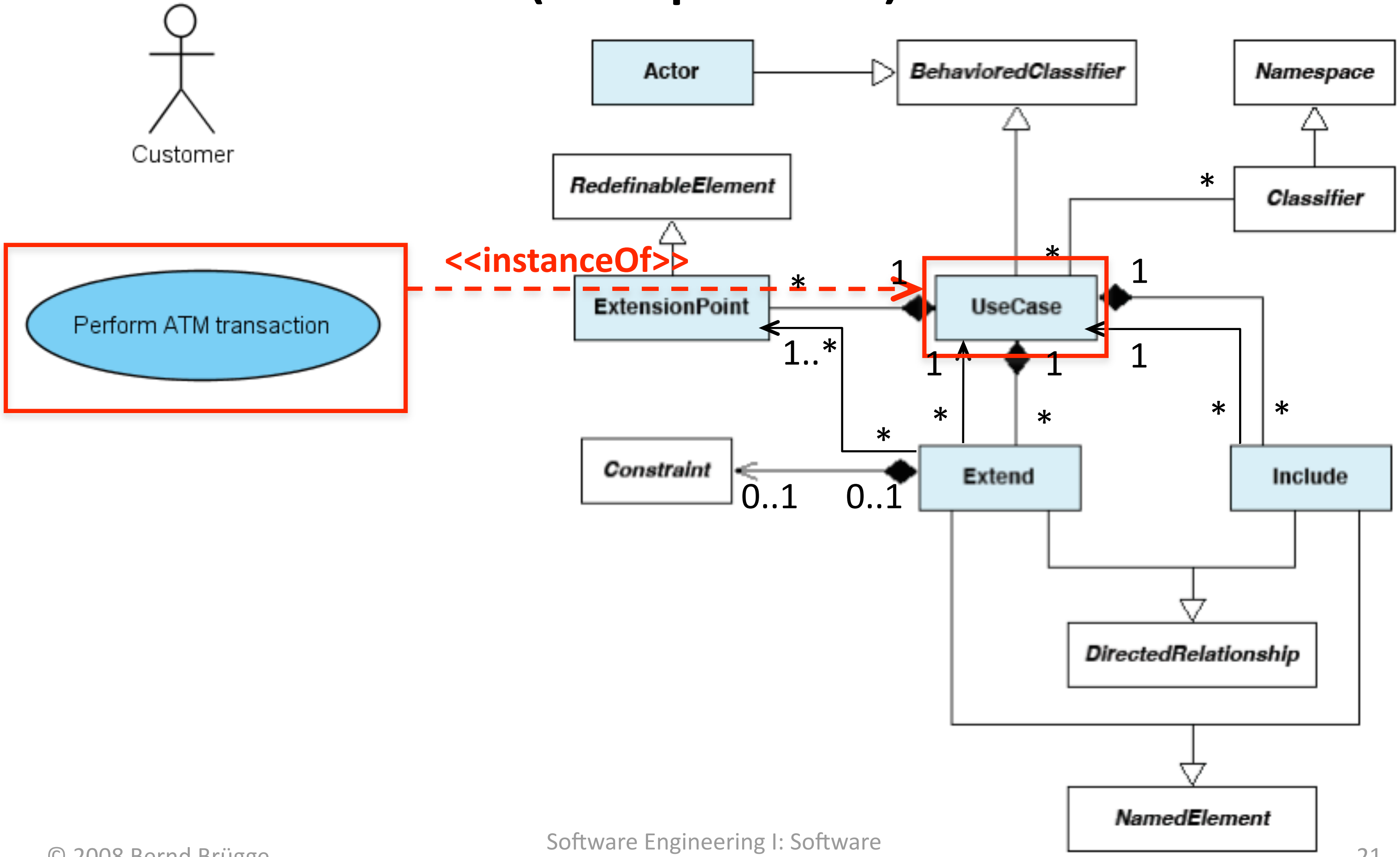

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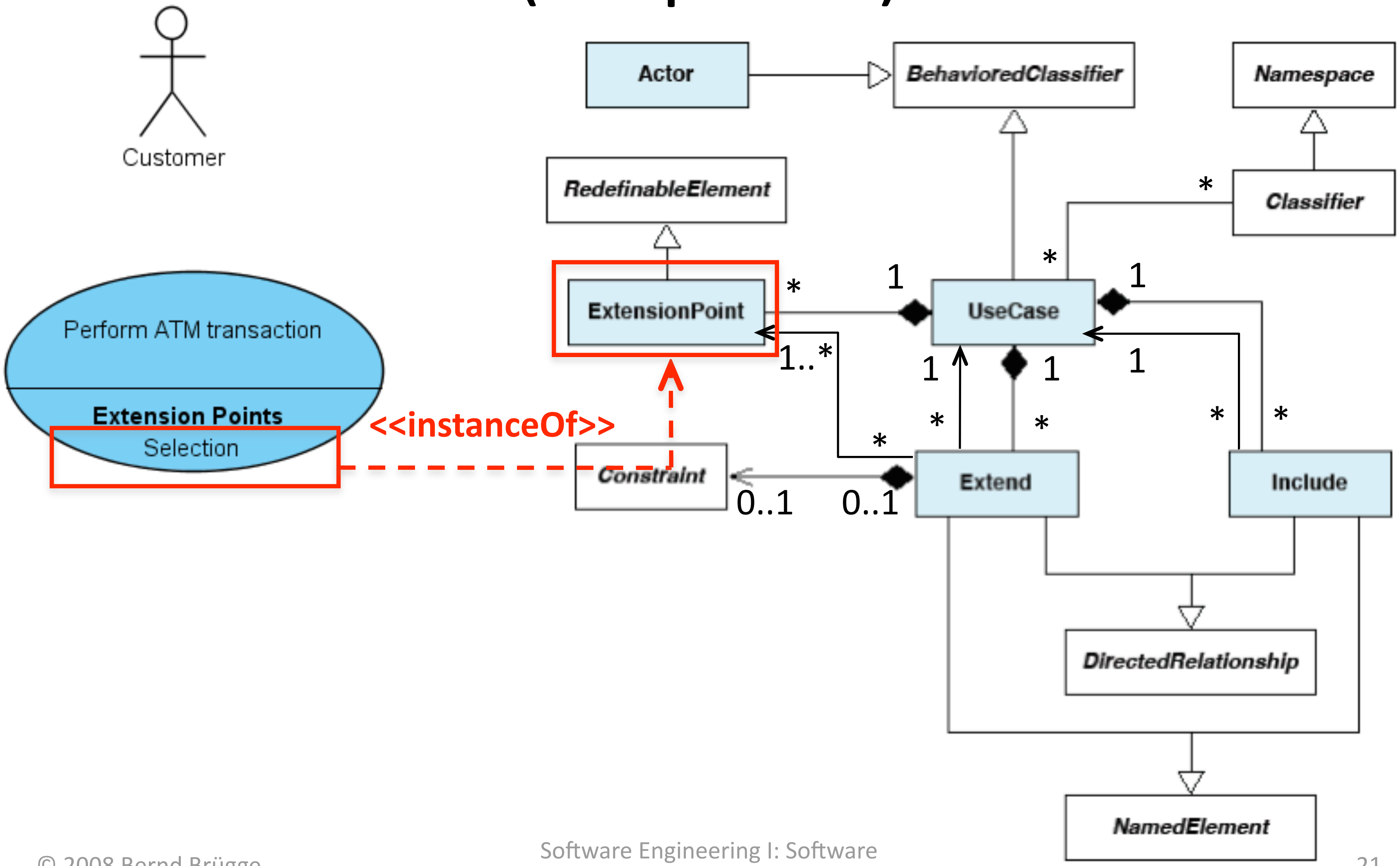

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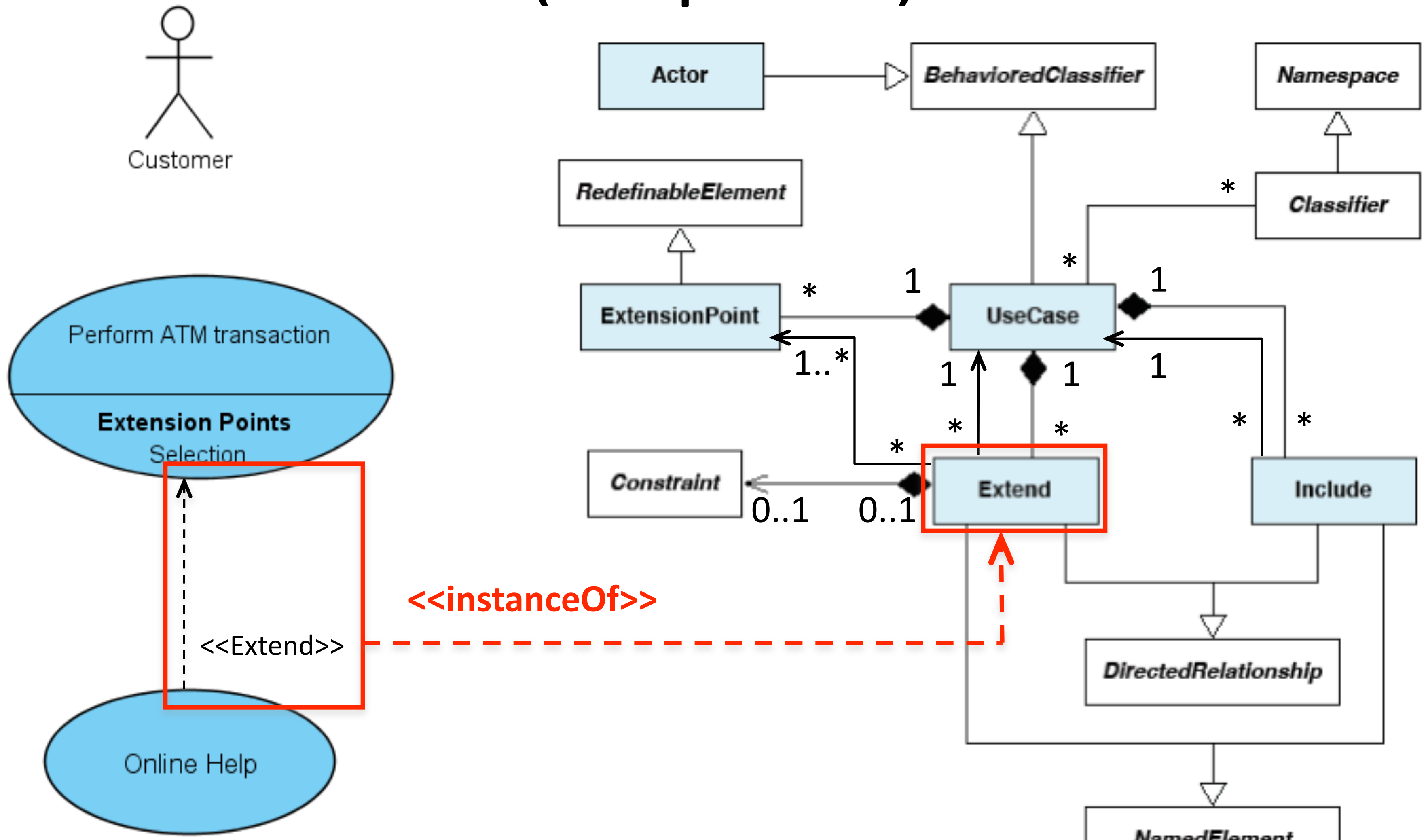

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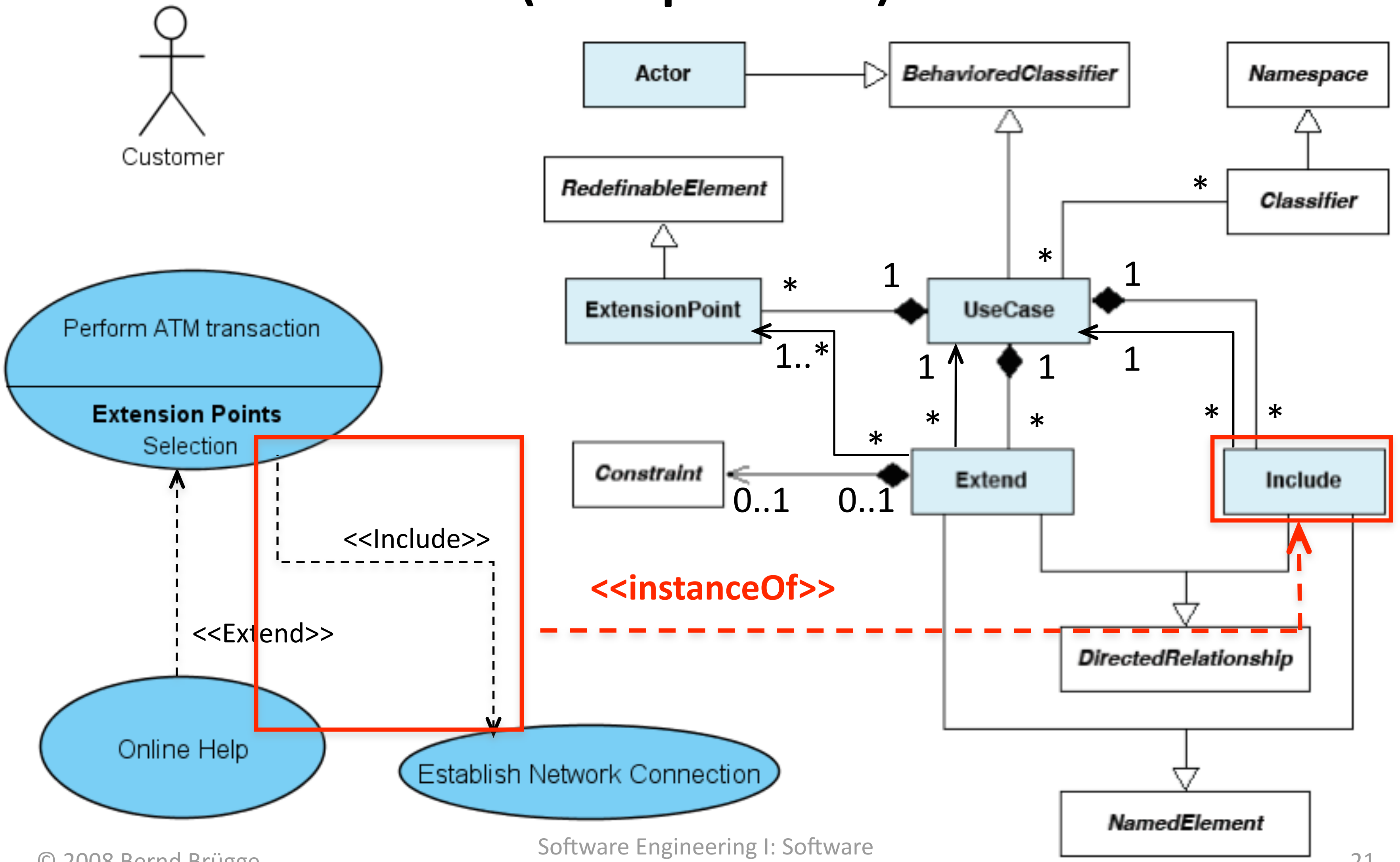

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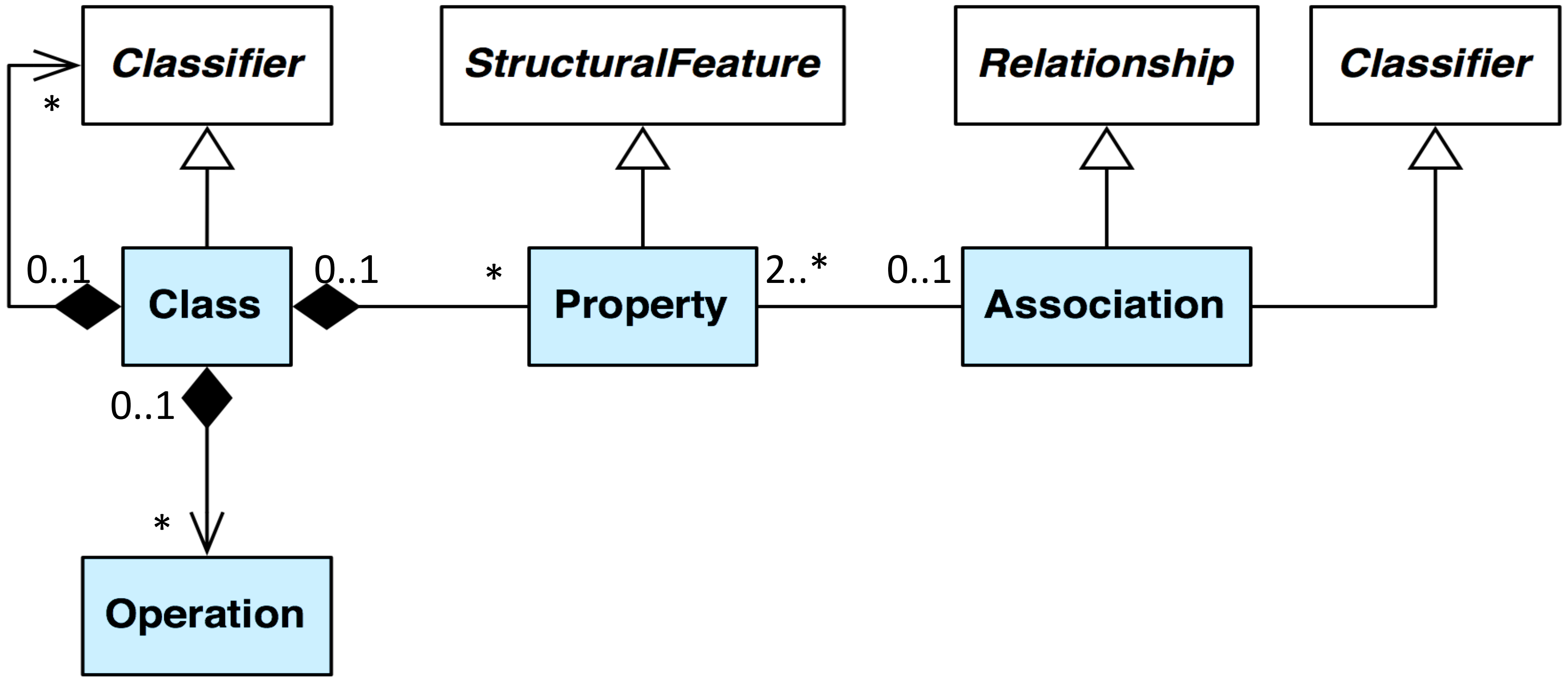

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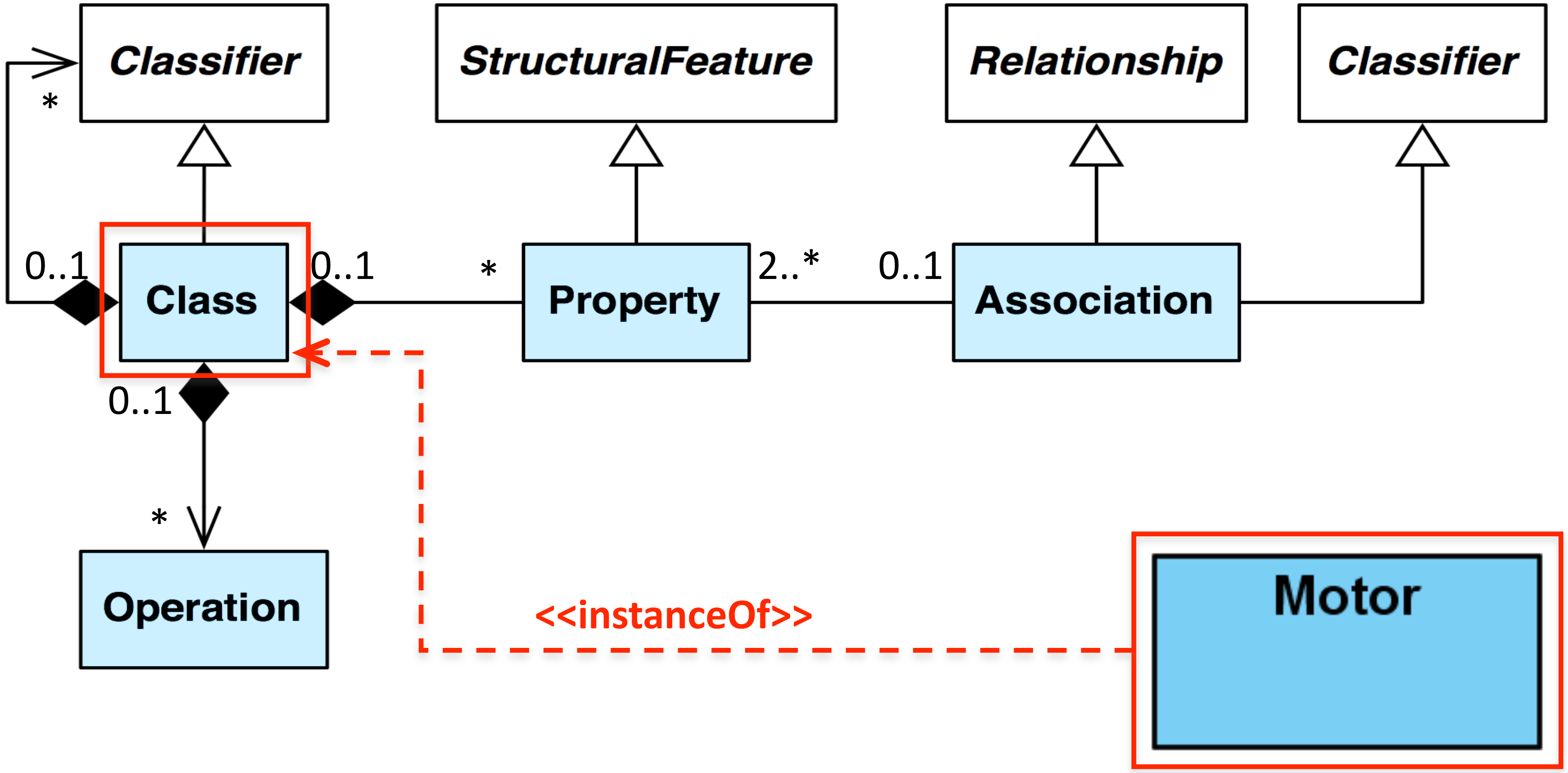

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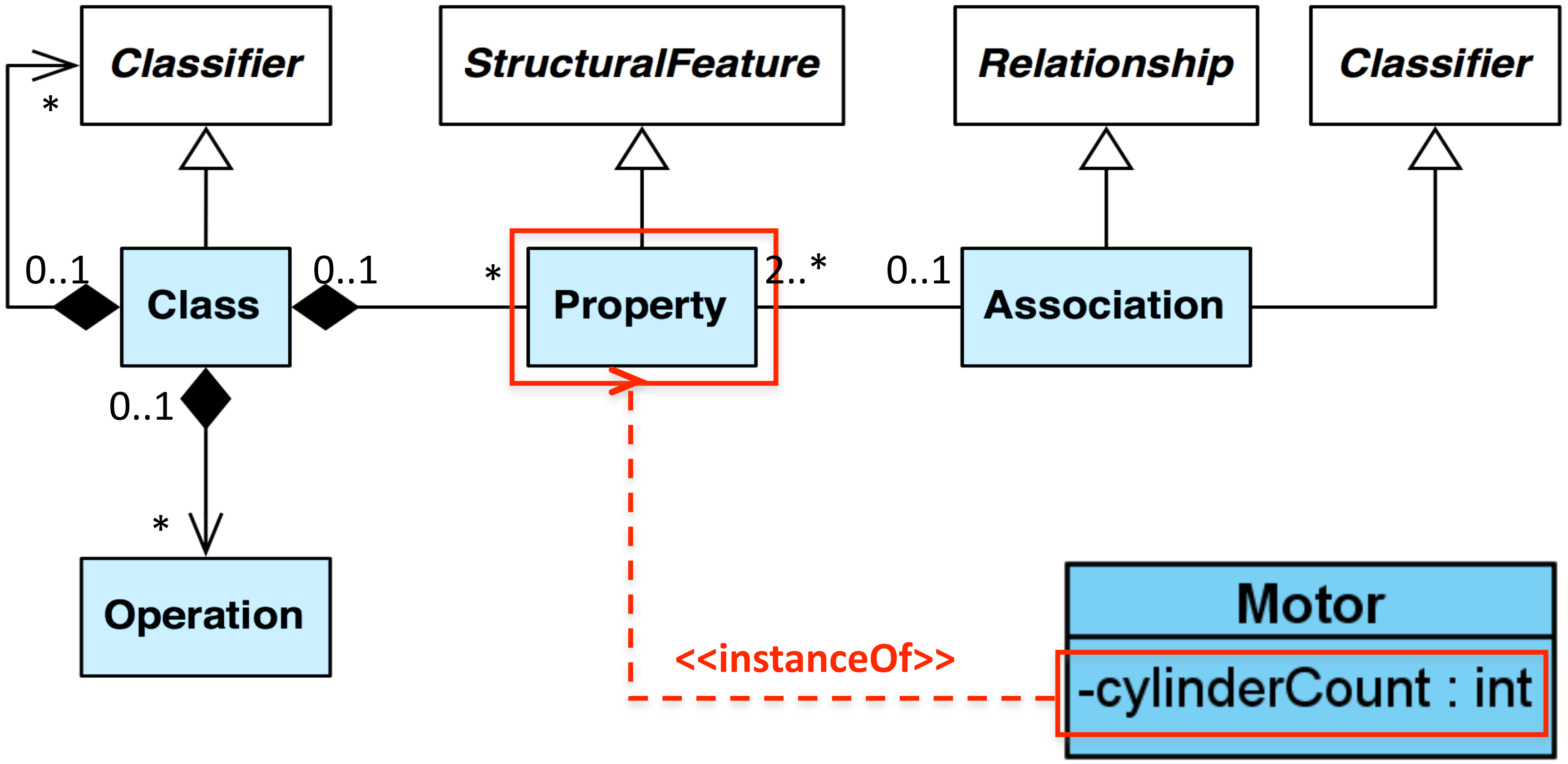

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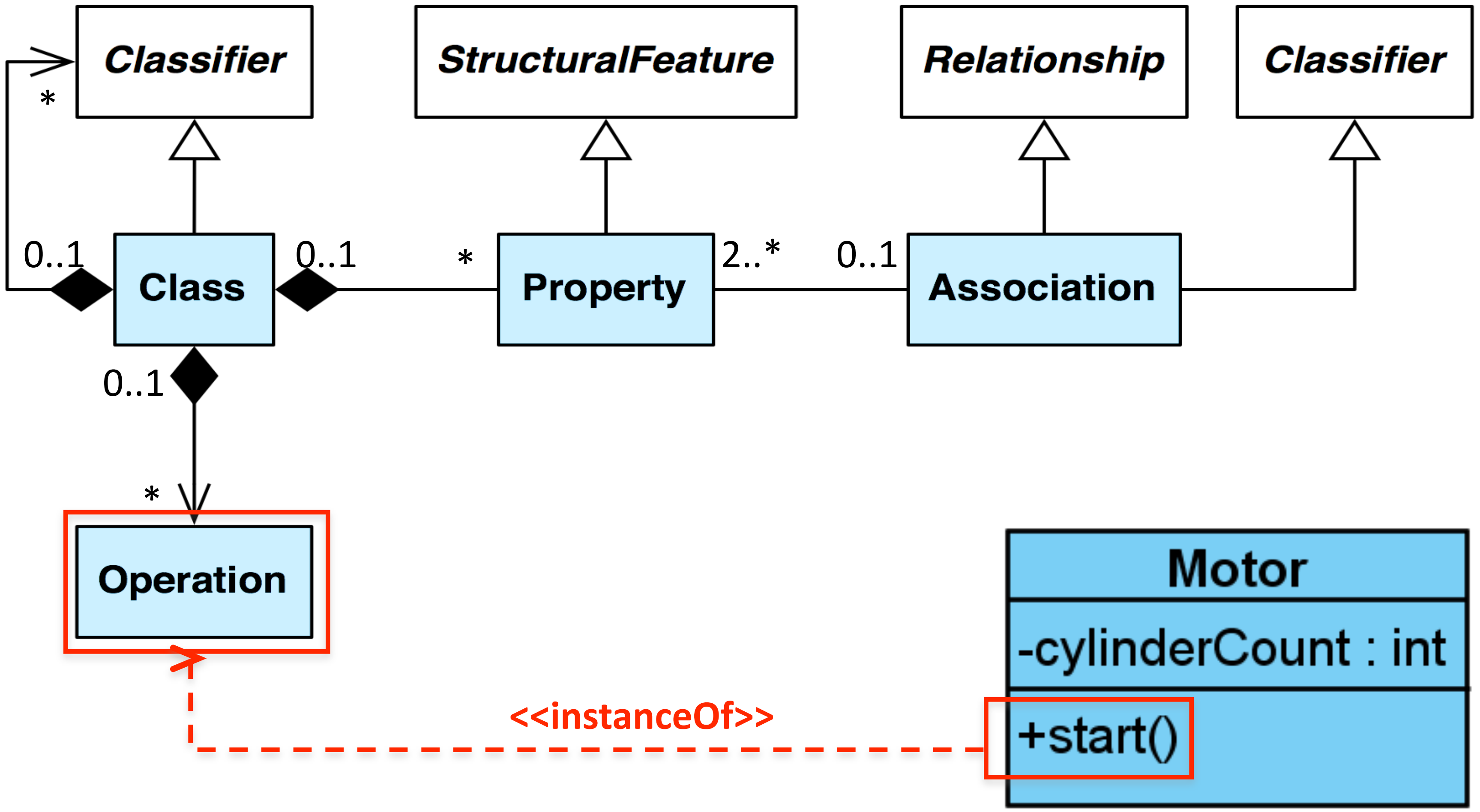

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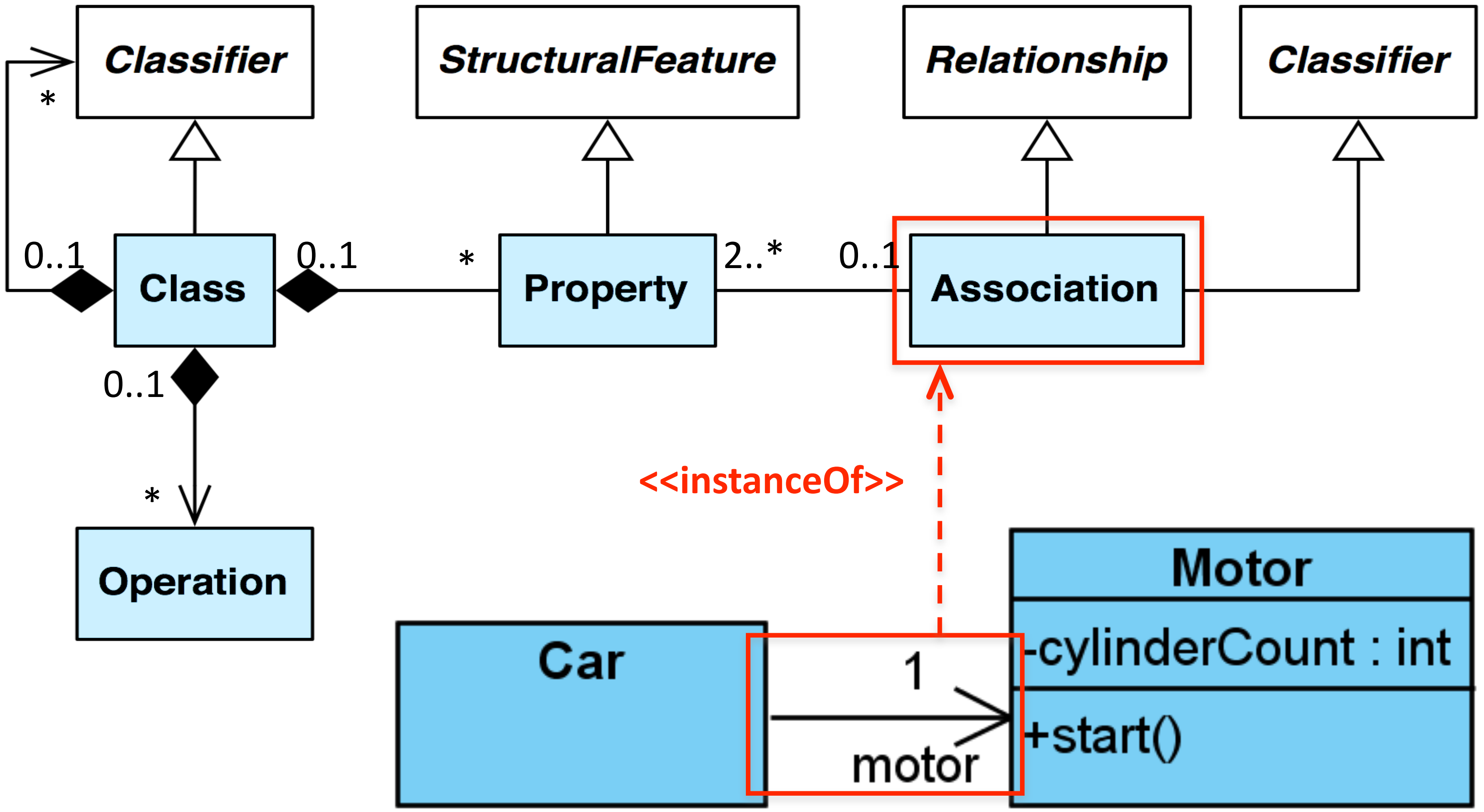

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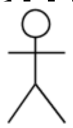
- ➢ Different notations for the UML meta model describe the same language
- UML Profiles: Adding new members to the family

Notations for the UML meta model

- The UML meta model defines a language for specifying UML models
- The notation used to *depict* UML models provides graphical constructs representing instances of meta model elements

  (Sticky figure represents an Actor)
- The notation is a function from meta model elements to model elements

  (“*uml-notation*(Actor) =  “)

Where are we?

- ✓ From model instances to meta models
- ✓ MOF meta model hierarchy
- ✓ How UML relates to MOF
  - ✓ Example: Use case diagram meta model
  - ✓ Example: Class diagram meta model
- ✓ Different notations for the UML meta model describe the same language
- ➢ UML Profiles: Adding new members to the family

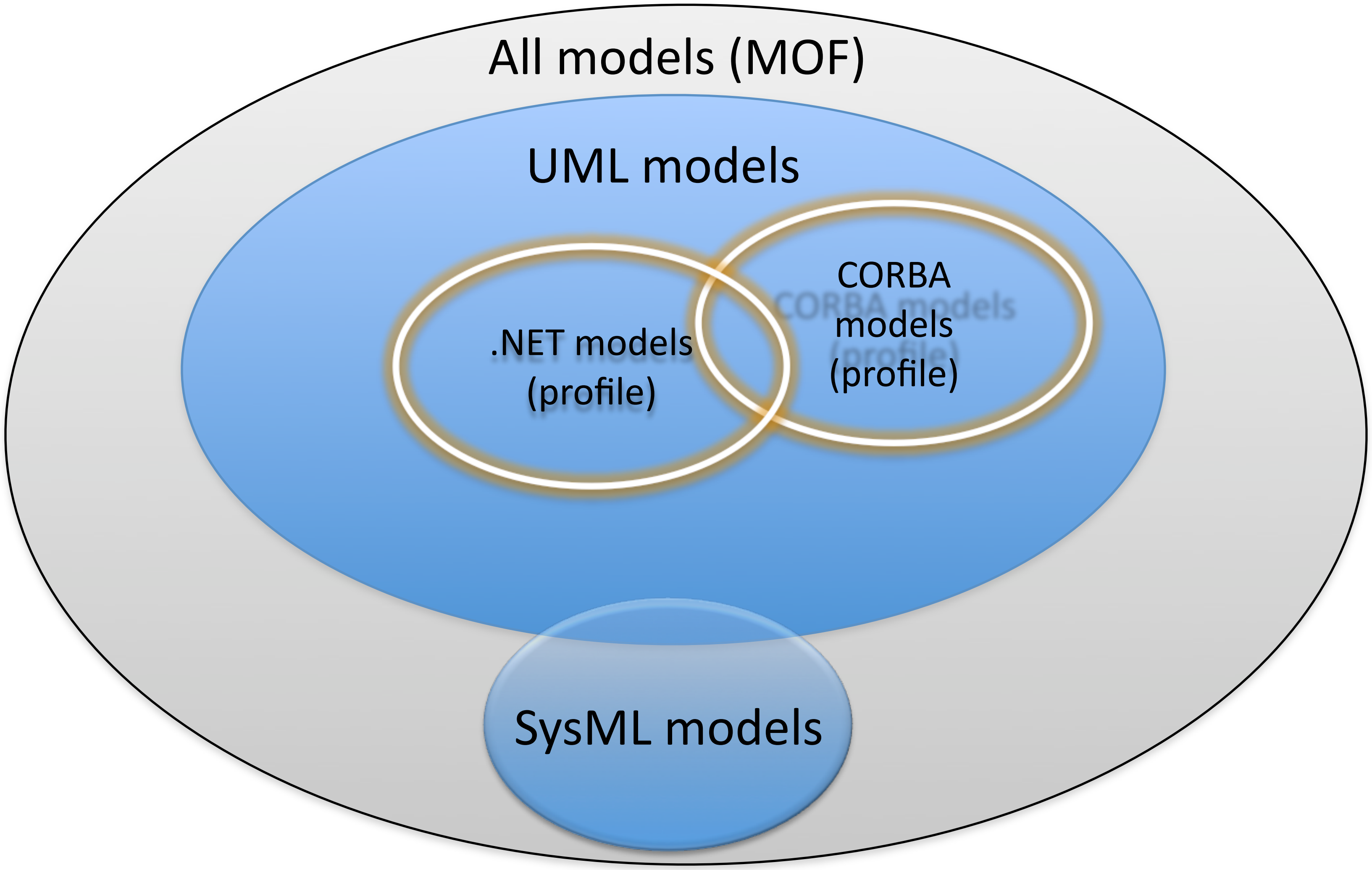
UML Profiles

- consist of stereotypes, tagged values and constraints
- customize UML models for particular domains or platforms
- are applied to elements of the UML meta model (M2)!
- are developed by manufacturers or standardization organizations (CORBA, .NET)

Applying UML Profiles

- By applying a UML profile,
  - you apply stereotypes to meta classes
  - you provide a deeper meaning for the model
  - the model gains integrity
  - you narrow the amount of valid models, as you can see on the following slide…

UML Profiles



Further reading

- MOF specification
  - URL to be delivered through the exercise portal
- Again, the UML 2 specification
  - See UML 2 Slides

Organizational Matters 1

- Mid term exam
  - Thursday, December 18th 17:30
  - Room to be announced
  - Registration procedure to be announced

Organizational Matters 2"

- For those of you interested in doing the homework, please read through the exercise sheet
  - Questions?
  - Please deliver the solution on Thursday, October 30th
    - Paper based: before the exercise
    - E-Mail based: send e-mail to Florian Schneider, same deadline