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# Meta-Modelling

# Model vs. System



René Magritte. La trahison des images. 1928–29.

# Model of a model — The correspondence continuum

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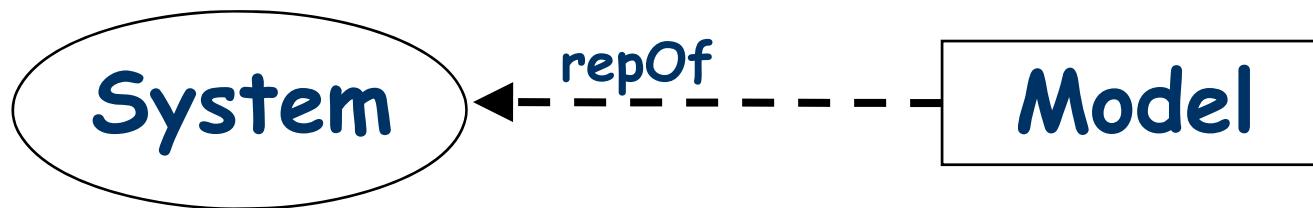
*Meaning is rarely a simple mapping from a symbol to an object; instead it often involves a **continuum of (semantic) correspondences** from symbol to (symbol to)\* object. [Barry Smith. The correspondence continuum. 1987]*

- Example
  - A photo of a landscape is a model of the landscape.
  - A photocopy of the photo is model of a model of the landscape.
  - A digitalization of the photocopy is a model of the model of the model of the landscape.
  - etc.



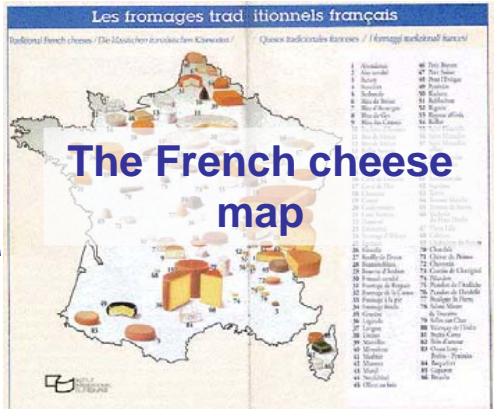
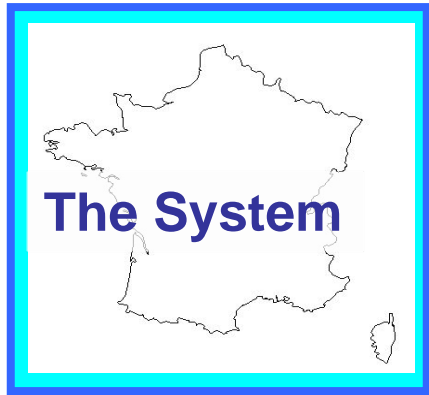
# Basic entities of MDE and MDSD

**System:** a group of interacting, interrelated, or interdependent elements forming a complex whole.

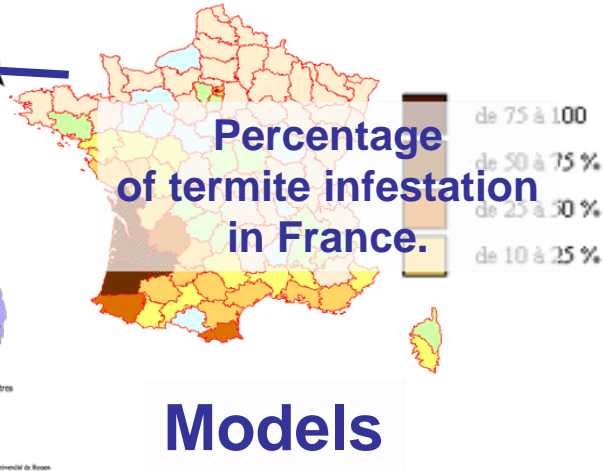
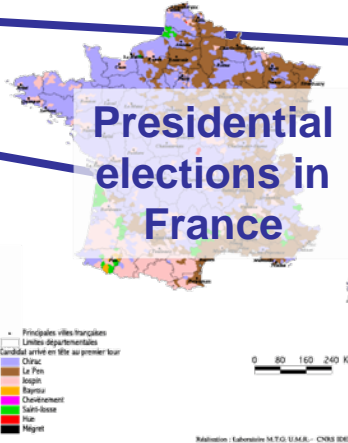


**Model:** an abstract representation of a system created for a specific purpose.

# A very popular model: Geographical maps



La France des "Huit présidents"  
candidat arrivé en tête à l'issue du premier tour



**Models**



repOf



# Limited substitutability principle

- The purpose of a model is always to be able to answer some specific sets of questions in place of the system, exactly in the same way the system itself would have answered similar questions.



- A model represents certain specific aspects of a system and only these aspects, for a specific purpose.

# Lewis Carroll and the 1:1 map

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“That’s another thing we’ve learned from your Nation” said Mein Herr, “map-making. But we’ve carried it much further than you. What do you consider the **largest** map that would be really useful?”

“About six inches to the mile.”

“Only *six inches!*” exclaimed Mein Herr. “We very soon got to *six yards to the mile*. Then we tried a hundred yards to the mile. And then came the grandest idea of all! We actually made a map of the country, on the scale of ***a mile to the mile!***”

”***Have you used it much?***” I enquired.

“***It has never been spread out,*** yet” said Mein Herr: “the farmers objected: they said it would cover the whole country, and shut out the sunlight! So we now use the country itself, as its own map, and I assure you it does nearly as well.”

Lewis Carroll. Sylvie and Bruno concluded.

# Lewis Carroll and the blank map

He had bought a large map representing the sea,  
Without the least vestige of land:  
And the crew were much pleased when they found it to be  
A map they could all understand.  
“What's the good of Mercator's North Poles and Equators,  
Tropics, Zones, and Meridian Lines?”  
So the Bellman would cry: and the crew would reply  
“They are merely conventional signs!  
Other maps are such shapes, with their islands and capes!  
But we've got our brave Captain to thank:”  
(So the crew would protest) “that he's bought us the best—  
A perfect and absolute blank!”

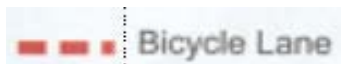


Lewis Carroll. The Hunting Of The Snark — An Agony in Eight Fits.

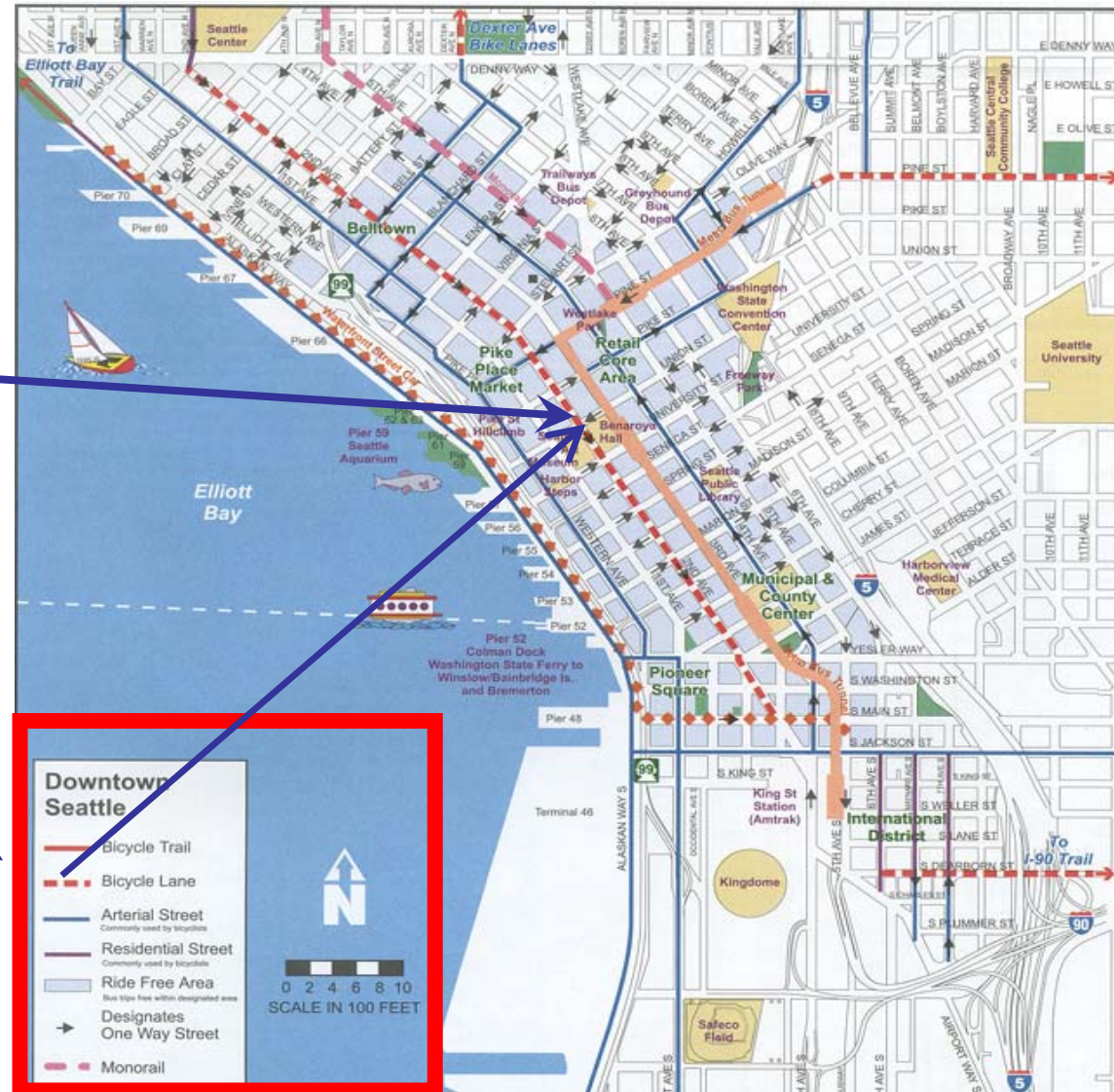


# Every map has a legend (implicit or explicit)

Same visual notation,  
different context,  
different meaning

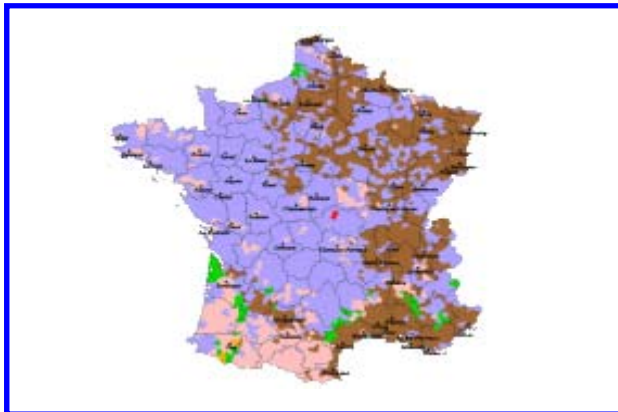


The legend  
is the metamodel

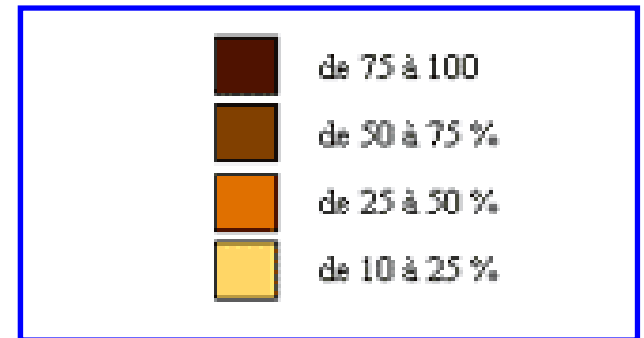
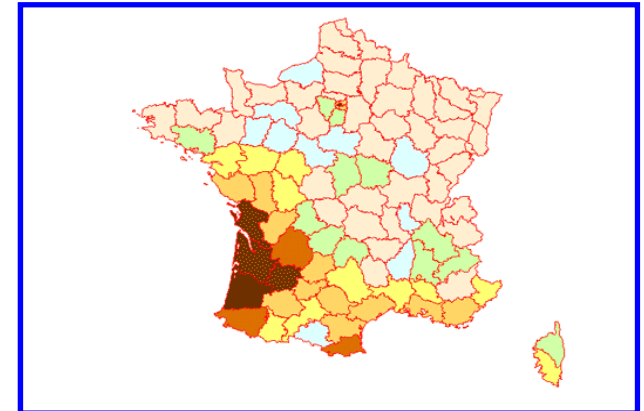


# Maps without legends are meaningless

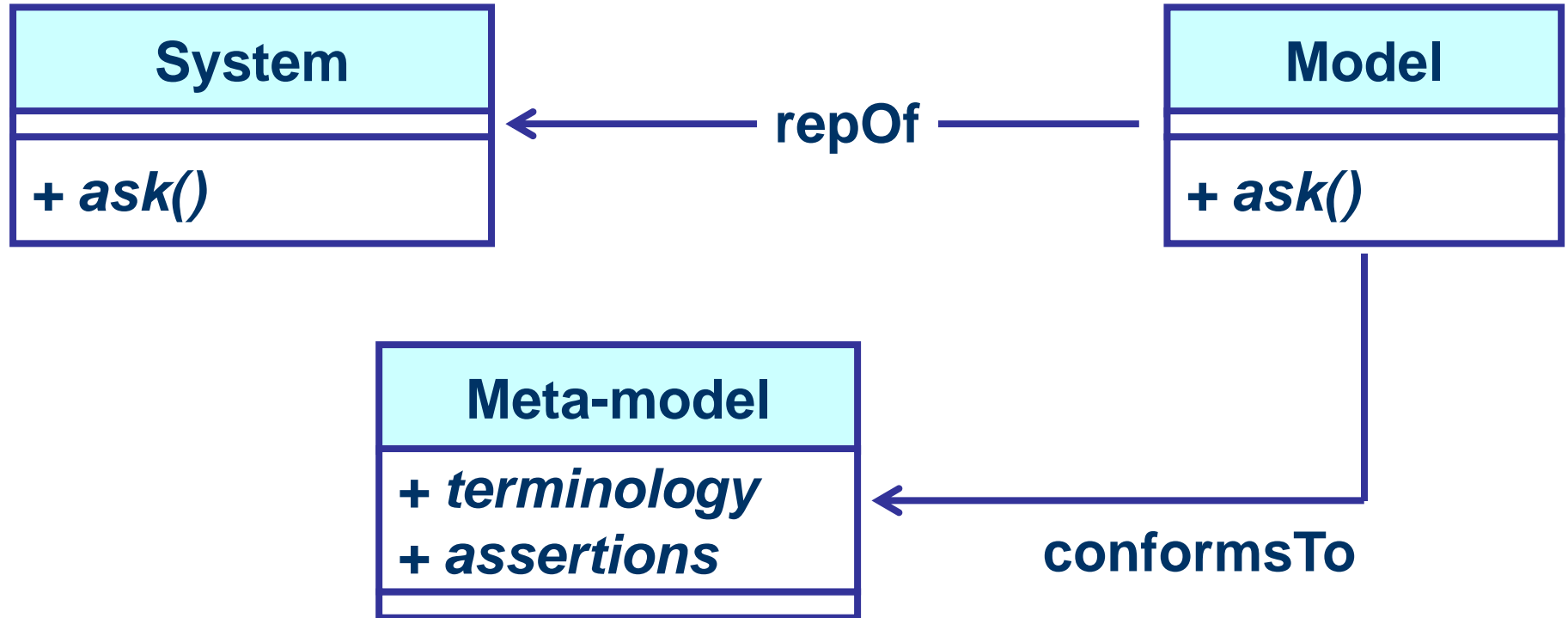
## First round of political election in France in 2002



## Percentage of places infested by termites in France

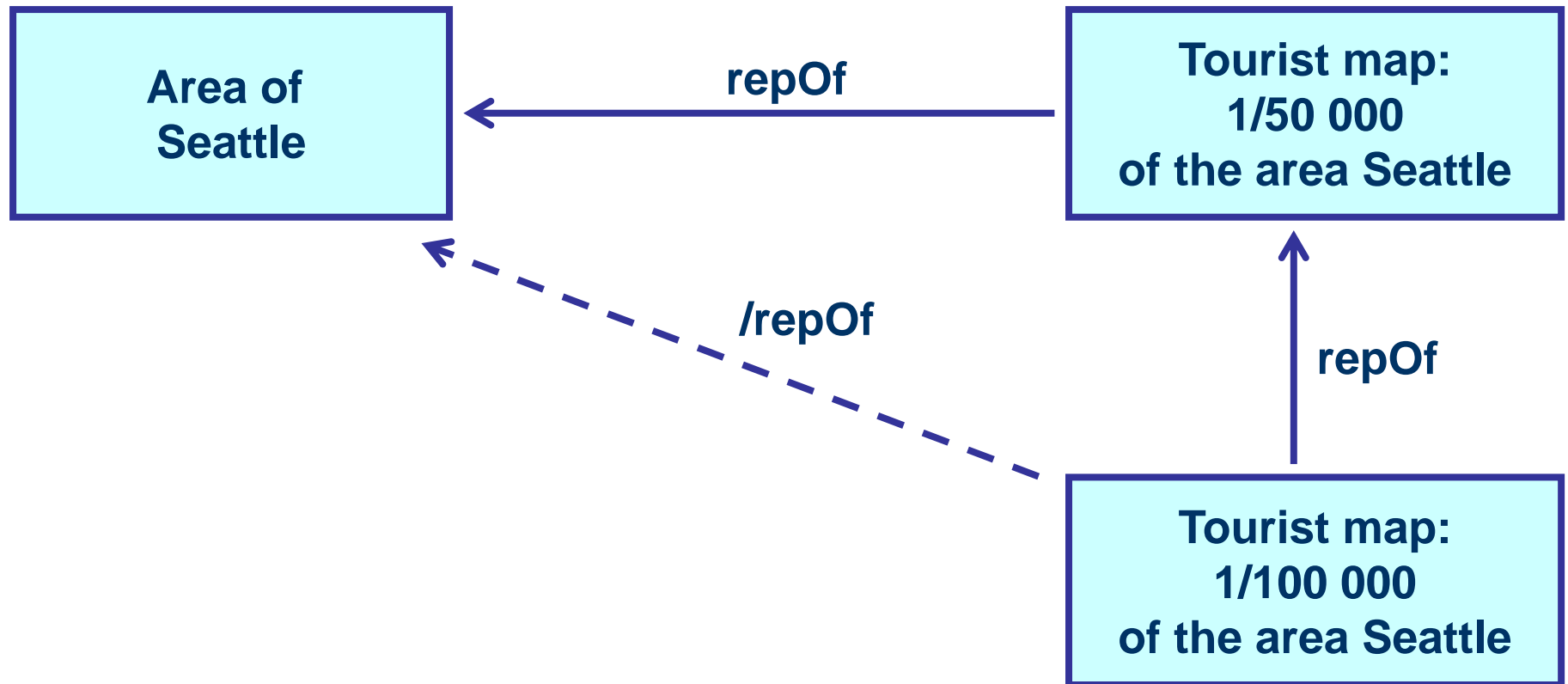


# The legend is a meta-model

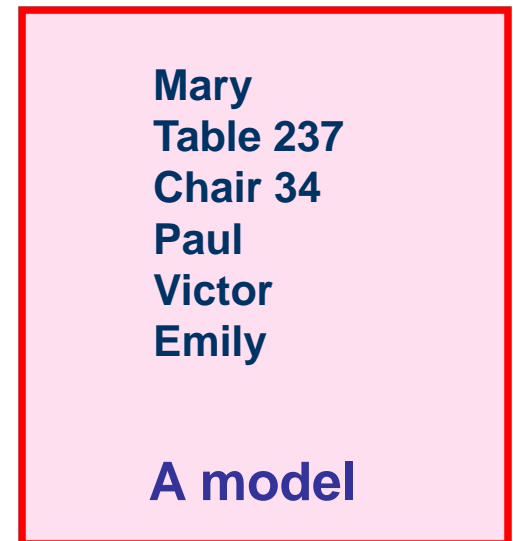
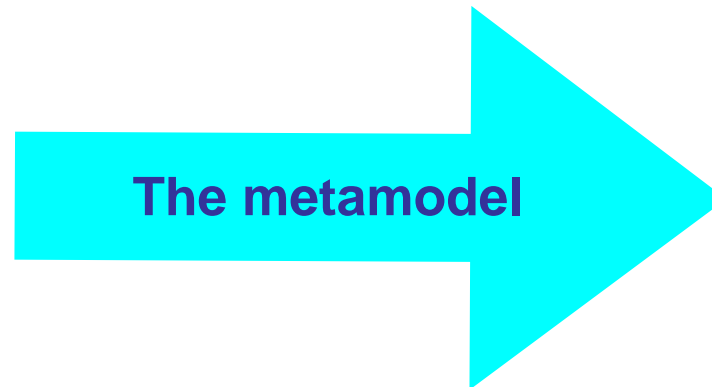
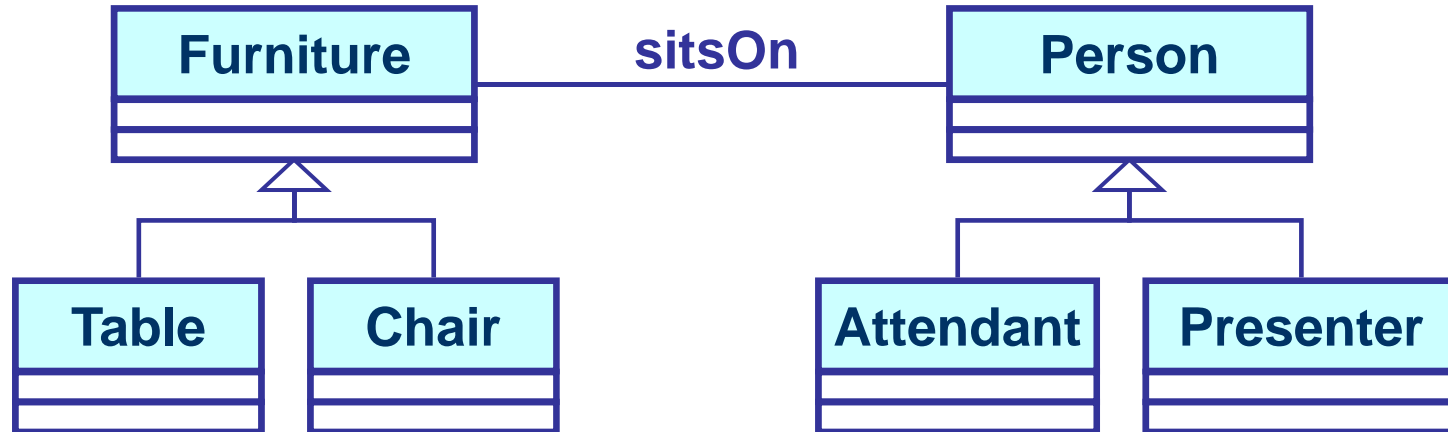




# The model of a model is not a meta-model

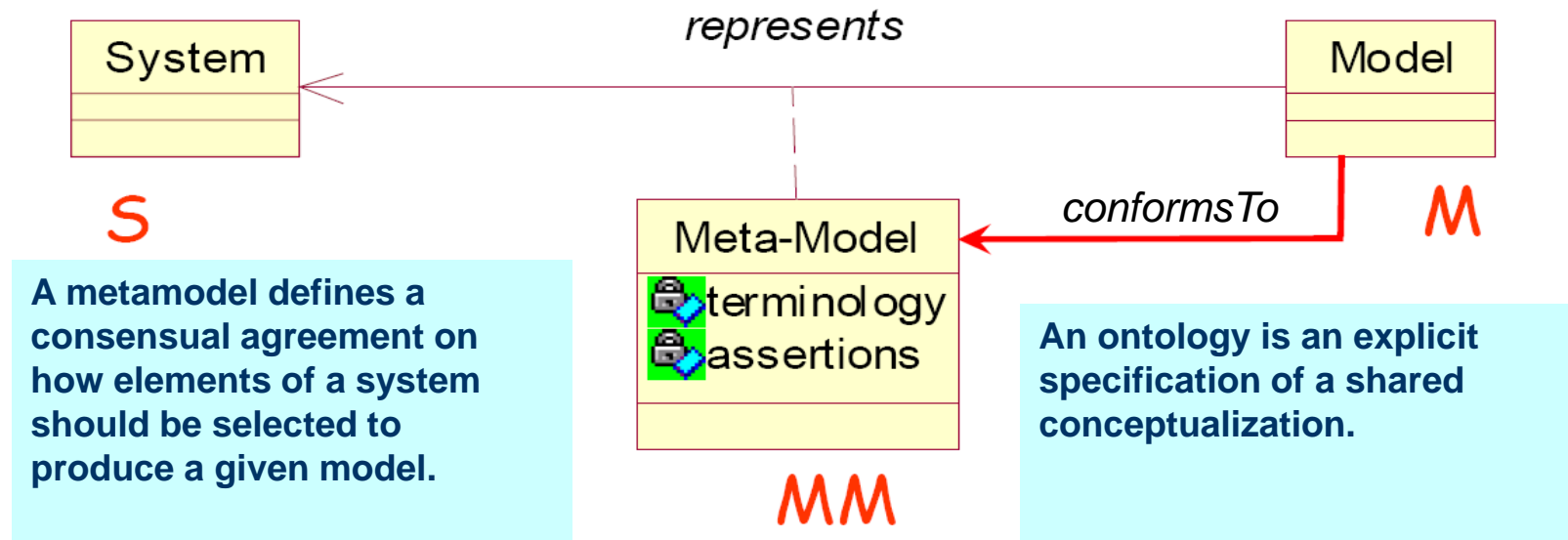


# Meta-models act as filters



# Meta-models as simple ontologies

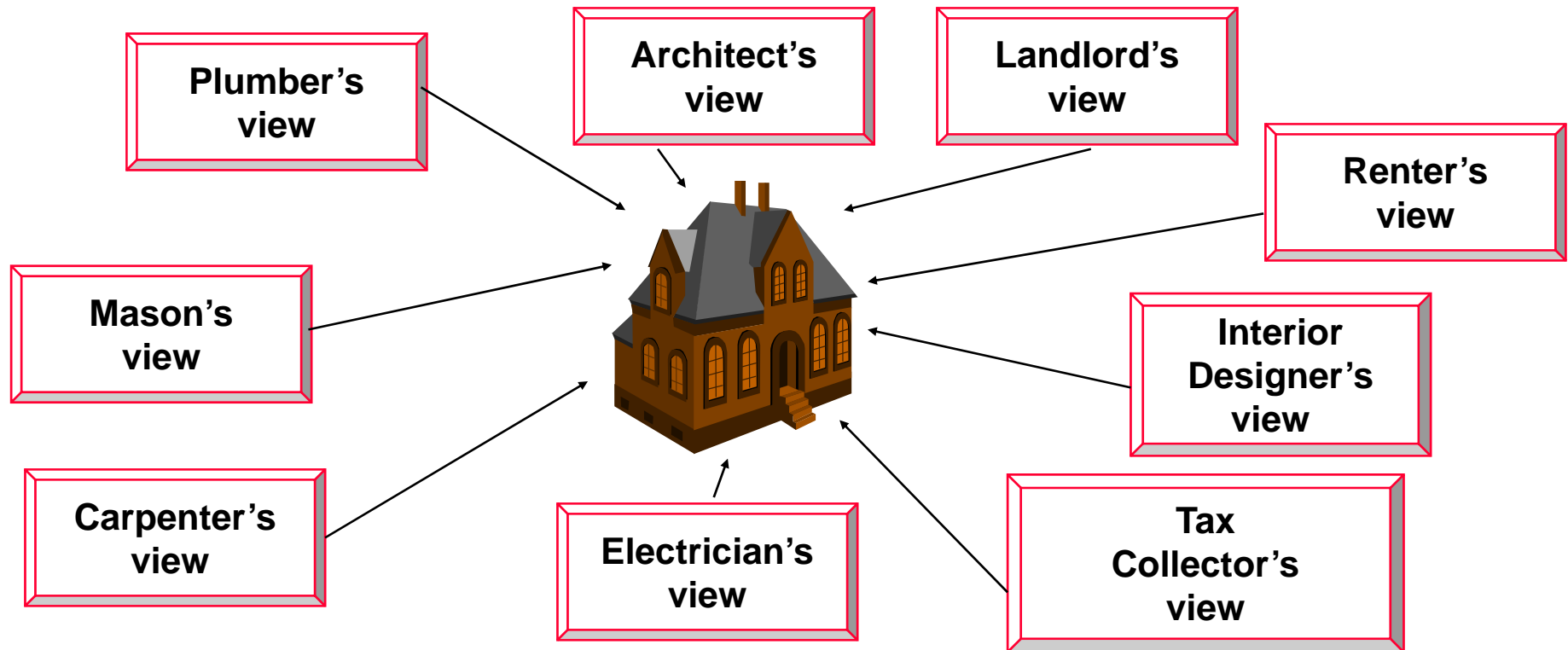
- Meta-models are precise abstraction filters.
- Each meta-model defines a domain-specific language.
- Each meta-model is used to specify which particular “aspect” of a system should be considered to constitute the model.



- The correspondence between a system and a model is precisely and computationally defined by a meta-model.

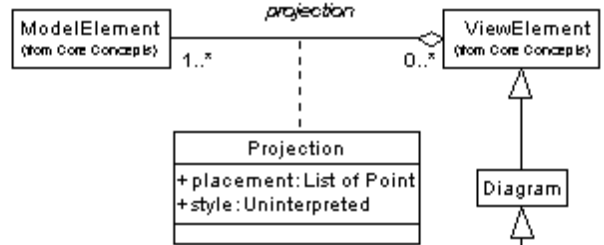
# Multiple views and coordinated DSLs

- 1:1 map vs. blank map
- Limited substitutability principle
- A model has no meaning when separated from its meta-model.

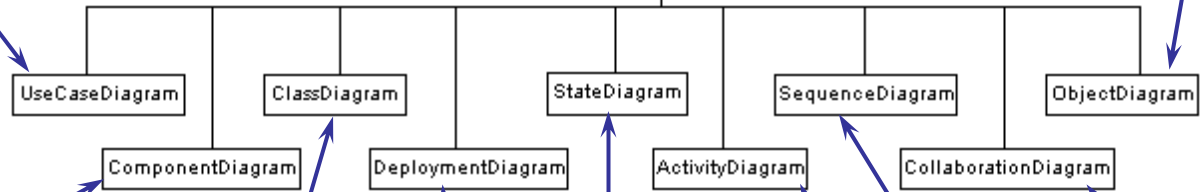


# Multiple views and aspects of a software system

System functions from the user view



Objects and basic relations between these objects



Physical components of an application

Representation of behavior in term of states

Representation of objects, of their mutual links and potential interactions

Schemas of component installation on hardware devices

Representation of objects and their temporal interactions

Class static structure and relations between these classes

Representation of operation behavior in terms of actions



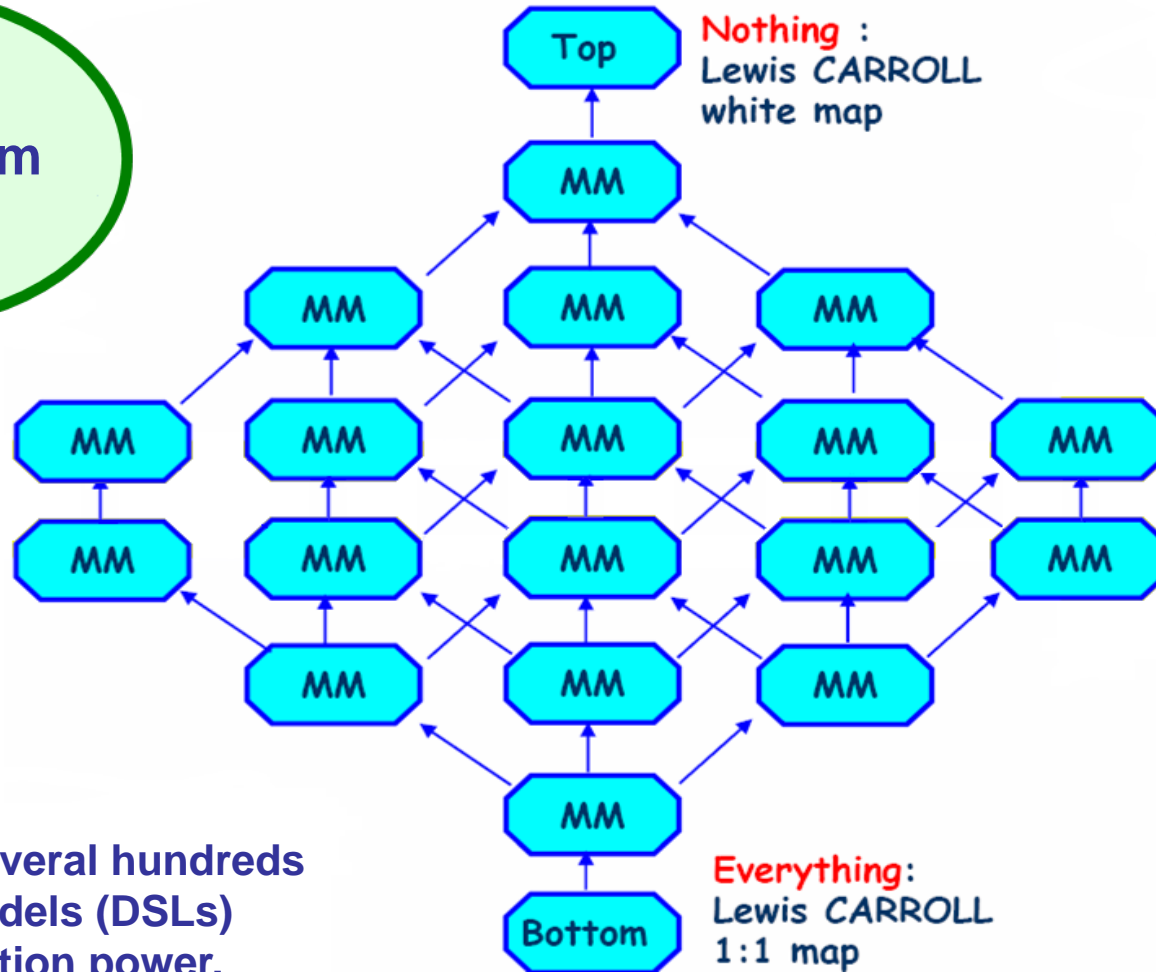
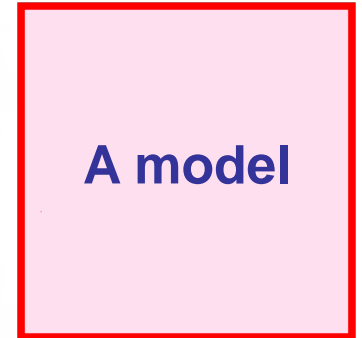
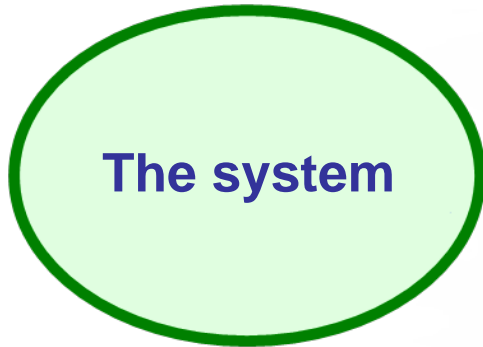


# Meta-models

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- A meta-model is just another model.
  - **Model of a set of models**
- Meta-models are specifications.
  - Models are valid if no false statements according to meta-model (e.g. well-formed)
  - Meta-models typically represent domain-specific models (real-time systems, safety critical systems, e-business)
- The domain of meta-modelling is language definition.
  - A meta-model is a model of some part of a language
  - Which part depends on how the meta-model is to be used
  - Parts: syntax, semantics, views/diagrams, ...
- **Meta-meta-model**
  - Model of meta-models
  - Reflexive meta-models expressed using itself

# A "lattice" of meta-models

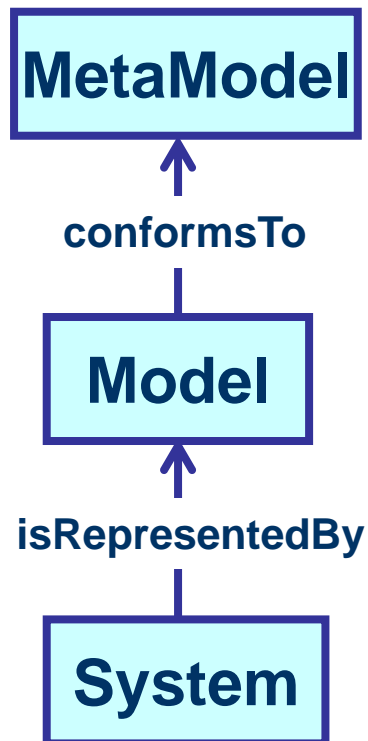


A collection of several hundreds of small meta-models (DSLs) with high abstraction power.

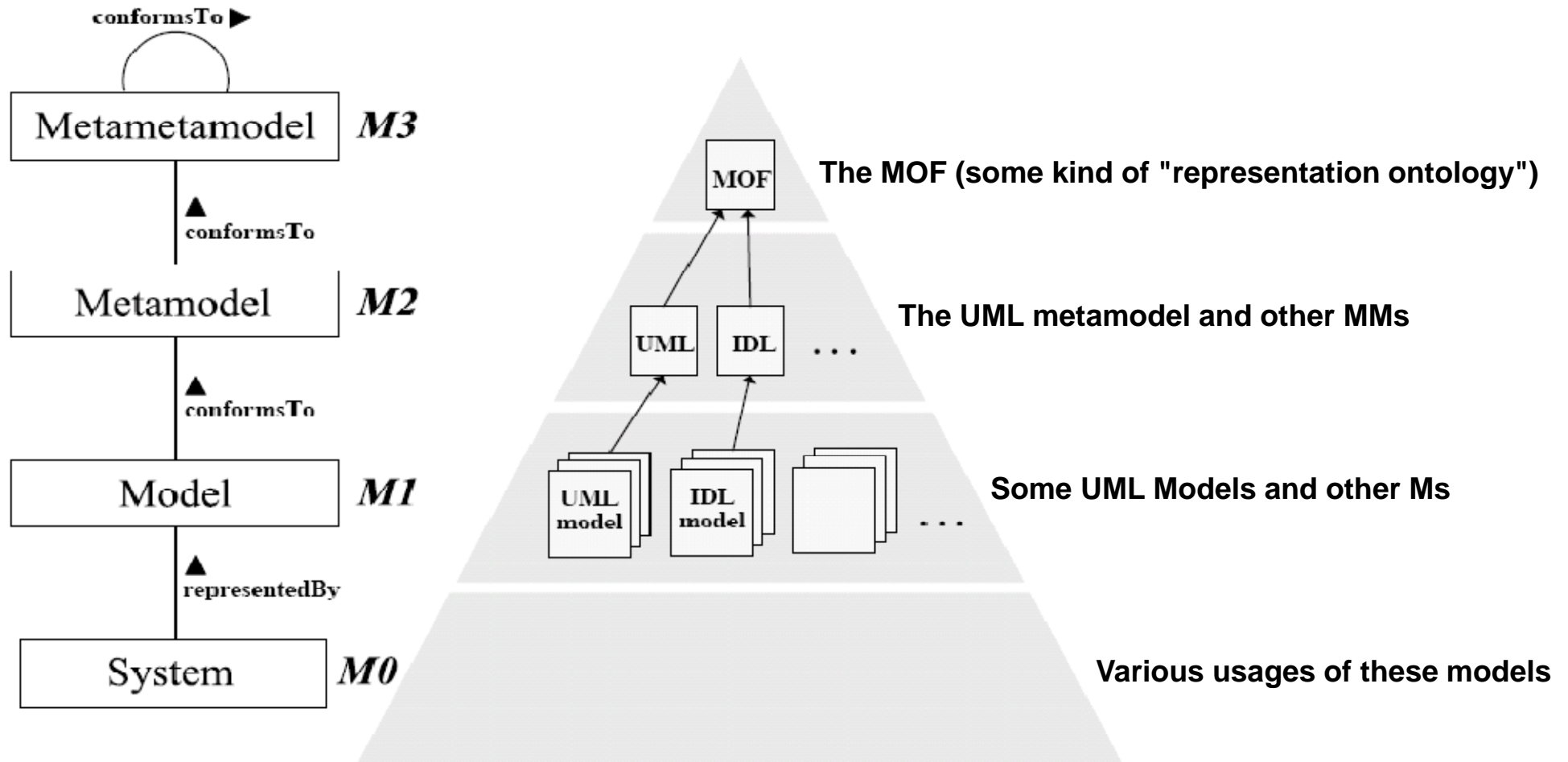


# The basic assumptions of MDE and MDSD

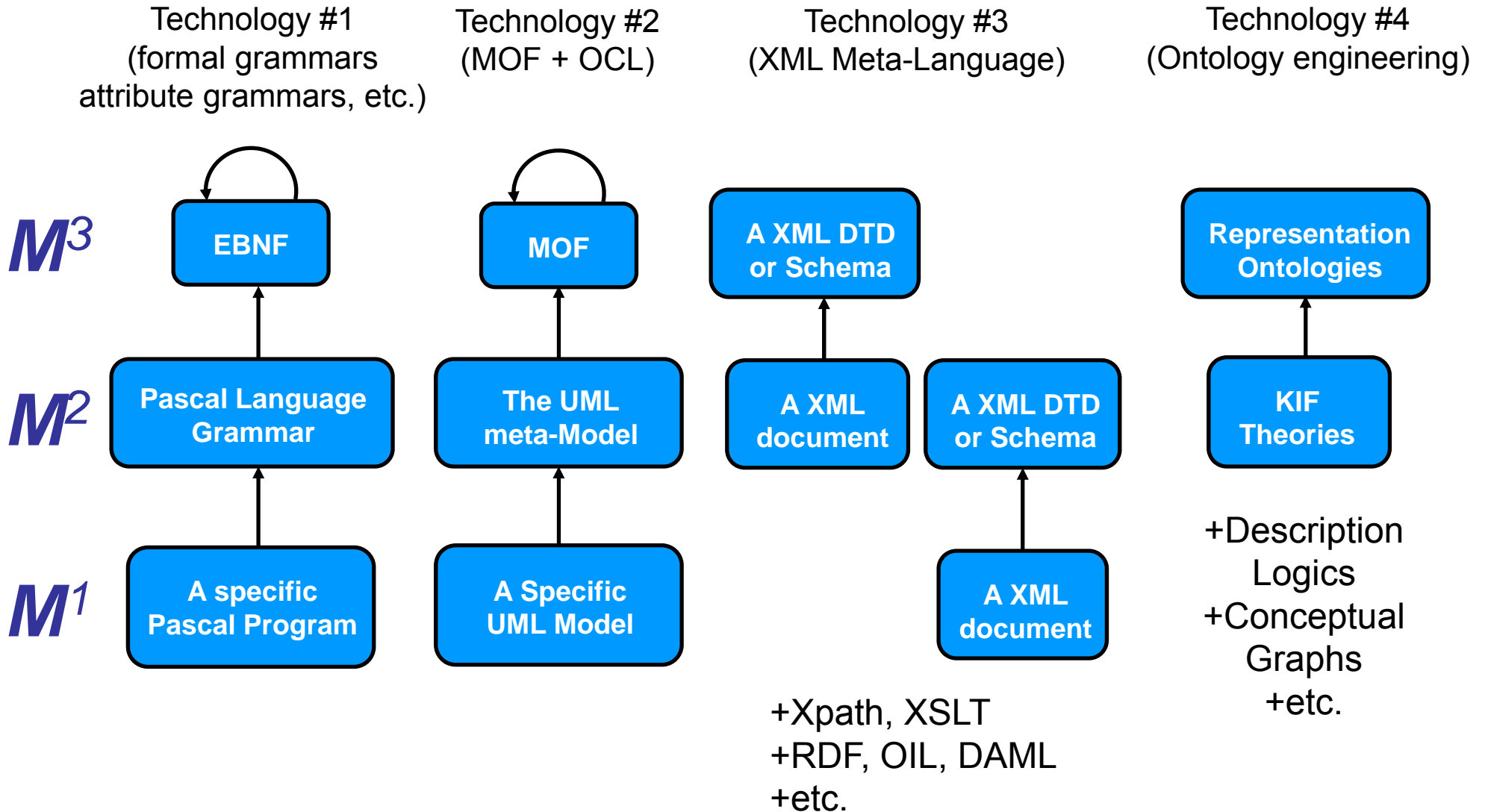
- Models as first class entities
- **Conformance** and **Representation** as kernel relations central to MDE
  - MDSD as a special case of MDE



# Meta-modelling hierarchy or the meta-modelling stack



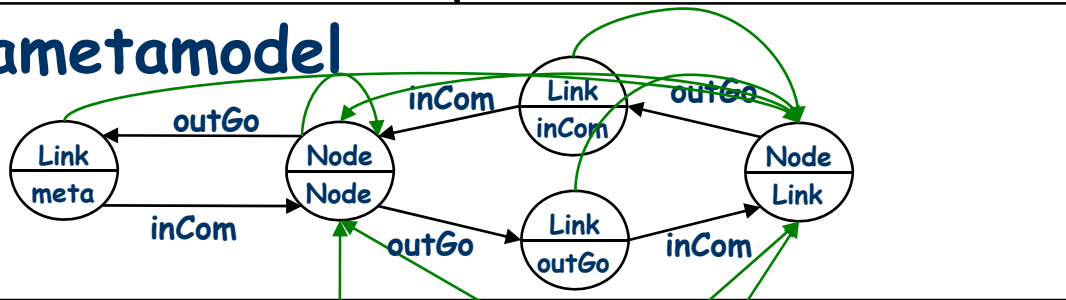
# Abstract Syntax Systems Compared



# Three-level hierarchy: Example — Petri-nets

conformsTo

## Metametamodel

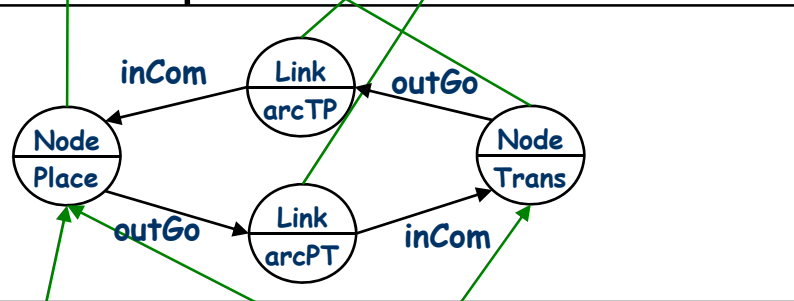


M3



conformsTo

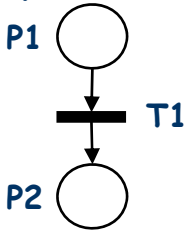
## Metamodel



M2

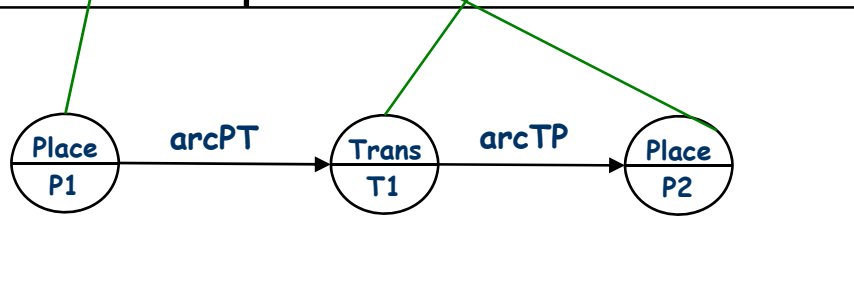
System

Classical representation



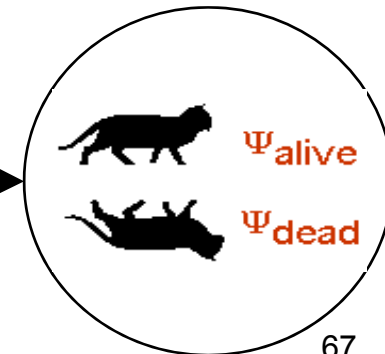
conformsTo

## Model

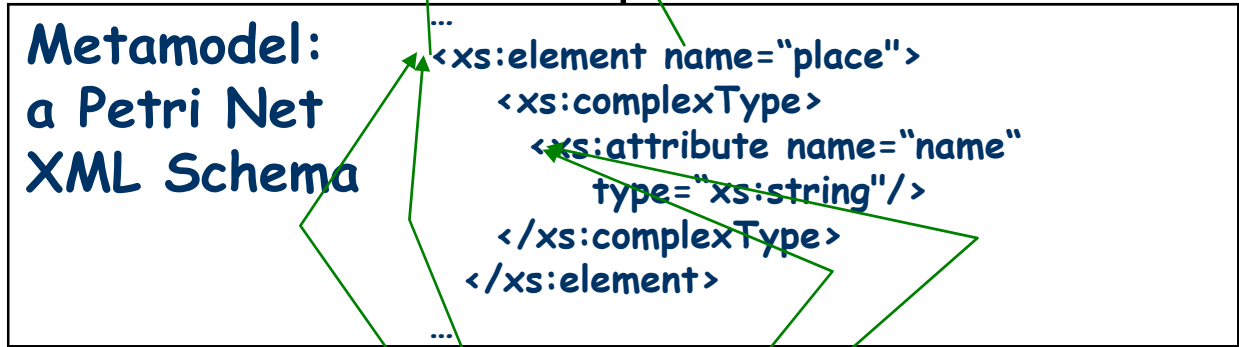
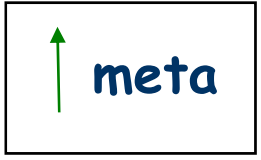
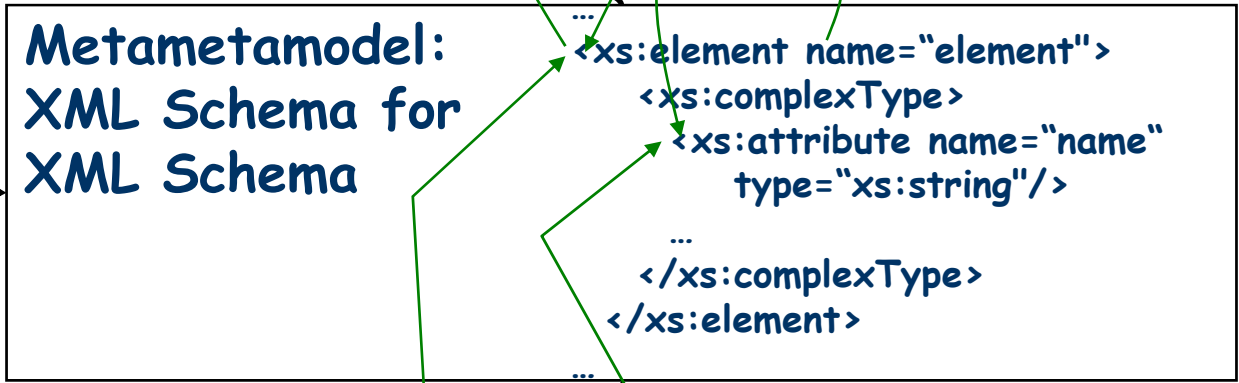


M1

repOf

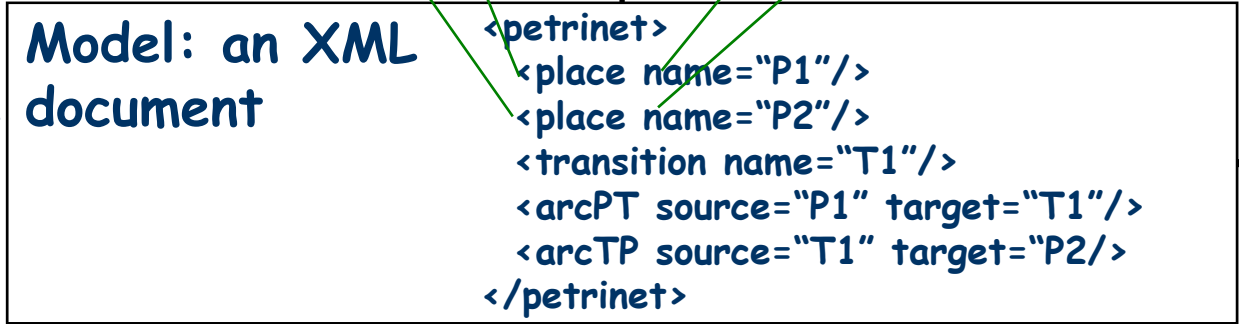
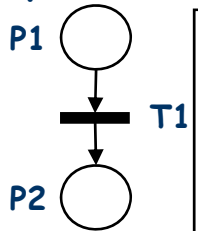


conformsTo

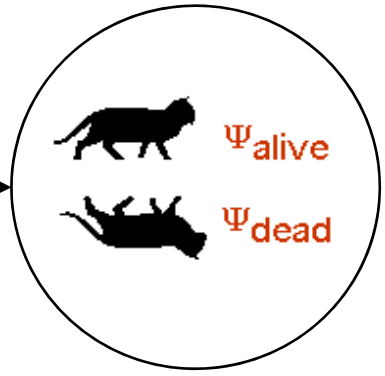


System

Classical representation



repOf



conformsTo

**Metametamodel:  
EBNF grammar  
of EBNF**

```

productionRule := IDENT ":@" seq ";";
seq := alternative seq?;
alternative := rep ("|" alternative)?;
rep := atom ("?" | "*" )?;
atom := terminal | "(" seq ")";
terminal := STRING | IDENT;

```

M3



**Metamodel:  
a Petri Net  
Grammar**

```

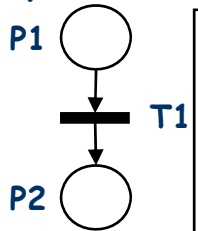
petrinet := "petrinet" "{"
           place* transition*
           arcPT* arcTP* "}";
place := "place" IDENT ";";
transition := "transition" IDENT ";";
arcPT := "arcPT" IDENT "->" IDENT;
arcTP := "arcTP" IDENT "->" IDENT;

```

M2

System

Classical representation



**Model: a string**

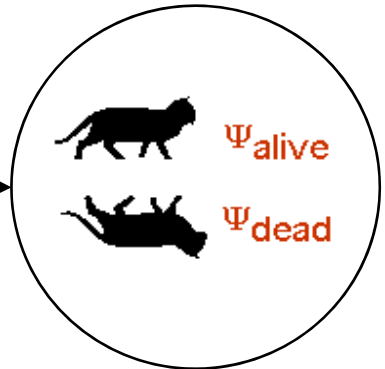
```

petrinet {
  place P1;
  place P2;
  transition T1;
  arcPT P1 -> T1;
  arcTP T1 -> P2;
}

```

M1

repOf

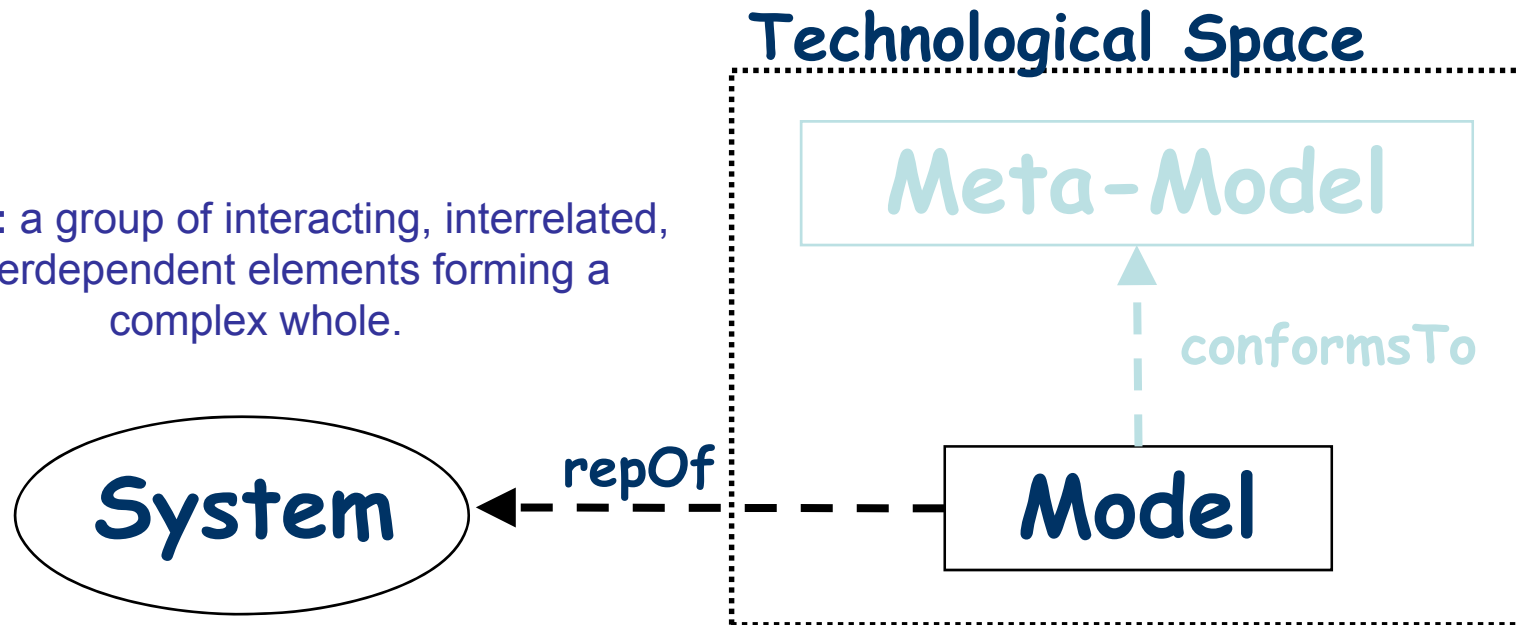




# Basic entities of MDE and MDSD

**Technological Space:** a model management framework usually based on some algebraic structures (trees, graphs, hypergraphs, etc.).

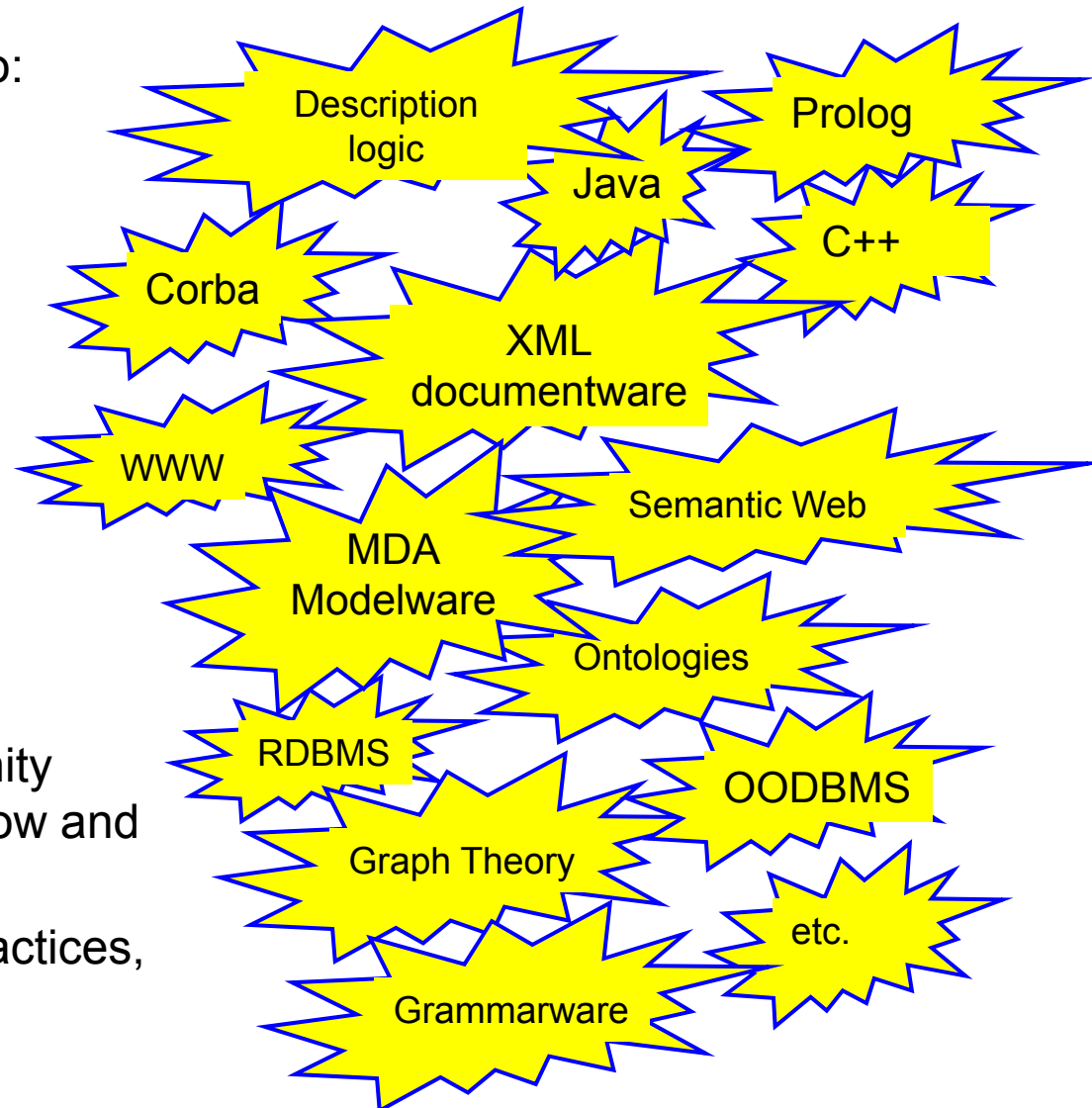
**System:** a group of interacting, interrelated, or interdependent elements forming a complex whole.



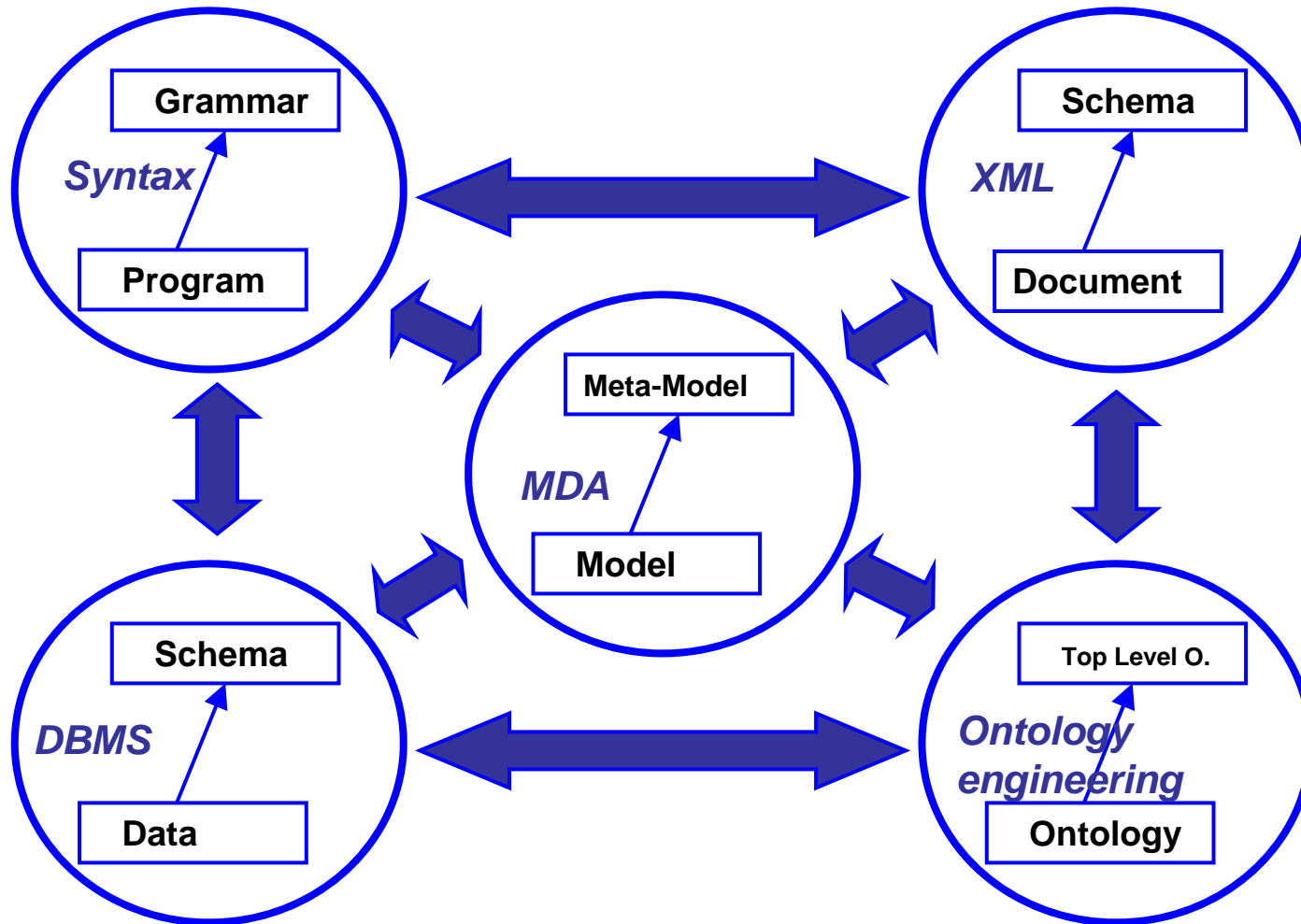
**Model:** an abstract representation of a system created for a specific purpose.

# The notion of Technological Space (TS)

- A Technological Space corresponds to:
  - A **uniform representation system**
    - Syntactic trees
    - XML trees
    - Sowa graphs
    - UML graphs
    - MOF graphs
  - A **working context**
  - A **set of concepts**
  - A **set of methods**
  - A **shared knowledge and know-how**
  - etc.
- It is usually related to a given community with an established expertise, know-how and research problems.
- It has a set of associated tools and practices, etc.
  - Protégé, Rational Rose, ...



# Main Technological Spaces



TS's may be connected via **bridges**