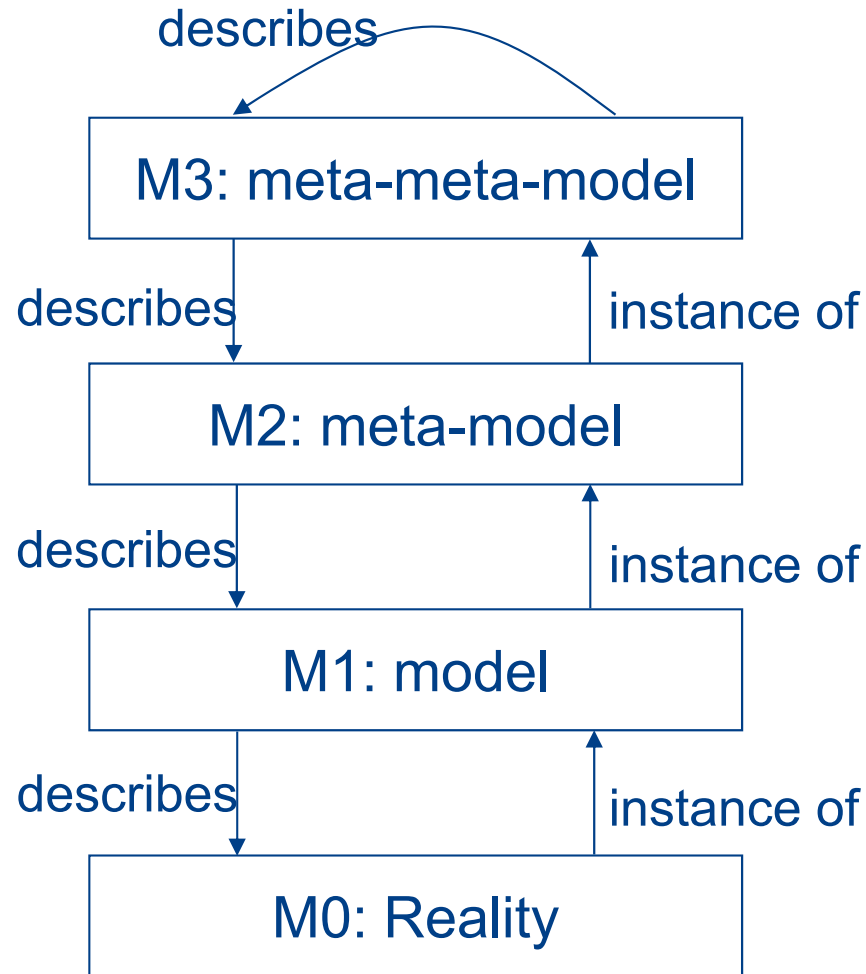# Meta-Modeling and Modeling Languages

Prof. Dr. Knut Hinkelmann

The Model Stack

- A model is a *simplified representation of a reality*

- A meta-model defines a **modeling language** in which a model can be expressed.

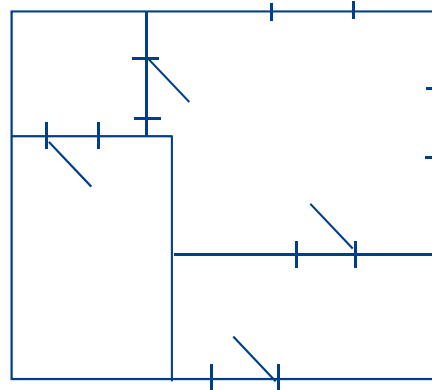- A meta-meta model defines the **language in which a meta-model** can be expressed.

Prof. Dr. Knut Hinkelmann
MSc Business Information Systems

Meta-Modeling

2

Model and Meta-Model in Architecture

real object

model

house

architect's drawing
(plan)

Prof. Dr. Knut Hinkelmann
MSc Business Information Systems

Meta-Modeling

3

Modelling Language

Model $\xrightarrow{\text{created with}}$ Modelling Language

indirect model of $\downarrow$

Reality

- A modelling "language" specifies the building blocks (elements) from which a model can be made.

- There can be different types of modelling languages, depending on the kind of model

  - ♦ graphical model
  - ♦ textual description
  - ♦ mathematical model
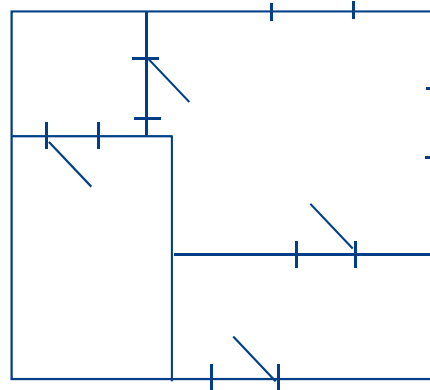 - ♦ conceptual model
  - ♦ physical model

Model and Meta-Model in Architecture

real object

model

modeling language
(concrete syntax)

object types:

————— wall

door

window

house

architect's drawing
(plan)

Prof. Dr. Knut Hinkelmann
MSc Business Information Systems

Meta-Modeling

5

Meta-model

Meta-model

indirect model of

direct model of

Model

created with

Modelling Language

model of

Reality

A meta-model defines the modelling language, i.e. the building blocks that can be used to make a model. It defines the

- ♦ object types that can be used to represent a model
- ♦ relations between object types
- ♦ attributes of the object types
- ♦ rules to combine object types and relations

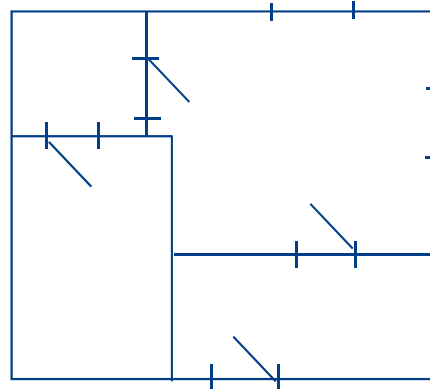■ The meta-model is the abstract syntax, the modeling language is the concrete syntax.

Prof. Dr. Knut Hinkelmann
MSc Business Information Systems

Meta-Modeling

6

Model and Meta-Model in Architecture

real object	model	modeling language (concrete syntax)	meta-model (abstract syntax)

real object

house

model

architect's drawing (plan)

modeling language (concrete syntax)

object types:

———— wall

door

window

meta-model (abstract syntax)

object types:
- wall
- door
- window

rules:
- a door is adjacent to a wall on both sides
- Windows are on outer walls.

Prof. Dr. Knut Hinkelmann
MSc Business Information Systems

Meta-Modeling

7

Abstract vs. Concrete Syntax

Abstract Syntax

■ Deep structure of a language.

■ What are the significant parts of the expression?

■ Example: a sum expression has two operand expressions as its significant parts

```
        plus

       /    \
      2      3
```
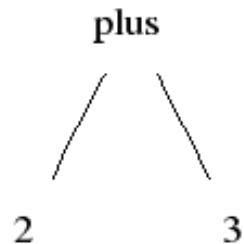
Concrete Syntax

■ Surface level of a language.

■ What does the expression look like?

Example: *the same* sum expression can look in different ways:

```
2 + 3                      -- infix

(+ 2 3)                    -- prefix

(2 3 +)                    -- postfix

bipush 2                   -- JVM
bipush 3
iadd

the sum of 2 and 3         -- English
```

http://www.cse.chalmers.se/edu/year/2011/course/TIN321/lectures/proglang-02.html

Prof. Dr. Knut Hinkelmann
MSc Business Information Systems

Meta-Modeling

8

Illustration: Meta-model and Model for Processes

Meta-model:

Classes and relations that can be used for modeling (abstract syntax and semantics)
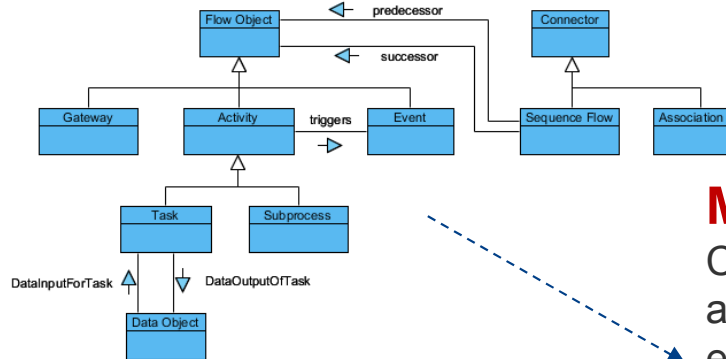

Example: A process model consists of object types for
- «task», «subprocess», «event», «gateway», «data object»
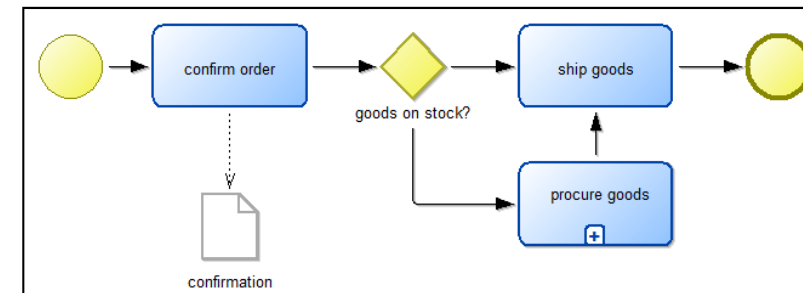- «sequence flow», «data association».

The elements have attributes and there are rules how the elements can be combined.

Modeling Language:

Concrete Syntax (notation, appearance) of meta-model elements

task

subprocess

event

gateway

data object

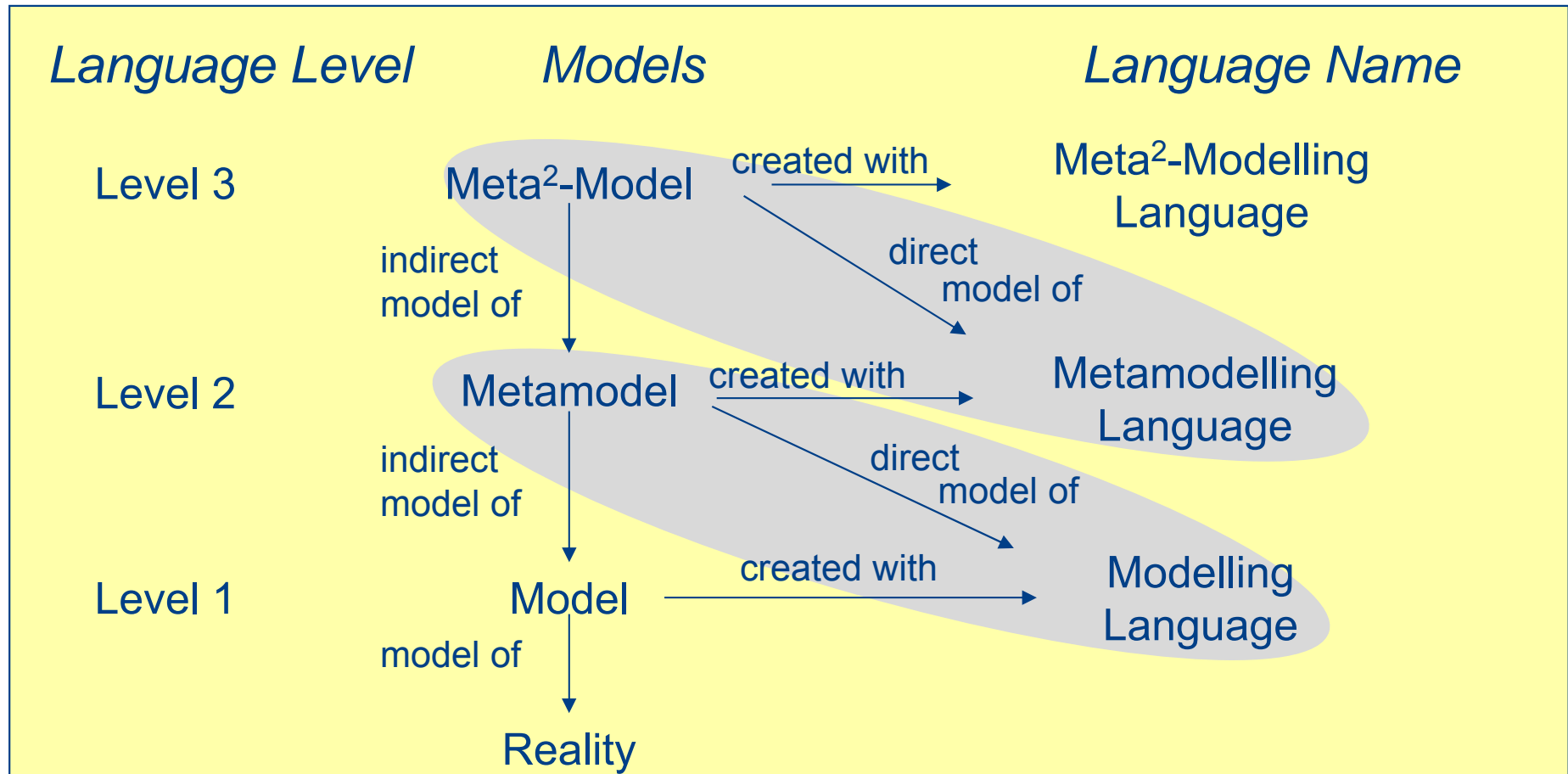sequence flow
data association
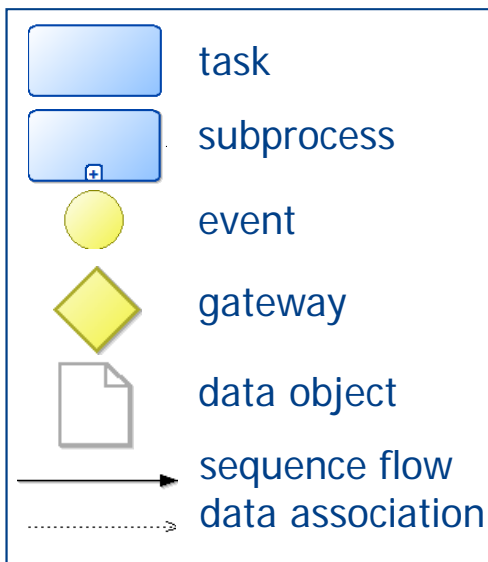
Model:

A model contains instances of the object types defined in the meta-model, according to the concrete syntax of the modeling language. The object „confirm order" represents a real entity; it is an instance of the object type «task"

Prof. Dr. Knut Hinkelmann
MSc Business Information Systems

Meta-Modeling

9

Meta Model Hierarchy

The meta-model must again be described in some language, which has to be specified in a meta-meta-model

Language Level	Models	Language Name

Level 3 — Meta^2-Model — created with → Meta^2-Modelling Language

direct model of → Metamodelling Language

indirect model of ↓

Level 2 — Metamodel — created with → Metamodelling Language

direct model of → Modelling Language

indirect model of ↓

Level 1 — Model — created with → Modelling Language

model of ↓

Reality

Karagiannis, D. & Kühn, H., 2002. Metamodelling Platforms. In K. Bauknecht, A. Min Tjoa, & G. Quirchmayer, eds. *Proceedings of the Third International Conference EC-Web at DEXA 2002*. Berlin: Springer-Verlag.

Meta-Meta Model: Modeling a Meta-Model

- OMG uses UML Class Diagrams as Meta-Modeling language

- Example: Business Motivation Meta-Model
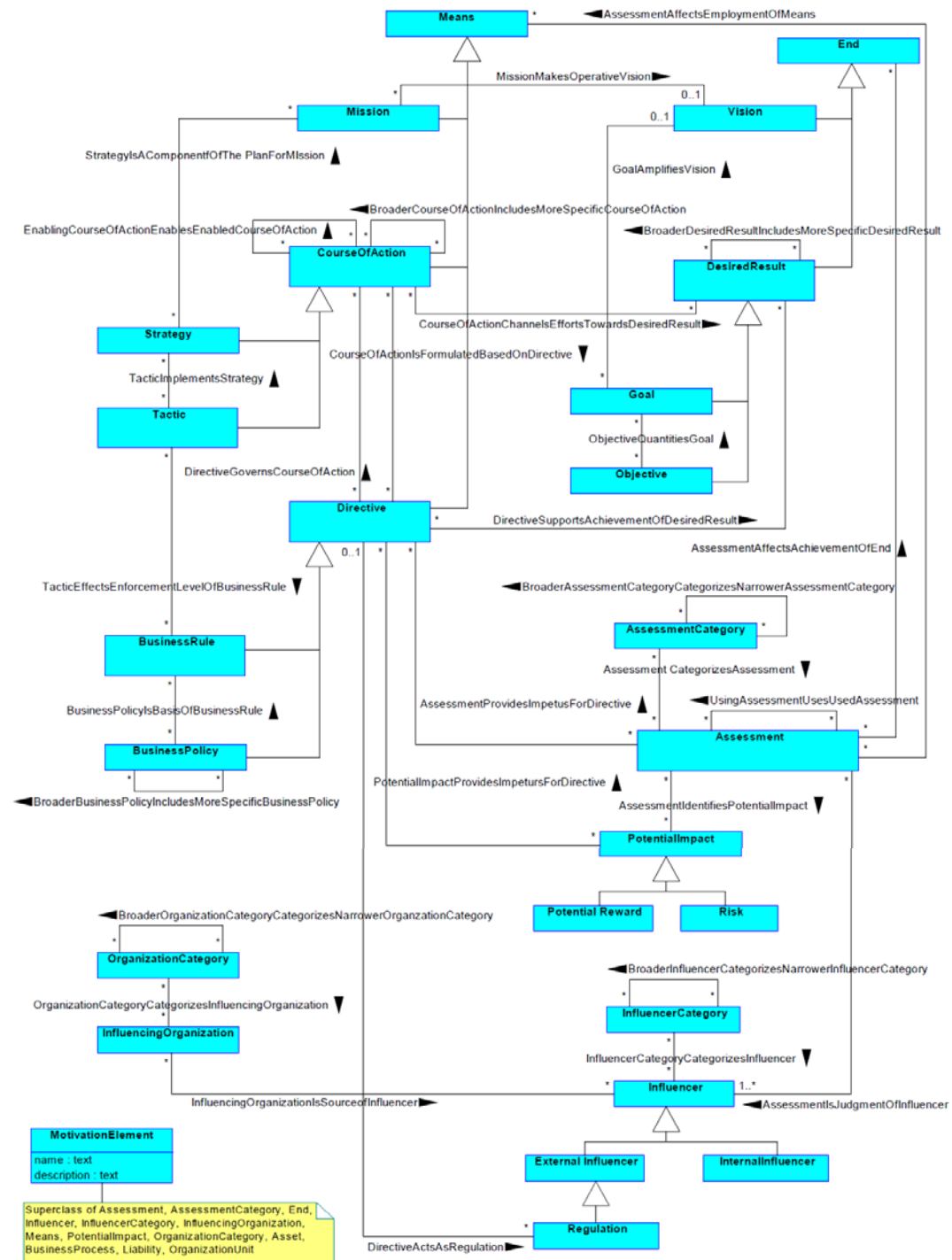
MOF – Meta Object Facility

- The Meta Object Facility (MOF) is an OMG meta-modeling standard.

- MOF is itself a *meta-meta-model*, a specification describing how one may build meta-models.

- MOF is closely based on Unified Modeling Language (UML):
  - Meta-models are represented with class diagrams of UML

- MOF defines the theoretical underpinnings of the XML Metadata Interchange (XMI)
  - XMI is a standard syntax for the Exchange of Models