Conceptual Modeling

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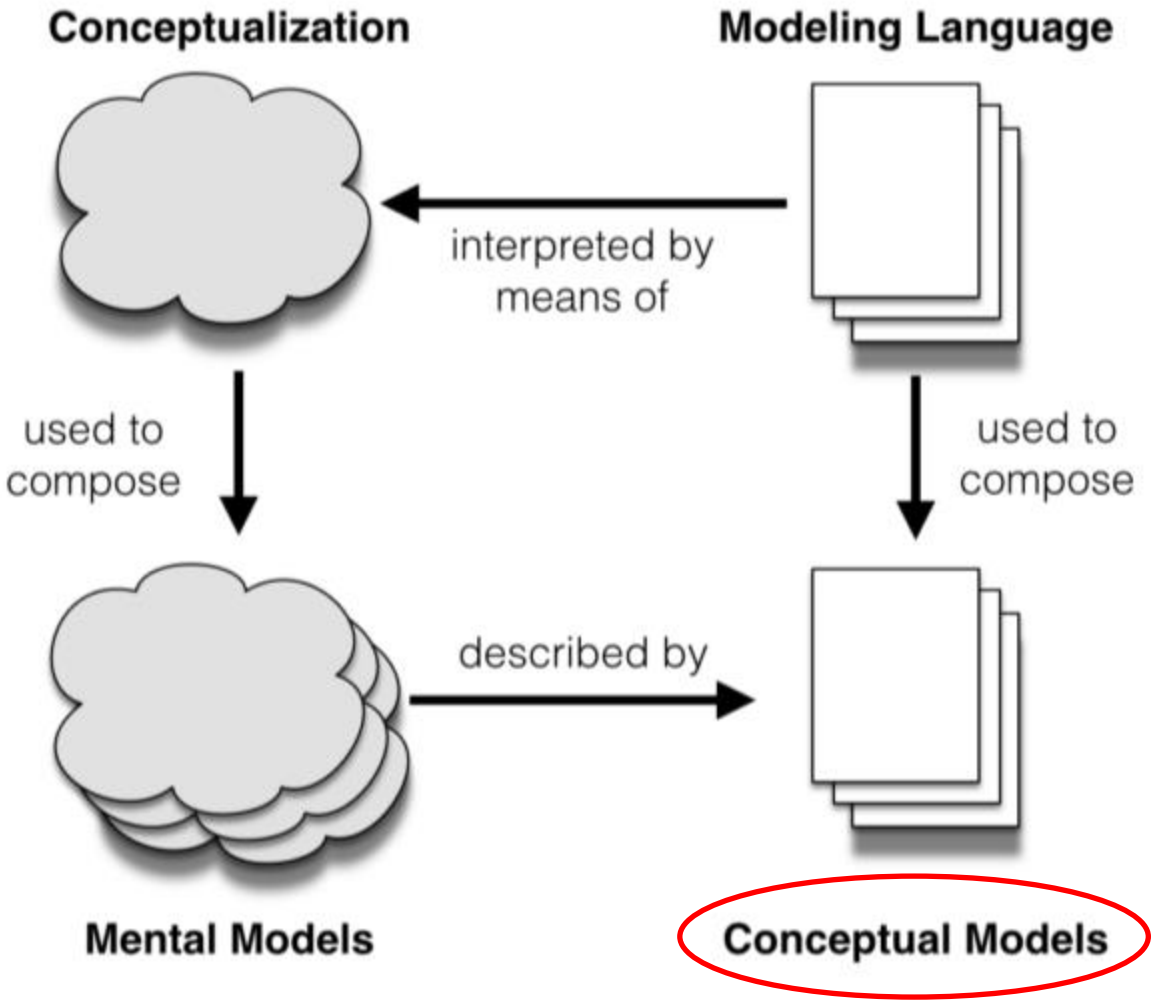
What are Conceptual models?

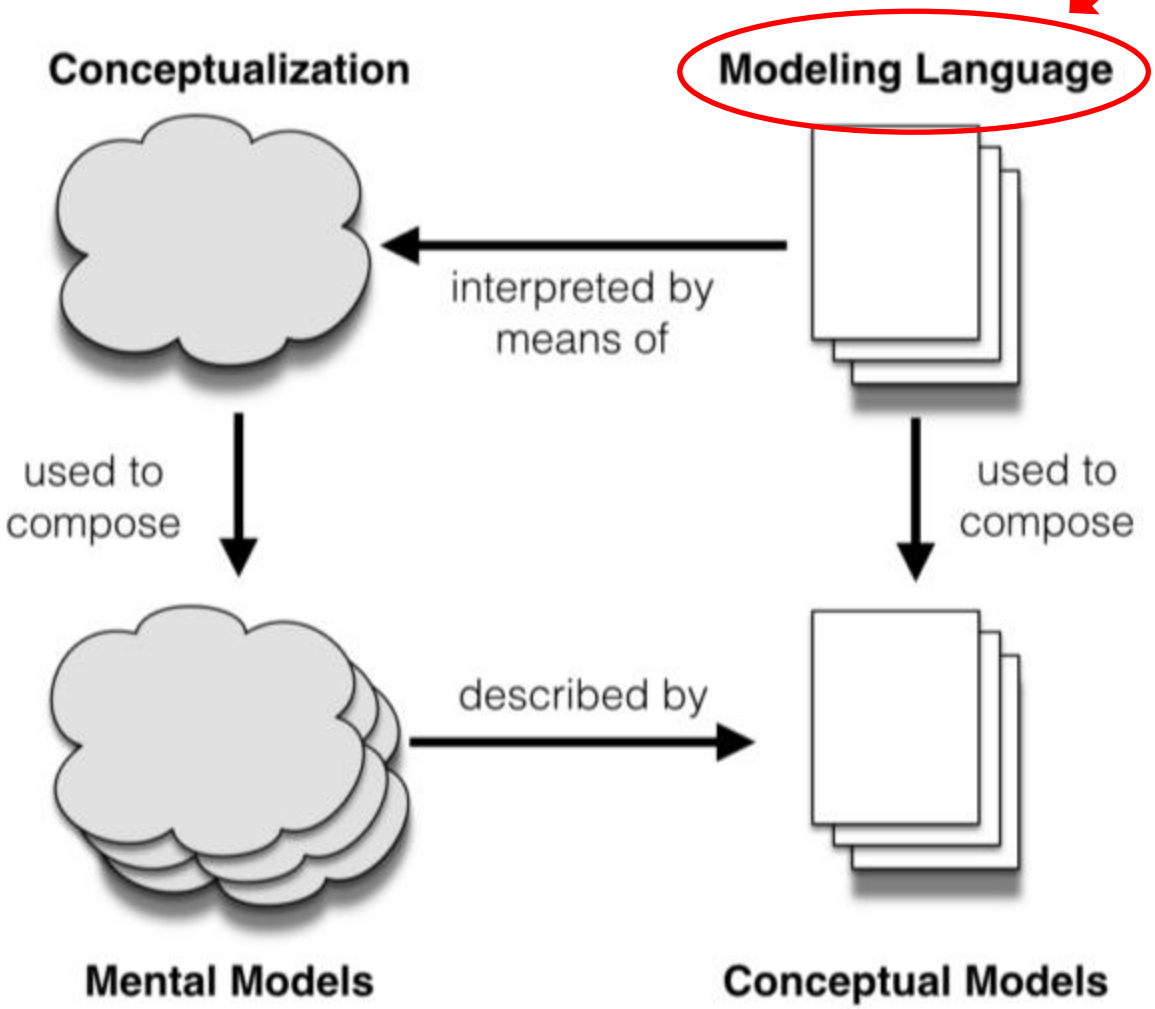
Overview



Guarino, N., Guizzardi, G. and Mylopoulos, J., 2020. On the Philosophical Foundations of Conceptual Models. *Information Modelling and Knowledge Bases XXXI*, *321*, p.1.

Overview

We all know what this is!



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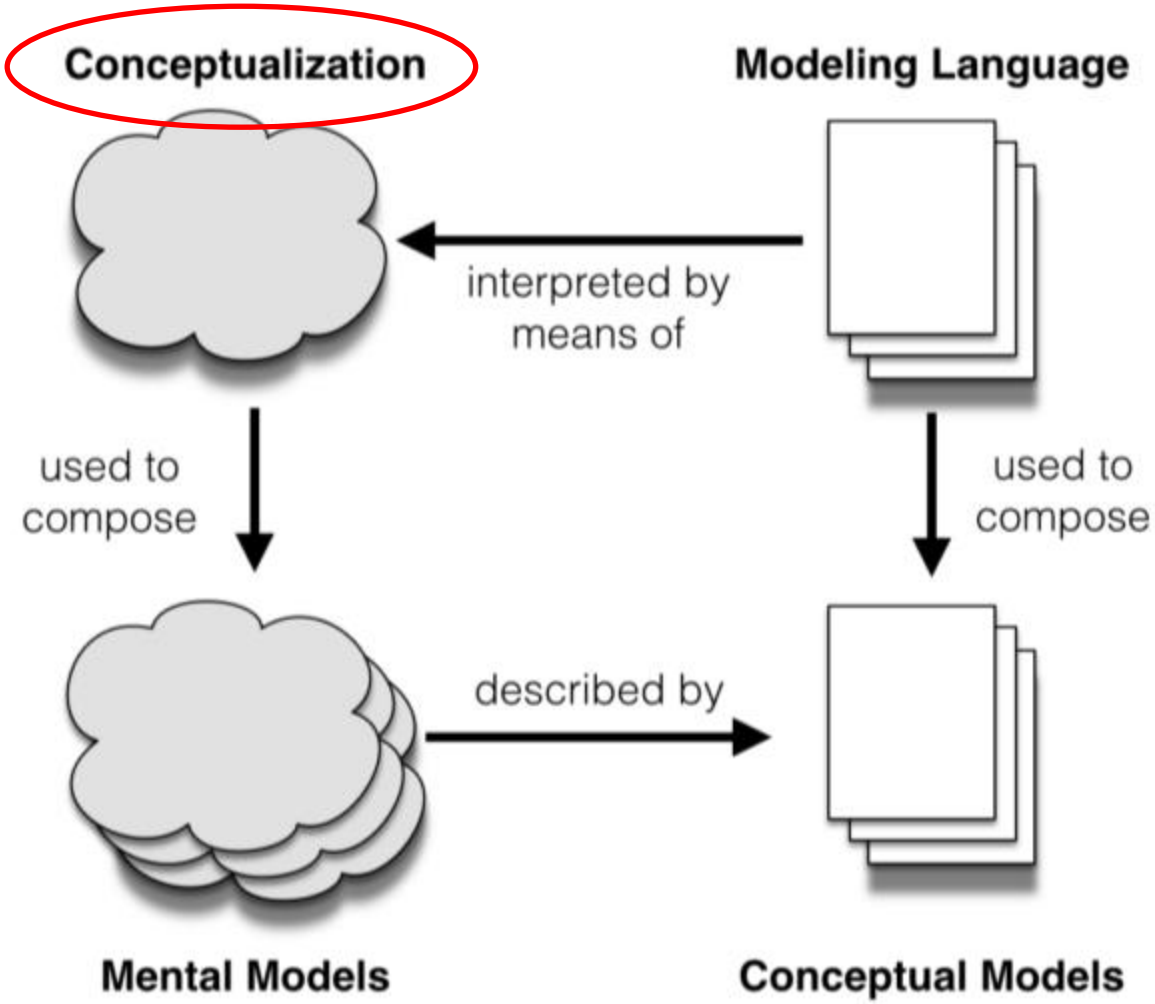

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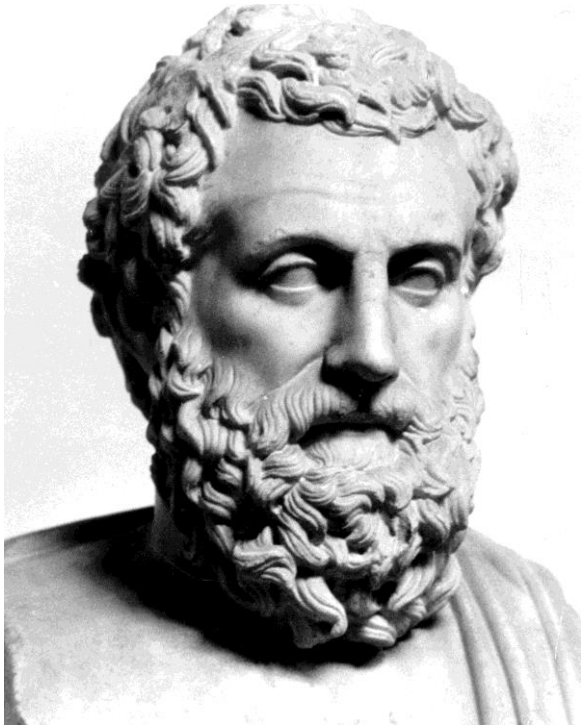
Conceptualization

= set of concepts in the mind of an agent

Concept

- Aristotle ±340BC
- Cognitive processes

  ↳ makes, uses and transforms mental representations
- Mental representations
  - Refer to / are about something
  - Non-conceptual (sensation)
  - Conceptual (thoughts/believes)



https://www.nytimes.com/2016/05/27/world/europe/greece-aristotle-tomb.html

Concept

Conceptual mental representation

→ Rely on representation primitives = concepts

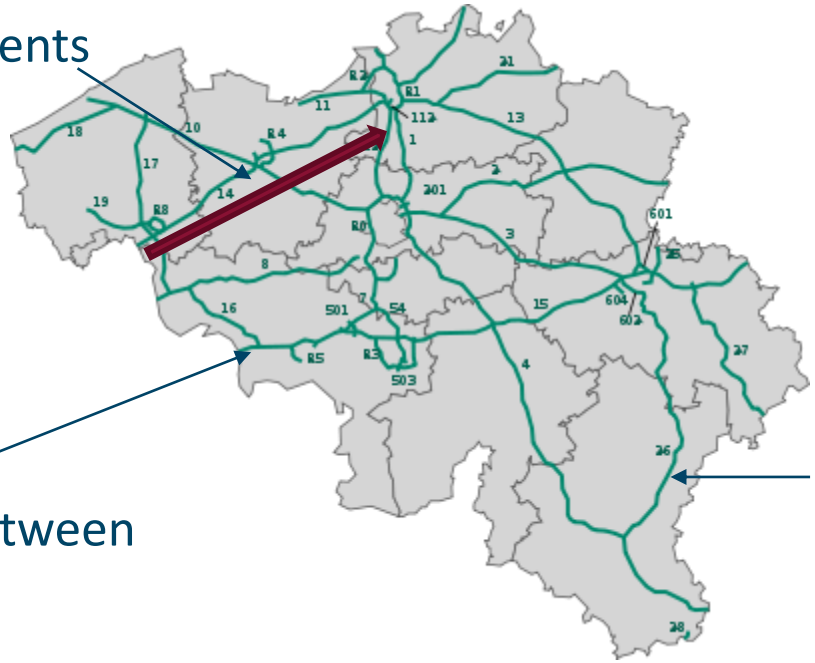
Concept

- Reflects regularities in reality that are cognitively relevant to us
- Cognitive filter → strip out properties unnecessary for the problem

Concept Example

Navigating on the Belgian's highways

Ordering of road segments



Intersection between road segments

Road segment

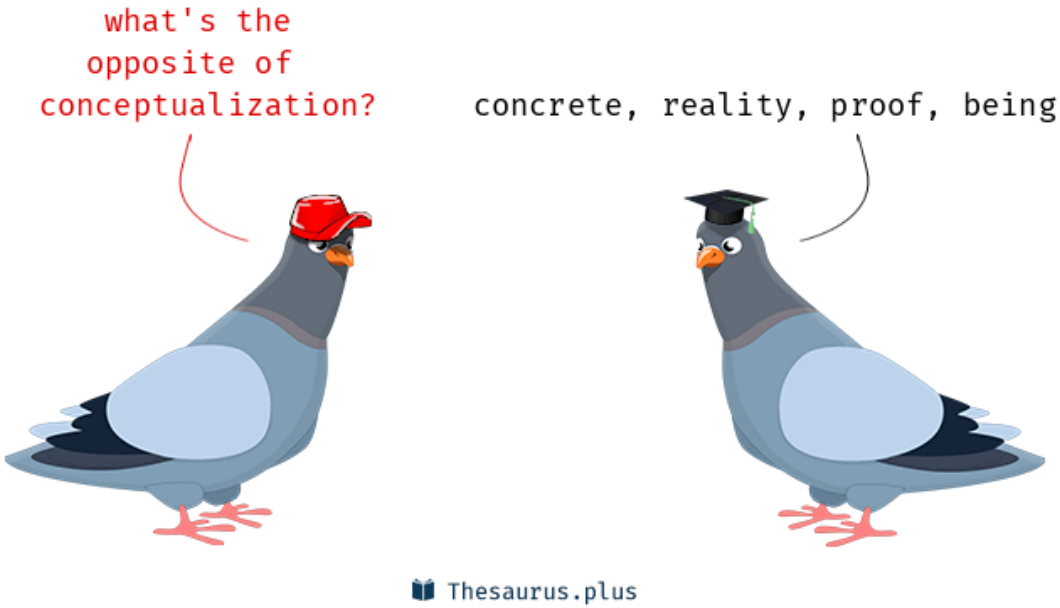
Filtered: width, distance of or traffic on the road segments

https://en.wikipedia.org/wiki/List_of_motorways_in_Belgium

Conceptualization

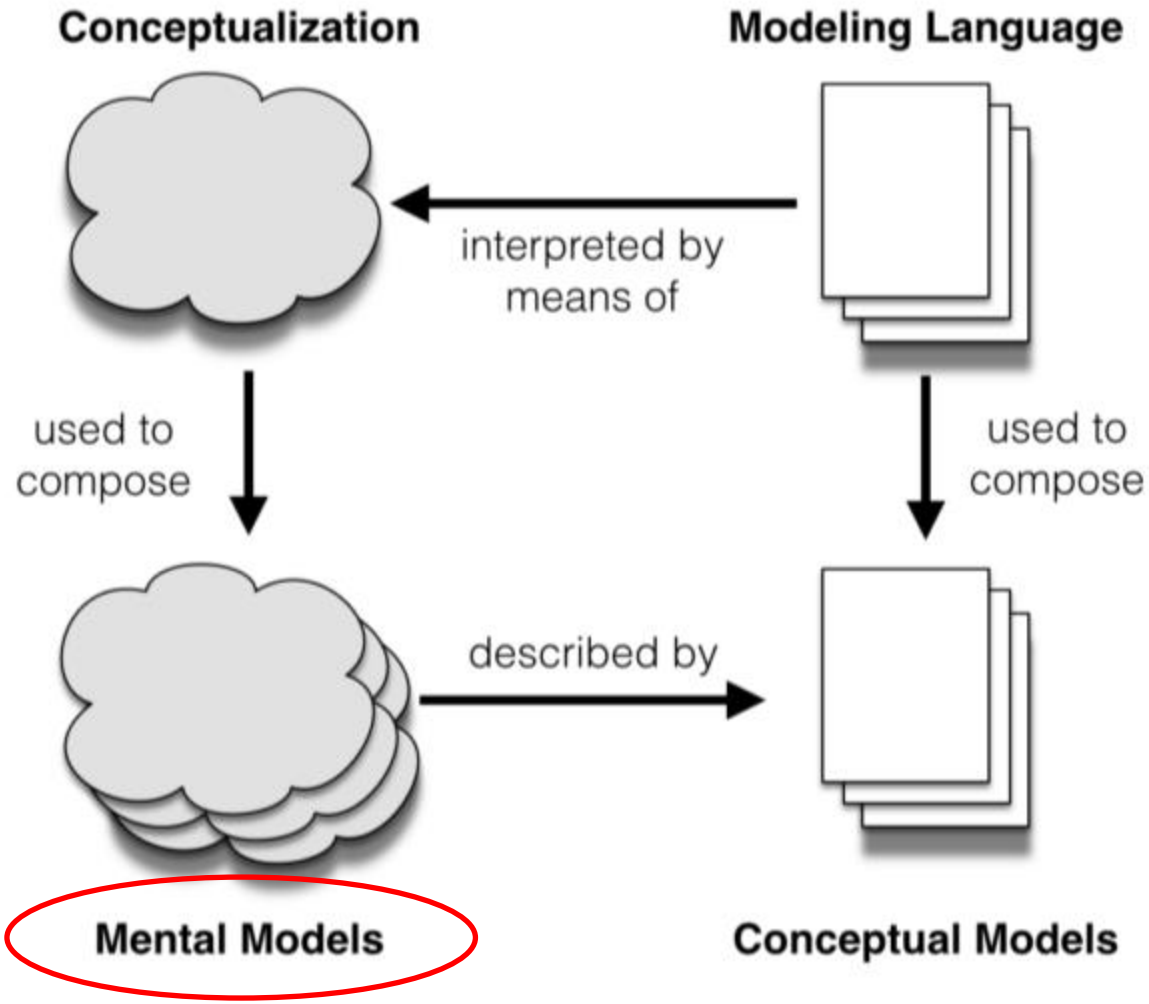
= set of concepts in the mind of an agent

- Individual concepts (e.g., E19)
- Relational concepts: associations that relate individual concepts



https://thesaurus.plus/antonyms/conceptualization

Overview



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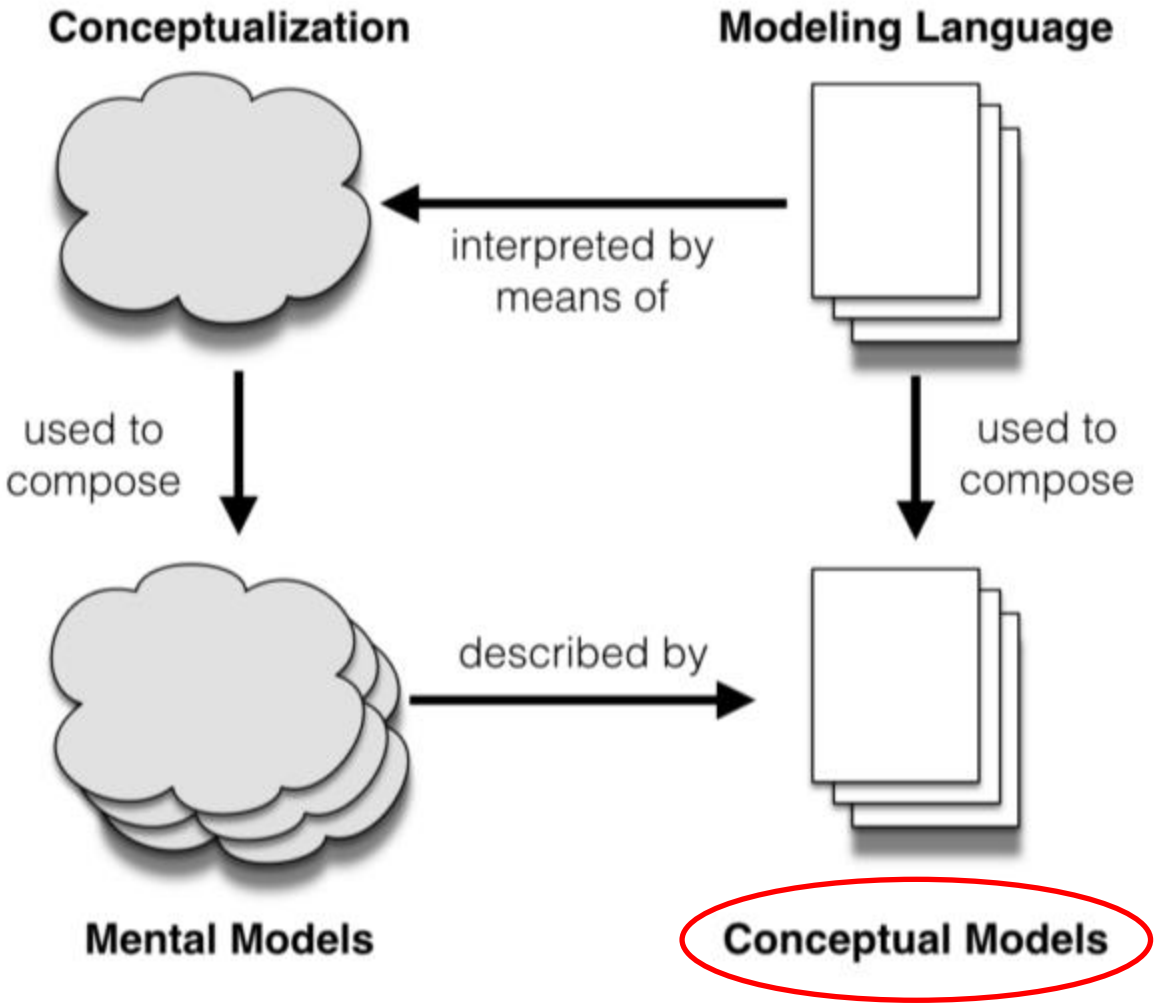
Mental Model

The external reality filtered through the lens of a conceptualization

Different levels of generality:

- Reflect general beliefs (e.g., every road segment has at least one crossing with another road segment)
- Describe the state of affairs (e.g., the current state of the highways in Belgium)

Overview



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Conceptual Model

- Rely on a Modelling Language
- Artifact produced with the deliberate intention of describing a conceptualized reality

  ⇒ conceptual model reflects a conceptualization

≠ model of a given domain

↳ design or implementation models

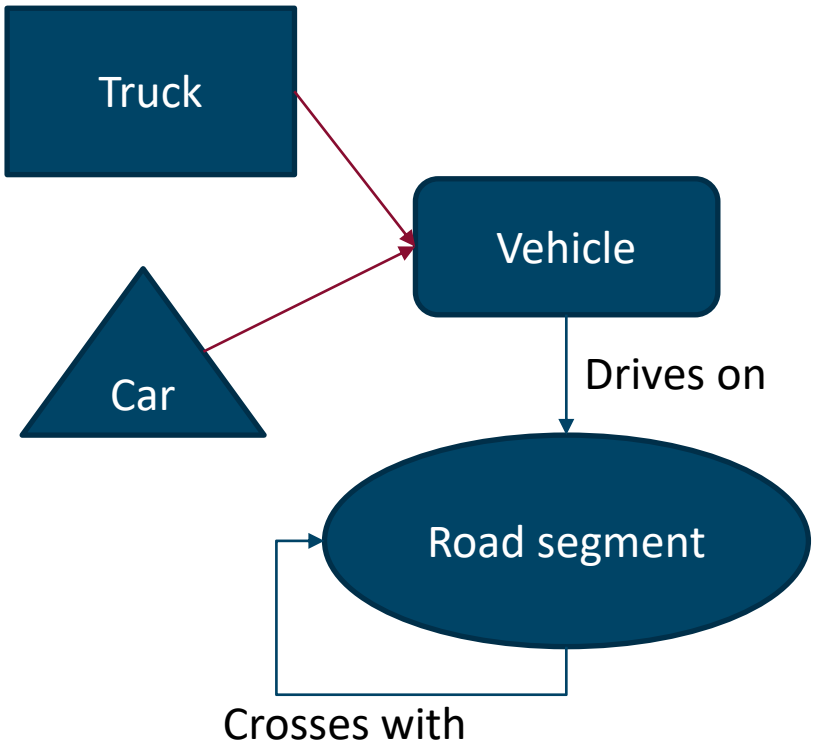
= model of how we conceive of that domain

⇒ improve understanding, promote communication

How are Conceptual models different from others? - Nonnecessity

Not restricted to type-level phenomena

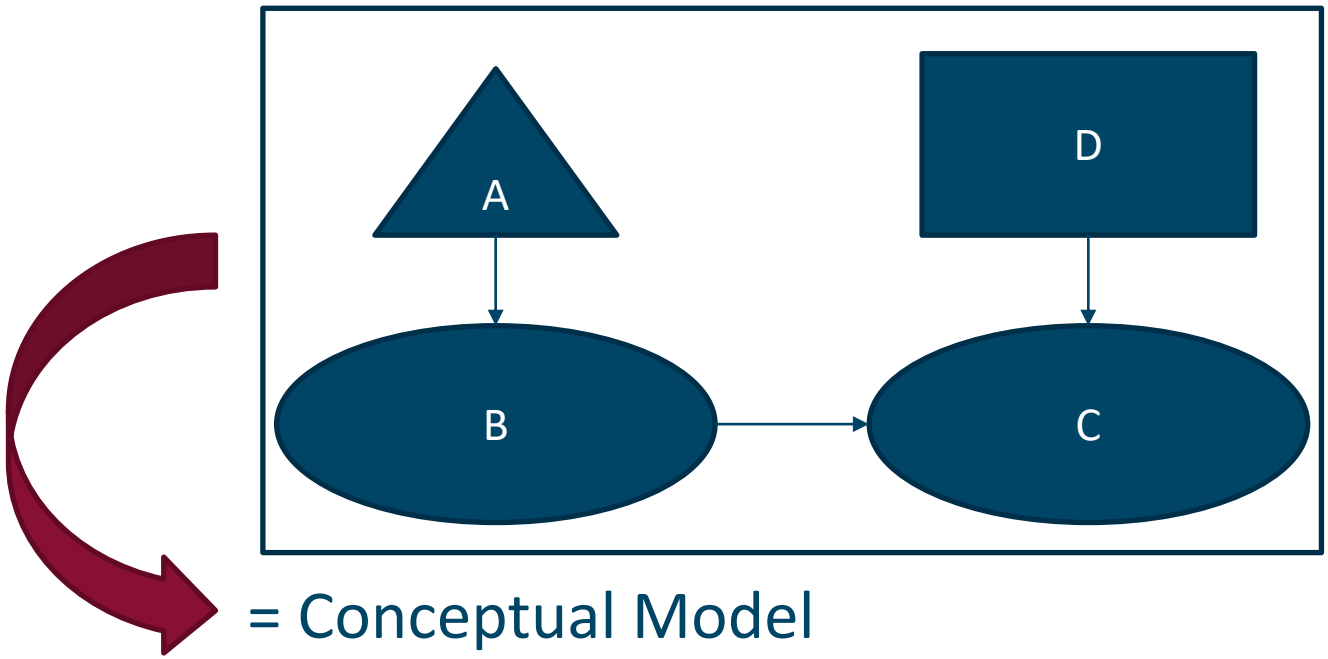
Only making use of types

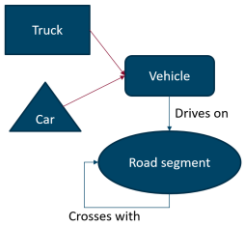


Not restricted to type-level phenomena

When using Domain-Specific Modelling language

⇒ some of their constructs represent instances





= Conceptual Model

A, B, C, D = instance

Not purely logical specifications

universal = what particular things have in common, namely characteristics or qualities

Relational concept represents a universal

Universals may be represented as logical predicates

Not a corresponding universal for every logical predicate!

Not purely logical specifications

Consider a disjunctive predicate: $P(x) = C(x) \vee M(x)$

A has a charge -> P(A) = True

B has a mass -> P(B) = True

$\Rightarrow$ P applies to both A and B

A and B have something in common?

Not purely logical specifications

Consider a disjunctive predicate: $P(x) = C(x) \vee M(x)$

A has a charge -> P(A) = True

B has a mass -> P(B) = True

$\Rightarrow$ P applies to both A and B

A and B have something in common? → NO

$\Rightarrow$ No genuine universal associated to this predicate

Similar for negative predicates ($P(X) = \neg C(X)$)

Not purely logical specifications

Mental model = set of beliefs about a conceptualized reality

Generalizing to mental models

⇒ logical forms of these beliefs should not contain disjunctions or negations

Not purely logical specifications

Conceptual model = explicit description of a mental model

⇒ Logical theory, whose signature denotes concepts, will not count as a conceptual model if it includes disjunctions or negations.

Conclusion:

- All conceptual models can be represented as logical theories
- Not all logical theories can be seen as a conceptual model

How are Conceptual models different from others? - Requirements

Computational Independent Model (CIM)

= model that reflects system and software knowledge from the business perspective

⇒ describe what to do independently of non-functional requirements such as computational efficiency

Does **NOT** mean that they can't:

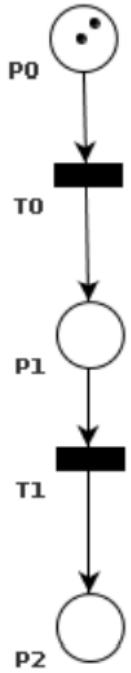
- Offer computational analysis
- Guide to the efficient choice of design and implementation

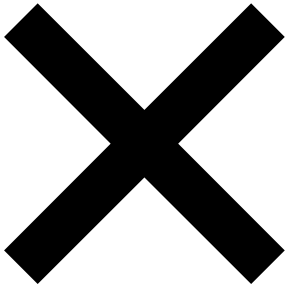
Conceptual semantics

Linguistic/Language constructs denote concepts

Conceptual semantics

Linguistic/Language constructs denote concepts





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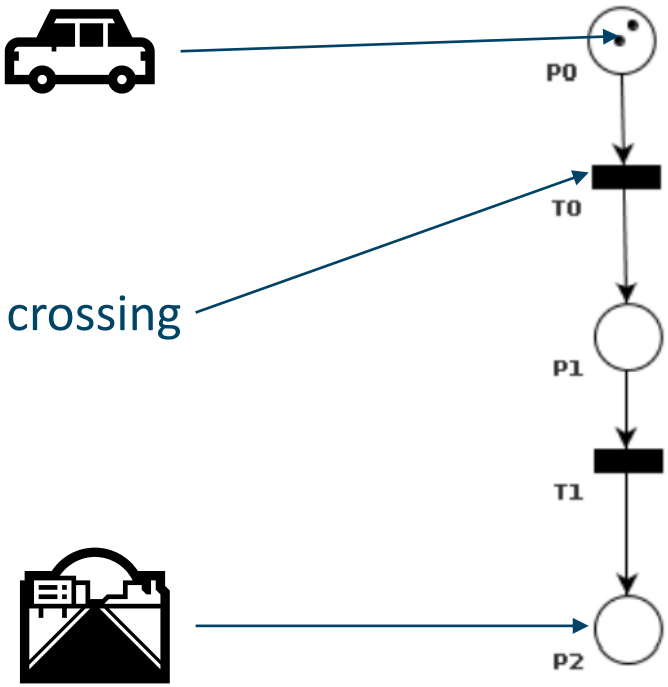
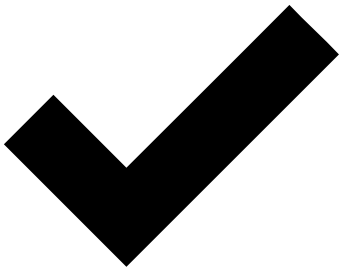
Conceptual semantics

Linguistic/Language constructs denote concepts





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Conceptual semantics

Linguistic/Language constructs denote concepts

Ideally:

- Complete
- Laconic
- Sound
- Lucid

Ontologically grounded

Considering mathematical models: $F = M * A$

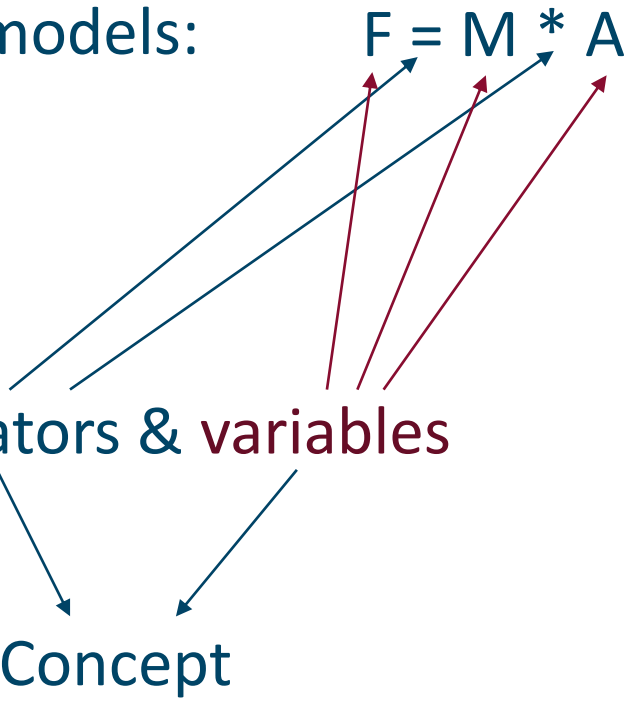
Is this a Conceptual model?

Ontologically grounded

Considering mathematical models:

Is this a Conceptual model?

→ NO

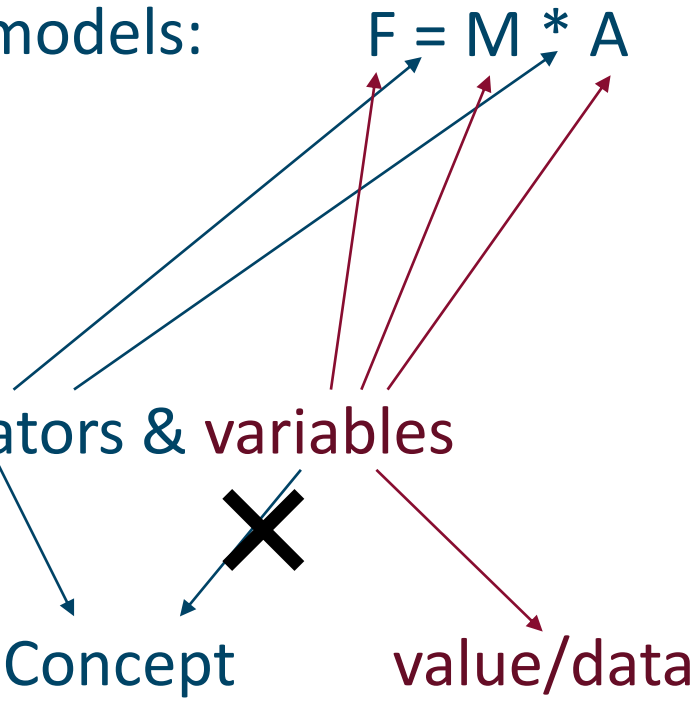


Ontologically grounded

Considering mathematical models:

Is this a Conceptual model?

→ NO



Ontologically grounded

Represent the variables

Represent physical quantities

Represent a physical object

Ontologically grounded

Mental models: properly attached to reality

Conceptual model: describes mental model

Conceptual models reflect the “hooks” for that attachment

Grounding requirement

Ontological commitments

Conceptual model is connected to a conceptualization or the worldview captured by it

⇒ all conceptual models make an ontological commitment

Example: Highway network

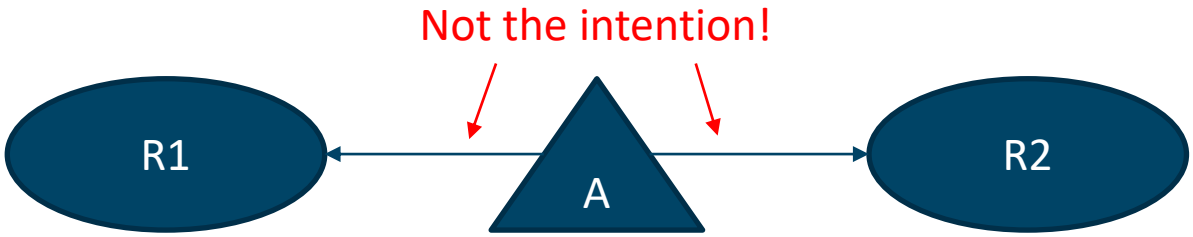
The model commits to the theory of what exists in that domain, an ontological view

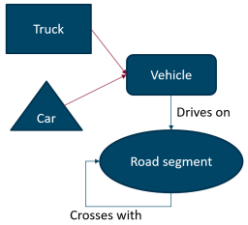
https://en.wikipedia.org/wiki/List_of_motorways_in_Belgium

Ontological commitments

Note: such commitment reflects the modeler's intention

⇒ can be interpreted with a different conceptualization!





Unless constrained are used in the model or its language

↳ eliminate unintended interpretations

Checking for unintended interpretations is very important!

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