

Requirements Engineering & Management

# Core Activities – Documentation III

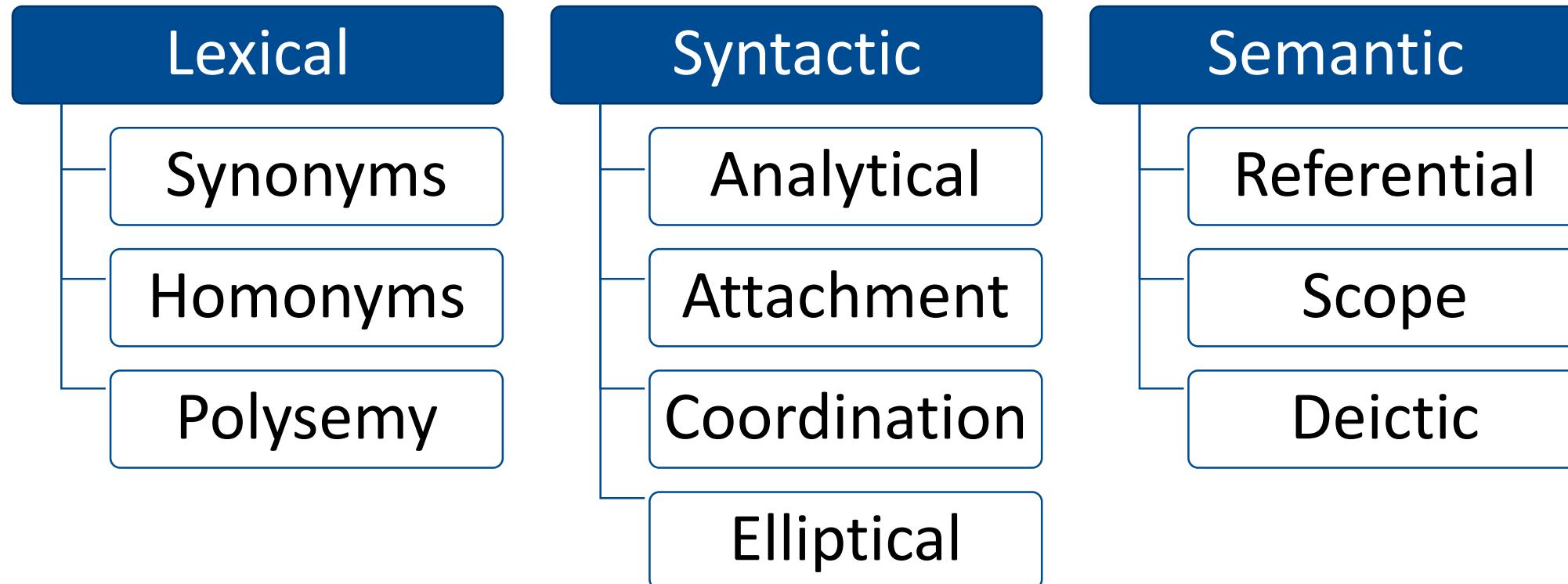
Prof. Dr. Klaus Pohl

**Wird in der Übung behandelt!  
Hier nur eine kurze Übersicht!**

# Ambiguity in Natural Language

- Natural language is **inherently ambiguous**.
- An ambiguously documented requirement has **more than one valid interpretation**.  
→ Different persons might interpret such a requirement differently.
- Two main reasons:
  - **Underspecified requirements**: i.e. missing details, vagueness, ...
  - **Defective specified requirements**: e.g., use of different words that sound alike, ....
- **Goal**: Document requirements unambiguously.  
→ All **stakeholders** with (almost) the **same knowledge** about the system and its context **interpret** the requirement **in the same way**.

# Defective Specified Requirements – Ambiguities



Based on [Berry et al. 2003]

# Three Techniques for Avoiding Ambiguity

- **Recommendation:** Be aware of ambiguities and be careful in writing or in inspections.
  - In addition:
    - Glossaries
    - Syntactic requirements patterns
    - Controlled languages
- Using these techniques reduces the risk of writing ambiguous natural-language requirements.

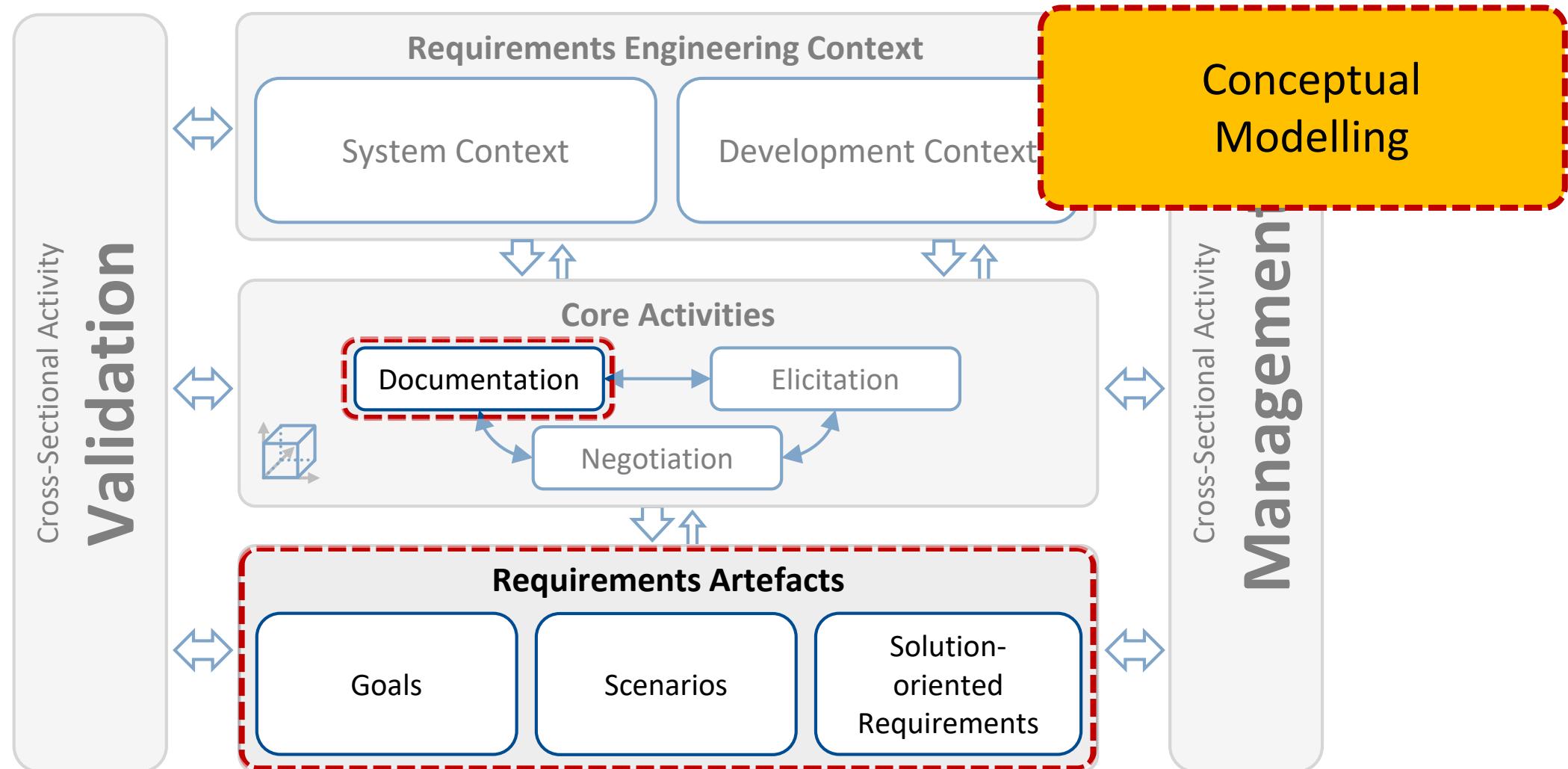
Vollständige Folien: siehe Documentation III  
→ Übung!

Requirements Engineering & Management

# Conceptual Modelling

Prof. Dr. Klaus Pohl

# Requirements Engineering Framework



# Agenda

1. Physical vs. Conceptual Models
2. Examples of Conceptual Models
3. Properties of Conceptual Models
4. Fundamentals of Conceptual Modelling
5. Semiotic of Conceptual Models
6. Quality of Conceptual Models
7. Modelling Languages (Meta Modelling)

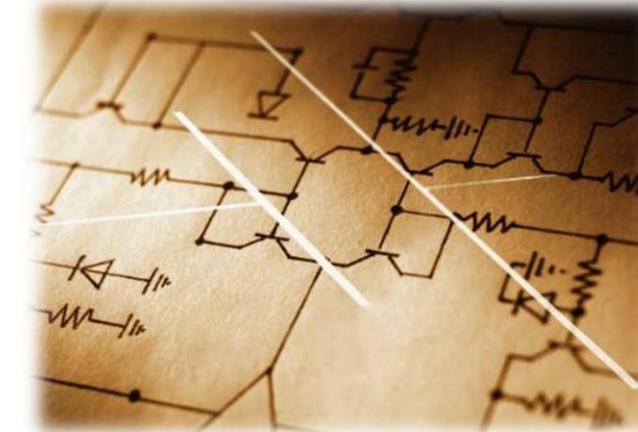
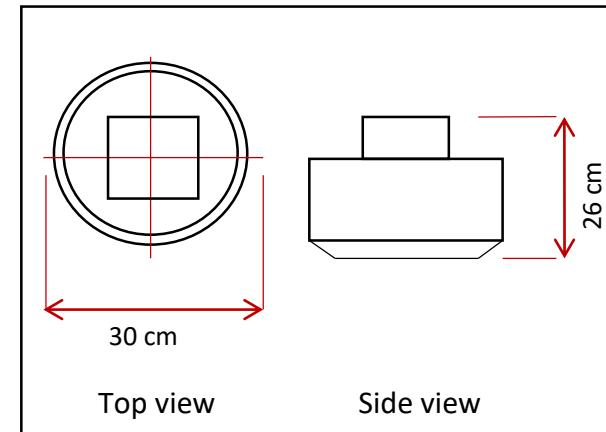
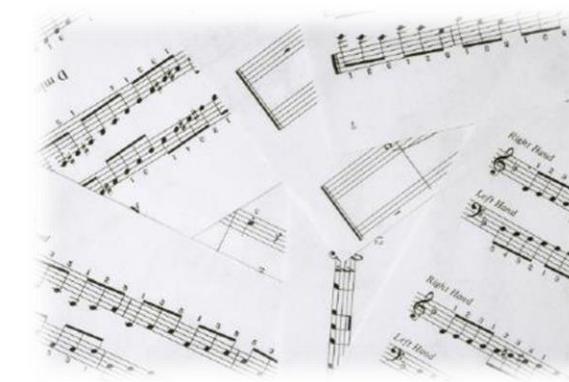


# 1. Physical vs. Conceptual Models

## Model: Definition

**D** A **model** is an abstract representation of the universe of discourse created for a specific purpose (use). Based on [Stachowiak 1973]

**D** The **universe of discourse** comprises any part or aspect of the existing or conceived reality under consideration. [Falkenberg et al. 1998]



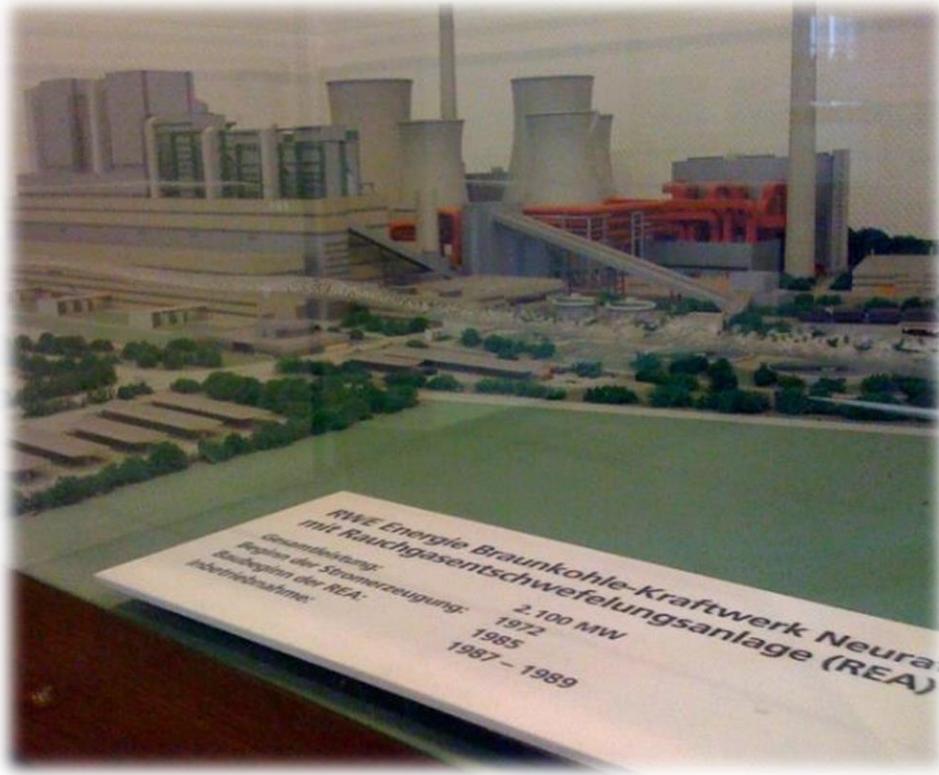
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# Physical vs. Conceptual Models

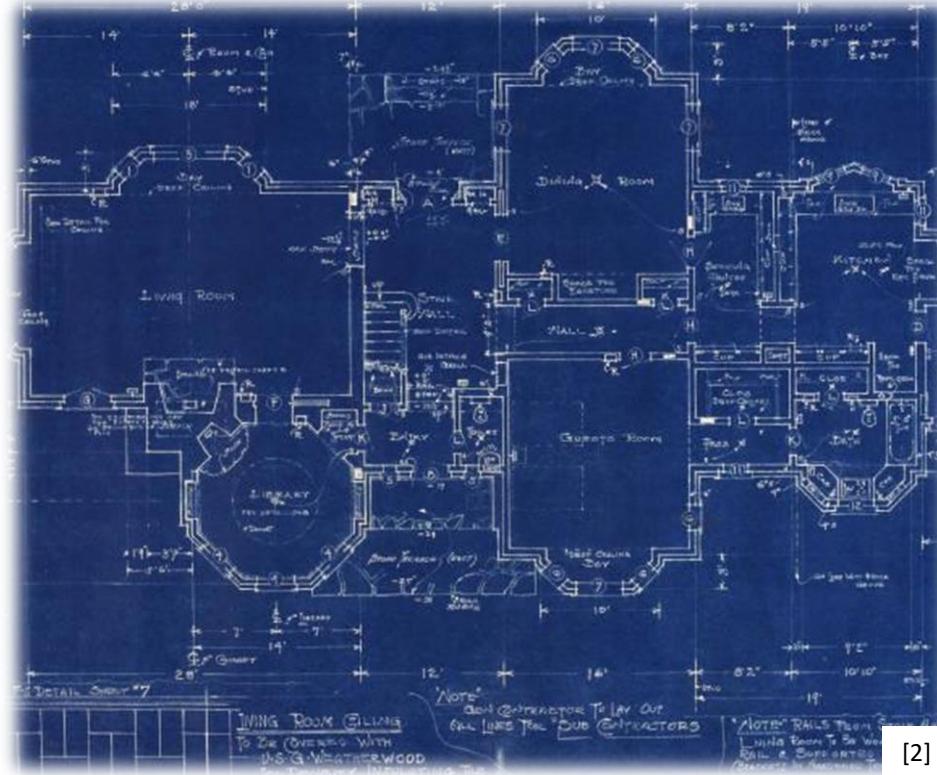
# Examples

E

# Physical Model



## Conceptual Model



## 2. Examples of Conceptual Models

# Models are Abstractions for a Specific Purpose

Universe of discourse:  
A village



Task:  
Reach my home

If you have reached the huge intersection, turn right



then drive through

If you have passed the village name sign, turn into the next street on the right hand side



Our house is the second one  
on the left hand side

# Street Map of England

- Streets are not to scale
- Focus on main streets
- Only bigger cities
- Maritime borders
- Ferry lines



© OpenStreetMap contributors

# Examples of Conceptual Models

## Street Map of London

- Different street types
- City quarters
- Housing
- Railway lines



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# Sightseeing Map of London

- Sights symbols
- Street names
- Streets straightened
- Parks and water highlighted



# Underground Map of London

- Metro lines (coloured)
- Metro stations
- Change between lines
- ...

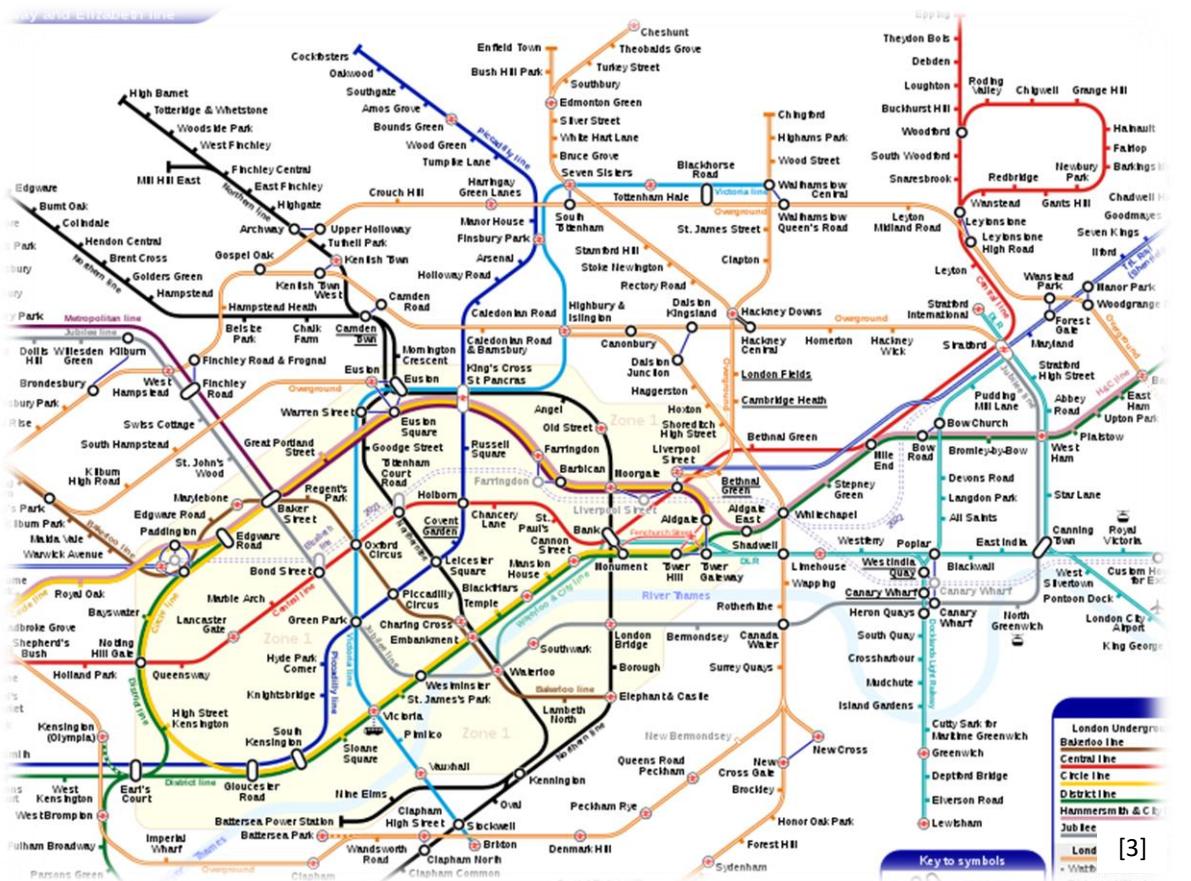


# Different Abstractions of the Same Reality

# Street map



# Underground map



# Characteristics of Models

- A model is always **defined for a given purpose.**
  - The **content** and **representation** of a model depends on this purpose!
  - There are different conceptual models supporting **different purposes** (for the same reality).
  - The content of the different models can **overlap**
- Models...
  - are **easier to comprehend** than natural language text.
  - are **used in daily life** frequently.
  - can differ in the **level of abstraction and detail** (e.g., street maps and underground maps).
  - ...

# 3. Properties of Conceptual Models

# Descriptive vs. Prescriptive Models

- **Descriptive models:**

Document information about the **current state** of the universe of discourse

- **Prescriptive models:**

Represent an **intended, future state** of the universe of discourse.

# Two Central Properties

- Any kind of model has **two central properties** concerning the representation of the universe of discourse:
  - **Reduction:**
    - Only **relevant aspects** of the universe of discourse are represented in the model.
    - **Abstraction mechanisms** are used to **filter out irrelevant aspects**.
  - **Extension:**
    - **Additional information** (not observable in the universe of discourse) can be added in the model (e.g., to improve usability)

# Reduction Property (1)

- **Abstraction mechanisms:**

- **Selection**: Particular aspects of the real world are represented in the model (selected), while other aspects are ignored.
- **Aggregation**: Different aspects are combined and represented in the model in a condensed form.
- **Classification / generalization**: Commonalities in the real world are generalized and objects are classified; differences might be ignored.

## Reduction Property (2)



### E Selection:

Only roads and settlements

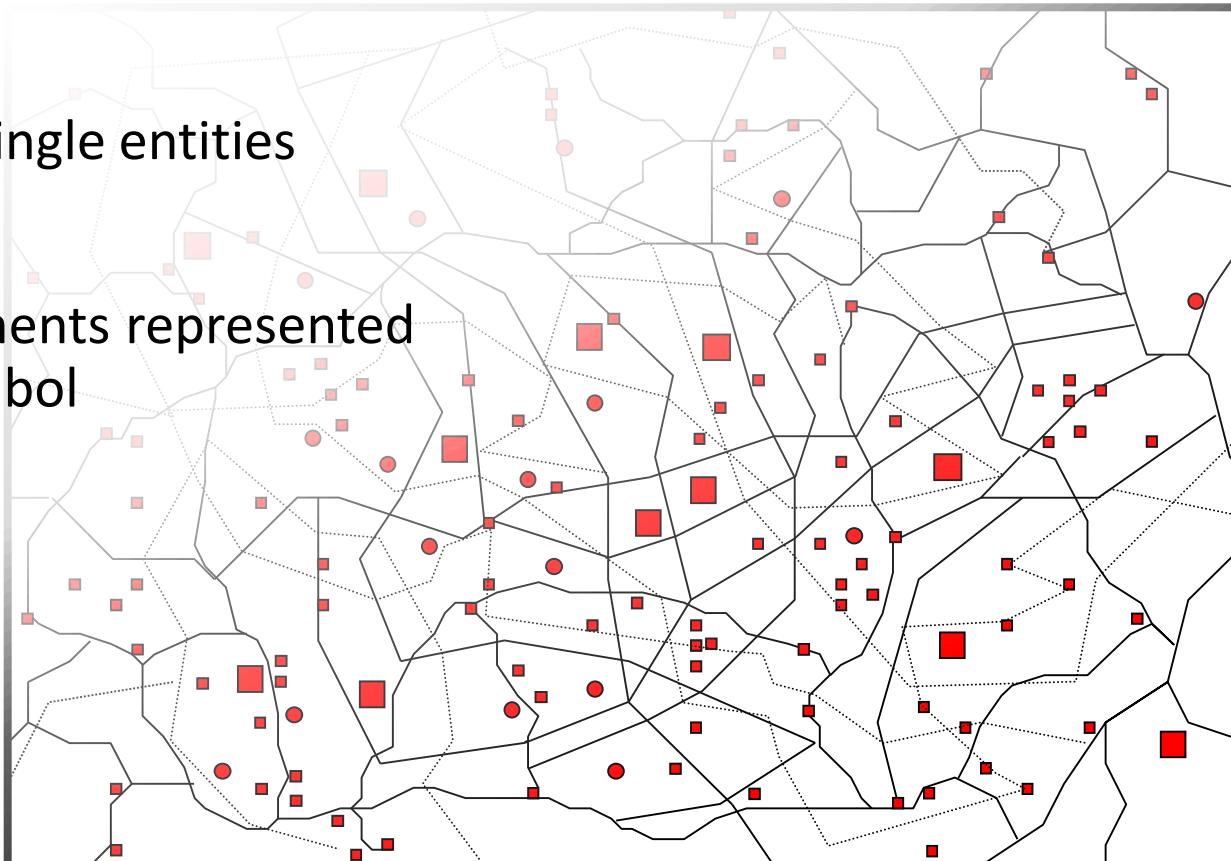
### Aggregation:

Settlements as single entities

### Classification:

Different settlements represented by the same symbol

- population < 10,000
- population > 10,000
- population > 100,000

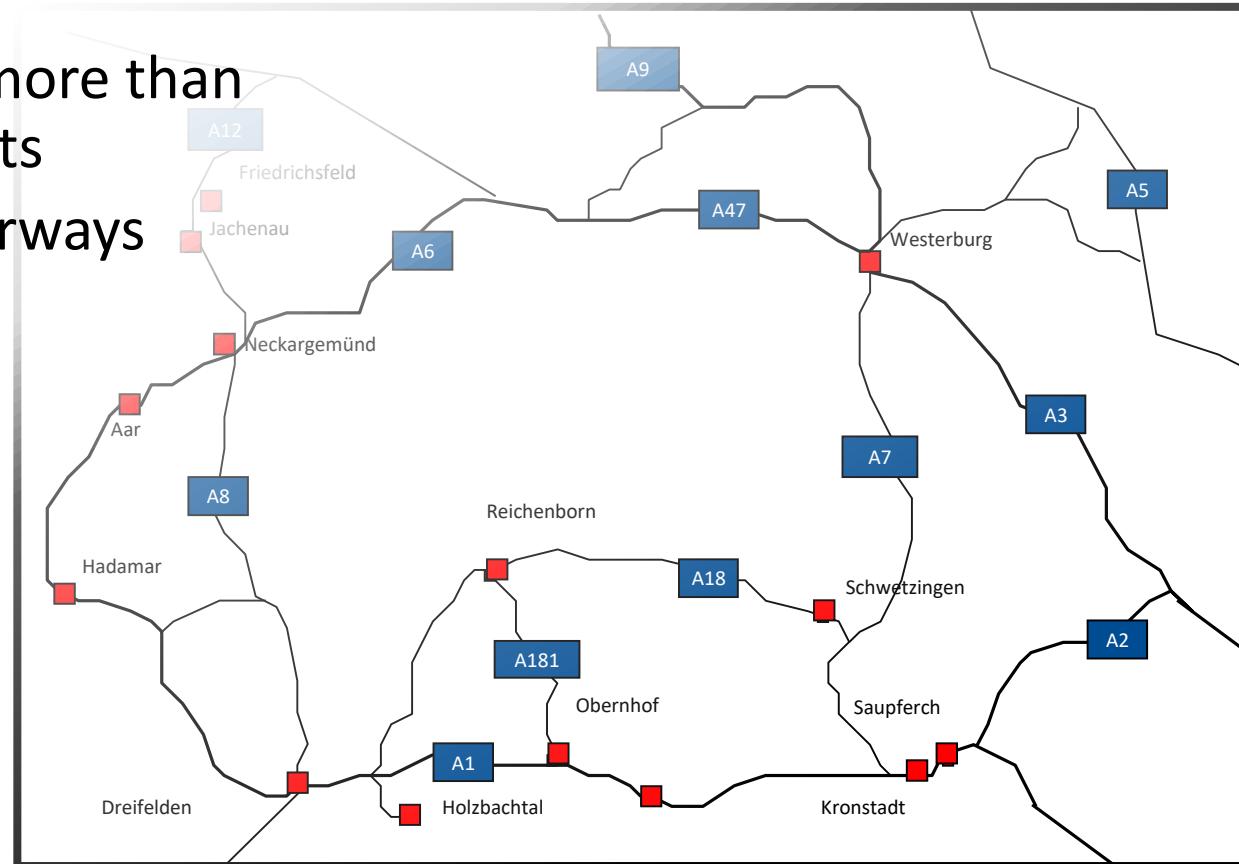


# Reduction Property (3)



## E Selection:

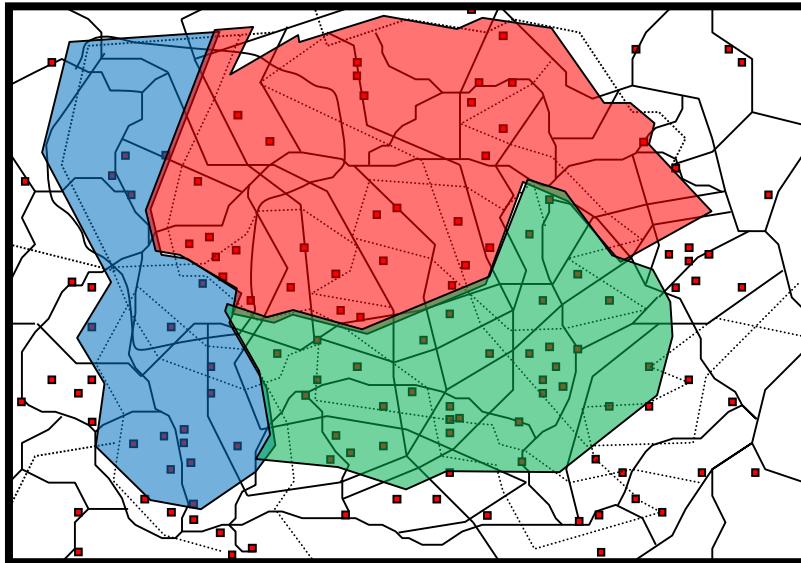
- Only main roads
- Only cities with more than 50,000 inhabitants
- Number of motorways



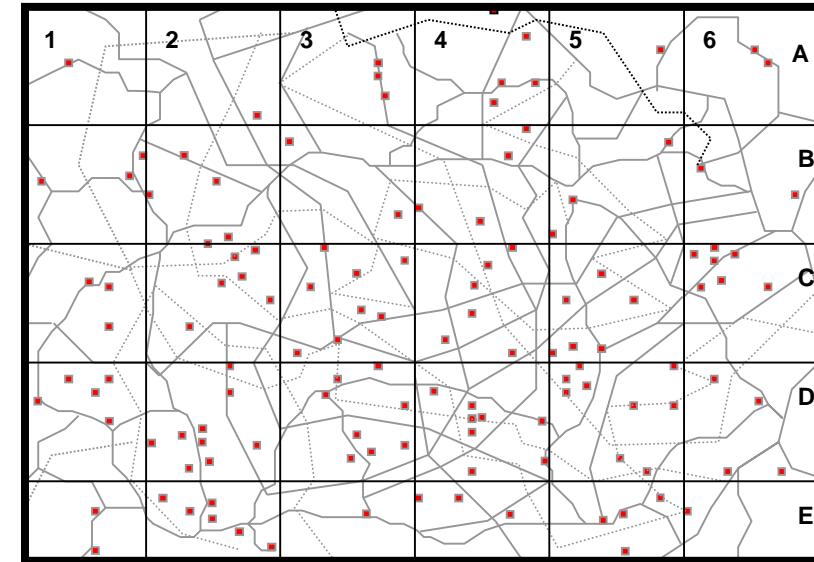
## Extension Property

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- Improve the comprehension by adding shapes to a map



- Improve the usability through quadrants



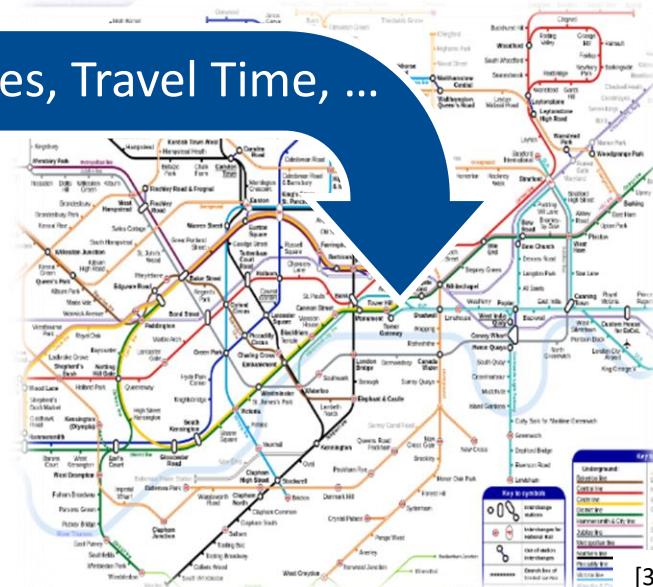
# Definition of Models: Modelling Language

- A model is created using a **modelling language**.
- Information is documented using the **modelling constructs** of the language.
- A modelling language is designed for a **specific purpose**.



Reality  
(universe of discourse)

Stations, Lines, Travel Time, ...



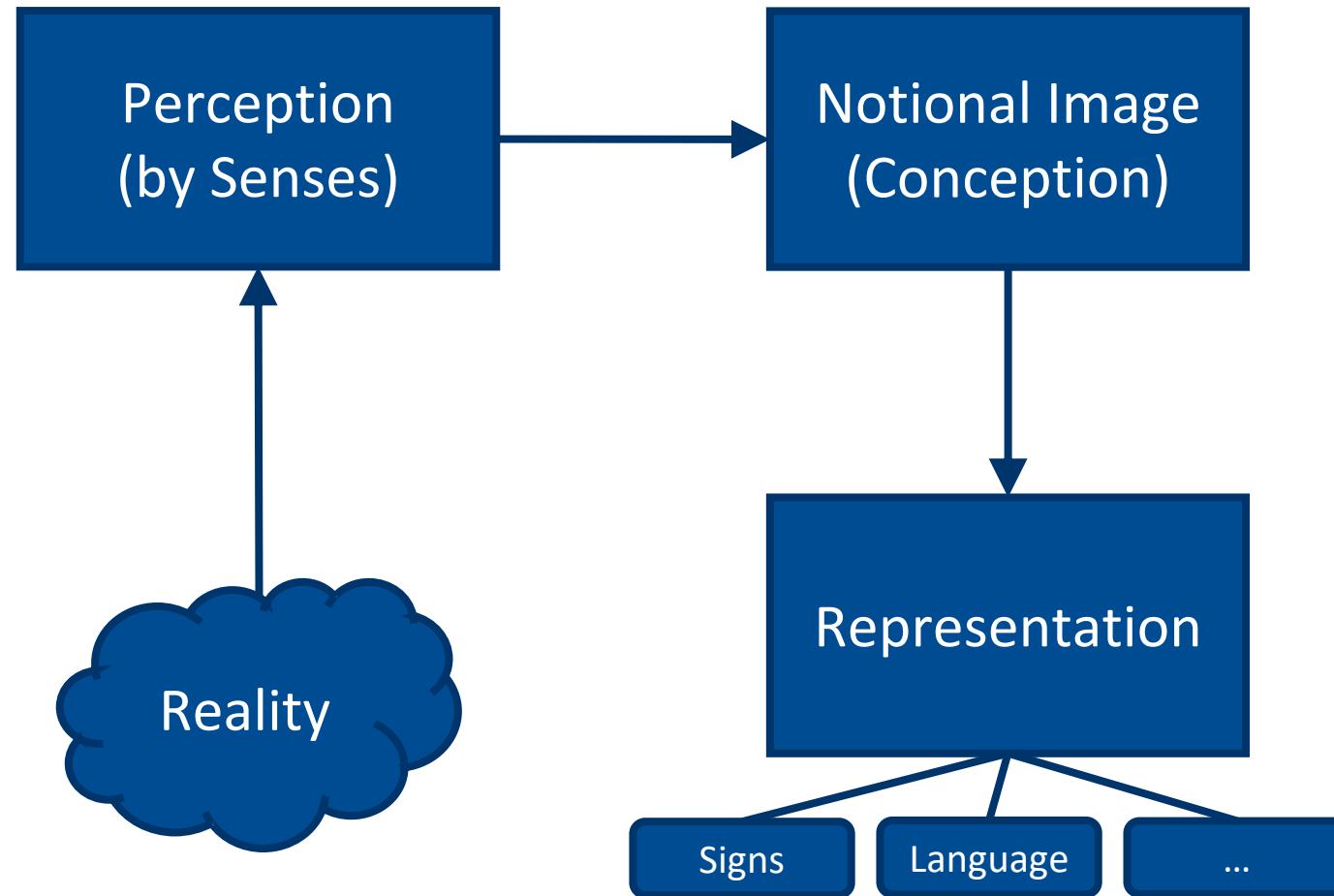
Purpose-driven model  
(representation)

# Key Benefits of Conceptual Models

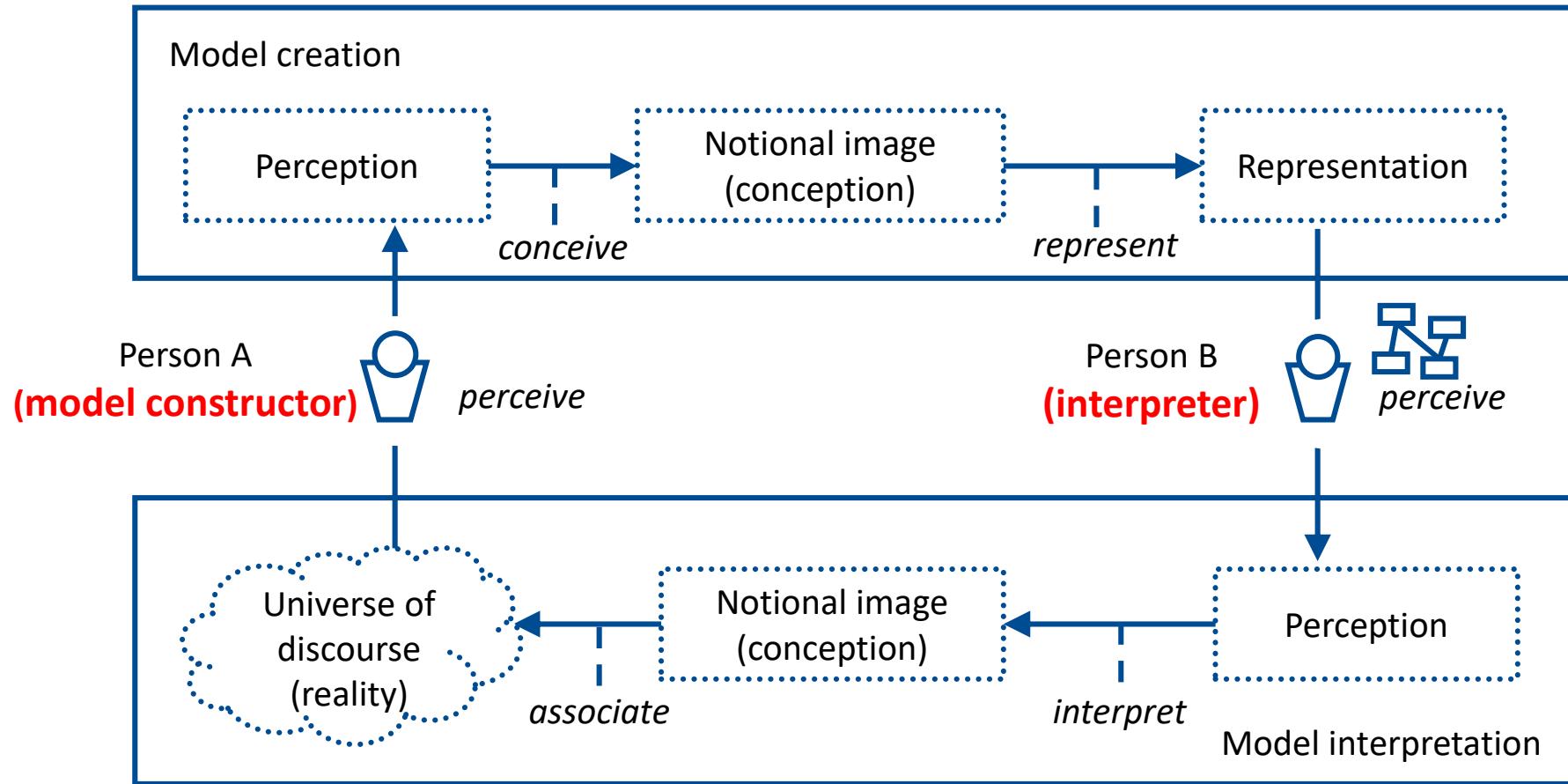
- Focus on **specific purpose** supported by specific modelling languages.
- Easy to **comprehend** and **memorize** (knowledge of the modelling language is a prerequisite).
- **Reduction of complexity** by focusing on relevant aspects.
- Foster communication by **purpose-based abstractions**.
- Support of **problem understanding and solving**.
- Support for **automation** by partial formalization, e.g., for quality assurance activities.

# 4. Fundamentals of Conceptual Modelling

# From Reality to Representation



# Model Construction and Model Interpretation



Persons A and B need to understand the same language.

Prerequisite: The interpreter can associate the elements represented in the language with the same aspects in reality.

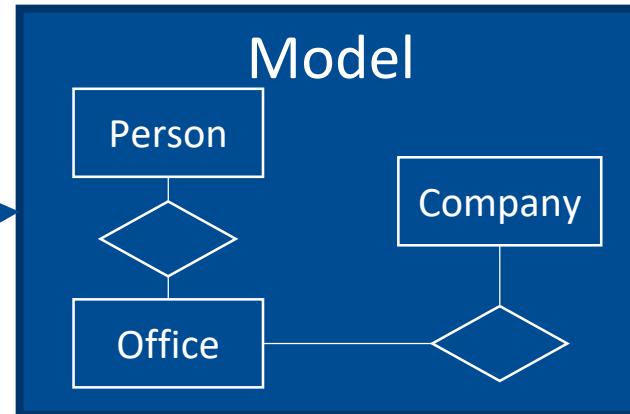
## Data Modelling

**E**

Requires knowledge about the language and modelling method



Create model



Requires knowledge about the language

Interpret model



Perceive world

Requires domain knowledge



Associate

Good model

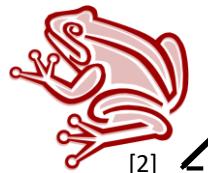
Requires domain knowledge

Bad model

# 5. Semiotic of Conceptual Models

# The Semiotic Triangle (1)

**Referent:** Existing or conceived object in the universe of discourse



Real world  
(referent)

[2]

“Frog”<sup>o</sup>  
(reference)

Set of properties the term comprises:  
e.g., green, smooth, slippery

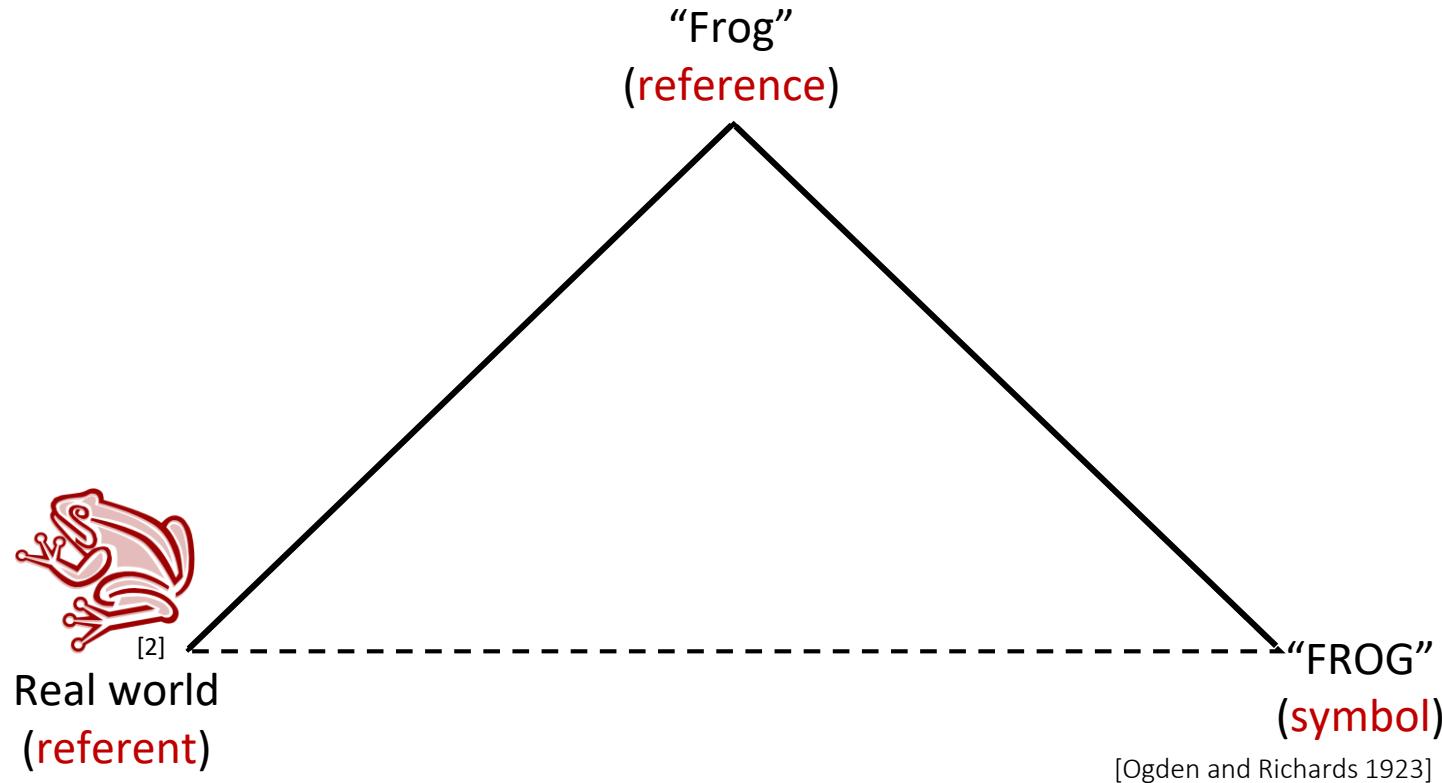
**Reference:** The image a person has in mind about the referent and symbol

“FROG”  
(symbol)

**Symbol:** An atomic construct of the language

[Ogden and Richards 1923]

# The Semiotic Triangle (2)



No direct relationship between symbol and referent.

# The Semiotic Tetrahedron according to FRISCO

## Domain:

Universe of discourse

## Conception:

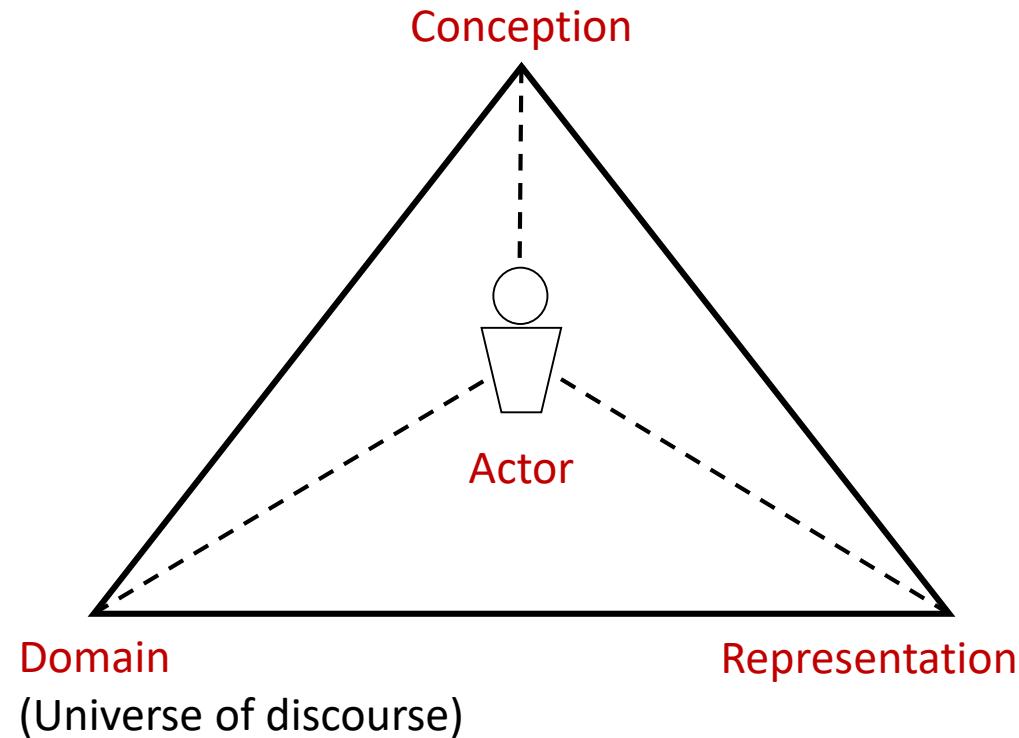
“Image” of the real-world object in the mind of the interpreting person

## Representation:

Result of a human actor describing his/her conceptions

## Actor:

Model constructor or interpreter



[Falkenberg et al. 1998]

# Syntax, Semantic and Pragmatic (1)

## Syntax:

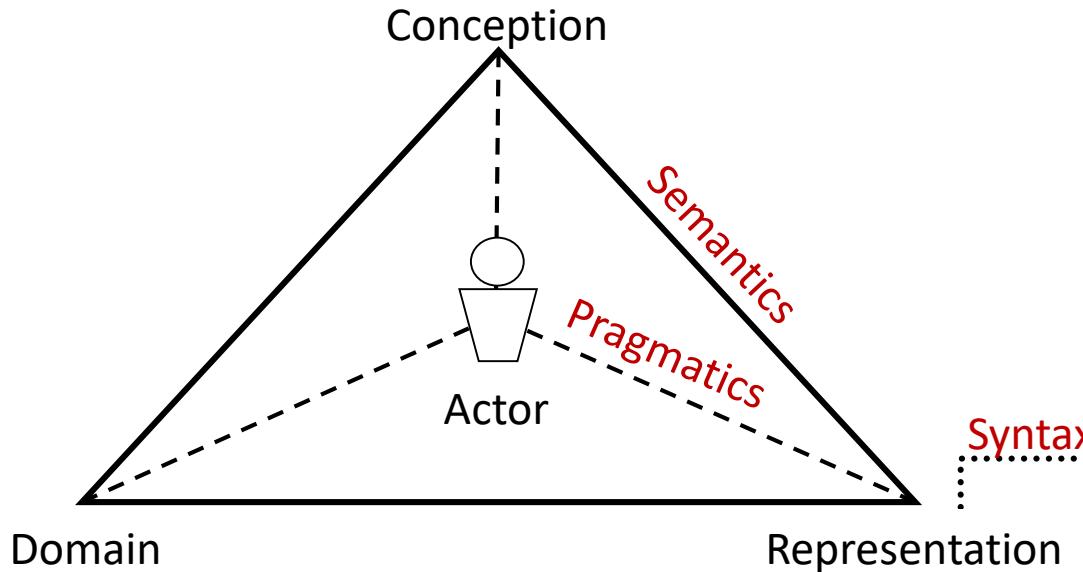
Atomic language constructs and their valid combinations

## Semantics:

Meaning of the language constructs and meaning of combined constructs is defined with composition principle

## Pragmatics:

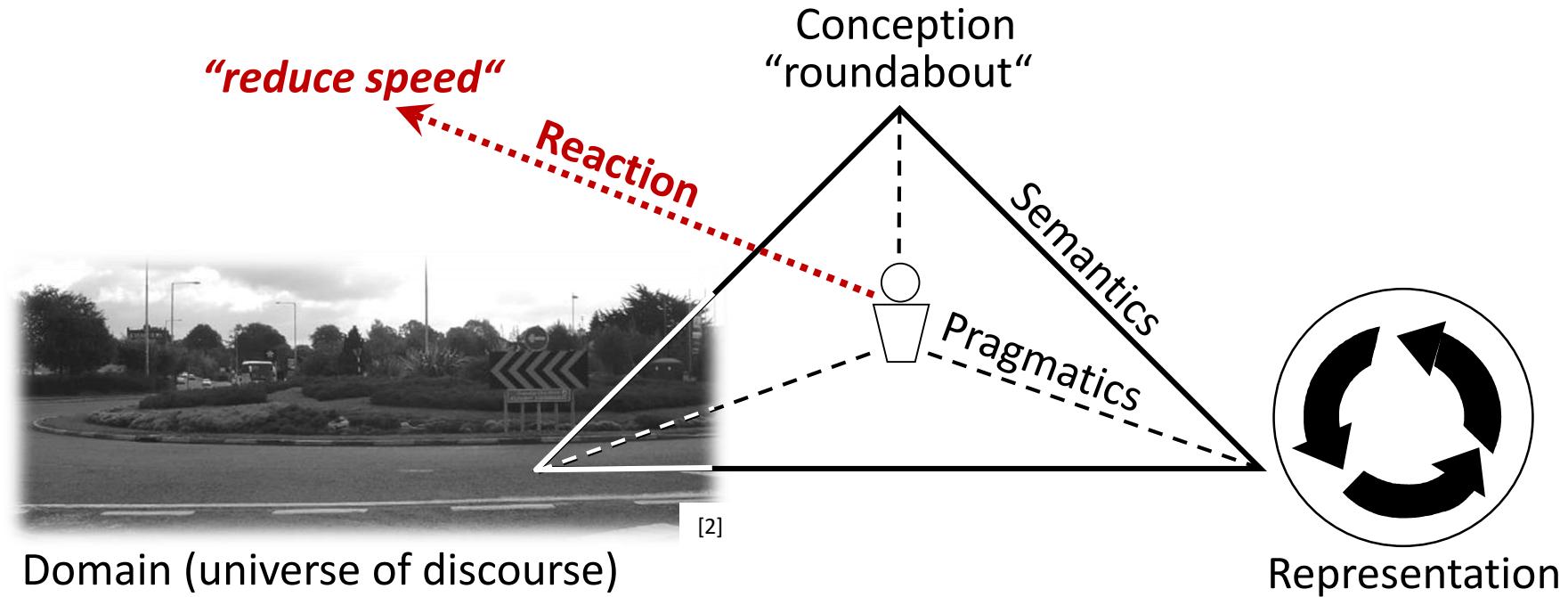
Deal with effects of the symbol on the behaviour of the interpreting actor



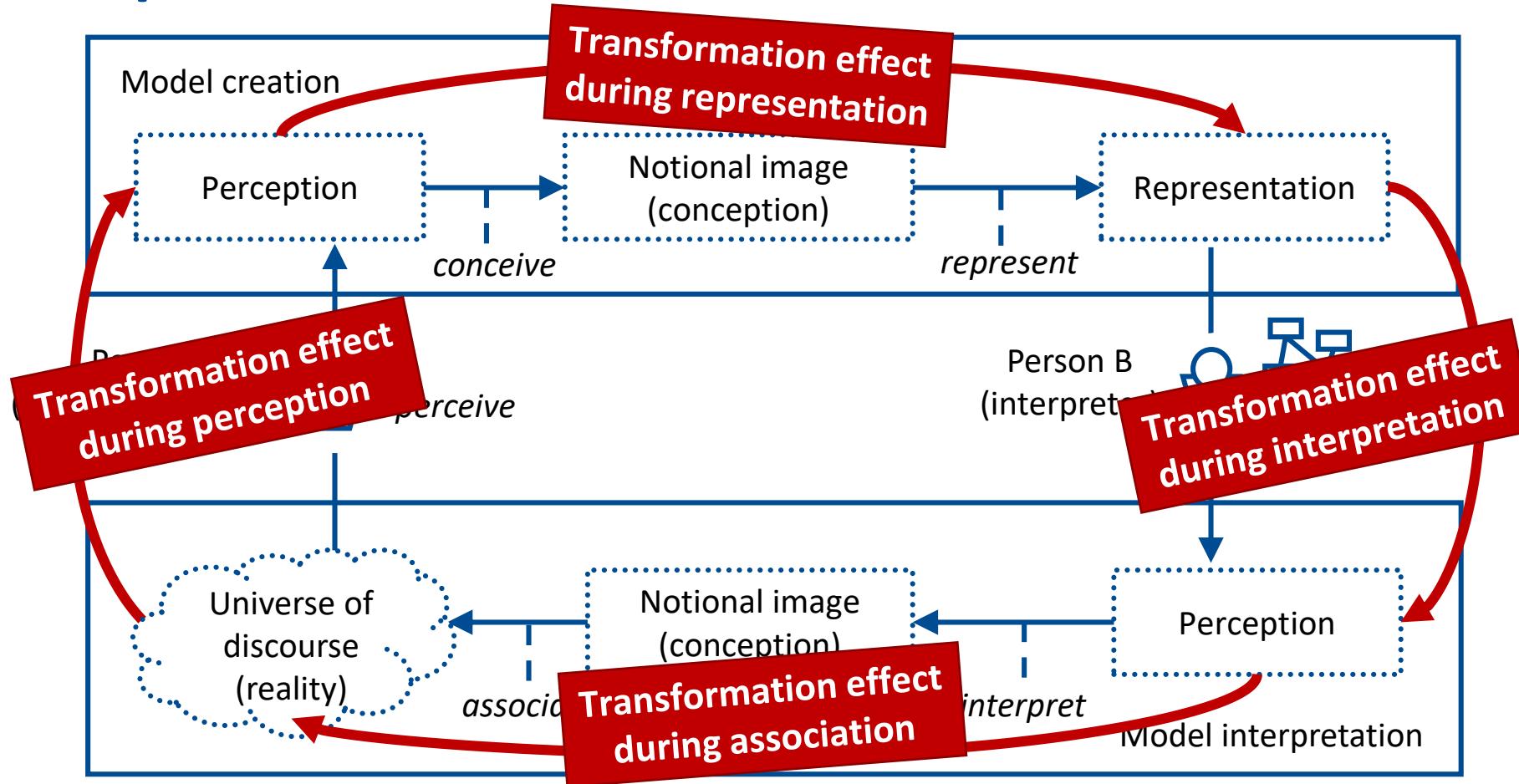
[Falkenberg et al. 1998]

# Syntax, Semantic and Pragmatic (2)

E



# Four potential Transformation Effects

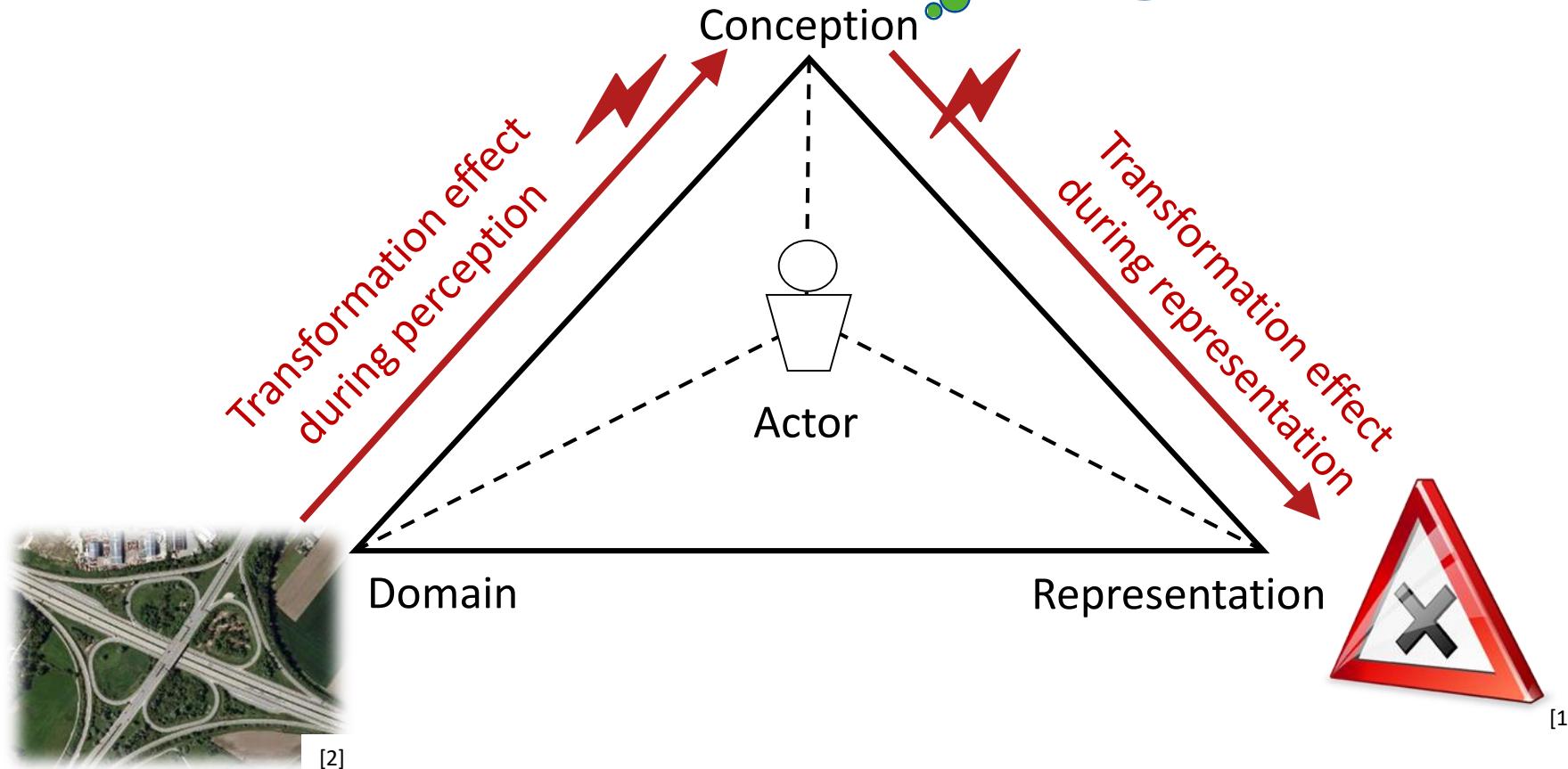


Persons A and B need to understand the same language.

Prerequisite: The interpreter can associate the elements represented in the language with the same aspects in reality.

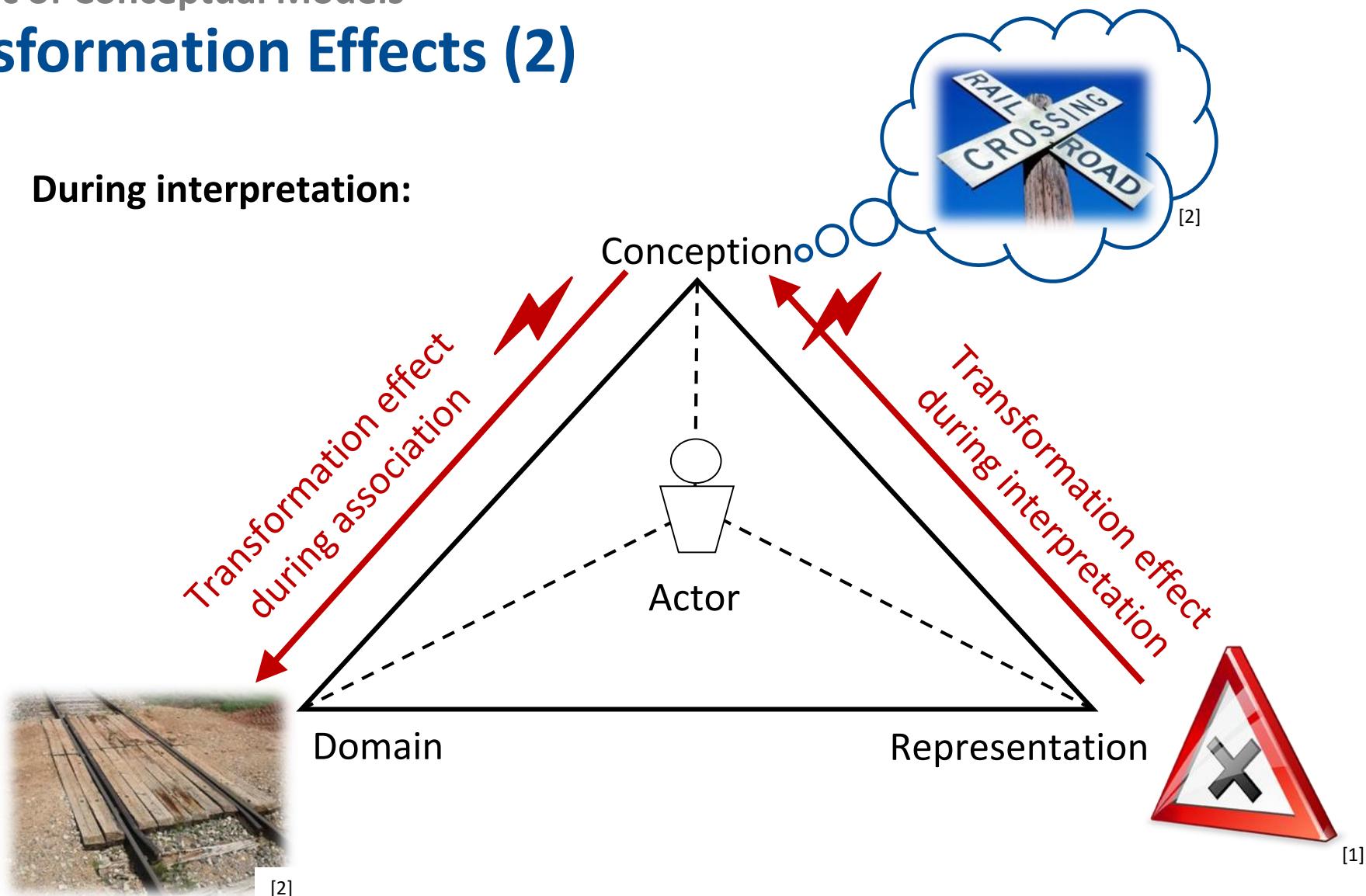
# Transformation Effects (1)

During construction:



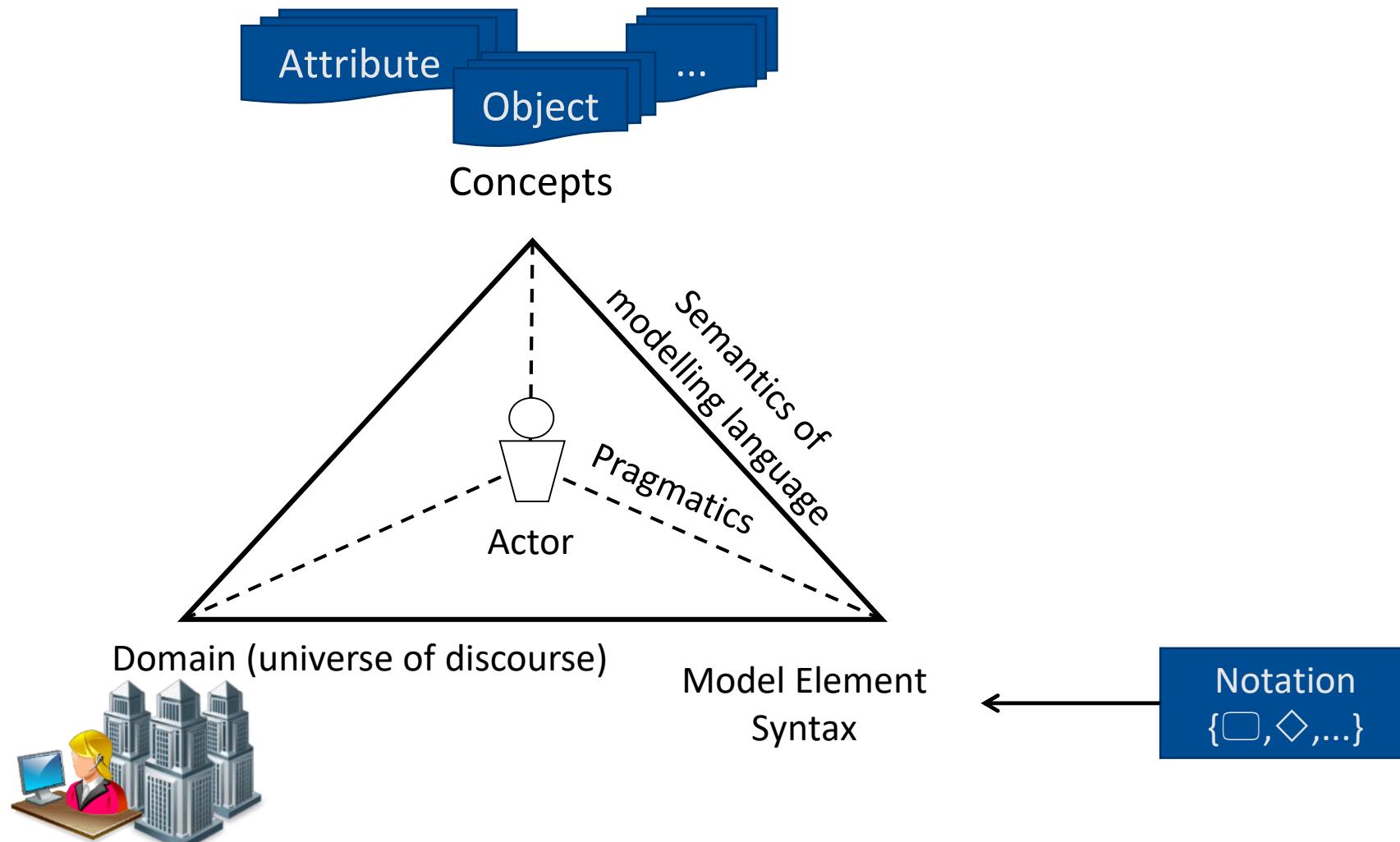
# Transformation Effects (2)

During interpretation:



# Combination of Languages: Data Model (1)

E

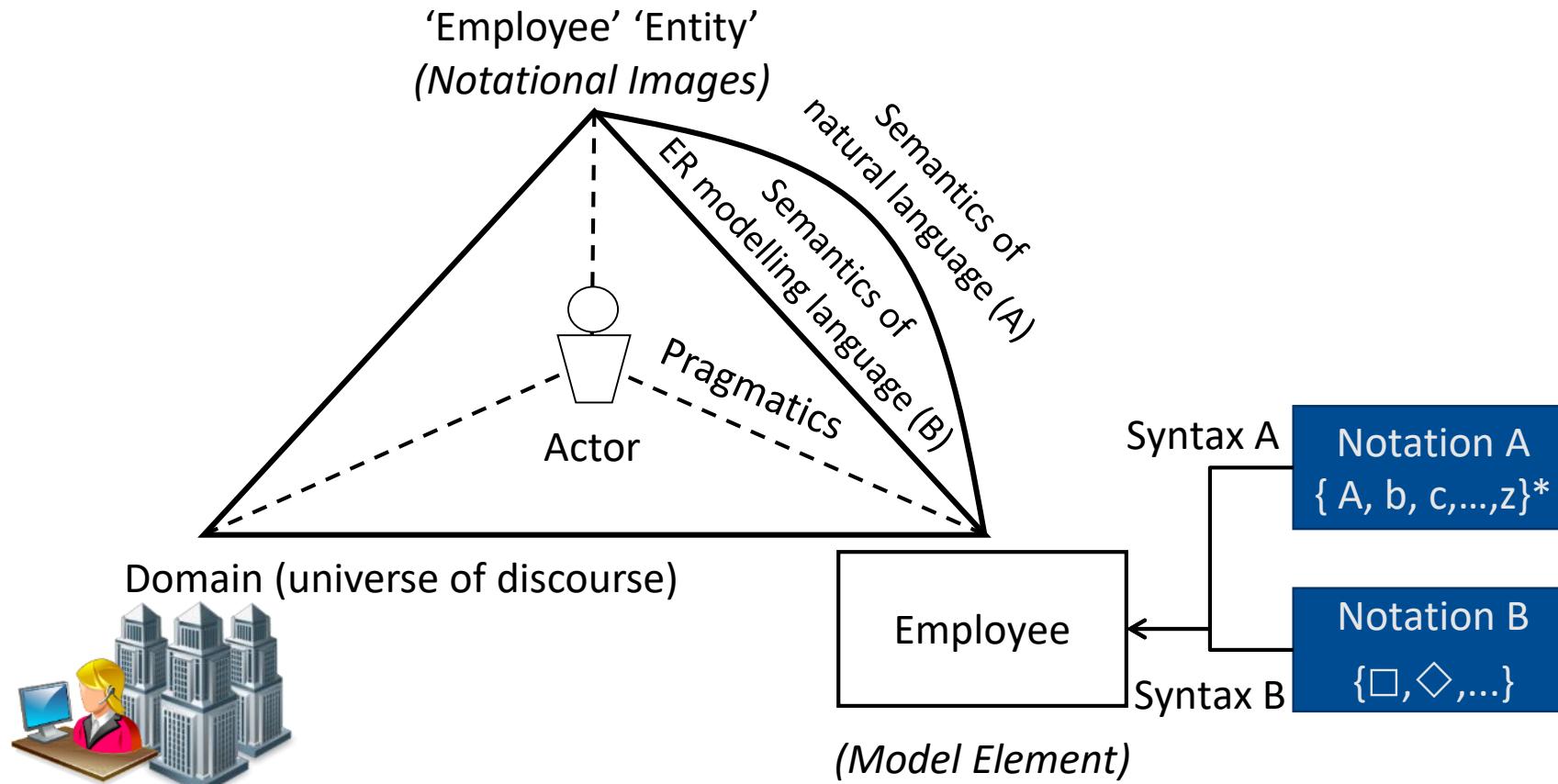


All icons from [1]

# Combination of Languages: Data Model (2)

**E**

In Data Models **two different kinds of abstractions** are used:  
Natural Language (A) and ER-Models (B)!



All icons from [1]

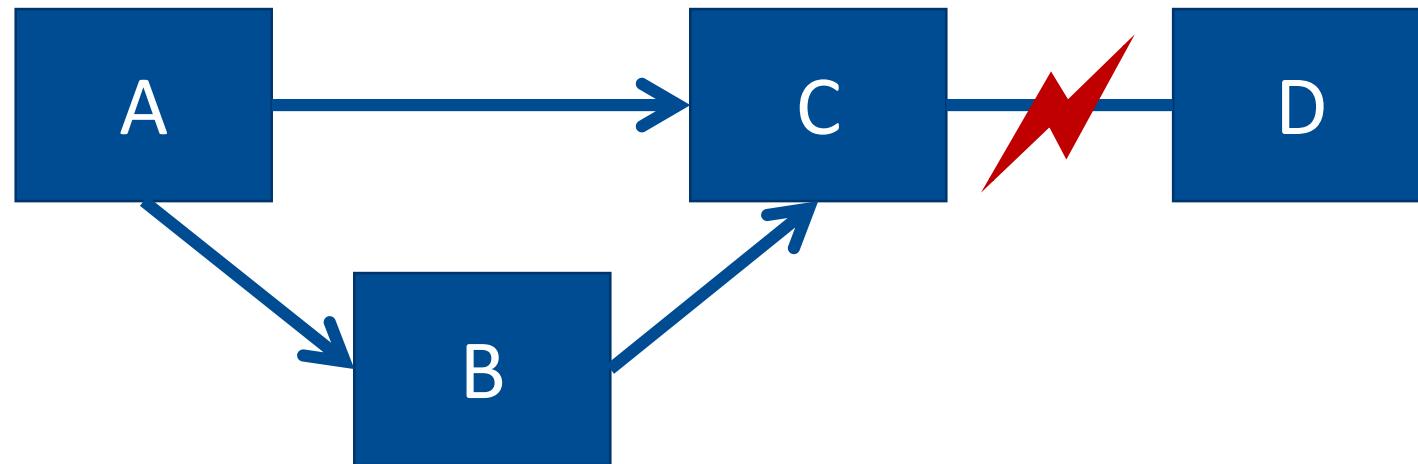
# 6. Quality of Conceptual Models

# Assessing the Quality of Conceptual Model

- **Syntactic quality:**  
Adherence to syntactic rules
- **Semantic quality:**  
Validity and completeness of the model
- **Pragmatic quality:**  
Suitability for intended use / purpose

Deficiencies in one quality aspect often affect the other quality aspects of a conceptual model!

# Syntactic Quality

**E****Syntactical rule:**Rectangles shall only be connected using directed edges.

# Semantic Quality

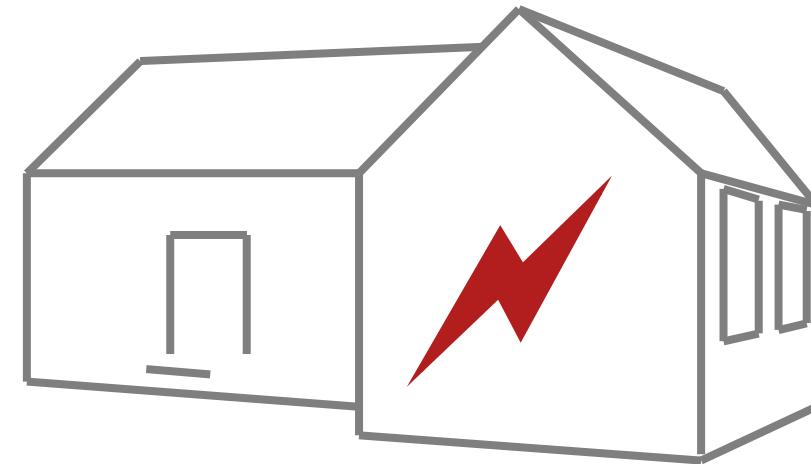
E

**Goal of the model:**

Model the shape of a house, its front doors and windows.



Universe of discourse (reality)



Model

# Pragmatic Quality



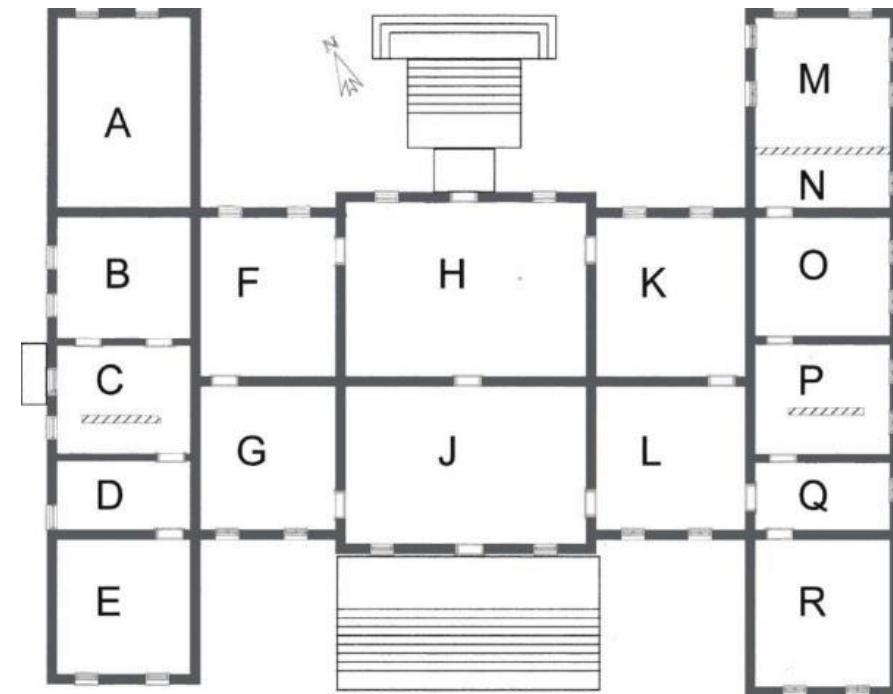
## E Suitability for a purpose:



[6]

Used for, e.g., evaluating

- the overall architecture
- the face of a building



[7]

Used for, e.g.,

- highlighting emergency exits
- navigation between rooms

# 7. Modelling Languages (Meta Modelling)

# Conceptual Modelling Languages (simplified Example)

**E**

## Semantic

A **Process** represents a task or activity that the system shall provide or implement. A Process consumes some input data [...]

A **Data Flow** describes the transportation of information packets of known composition and defines a stream of flowing data. [...]

## Abstract Syntax



## Notation

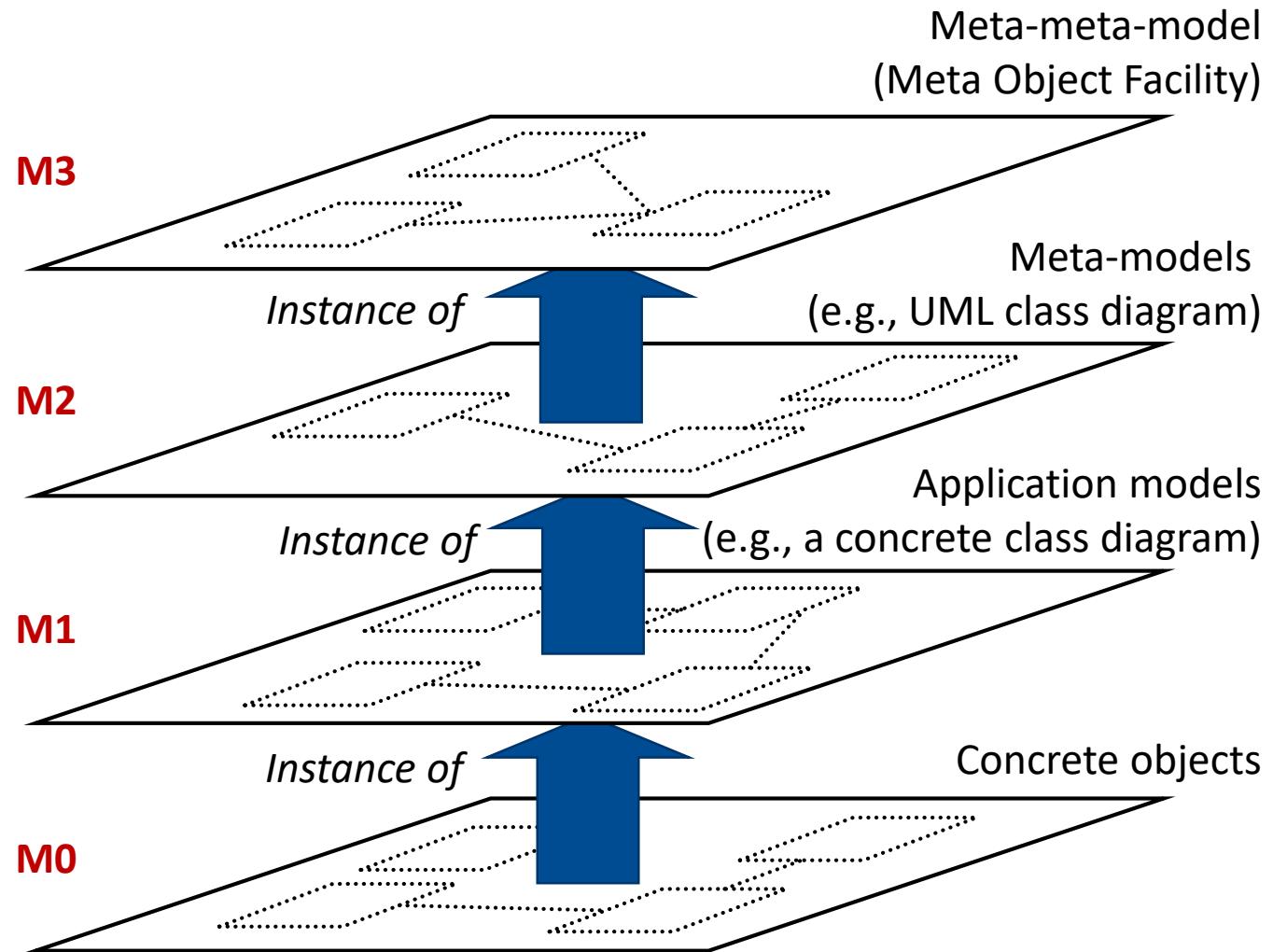
Process                      Dataflow →

## Concrete Syntax



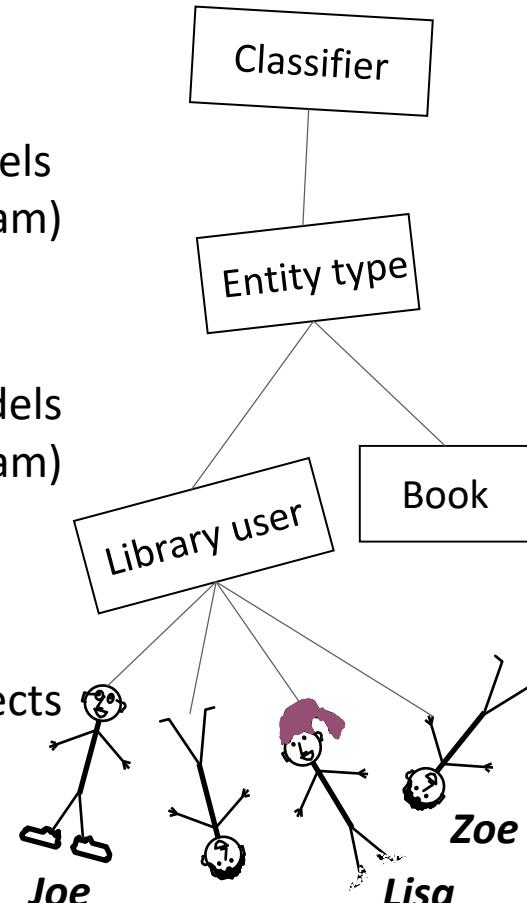
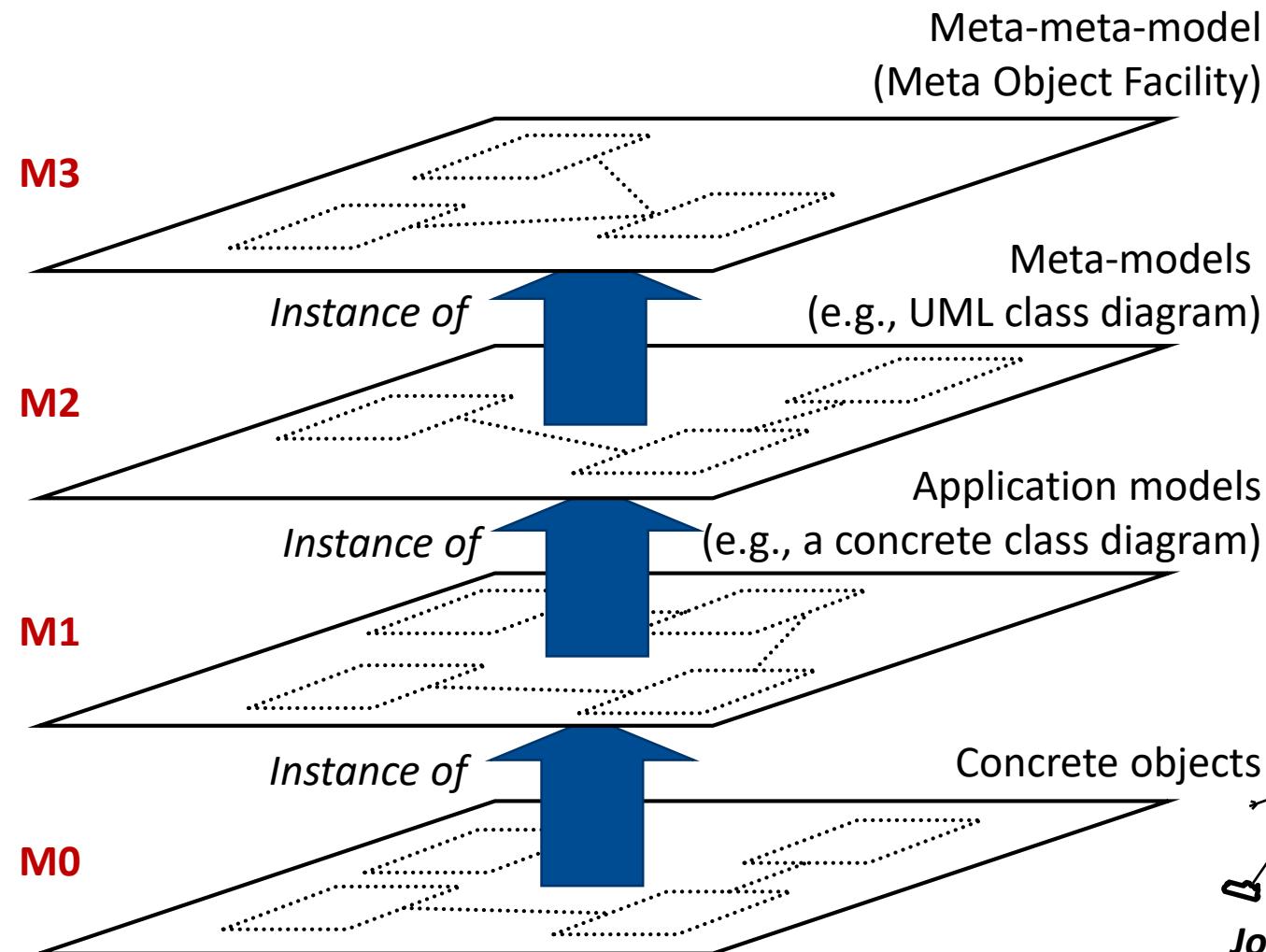
# Four Modelling Layer (1)

E



# Four Modelling Layer (2)

**E**



# Summary (1)

- A model is created for a specific purpose.
- A model is an abstract representation of the universe of discourse.
- There are physical and conceptual models.
- Conceptual models are used in many areas of the daily life.
- Conceptual models are abstract representations of the current or a future reality.
- The Semiotic Triangle illustrates the semiotics of a conceptual model.
- The Semiotic Tetrahedron extends the Semiotic Triangle by an actor who is the “constructor” and/or “interpreter” of a conceptual model.

# Summary (2)

- Syntax defines the atomic language constructs and their valid combinations.
- Semantic defines the meaning of the language constructs. The meaning of combined constructs is defined through composition principle.
- Transformation effects can occur during model construction and during model interpretation.
- A conceptual model has a syntactic, semantic and pragmatic quality. Each of them can be assessed separately.
- Conceptual modelling languages are defined by an abstract syntax, notation, concrete syntax and semantic.
- Conceptual modelling languages can be defined by meta modelling.

# Literature

[Falkenberg et al. 1998]

E. D. Falkenberg, W. Hesse, P. Lindgreen, B. E. Nilsson, J. L. Han Oei, C. Rolland, R. K. Stamper, F. J. M. Van Assche, A. A. Verrijn-Stuart, K. Voss: A Framework of Information System Concepts – The FRISCO Report. IFIP Report, 1998.

[Pohl 2010]

K. Pohl: Requirements Engineering - Fundamentals, Principles and Techniques, 1st ed., Springer, 2010.

# Literature for Further Reading

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E. Seidewitz: What Models Mean. IEEE Software, Vol. 20, No. 5, IEEE Press, Los Alamitos, 2003, pp. 26-32.

[Stachowiak 1973]

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[Ogden and Richards 1923]

C. K. Ogden, I. A. Richards: The Meaning of Meaning – A Study of the Influence of Language upon Thought and of the Science of Symbolism. Routledge & Kegan, London, 1923 (new edition available: Harcourt Brace Jovanovich, 1989).

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- [2] Provided by Microsoft Office
- [3] London Tube Map, by Sameboat (Own work) [CC BY-SA 4.0 (<http://creativecommons.org/licenses/by-sa/4.0>)], via Wikimedia Commons. [https://commons.wikimedia.org/wiki/File%3ALondon\\_Underground\\_Overground\\_DLR\\_Crossrail\\_map.svg](https://commons.wikimedia.org/wiki/File%3ALondon_Underground_Overground_DLR_Crossrail_map.svg), accessed on November 4, 2021.
- [4] Satellite view of London, bird's-eye view, [Public domain], via Wikimedia Commons. <https://commons.wikimedia.org/wiki/File%3APIA04301.jpg>, accessed on March 5, 2015.
- [5] Inside Guide to London.
- [6] Jans House model, by Dusan Jurkovic (Own work) [CC BY-SA 4.0 (<http://creativecommons.org/licenses/by-sa/4.0>)], via Wikimedia Commons. [http://upload.wikimedia.org/wikipedia/commons/2/2b/Dusan\\_Jurkovic\\_Januv\\_dum.jpg](http://upload.wikimedia.org/wikipedia/commons/2/2b/Dusan_Jurkovic_Januv_dum.jpg), accessed on March 5, 2015.
- [7] Belton Plan, by Giano at en.wikipedia [Public domain], from Wikimedia Commons. [http://upload.wikimedia.org/wikipedia/commons/f/f7/Belton\\_Plan.jpg](http://upload.wikimedia.org/wikipedia/commons/f/f7/Belton_Plan.jpg), accessed on March 5, 2015.

## Legend



**D** Definition



**E** Example



**Incorrect**

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**Vielen Dank für Ihre Aufmerksamkeit**