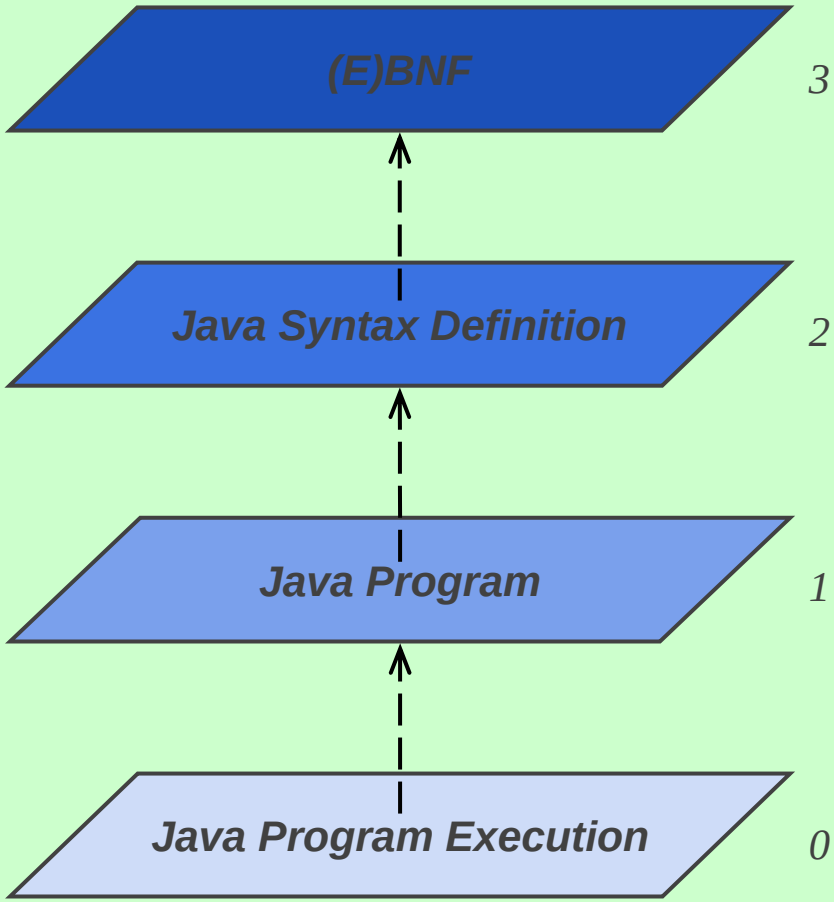
Bits and Pieces about Metamodeling

Thomas Kühne
Victoria University of Wellington

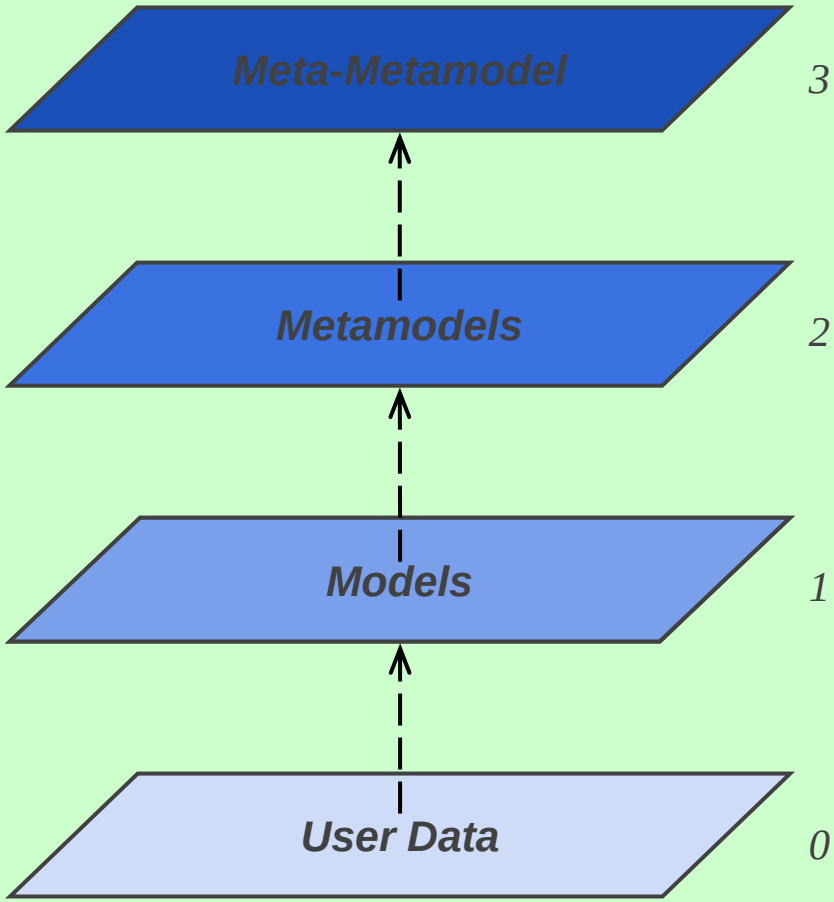
(E)BNF as a Metalanguage



- Level transitions 1→2 and 2→3 are of the same kind
- Level transition 0→1 can be also regarded as “described by”, but is different in nature

CDIF (case data interchange format)

inspired by IRDS (Information Resource Dictionary System)



CDIF is not concerned about the ‚0‘ layer which would be the result of instantiating a model

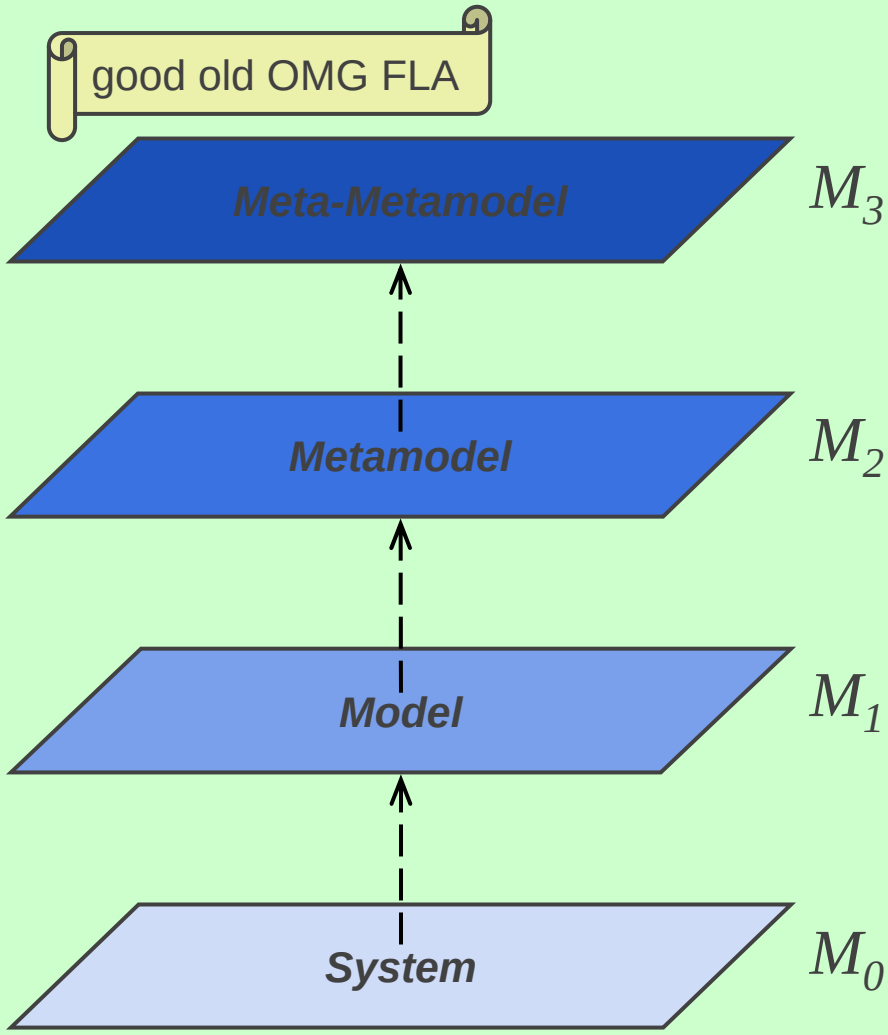
→ three level architecture

Four Layer Architecture

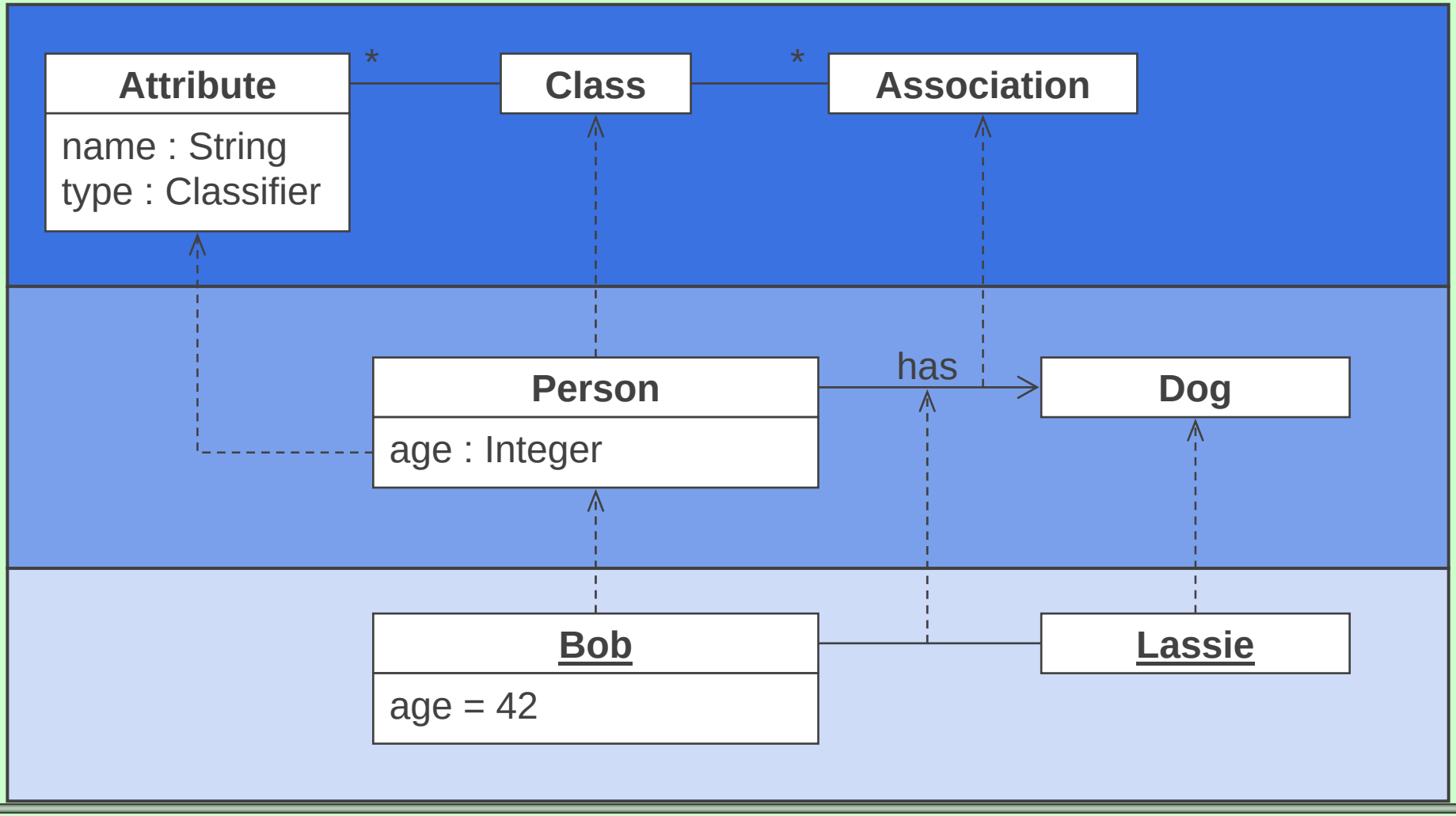
Layer	Description	Example
Meta Meta Model	Defines the core ingredients sufficient for defining languages for specifying meta-models	(CDIF) MetaEntity, MetaAttribute (MOF) Class, MofAttribute
Meta Model	Defines a language for specifying Models	(UML) Class, Attribute, Association (Database) Table, Column, Row
Model	Defines a language to describe an information domain.	Student, Course, enrolledin
User Objects	Describes a specific situation in an information domain.	Student#3, Course#5, Student#3.enrolledin.Course#5

Four Layer Architecture

- MOF
  - » defines language for formulating metamodels with
- UML, CWM, ...
  - » languages for creating user models
- User Models
  - » describing the system
- Systems
  - » user objects

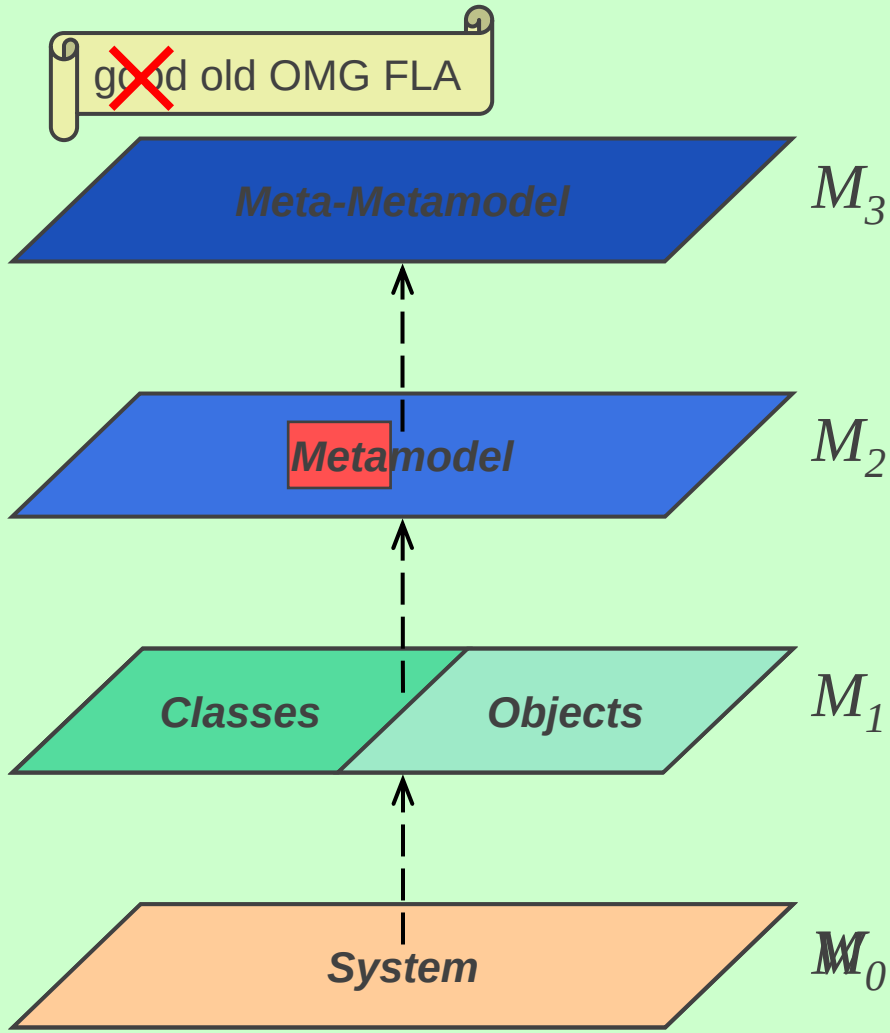


UML Metamodeling

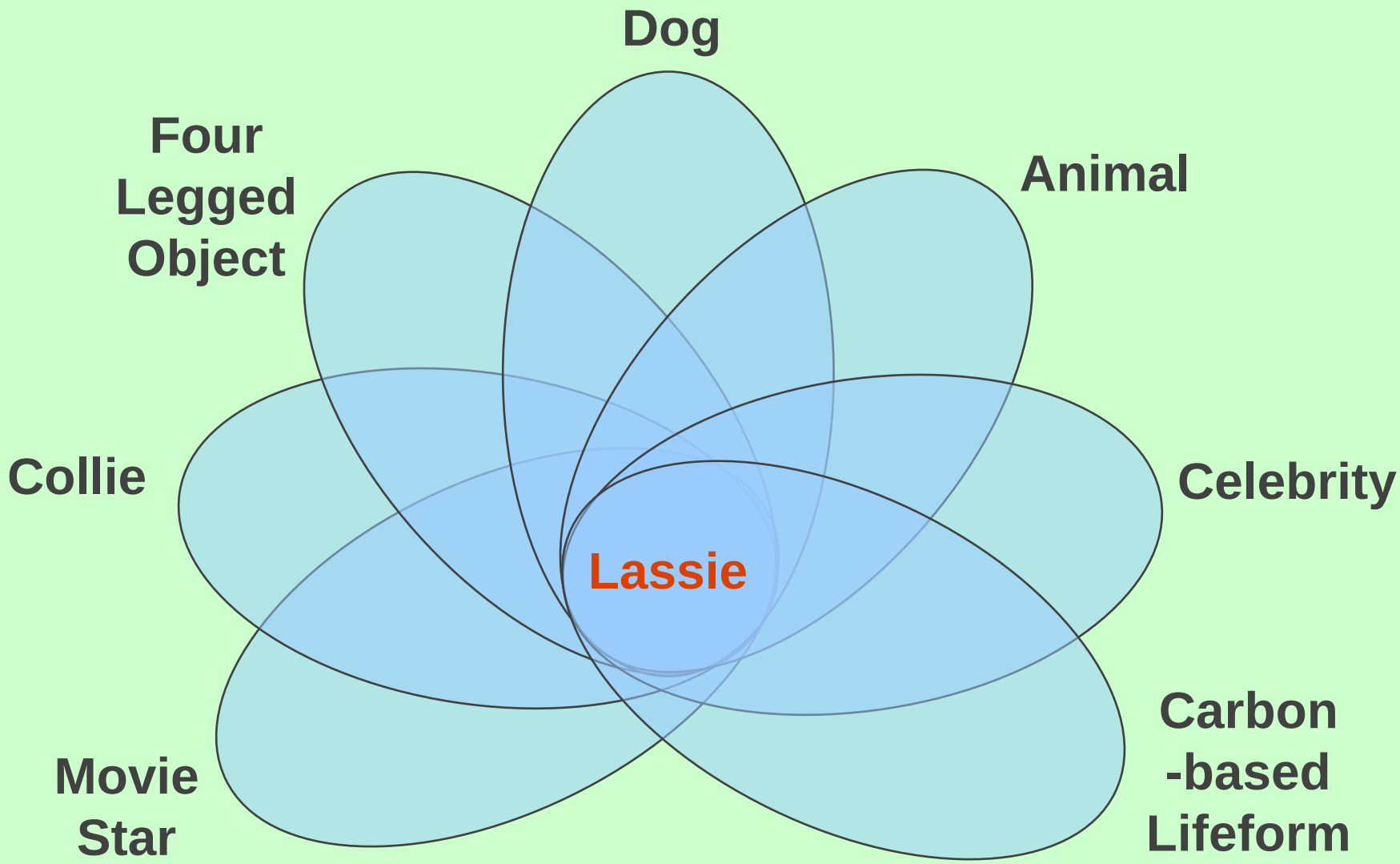


Four Layer Architecture

- MOF
  - » defines language for formulating metamodels with
- UML, CWM, ...
  - » languages for creating user models
- User Models
  - » describing the system
- Systems
  - » modeling target / user domain



What's the Meta?



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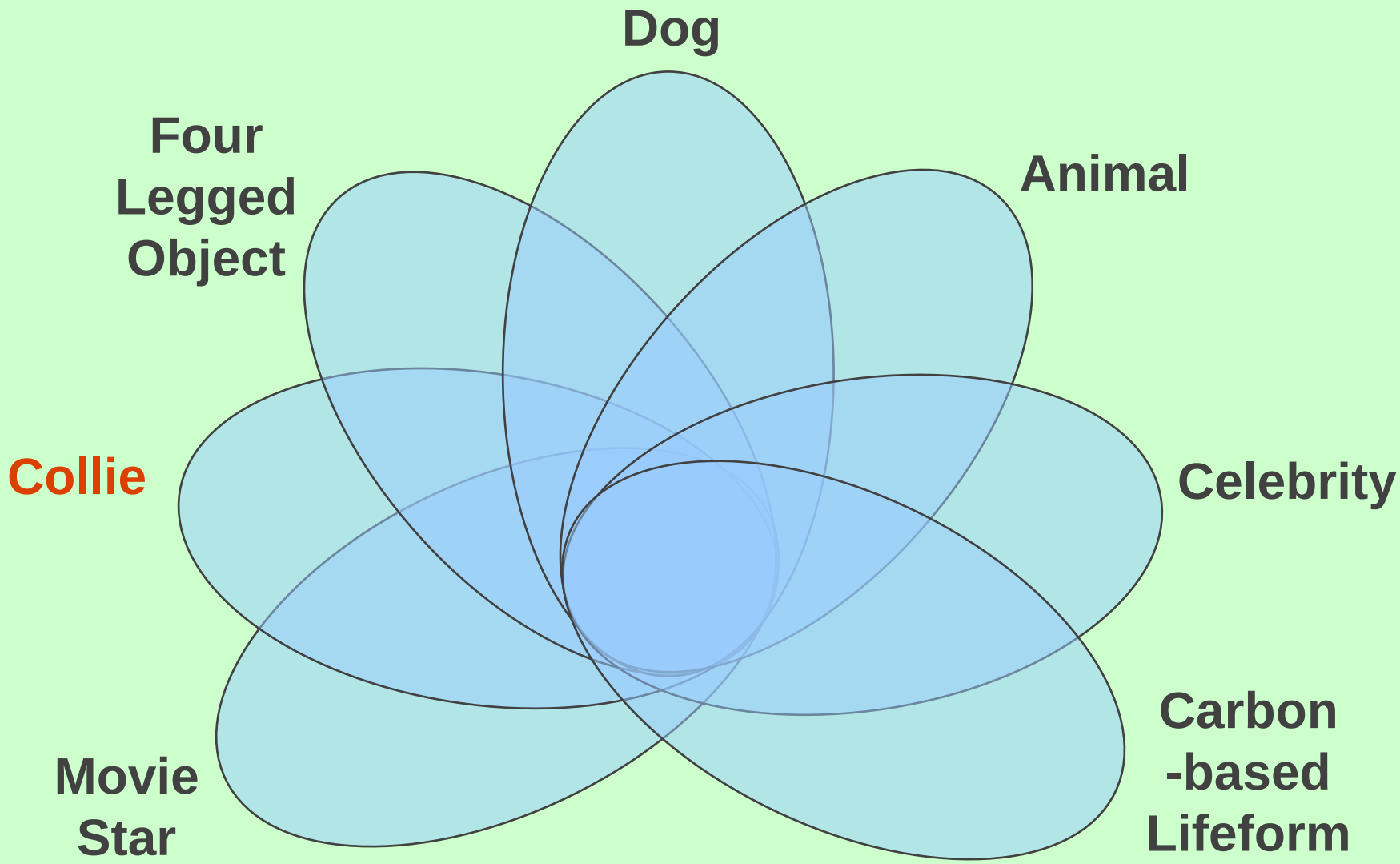

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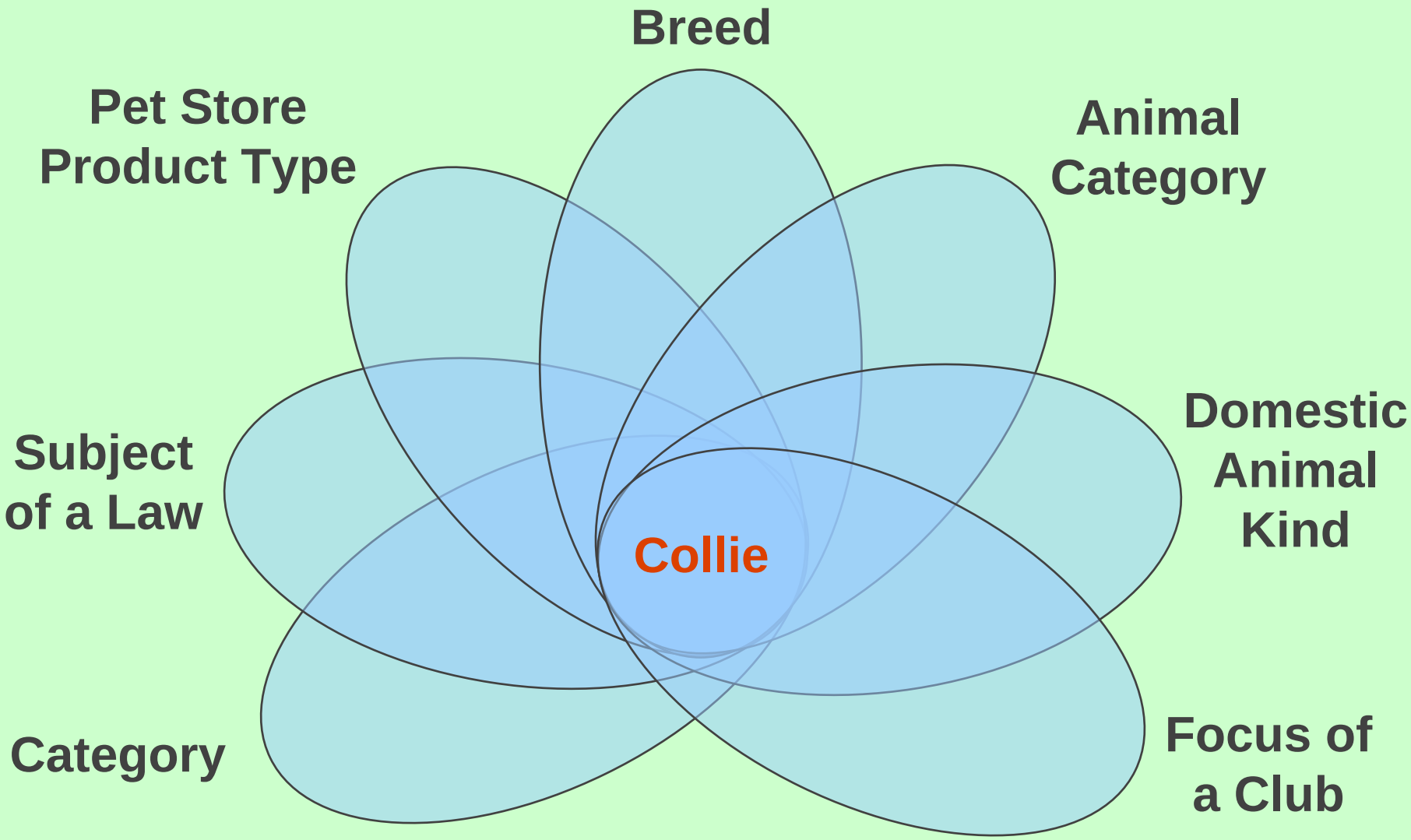

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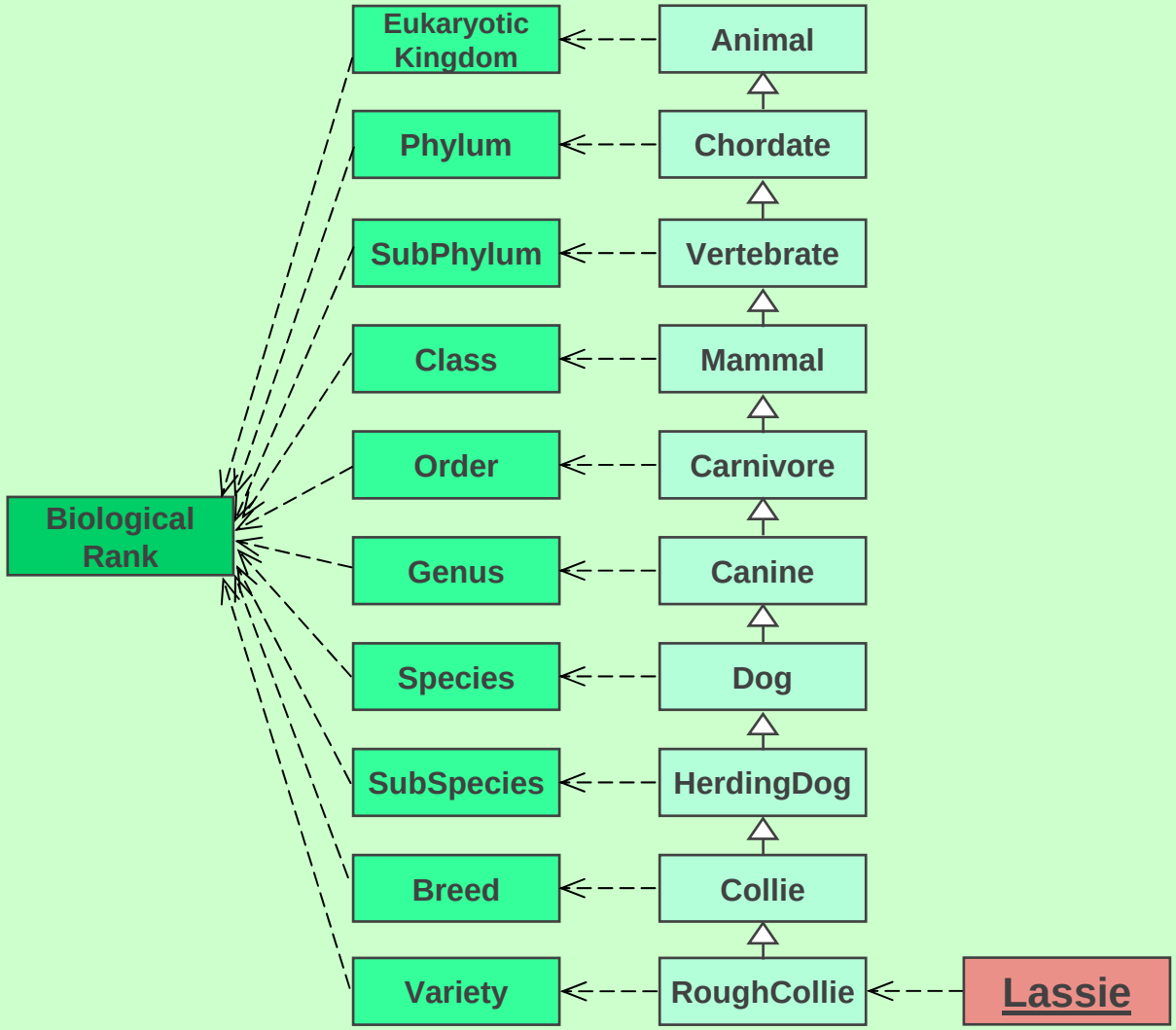
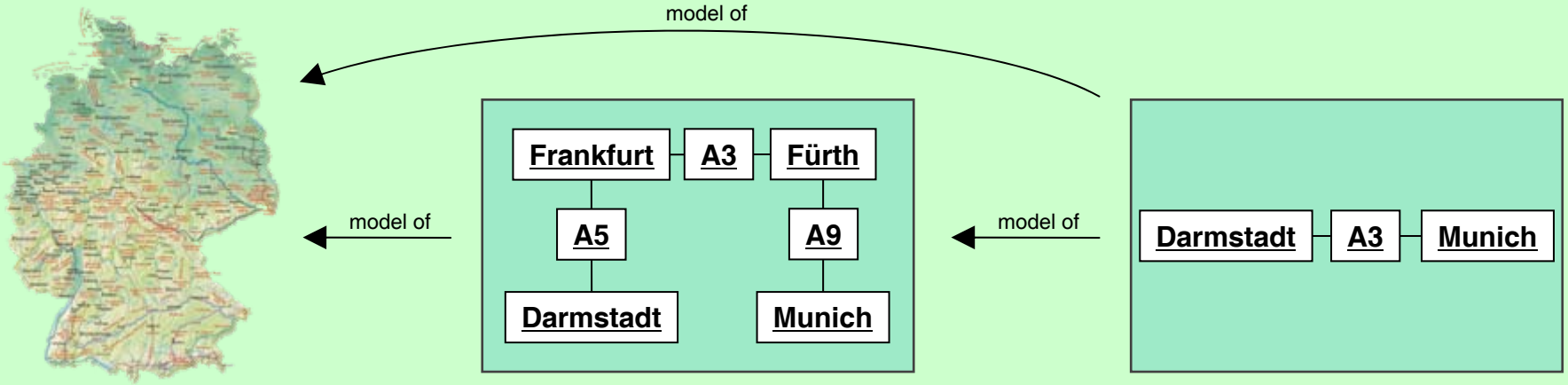


Models & Metamodels

- When is a model a metamodel?
  - » metamodel = model of a model?



- anti-transitivity required

Models & Metamodels

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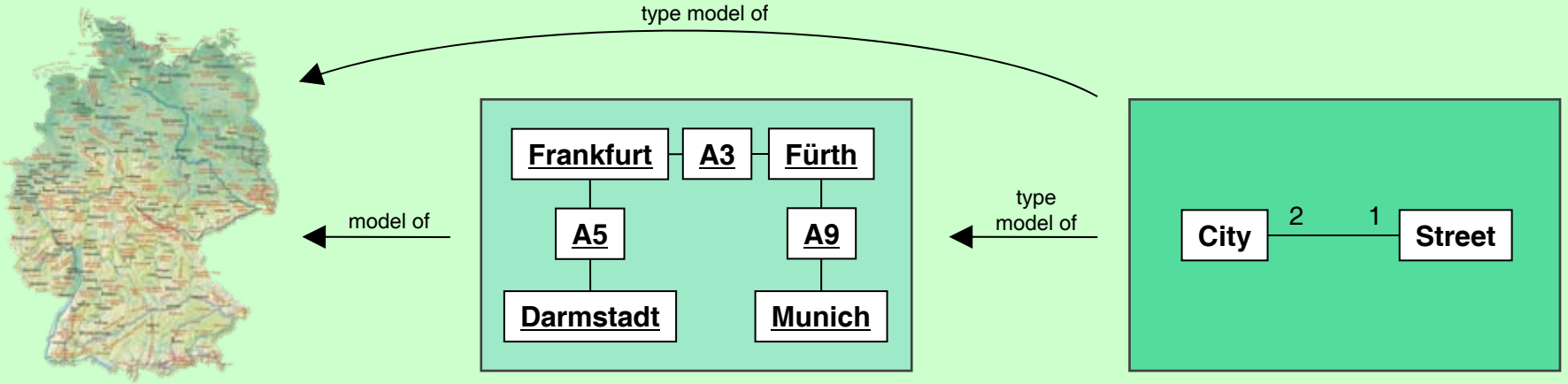

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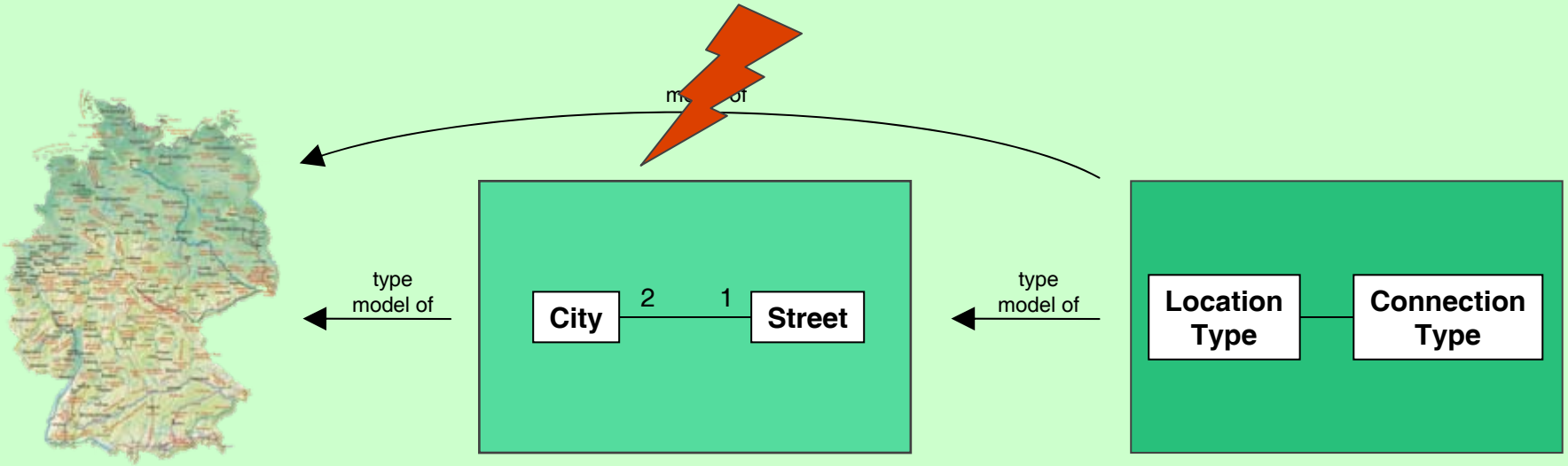

- anti-transitivity through double classification

Models & Metamodels

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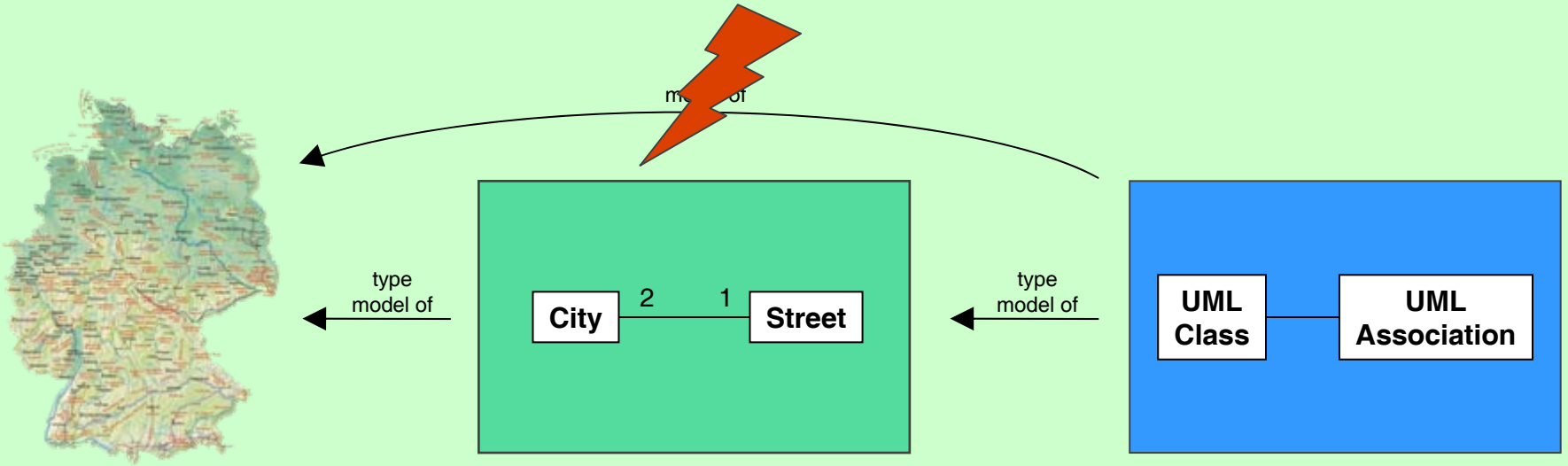

- anti-transitivity through linguistic types

Models & Metamodels

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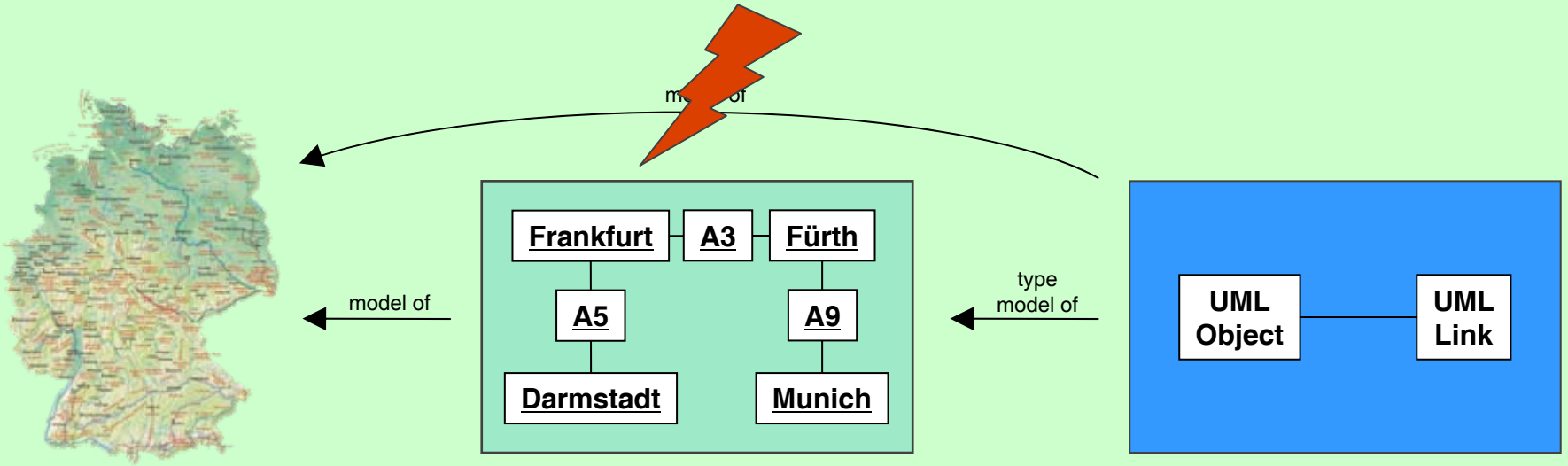

- anti-transitivity through linguistic types

Meta-Relation Requirements

- a relation R is capable of erecting meta-hierarchies, if it has the following properties
  - » irreflexive $\neg\exists e : e \, R \, e$
  - » anti-cyclic $\forall n, m, e_1, e_2 : e_1 \, R^n \, e_2 \rightarrow \neg \, (e_2 \, R^m \, e_1)$
  - » anti-transitive $\forall n \geq 2 : R^n \cap R = \emptyset$
  - » level-respecting $(\exists \, e_1, e_2, n, m : e_1 \, R^n \, e_2 \wedge e_1 \, R^m \, e_2) \rightarrow n=m$

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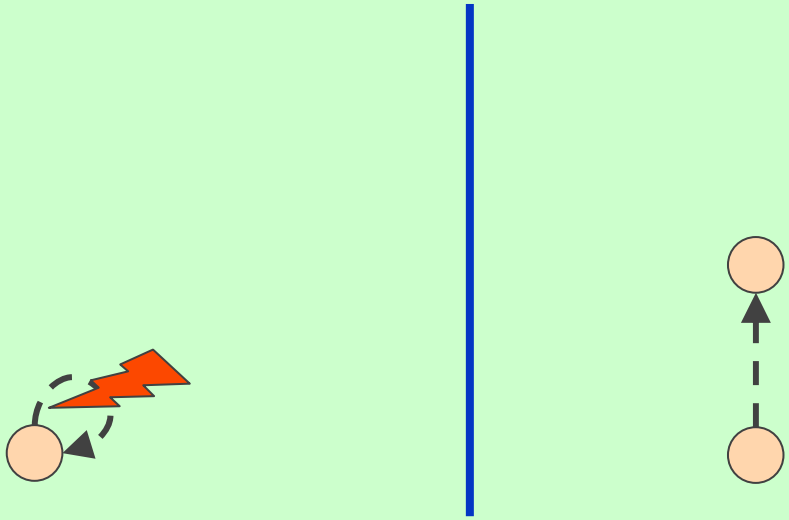

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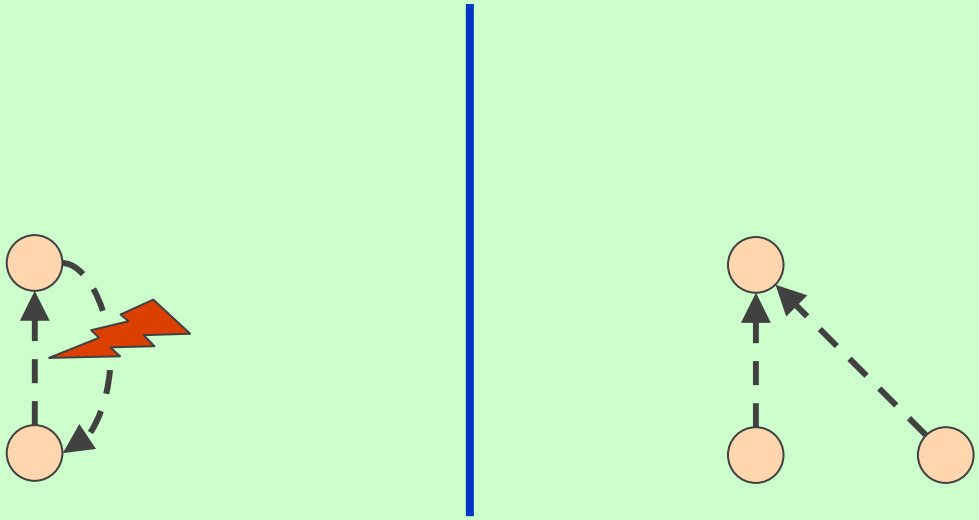

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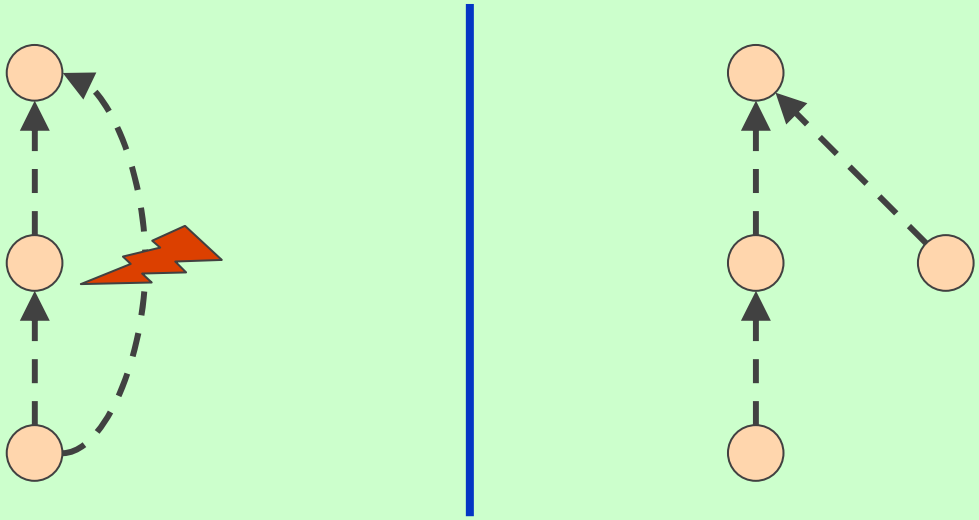

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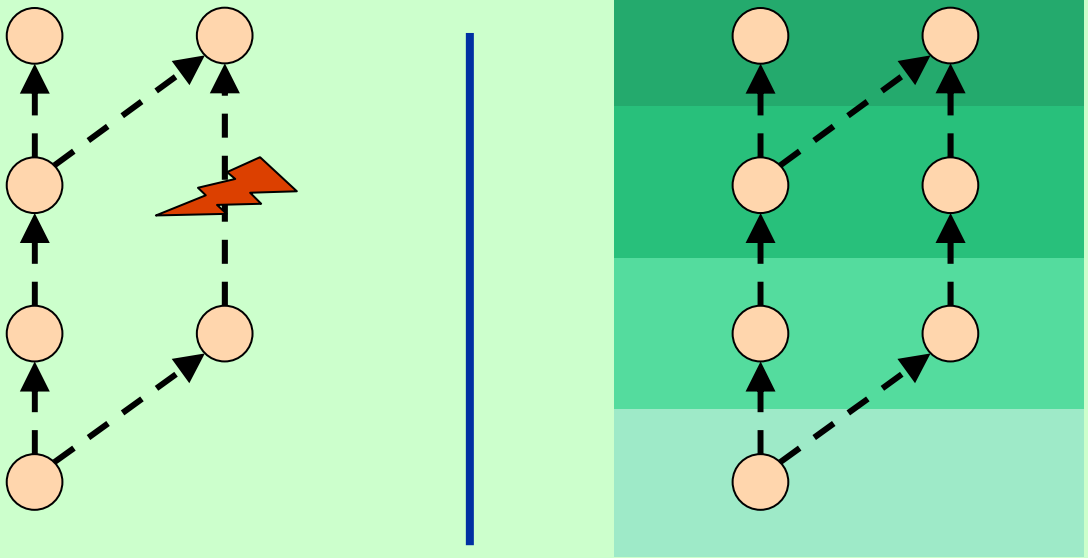

Syllogisms

Man is a Mammal
Aristotle is a Man

Aristotle is a Mammal

Sillygisms

Man is a Mammal
Aristotle is a Man

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Sillygisms

Man is a Mammal
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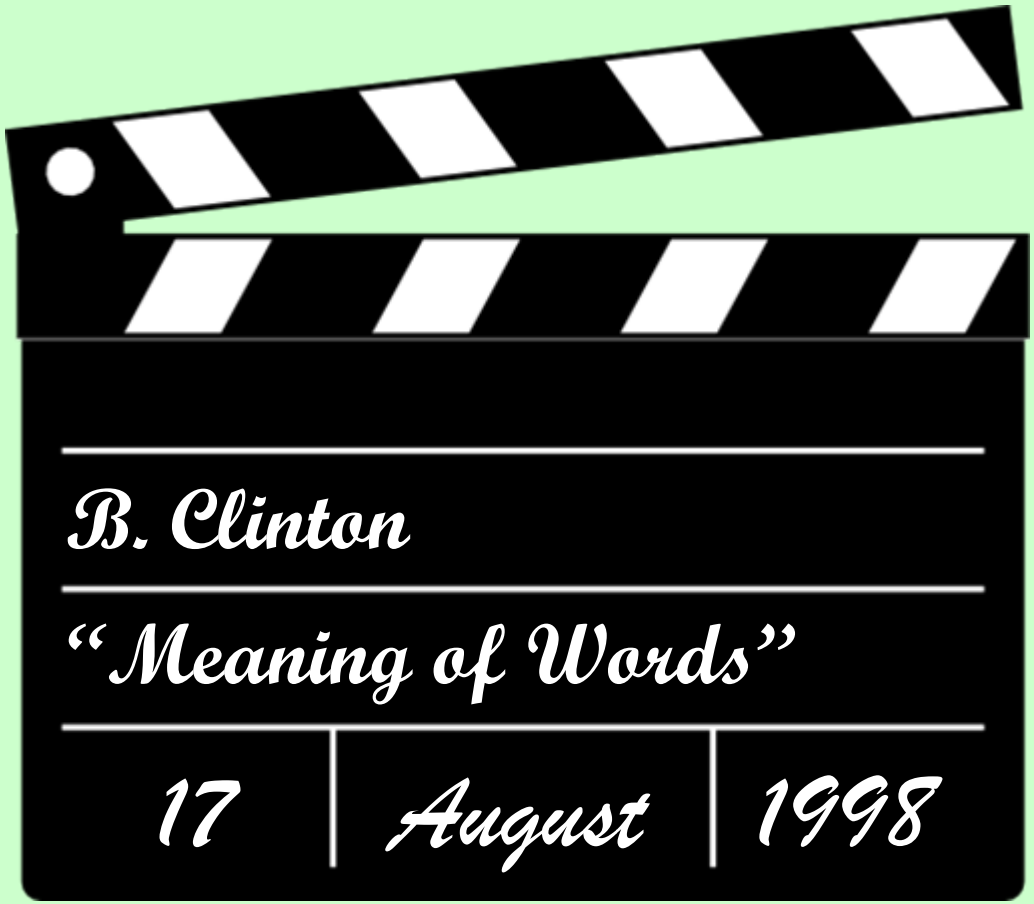
Man is a Species
Aristotle is a Man

Aristotle is a Species

Expert Opinion



Expert Opinion

It depends upon what the meaning of the word "is" is.

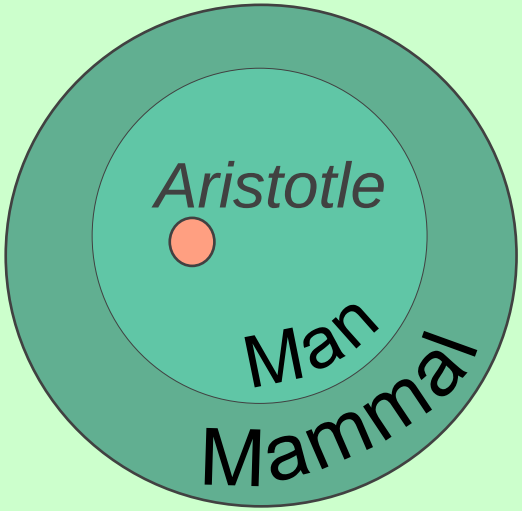
– Bill Clinton

Expert Opinion

It depends upon what the meaning of "is a" is.

The Meaning of "Is A"

Generalisation

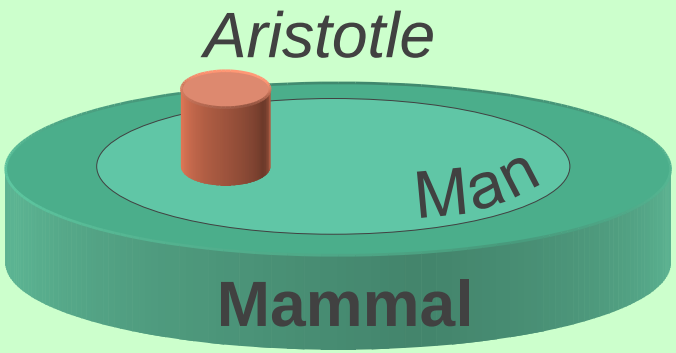


Man is a Mammal

Classification

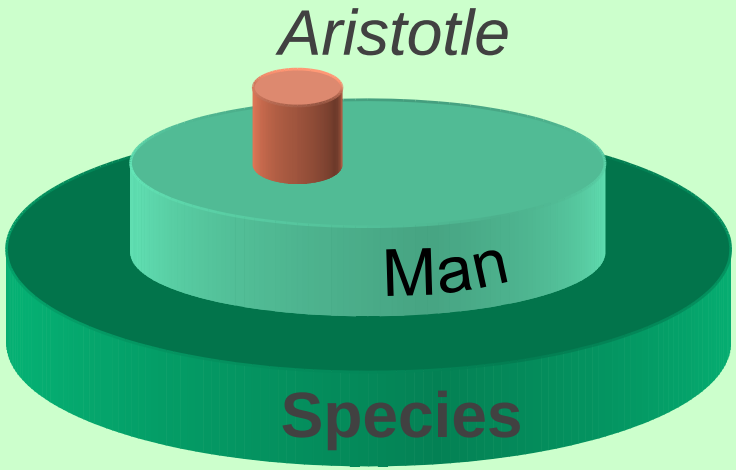
The Meaning of "Is A"

Generalisation



Man is a subset of Mammal

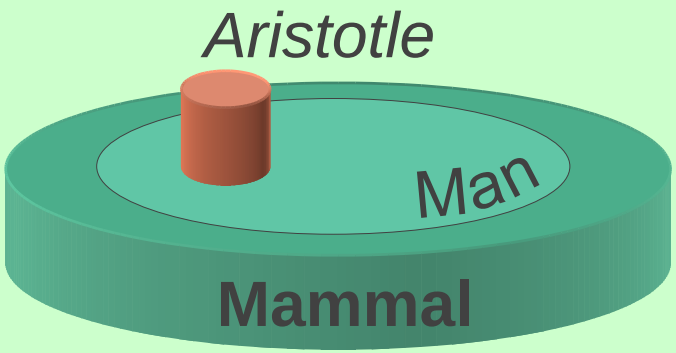
Classification



Man is a Species

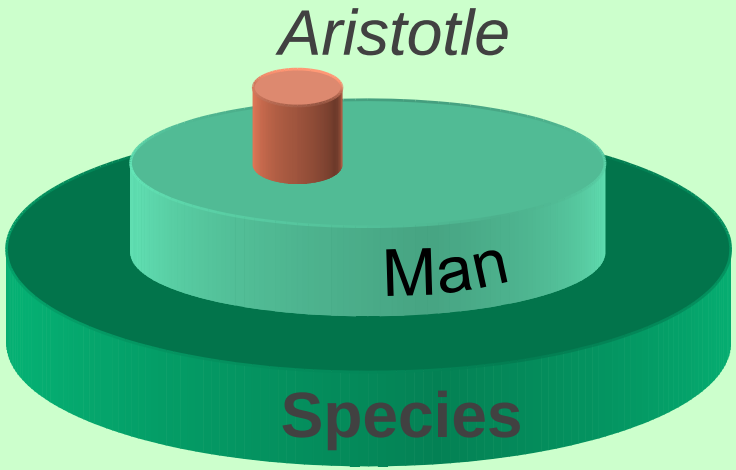
The Meaning of "Is A"

Generalisation



Man ⊆ Mammal

Classification



Man ∈ Species

Sillygisms

Man is a Mammal
Aristotle is a Man

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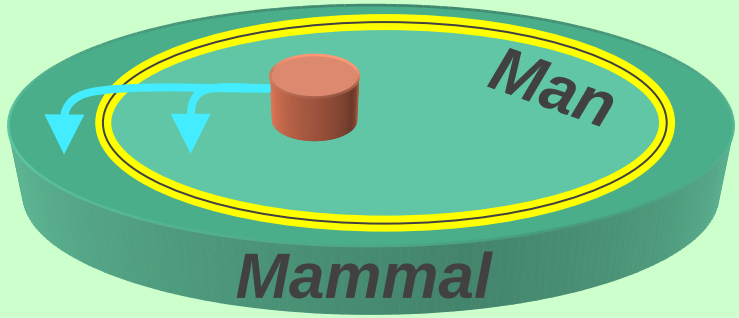

Man is a Species
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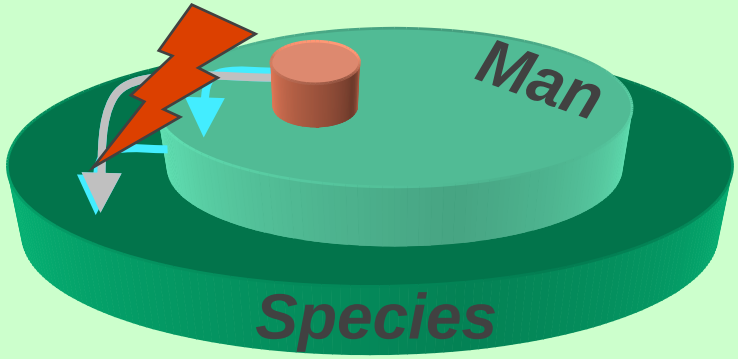
Aristotle is a Species



Alloy Quiz

Aristotle **in** Mammal

refers to an instance

refers to a set

Question

- does **in** refer to $\subseteq$ or to $\in$ ✓

Alloy Quiz

Aristotle **in** Mammal

Man **in** Mammal

refers to a subset

refers to a set

Question

- does refer to or to **in**
  - $\subseteq$ ✓
  - $\in$ ✓

Alloy Quiz

Aristotle **in** Mammal

Man **in** Mammal

Question

- does **in** refer to $\subseteq$ ✓ or to $\in$ ✓

refers to a subset

refers to a set

Set membership and subsets are both denoted ***`in`***.

Alloy Analyzer Tutorial 2008

Alloy Quiz

Aristotle **in** Mammal

Man **in** Mammal

Question

- is this a good idea?

Set membership and subsets are both denoted ***`in`***`.`

Alloy Analyzer Tutorial 2008

Alloy Quiz

Aristotle **in** Mammal

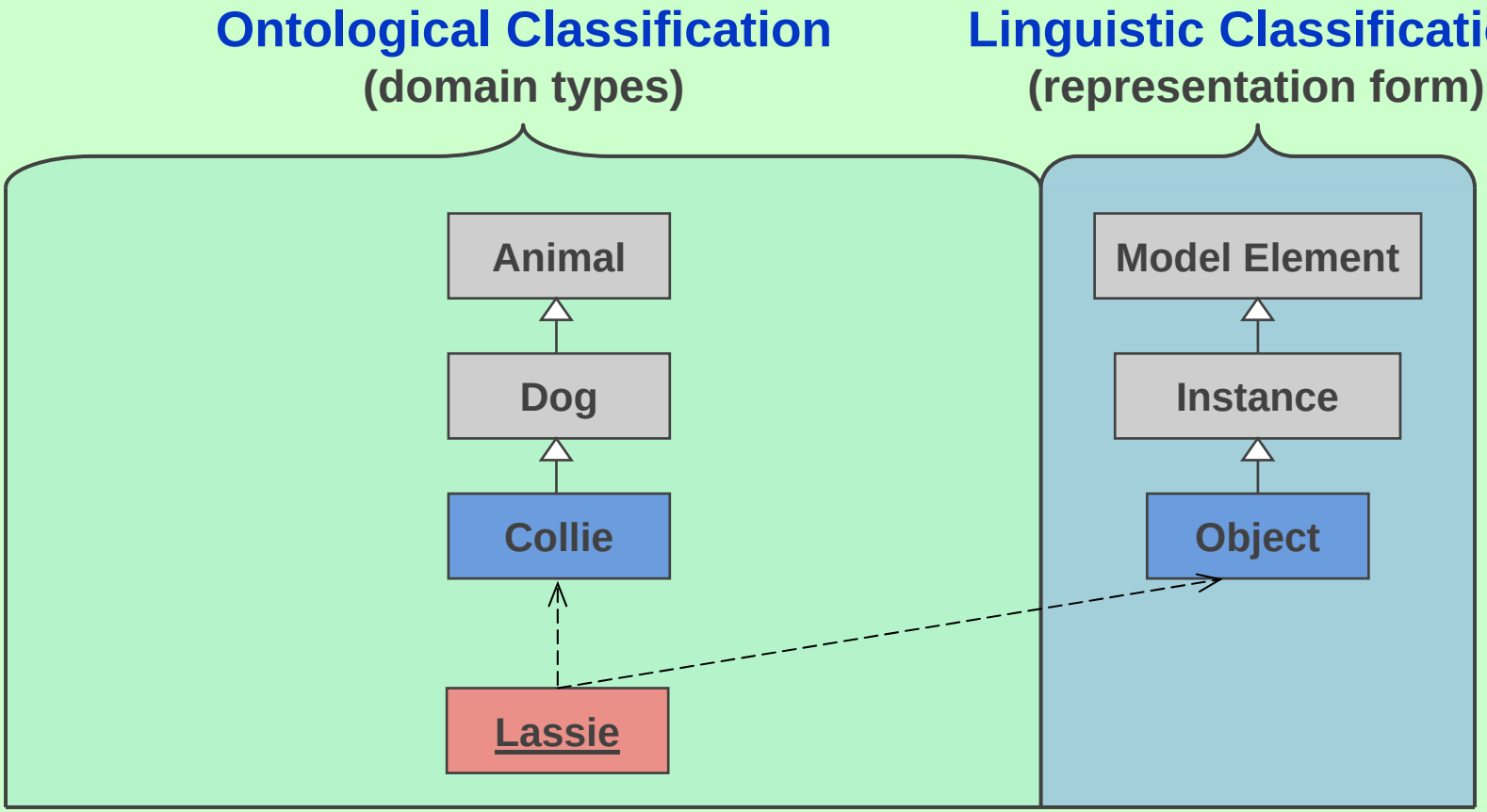
Man **in** Mammal

Set membership and subsets are both denoted ***`in`***`.`

Alloy Analyzer Tutorial 2008

Linguistic and Ontological Types

Two Dimensions of Classification



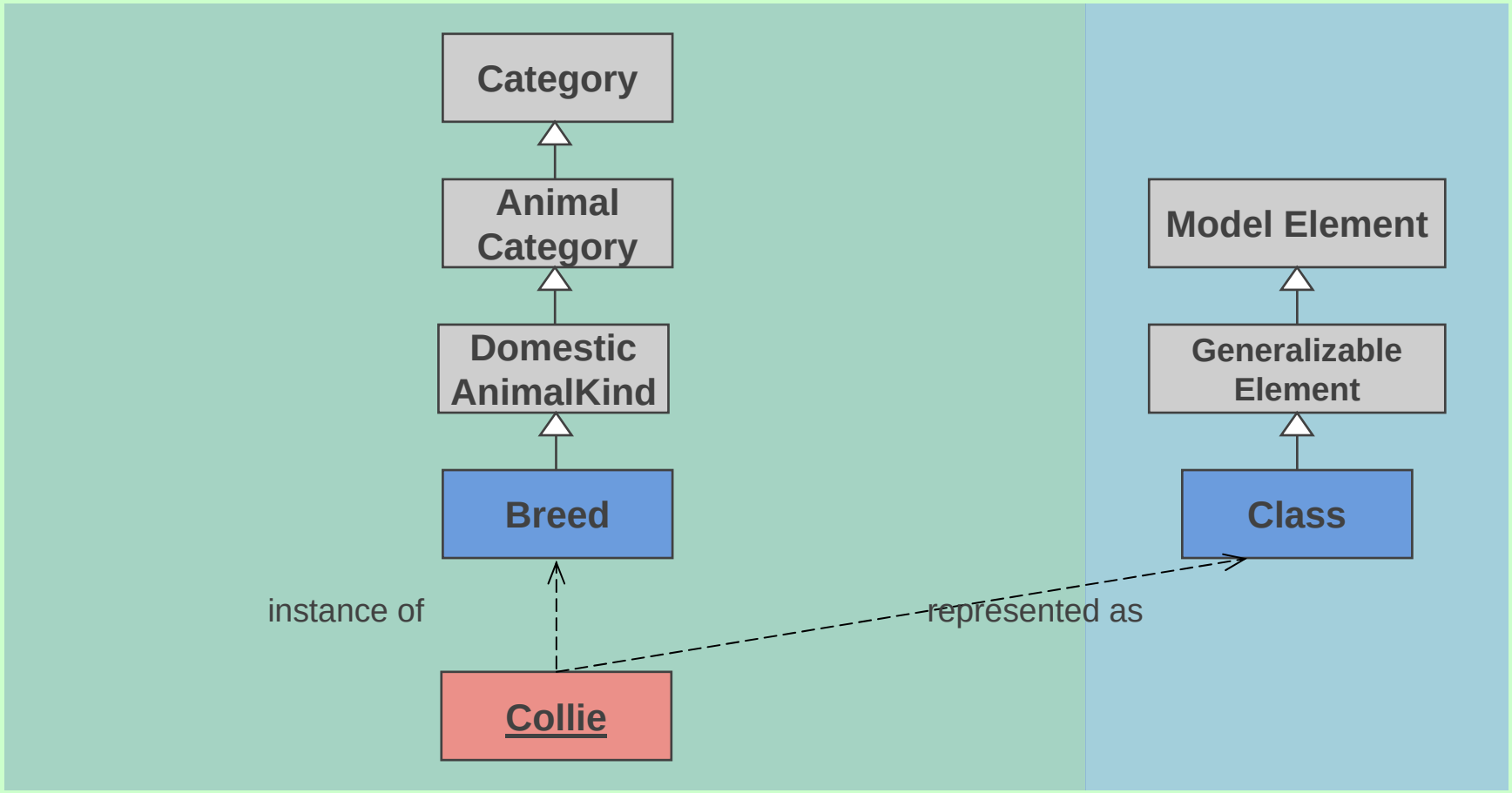
Usage versus Mentioning

The Case for Quotation Marks

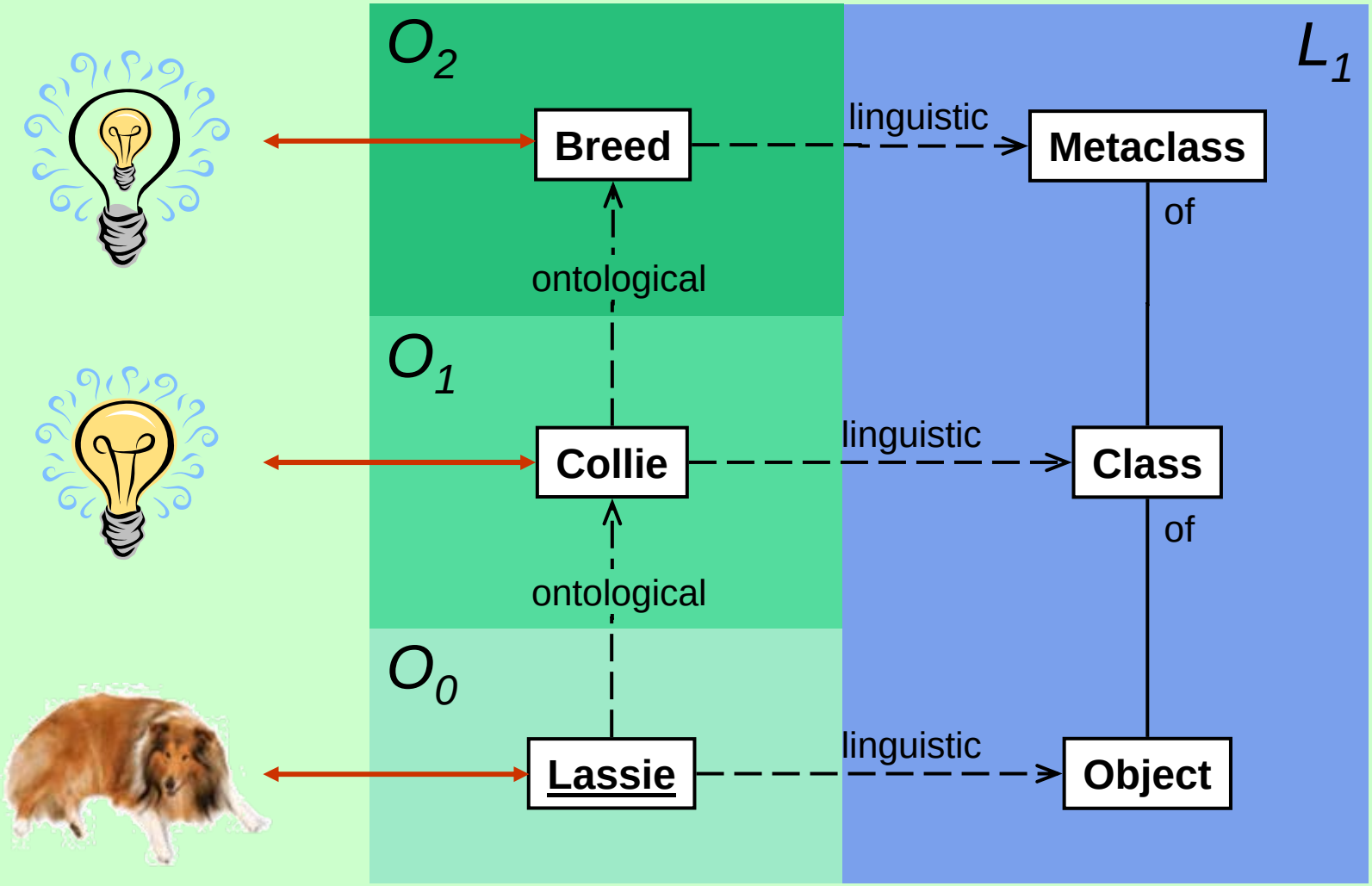
- a use of a word we refers to its meaning
  - » Lassie ε Dog
  - » Love is an Emotion
- a mentioning of a word, refers to the word itself
  - » "Lassie" ε Word
  - » "Love" is a Four Letter Word
- whenever we mention words, we should use quotation marks

Linguistic and Ontological Metatypes

Again, two Dimensions of Classification



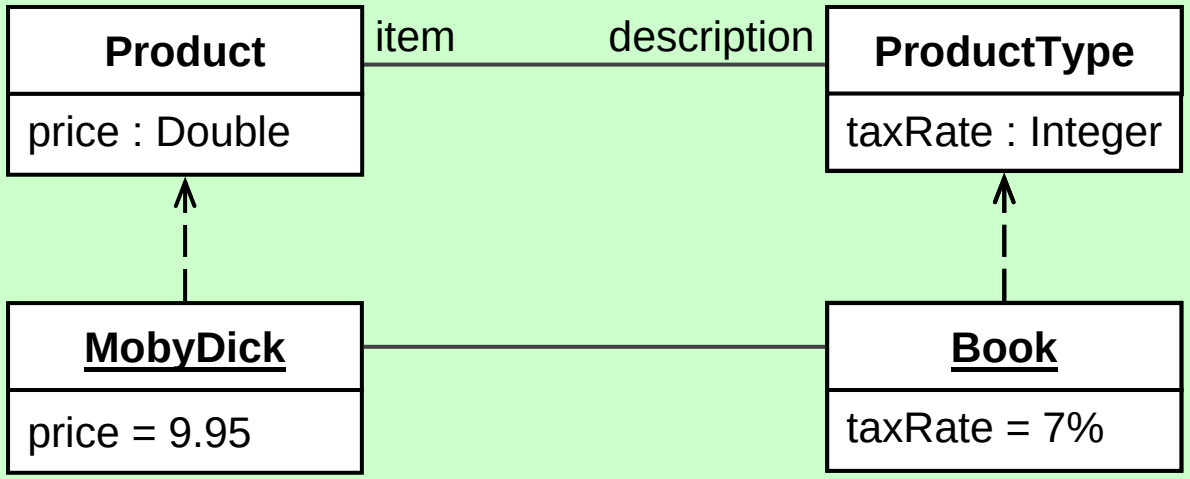
Two-Dimensional Framework



Dynamic Type Models

Electronic Warehouse

Type Object Pattern



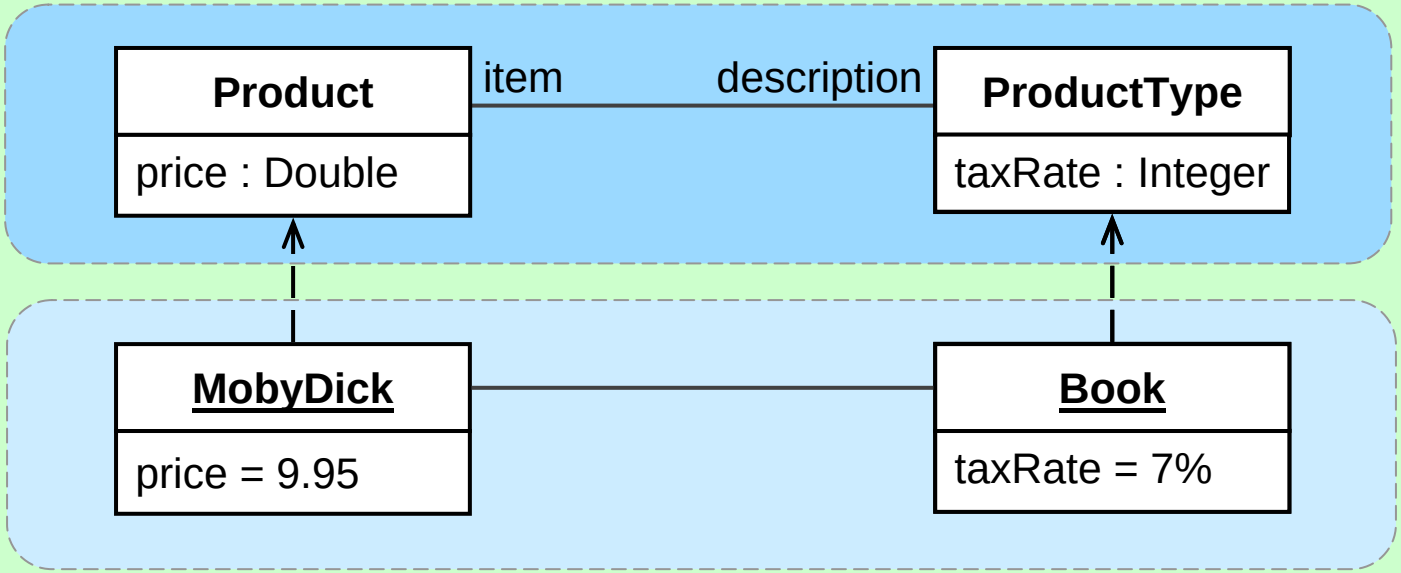
- information about instances & types needed

Modelling Levels

Electronic Warehouse

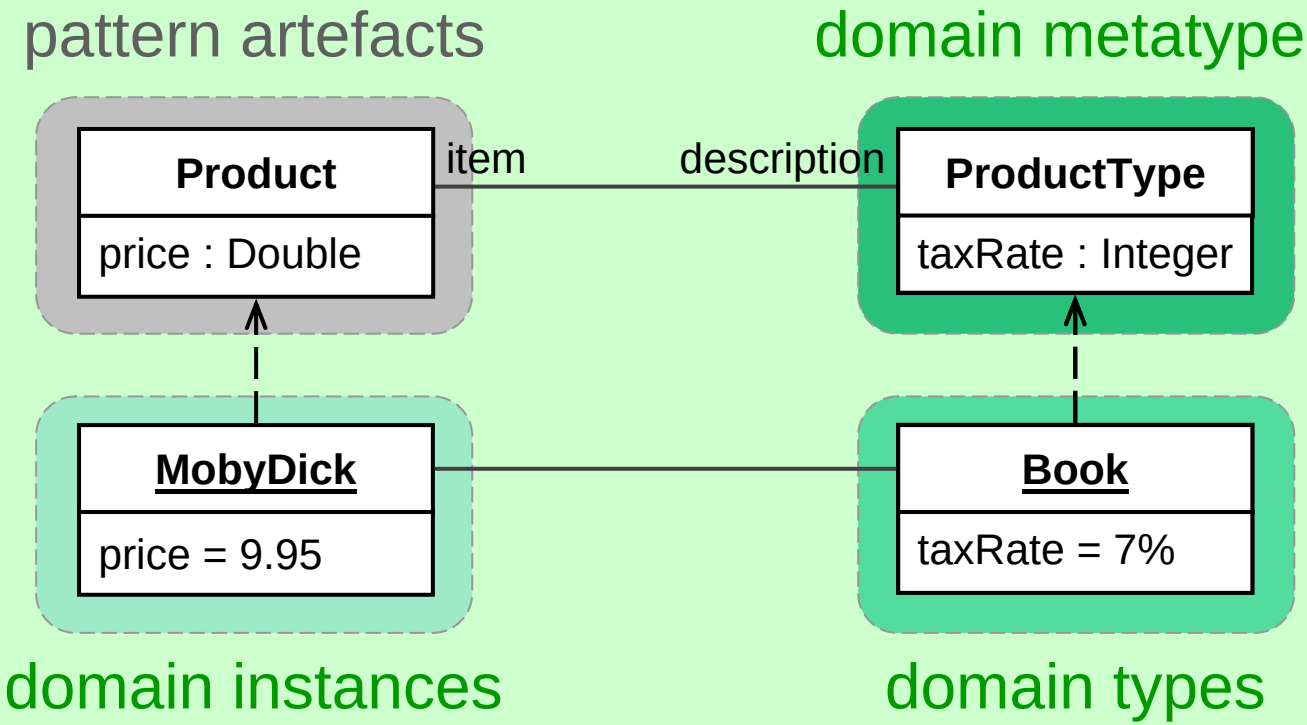
model types

model instances



Domain Levels

Electronic Warehouse



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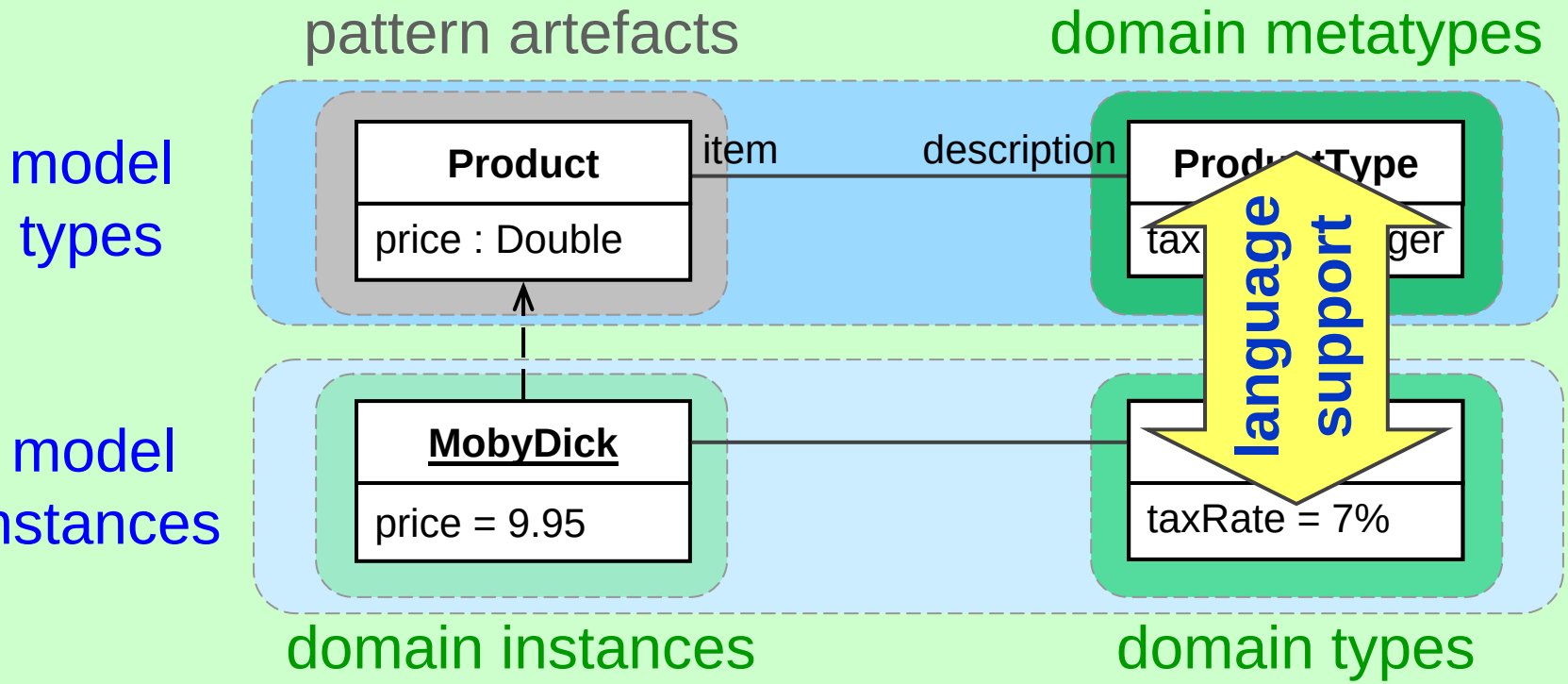
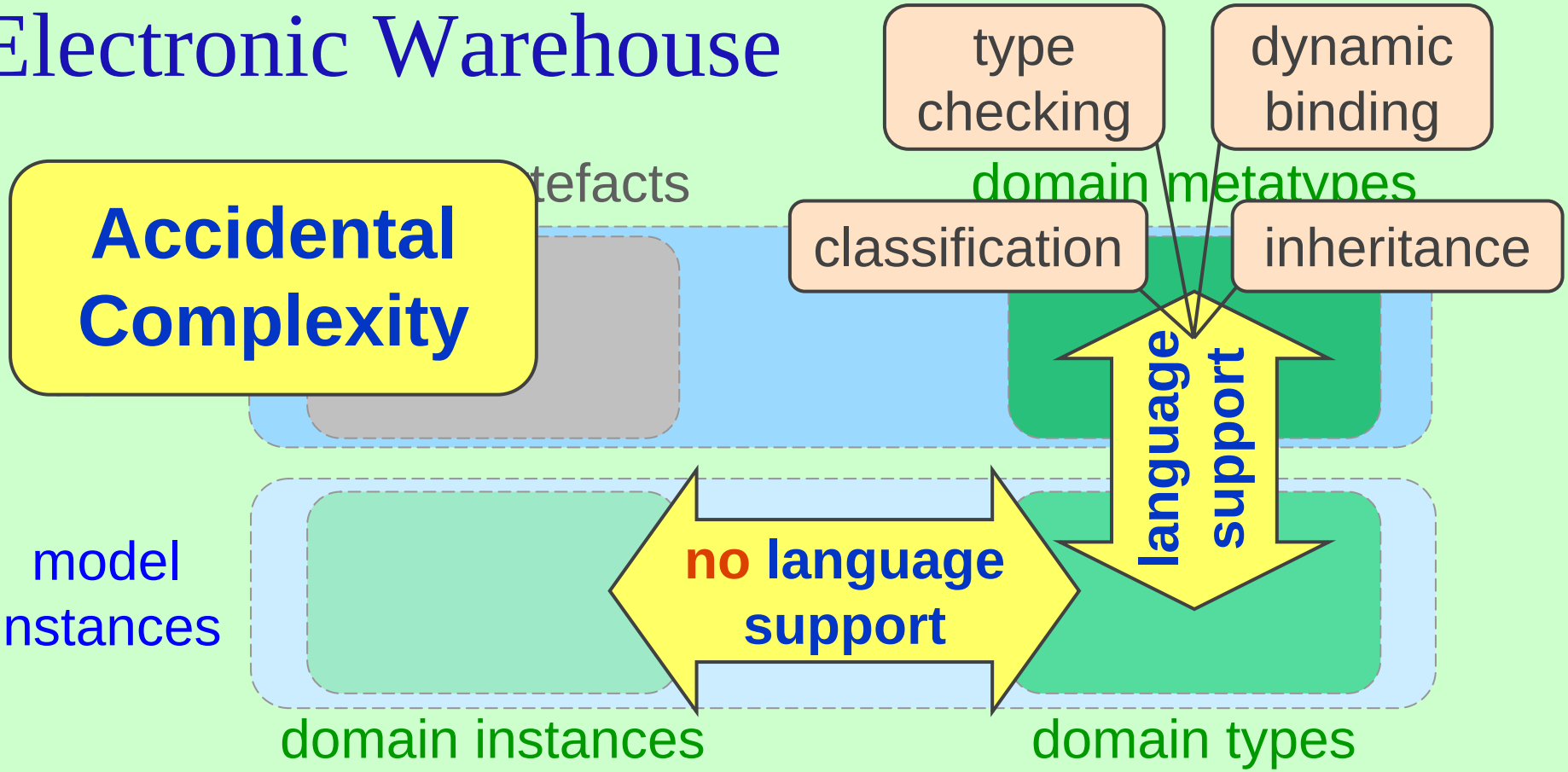


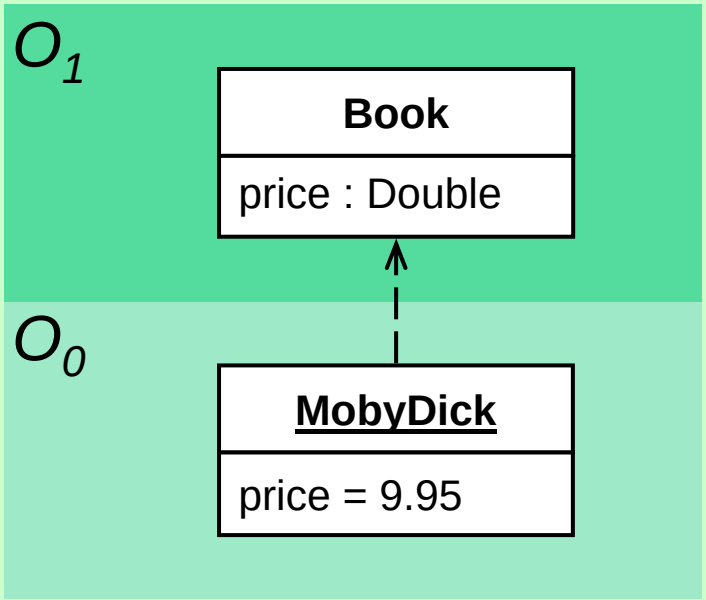
Paradigm Mismatch

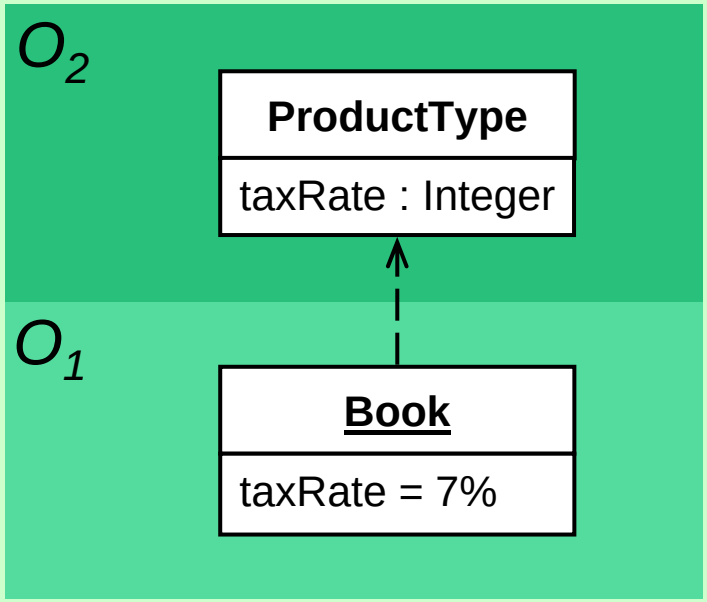
Electronic Warehouse



Multi-Level Modelling

Electronic Warehouse





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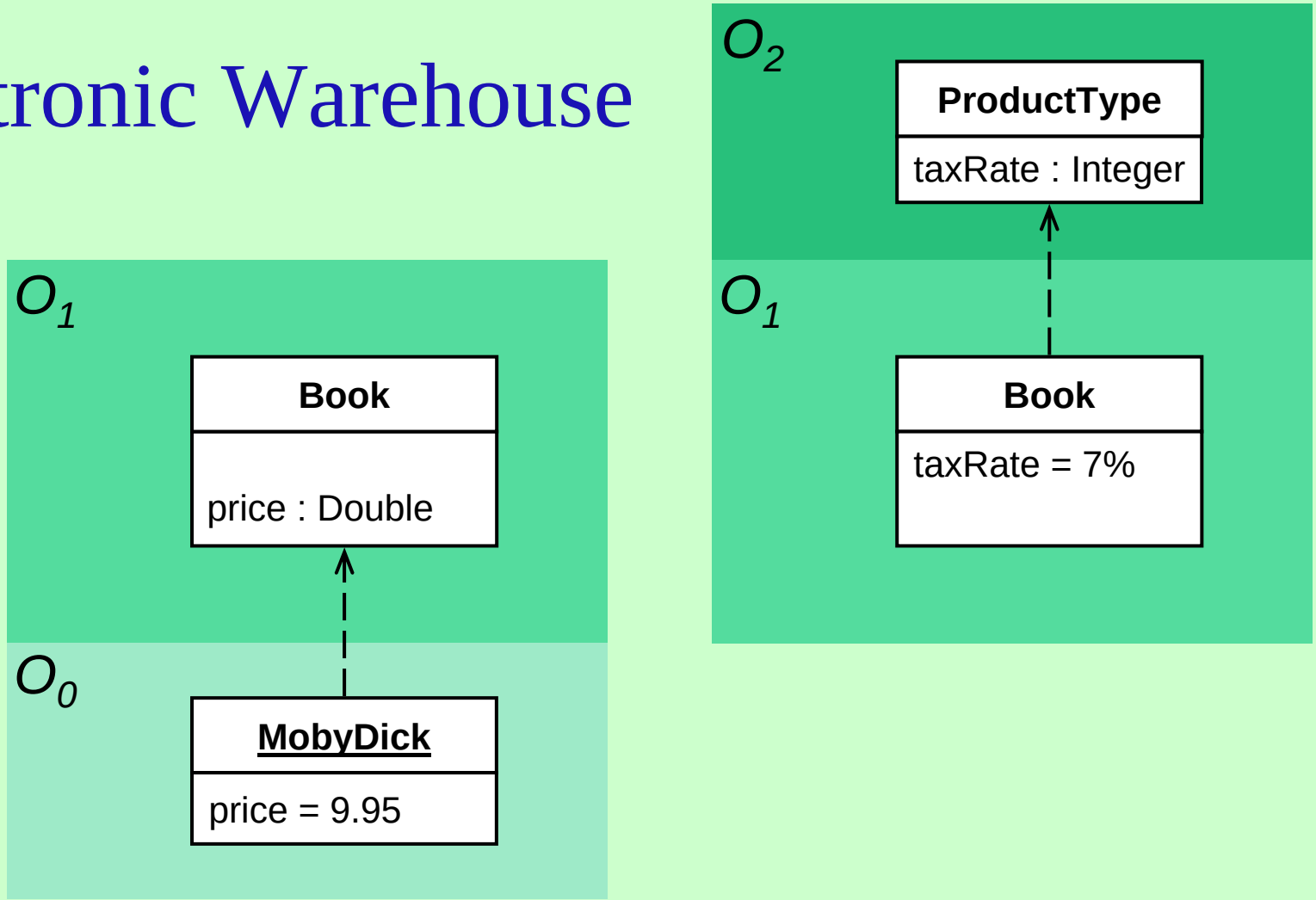

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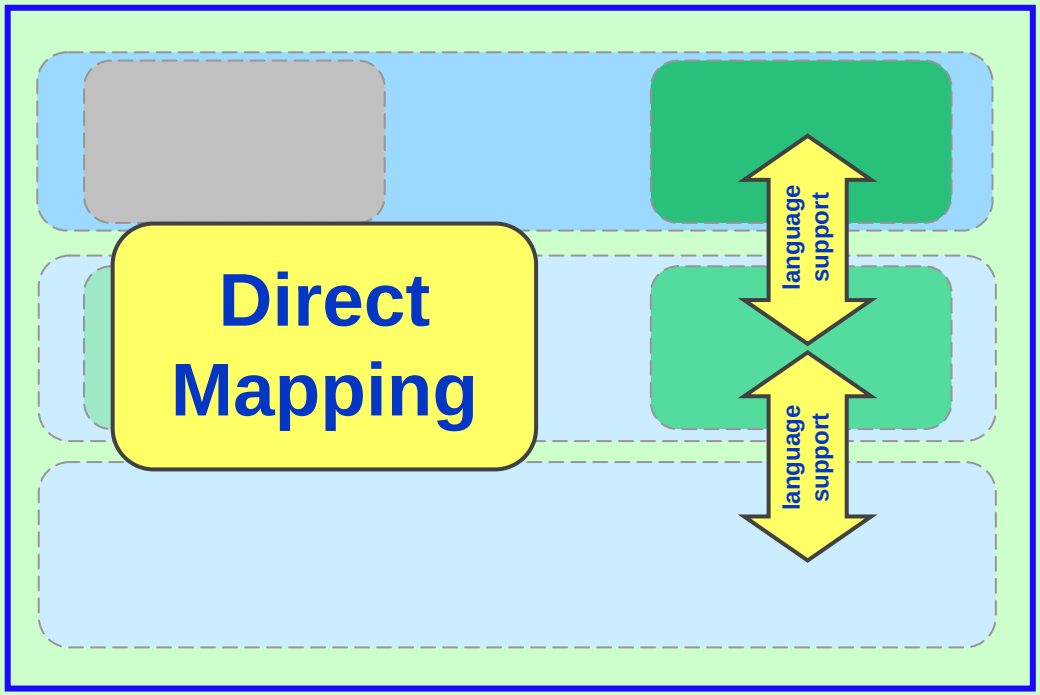
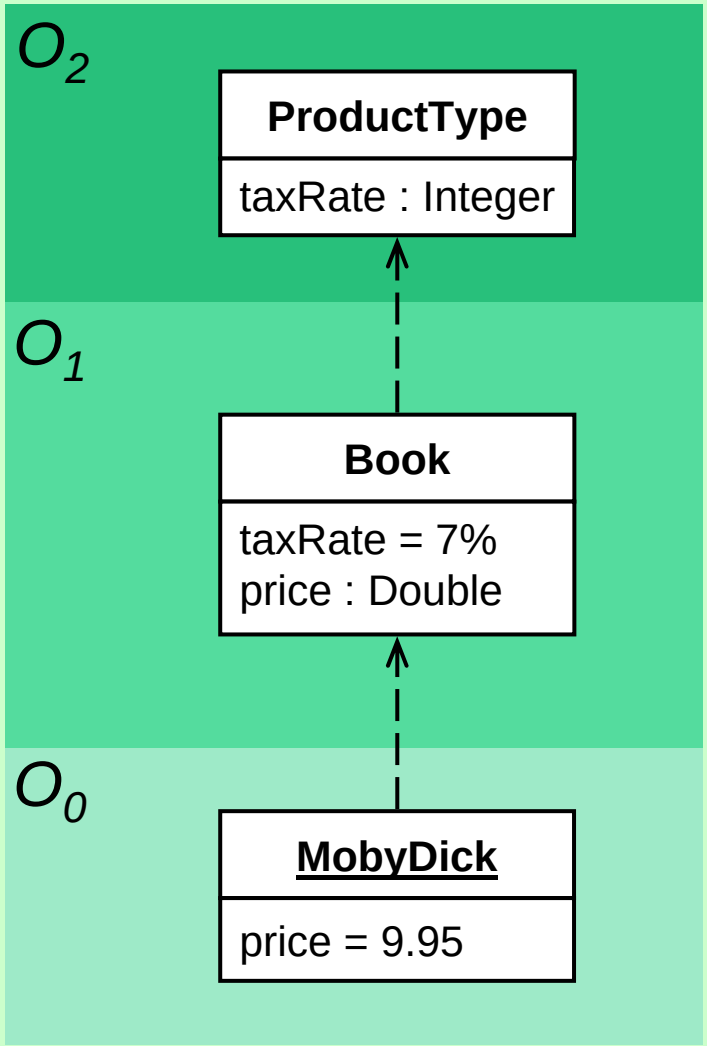
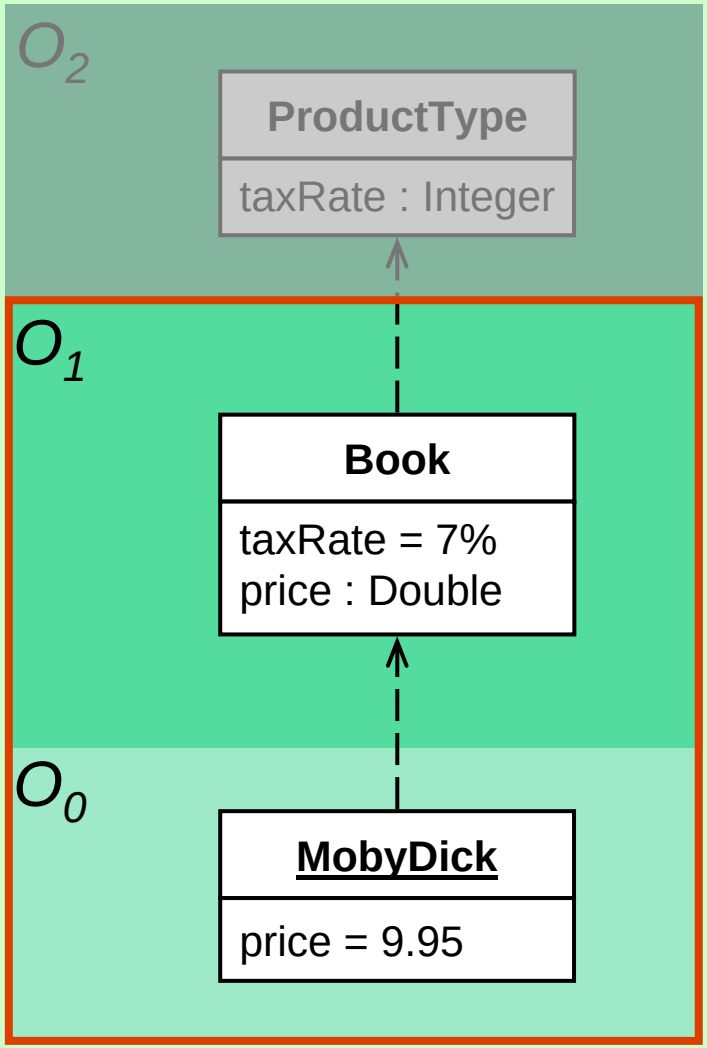




Multi-Level Modelling

Electronic Warehouse

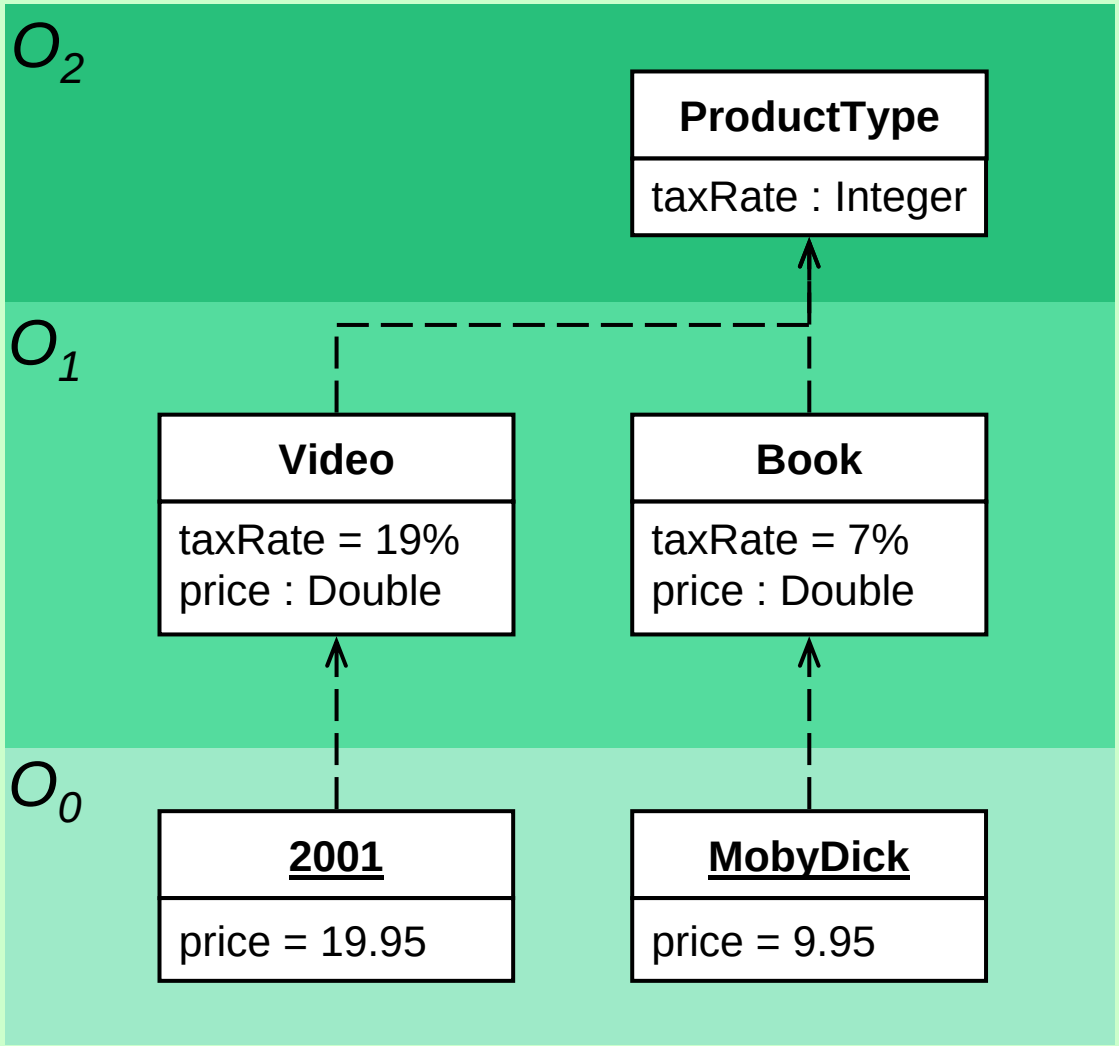
- both instance & type level information modeled
- product type information concentrated at one location
- easy to add further product types



Multi-Level Modelling

Electronic Warehouse

- ☹ instances of product type instances need not have a price
- how to enforce?



Deep Characterization

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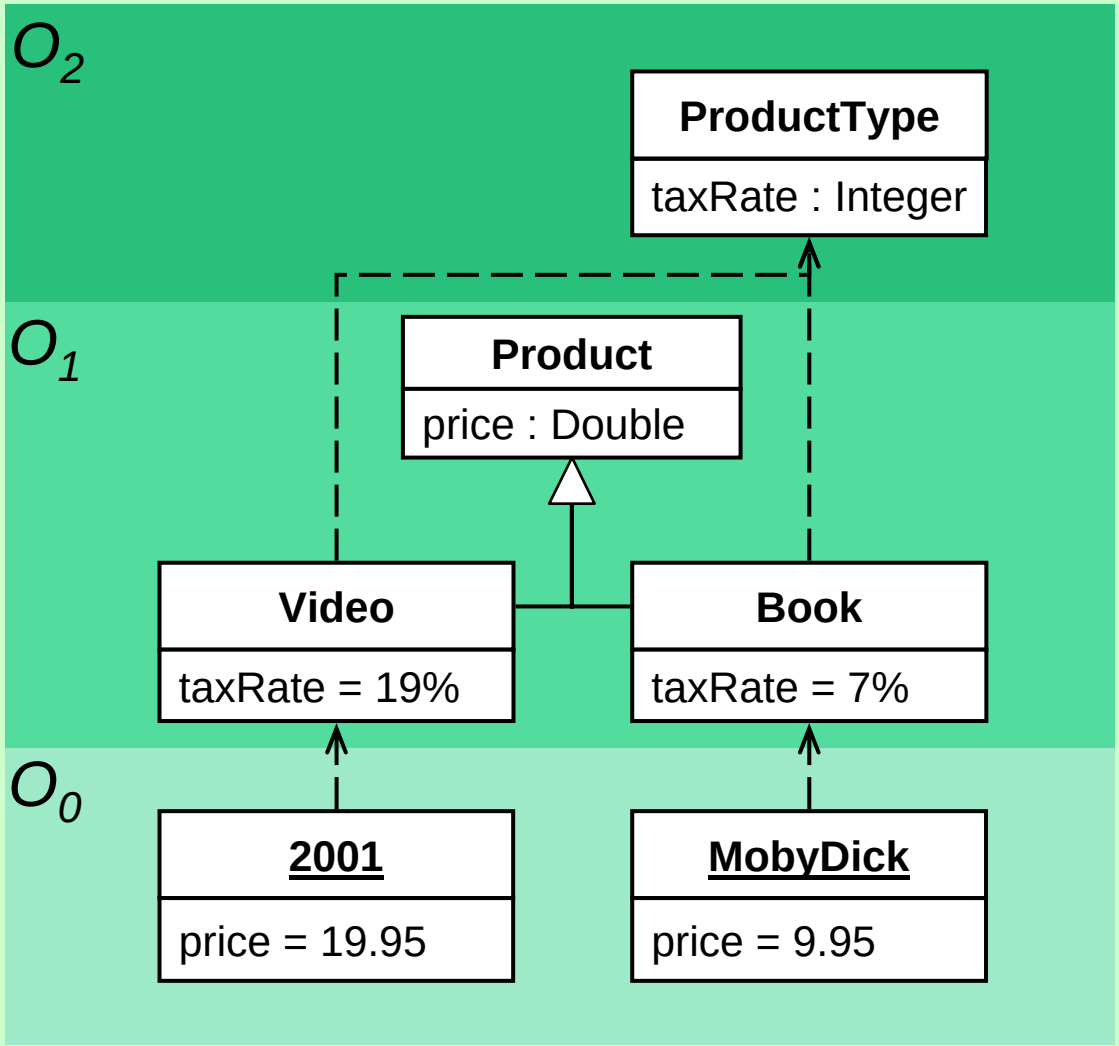
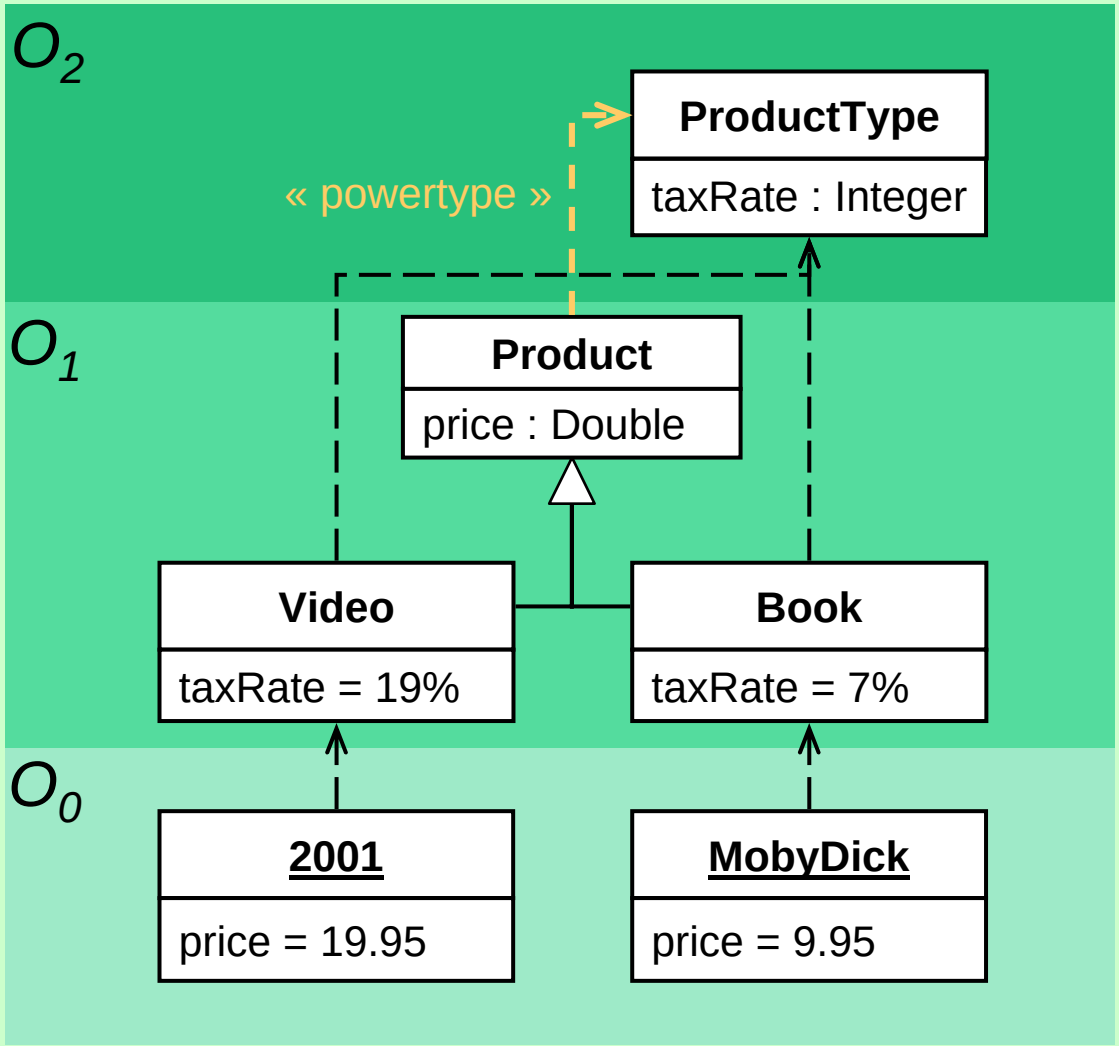


Deep Characterization

Powertype Concept

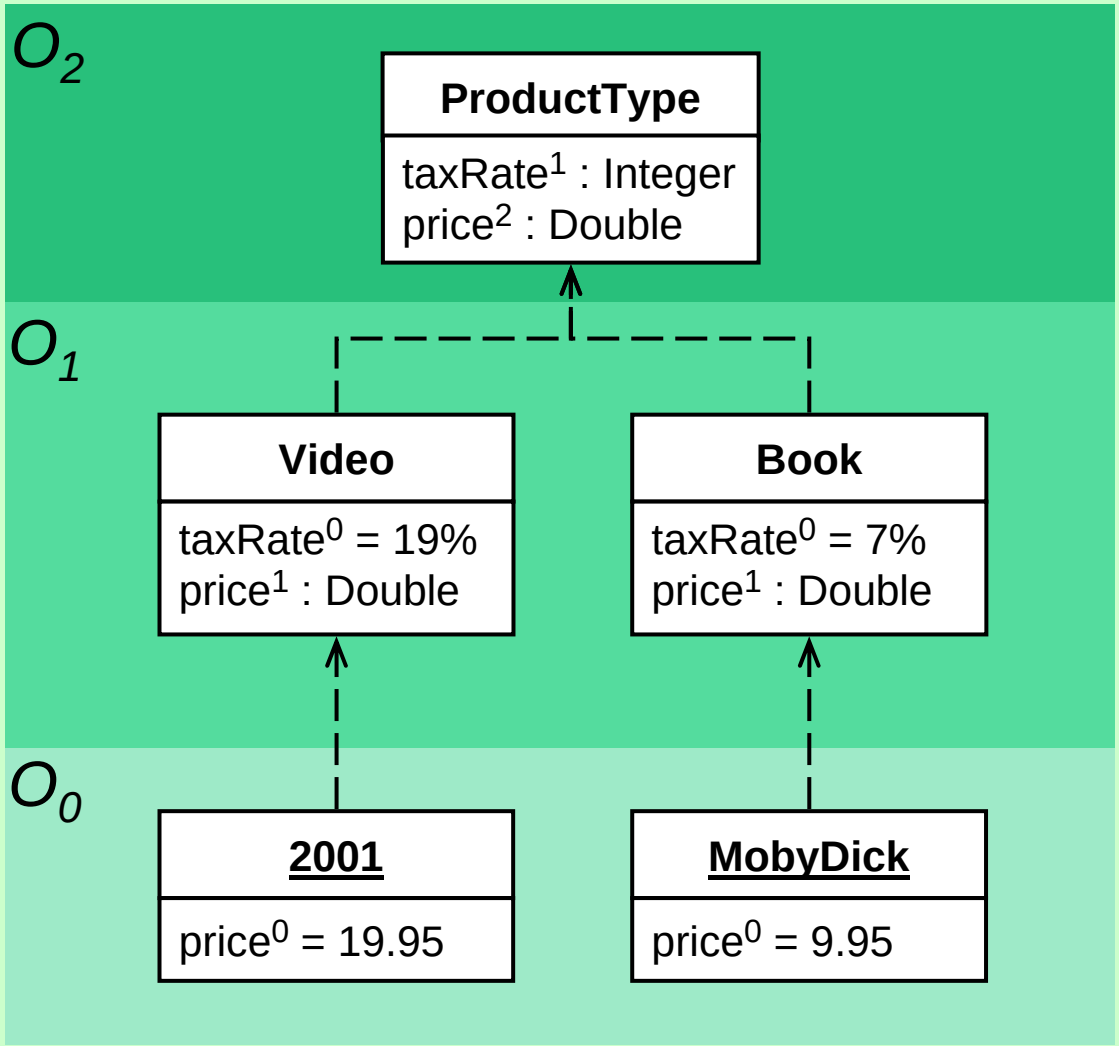
- ☹ doesn't scale well
- ☹ information distributed
- ☹ mandatory supertype



Deep Instantiation

Potency Concept

- directly specify that instances of product types have a price



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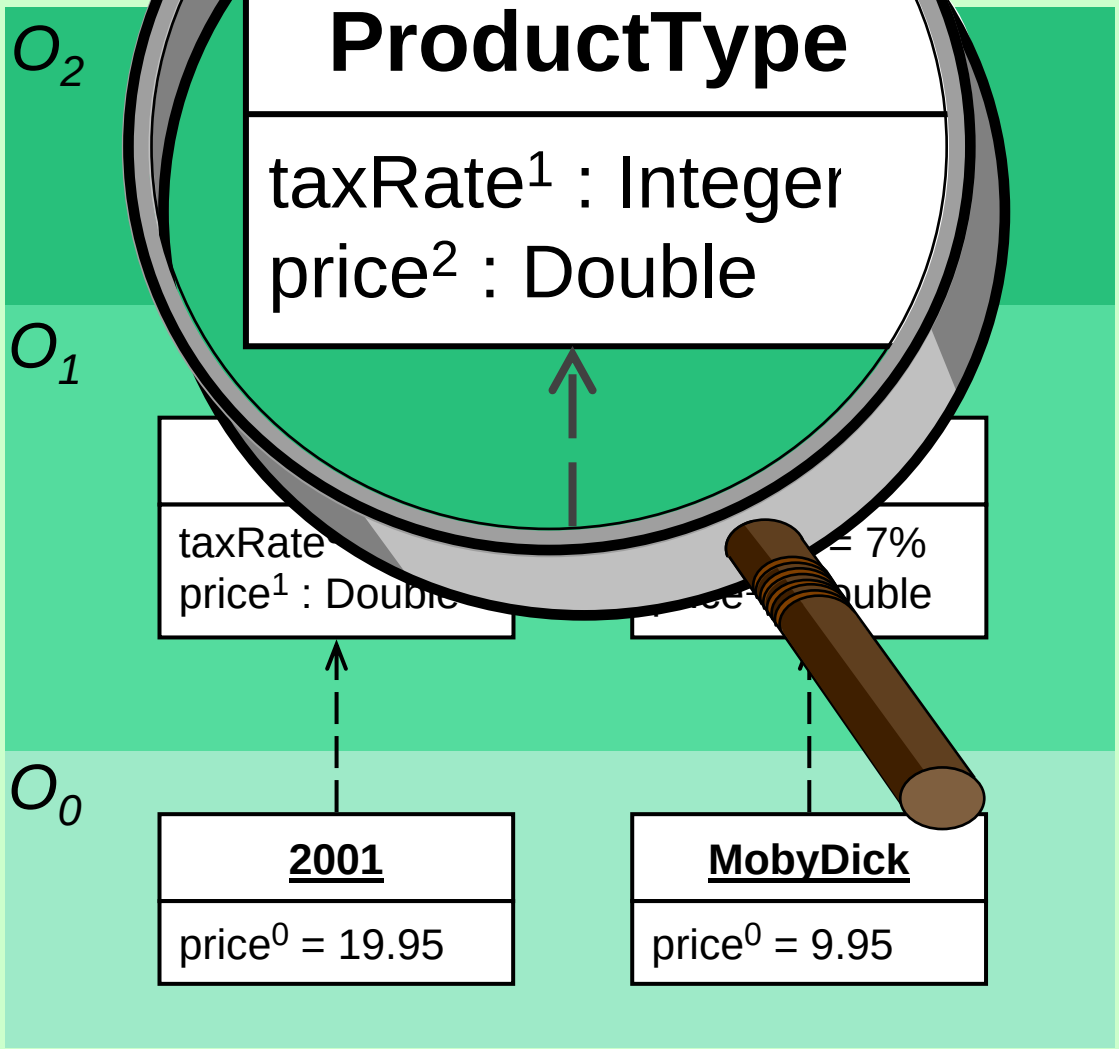

Deep Instantiation

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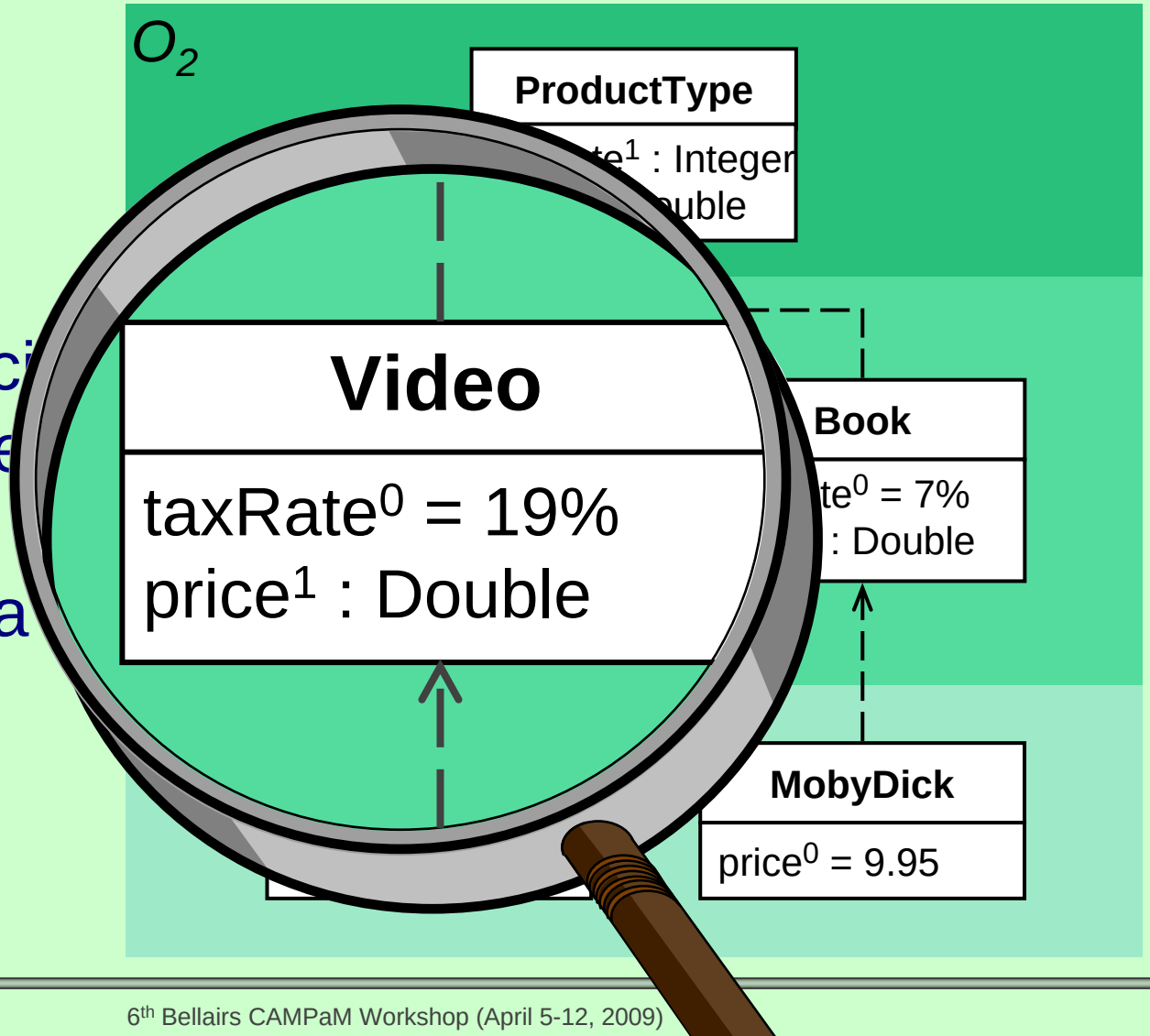
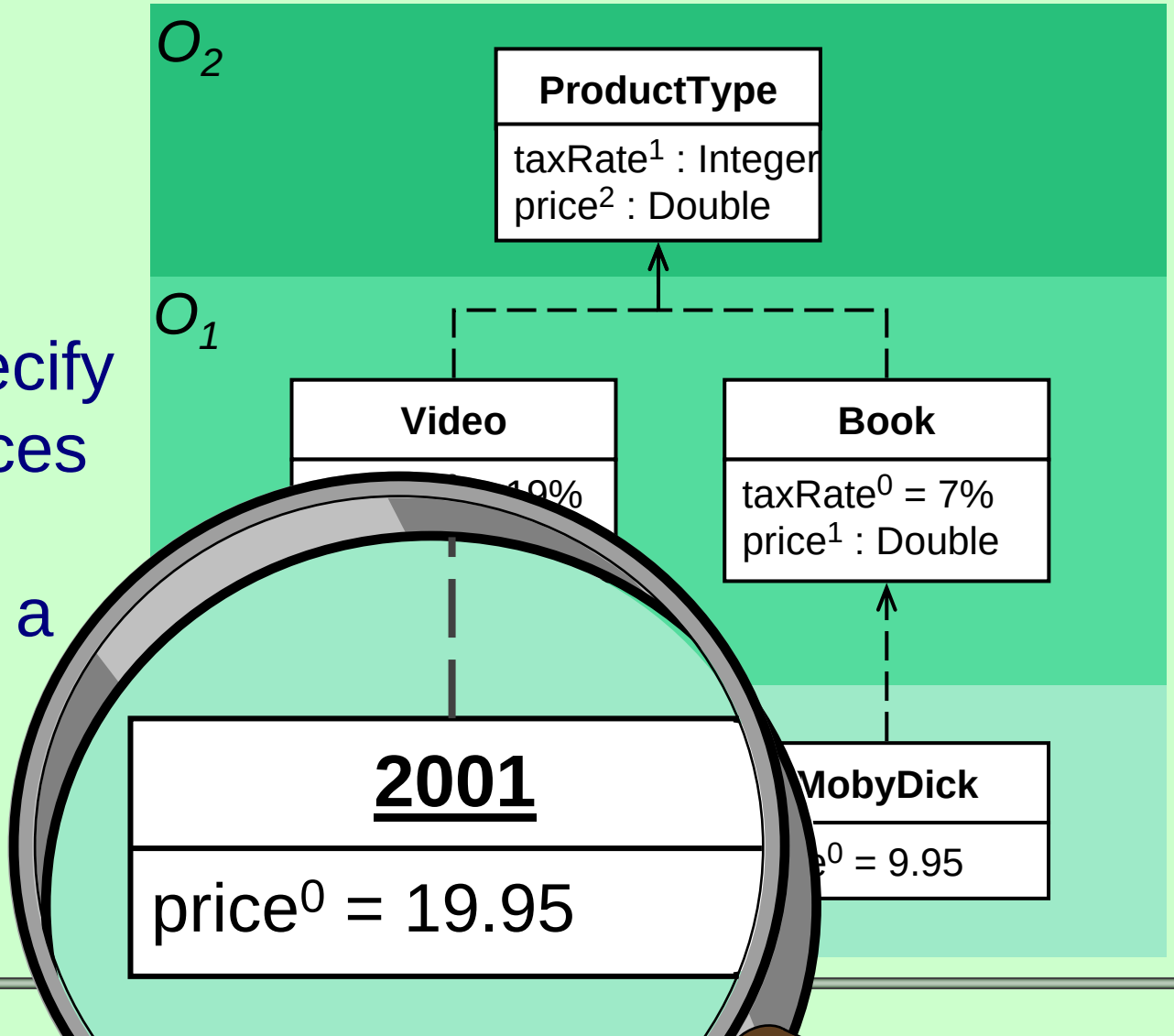
  types have a
  price



Deep Instantiation

Potency Concept

- directly specify that instances of product types have a price



Metamodeling Summary

- Basic Relationships in Modeling
  - » representation
  - » classification (linguistically & ontologically)
  - » generalization
- Metaness
  - » repeated application of an operation giving rise to anti-transitive relationships
  - » transfer of this definition to models, with a relaxed interpretation for allowing established terminology

Metamodeling Summary

- Ontological Classification
  - » domain modeling ≠ language engineering
- Multi-Level Modeling
  - » direct mapping
  - » dynamic type level
  - » full language support
- Deep Instantiation
  - » concise mechanism for deep characterization
  - » enables static type checking