When and How to Use Multi-Level Modelling

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Presenter: Nick Fung

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Running Example

- Task
  - Create a model-based computer system for managing the products sold in a bookstore

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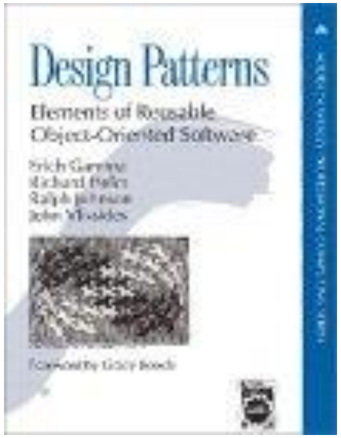

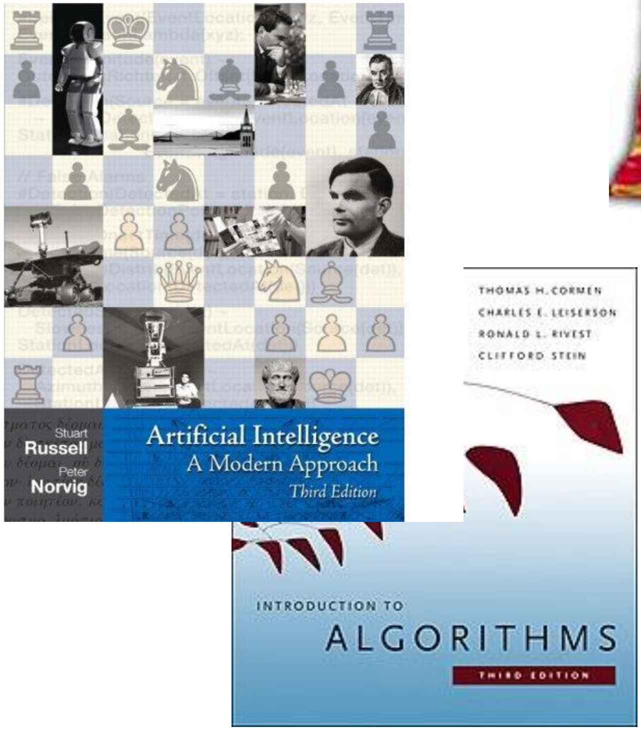

Standard Metamodelling Architecture

- **M0 (Terminal) Model**
  - Representation of a system

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- **M2 Metametamodel**
  - Metamodelling facilities
  - Auto-descriptive

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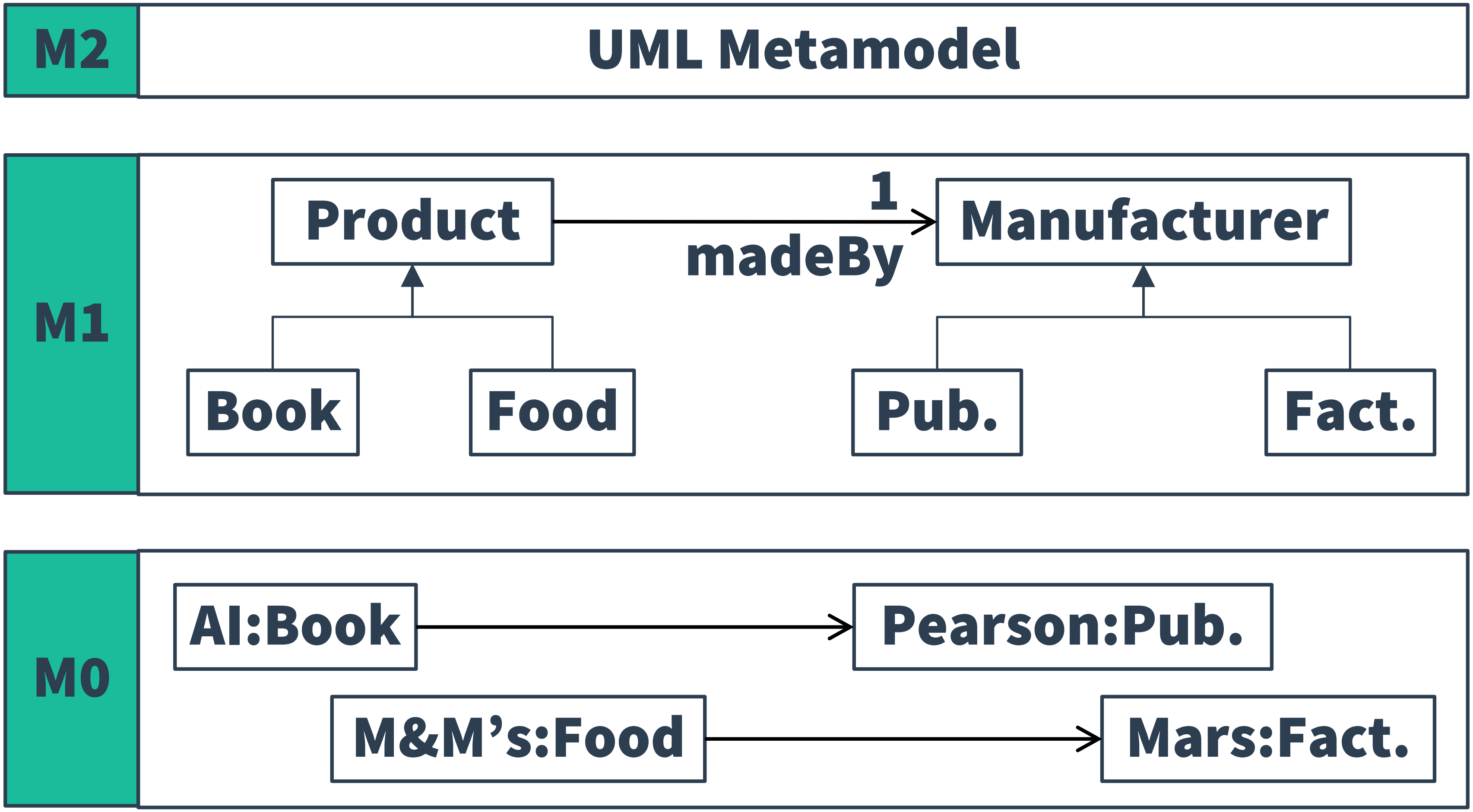

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  - New types (i.e. classes) cannot be instantiated dynamically

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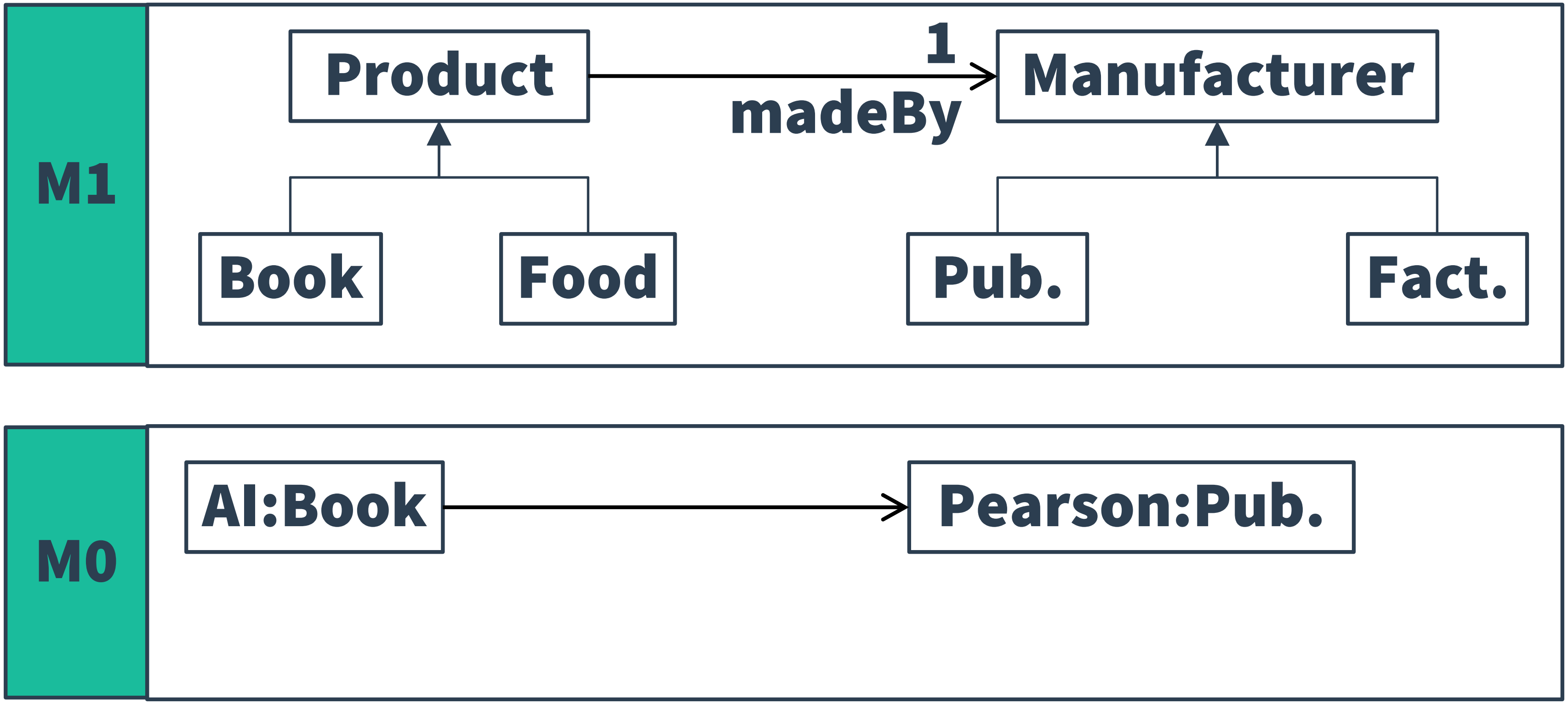

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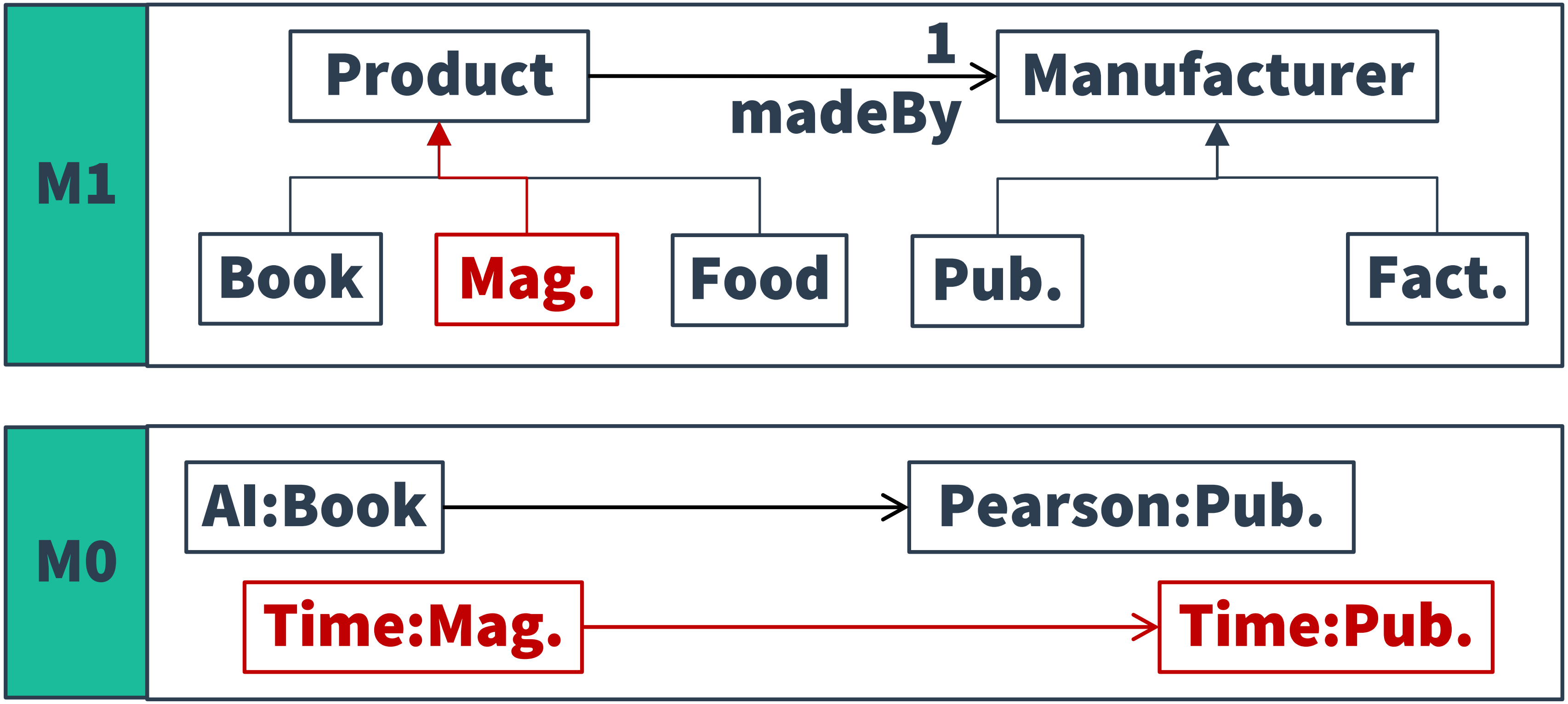
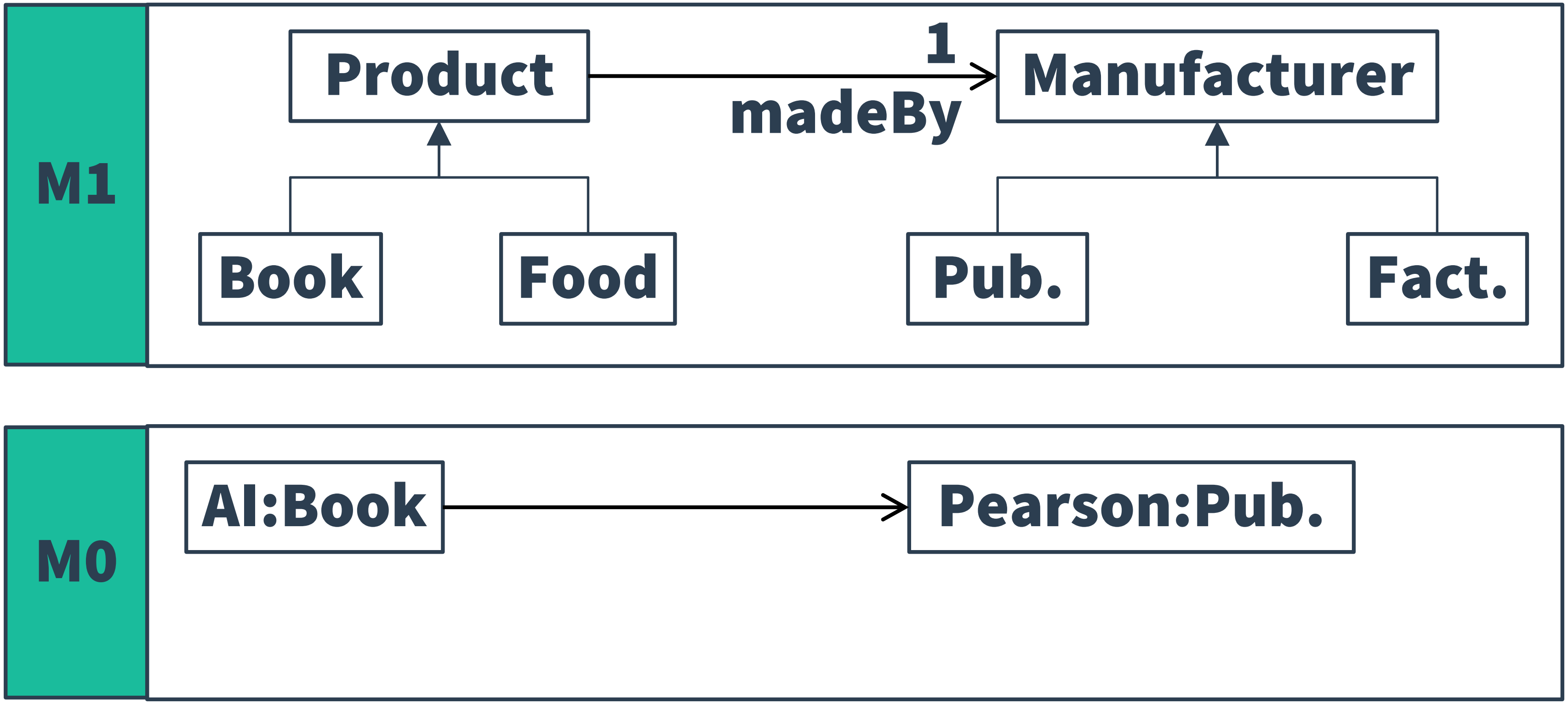


Limitations of Architecture (2)

- Dynamic Features
  - New features cannot be added to a type



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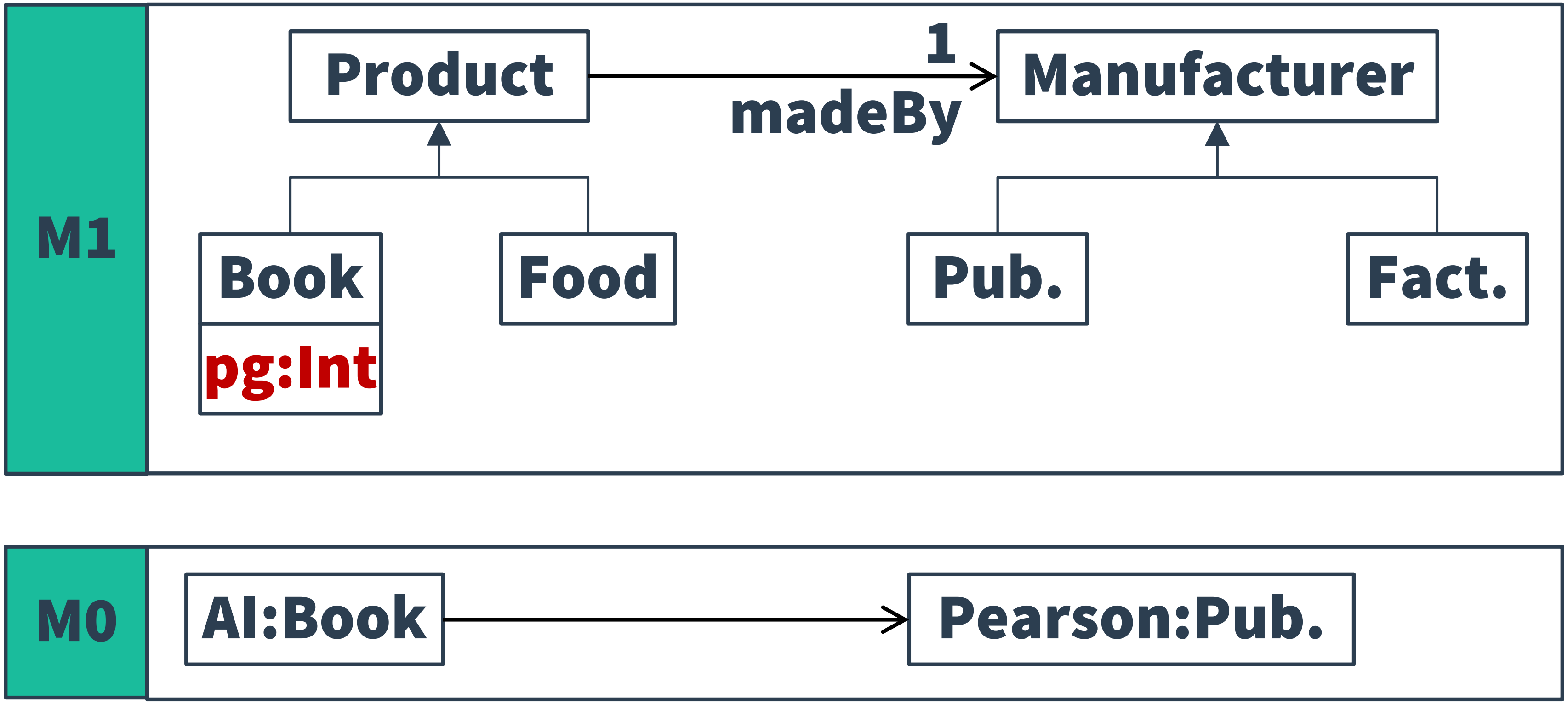
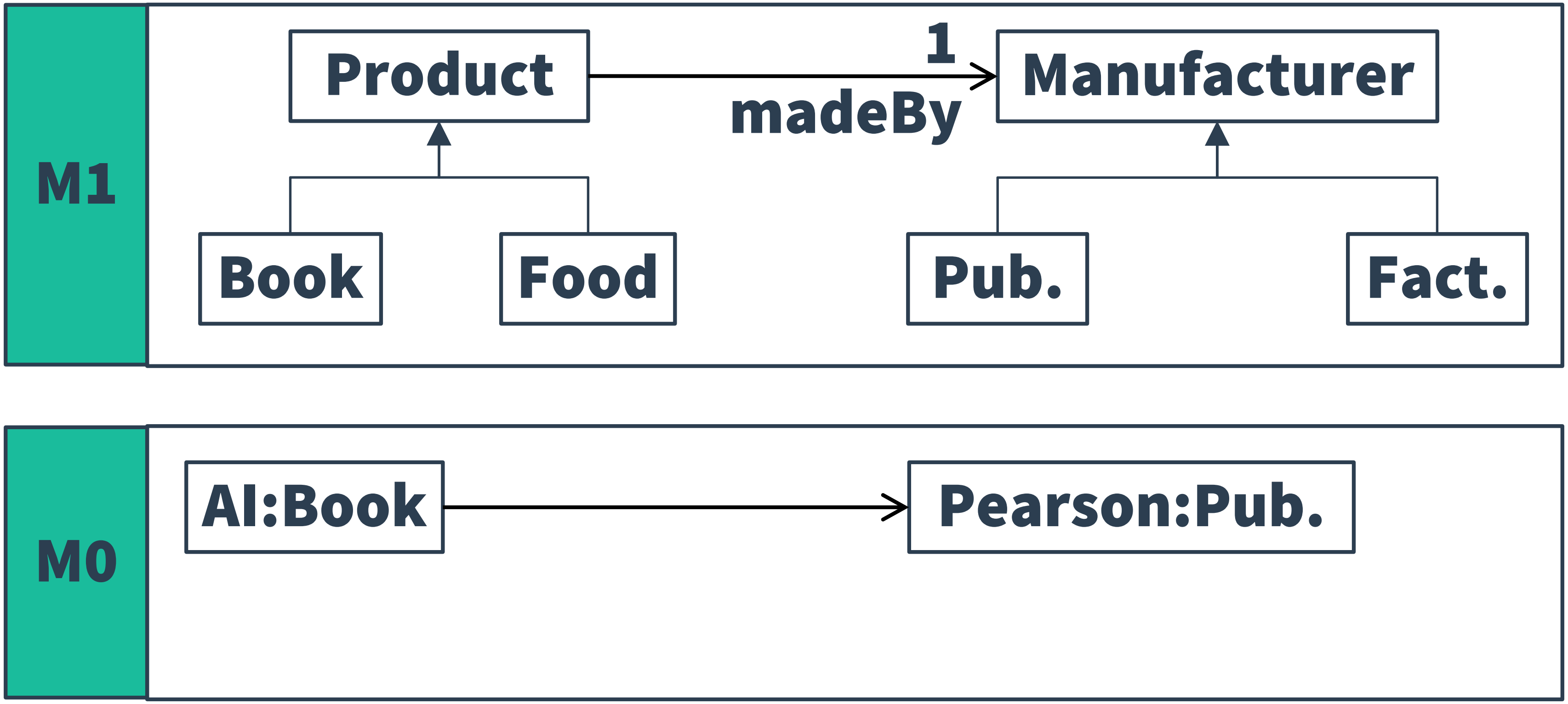


Limitations of Architecture (3)

- Auxiliary Domain Concepts
  - New entities relevant to an existing type cannot be added



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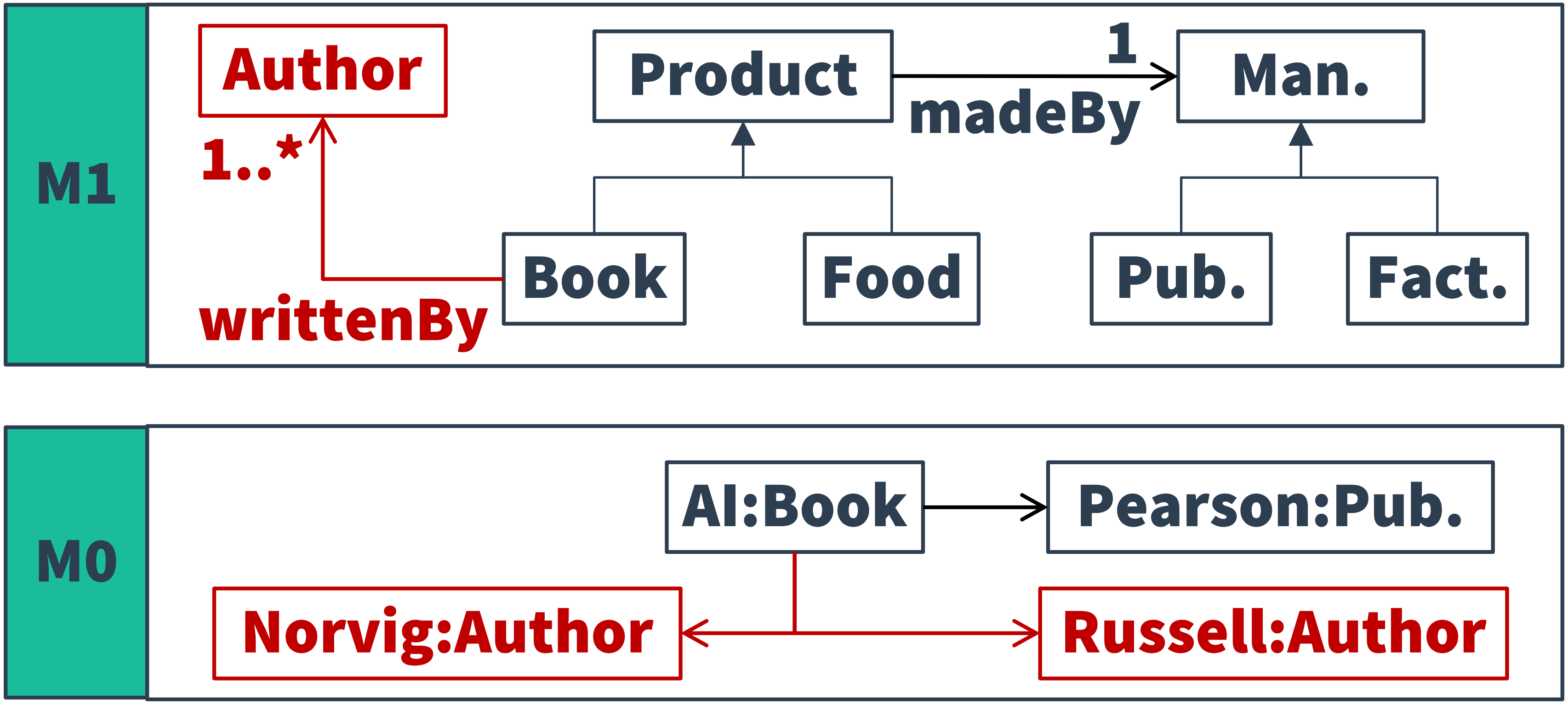

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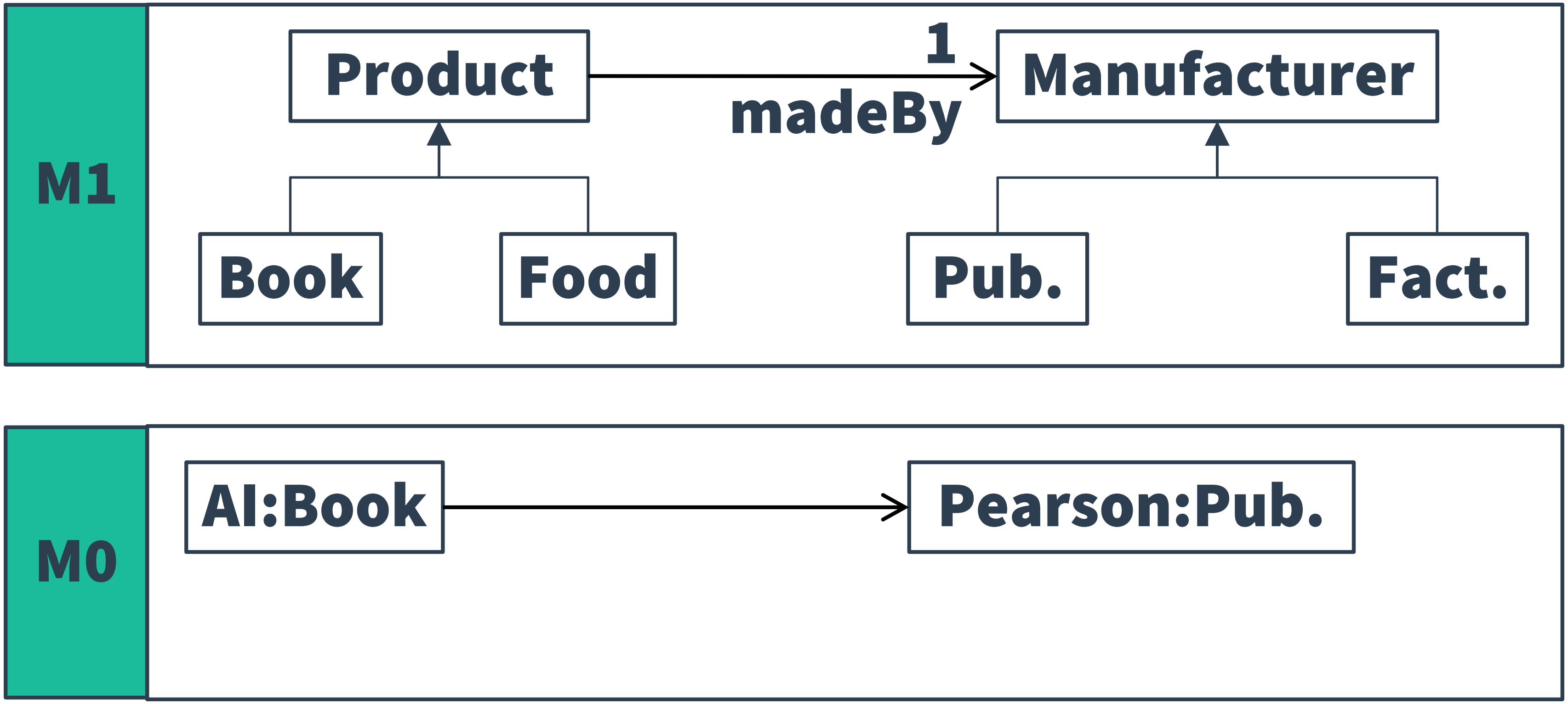
- Relation Configuration
  - Reference types (i.e. relations) cannot be reconfigured



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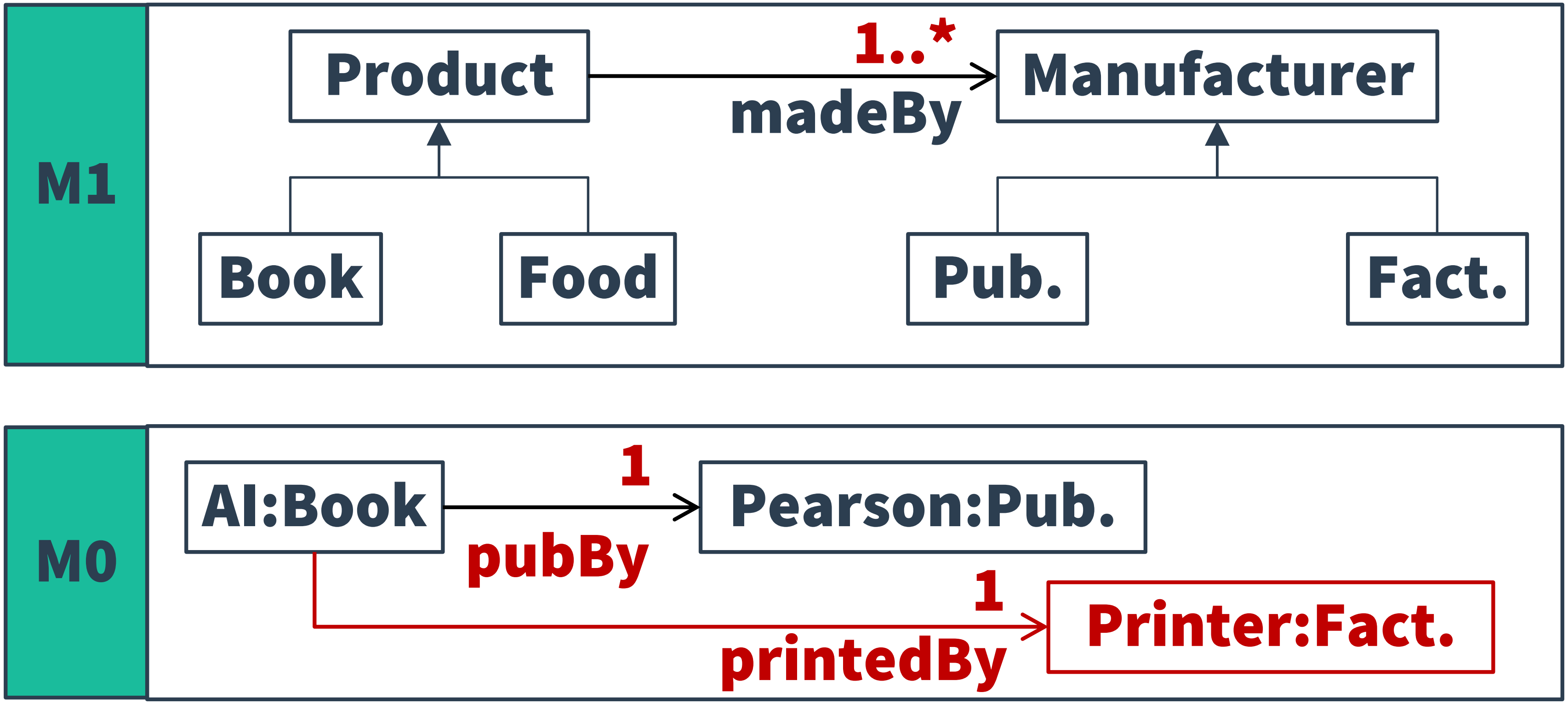

Limitations of Architecture (5)

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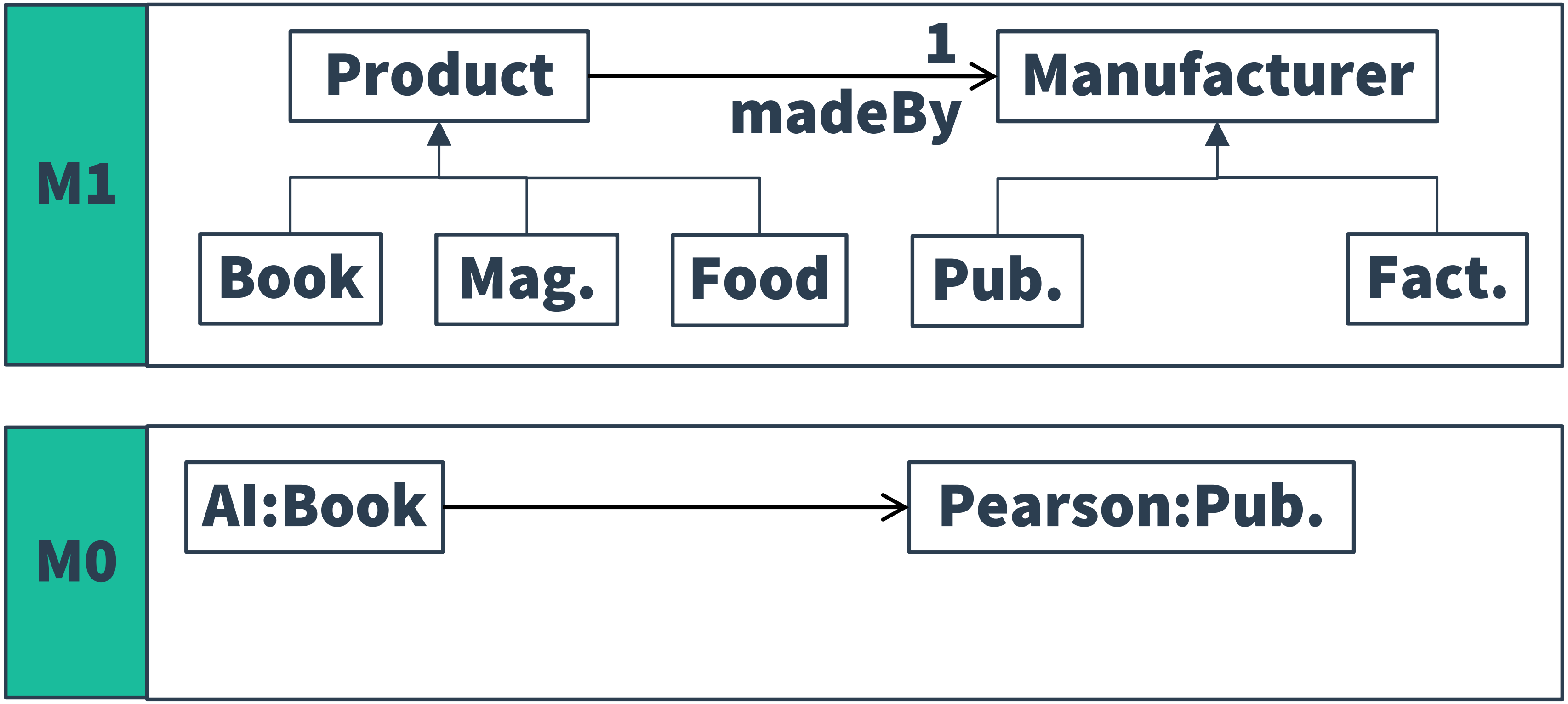
  - New classifications for (new) classes cannot be created



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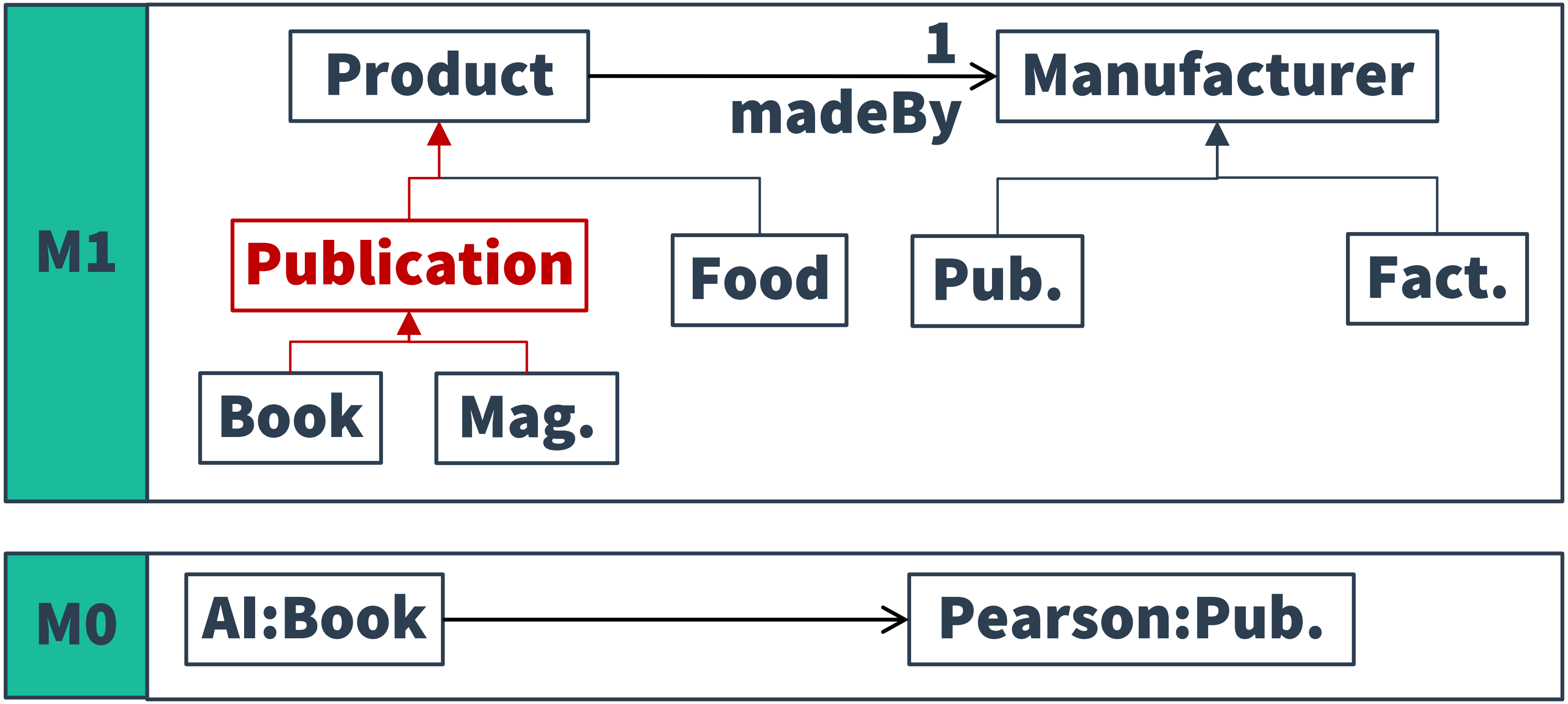
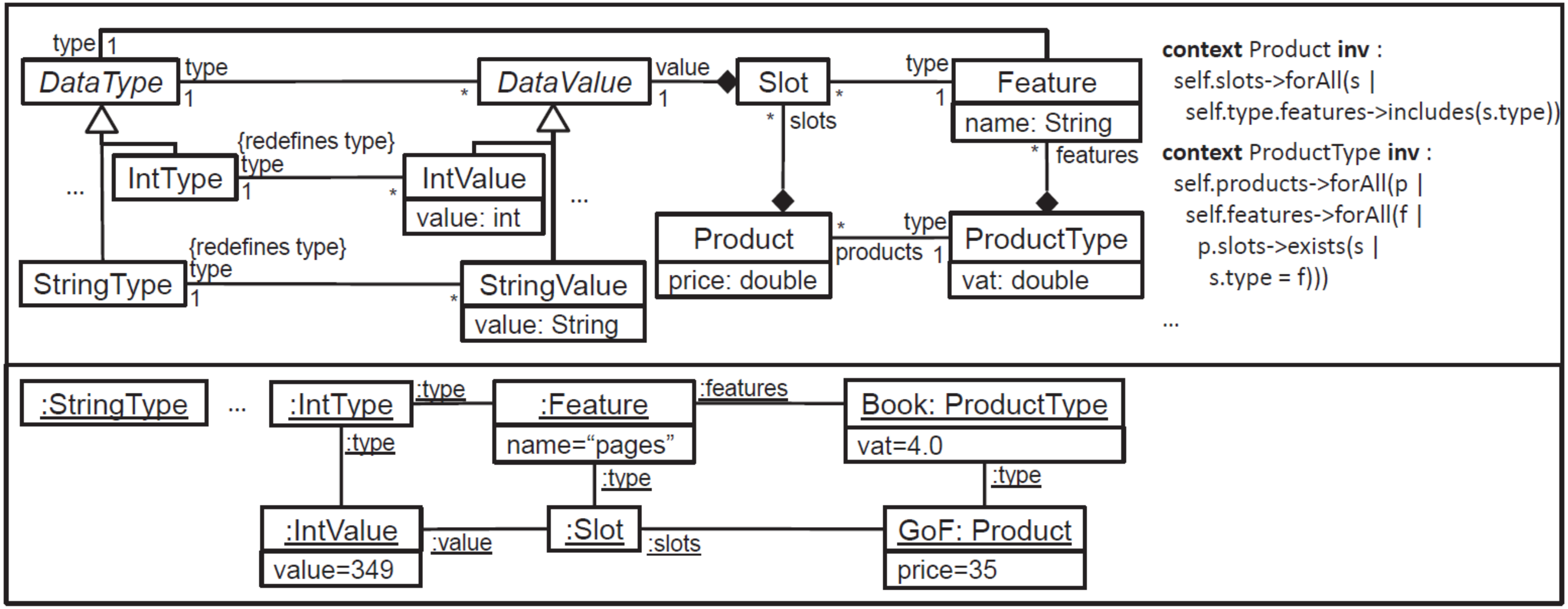


Two-Level Solutions (1)

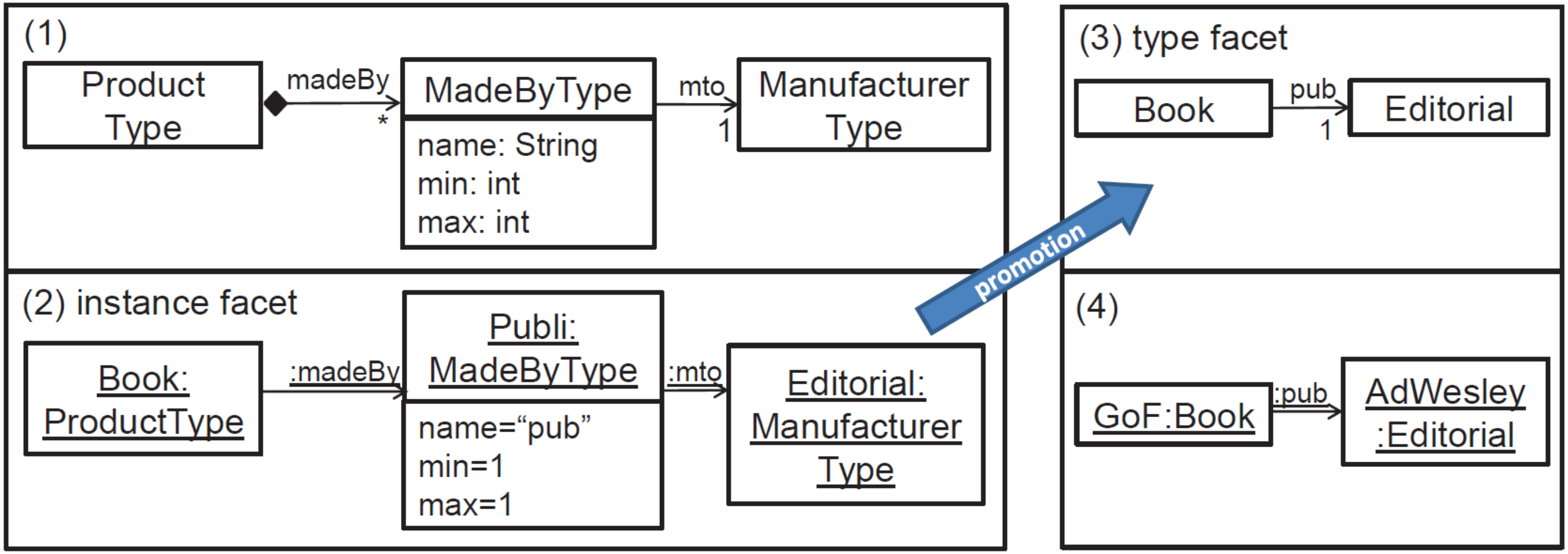
- **Explicit Modelling**
  - Model dynamic types, relations, etc. at the M0 level
  - Flexible, but yields complicated models



```
context Product inv :
  self.slots->forAll(s |
    self.type.features->includes(s.type))
context ProductType inv :
  self.products->forAll(p |
    self.features->forAll(f |
      p.slots->exists(s |
        s.type = f)))
...
```

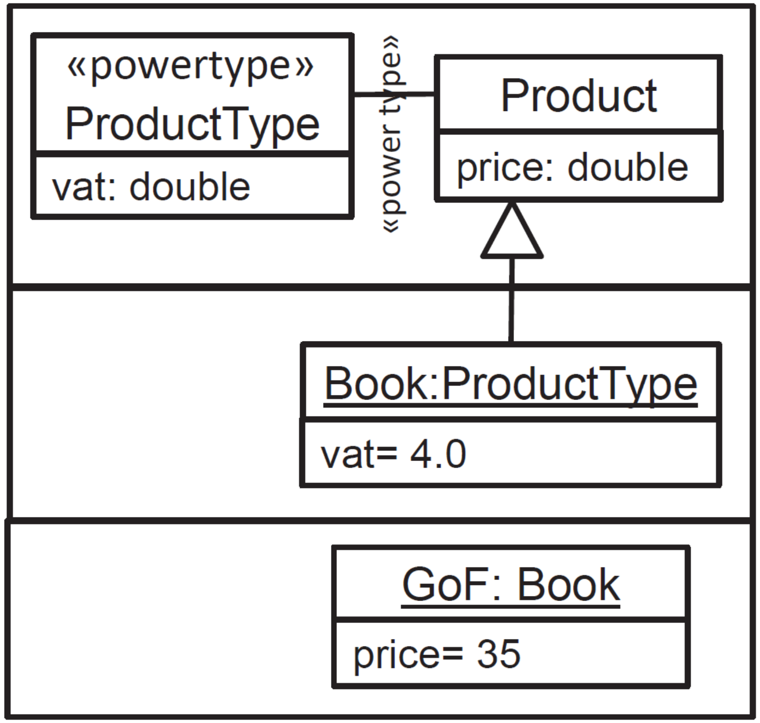
Two-Level Solutions (2)

- **Promotion**
  - Model types at M0 and transform into a meta-model
  - Flexible, but may require complex transformation



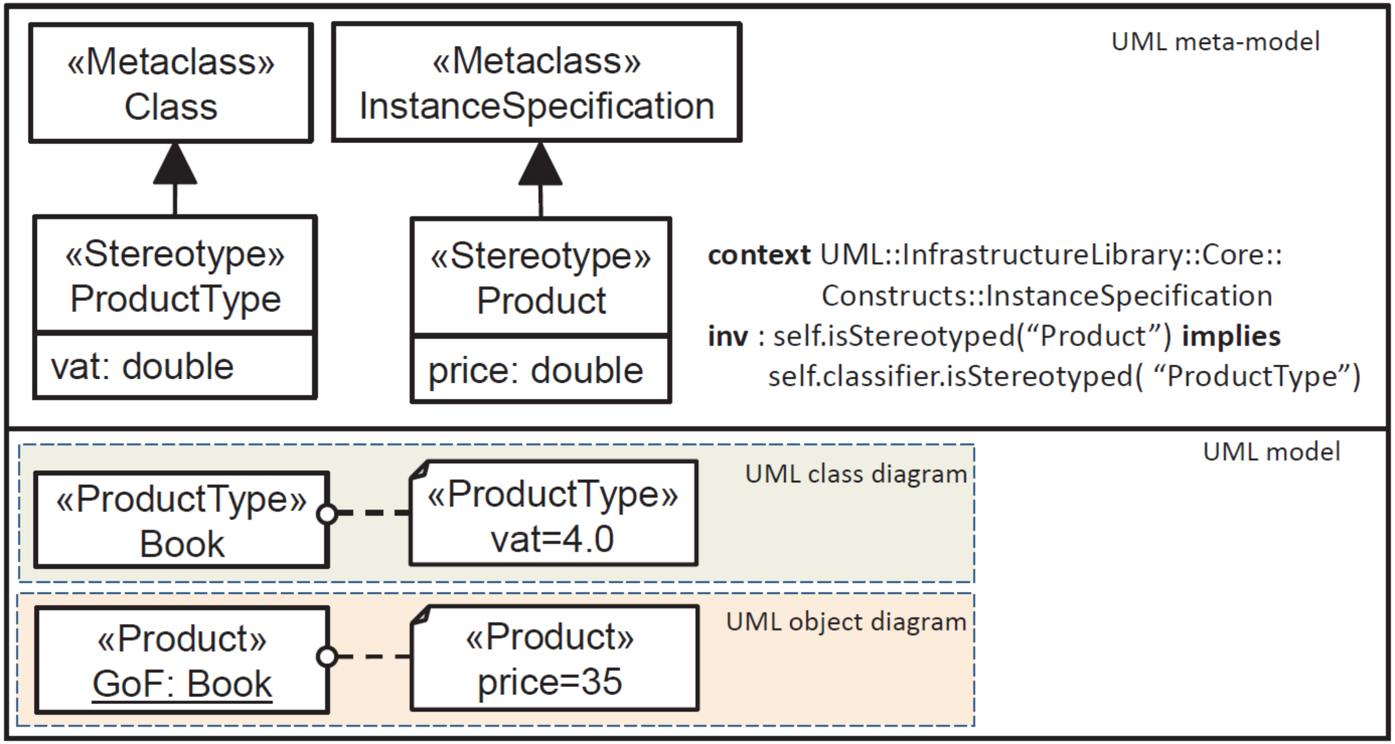
Two-Level Solutions (3)

- Powertypes
  - Types whose instances are subtypes of another type
  - Limited to modelling features in the next two levels



Two-Level Solutions (4)

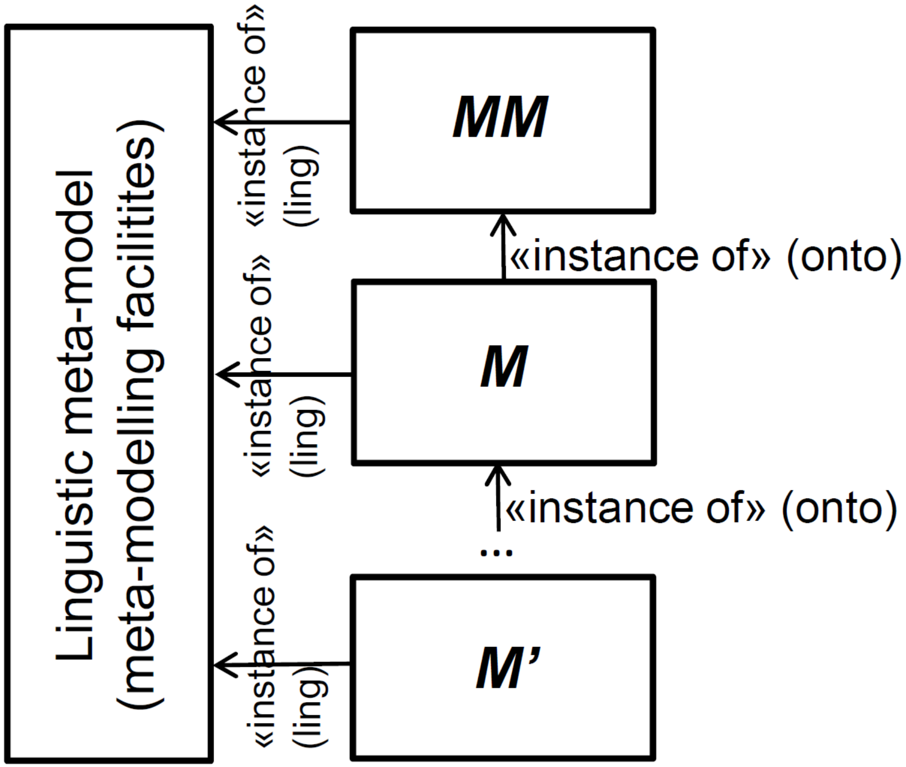
- Stereotypes
  - Extensions of the metametamodel
  - Limited to modelling domain concepts at two levels



```
context UML::InfrastructureLibrary::Core::
        Constructs::InstanceSpecification
inv : self.isStereotyped(“Product”) implies
      self.classifier.isStereotyped( “ProductType”)
```

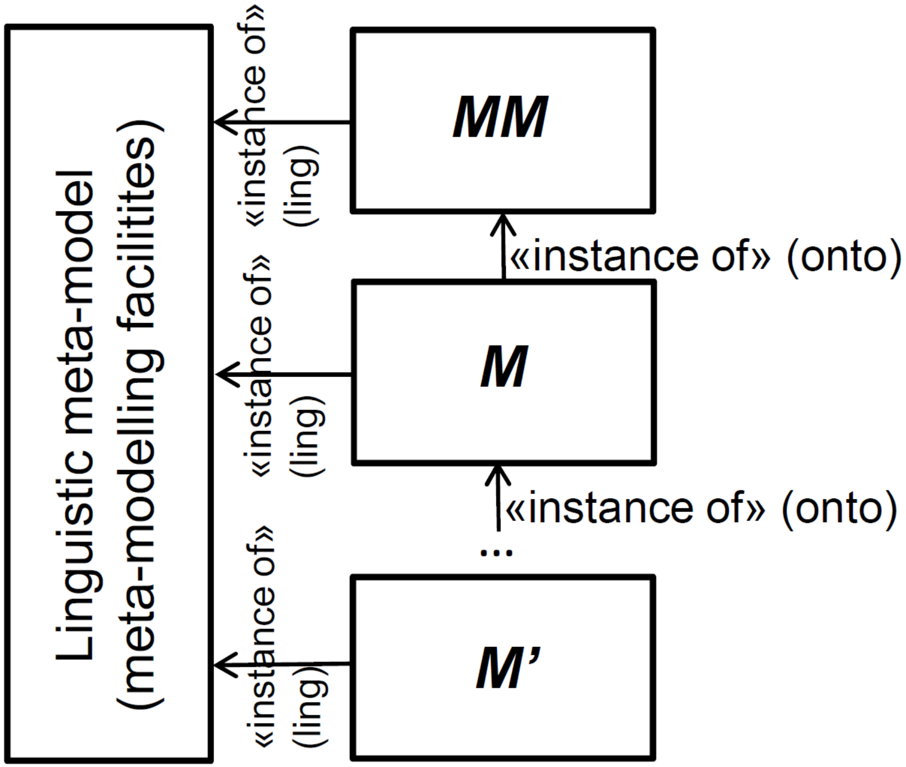
Multi-Level Modelling

- Potency
  - Model elements are clabjects
  - All elements are instantiable (for given number of times)



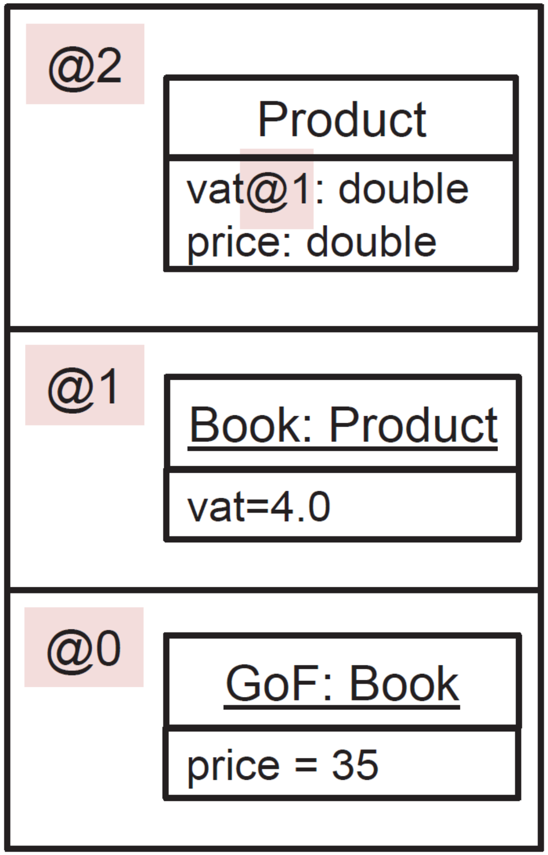
Multi-Level Modelling

- **Potency**
  - Model elements are clabjects
  - All elements are instantiable (for given number of times)
- **Orthogonal Classification Architecture**
  - Metamodelling facilities available at all meta-levels
  - Two kinds of types: ontological & linguistic



Multi-Level Modelling

- Type-Object



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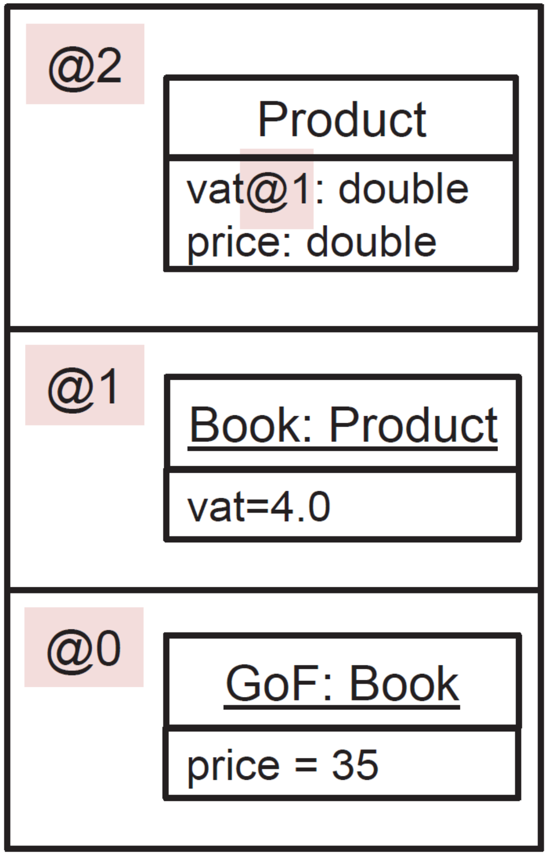
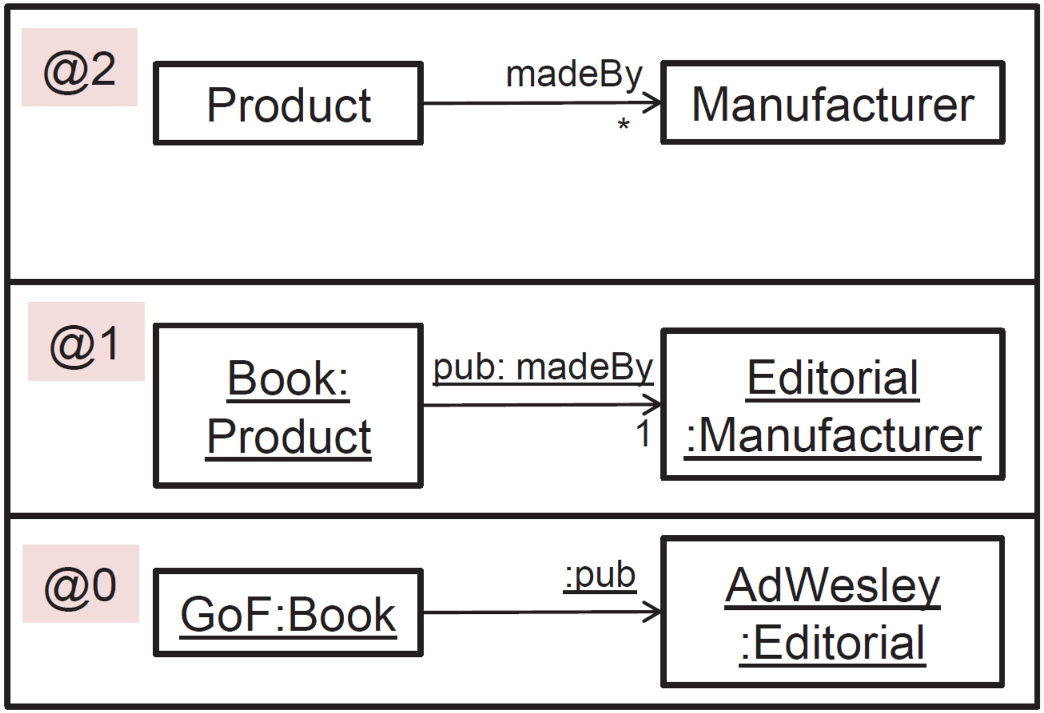


- Relation Configurator



Field Study

- Results
  - Over 400 metamodels surveyed
  - 84 contain at least one type-object
  - 459 occurrences of patterns in total

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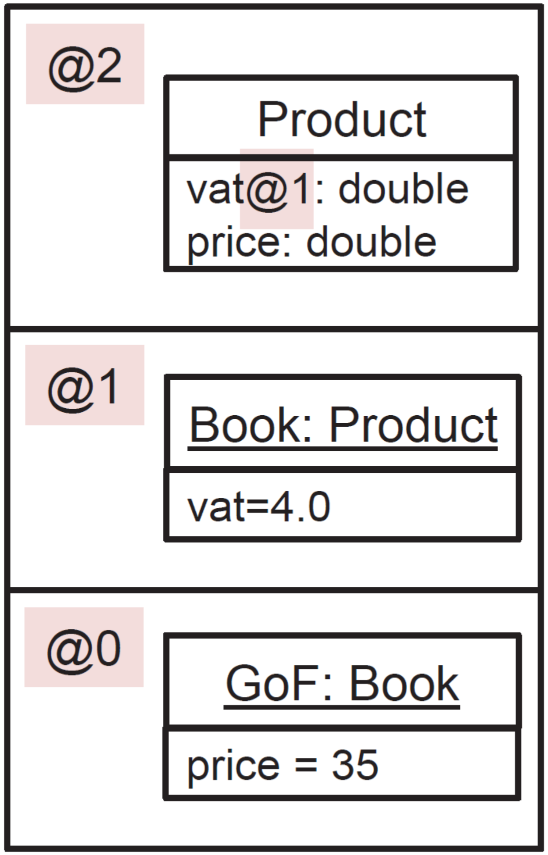
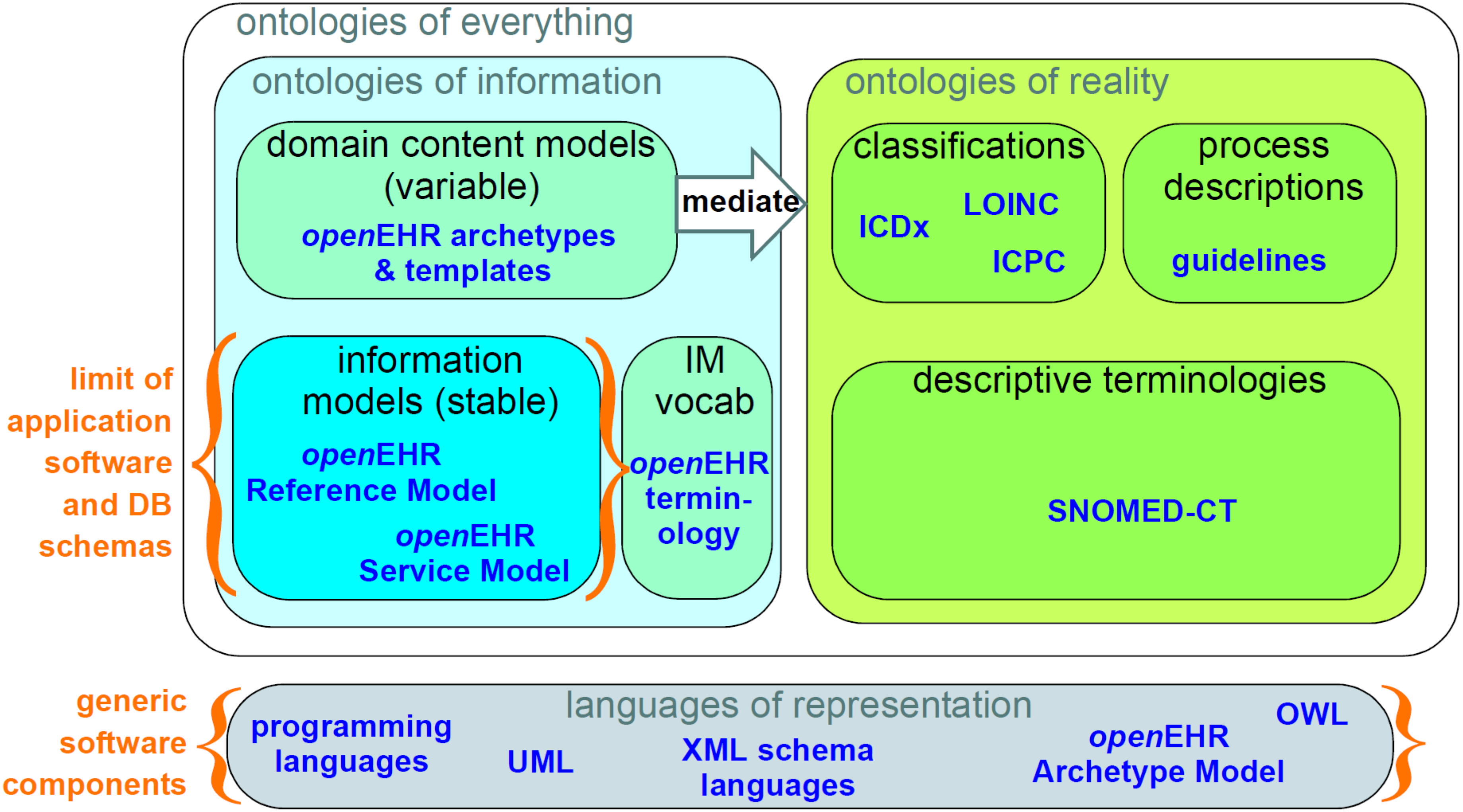
- **Discussion Points**
  - Which approach is more “natural”?
  - Is multi-level modelling a workaround?



Electronic Health Record (EHR)

- **Requirements**
  - Capture holistic view of patient
  - Applicable/extensible to all clinical domains
  - Applicable for all clinical environments

openEHR Architecture



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ontologies of everything

ontologies of information

domain content models (variable)

*open*EHR archetypes & templates

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*open*EHR Service Model

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*open*EHR termin-ology

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SNOMED-CT

generic software components

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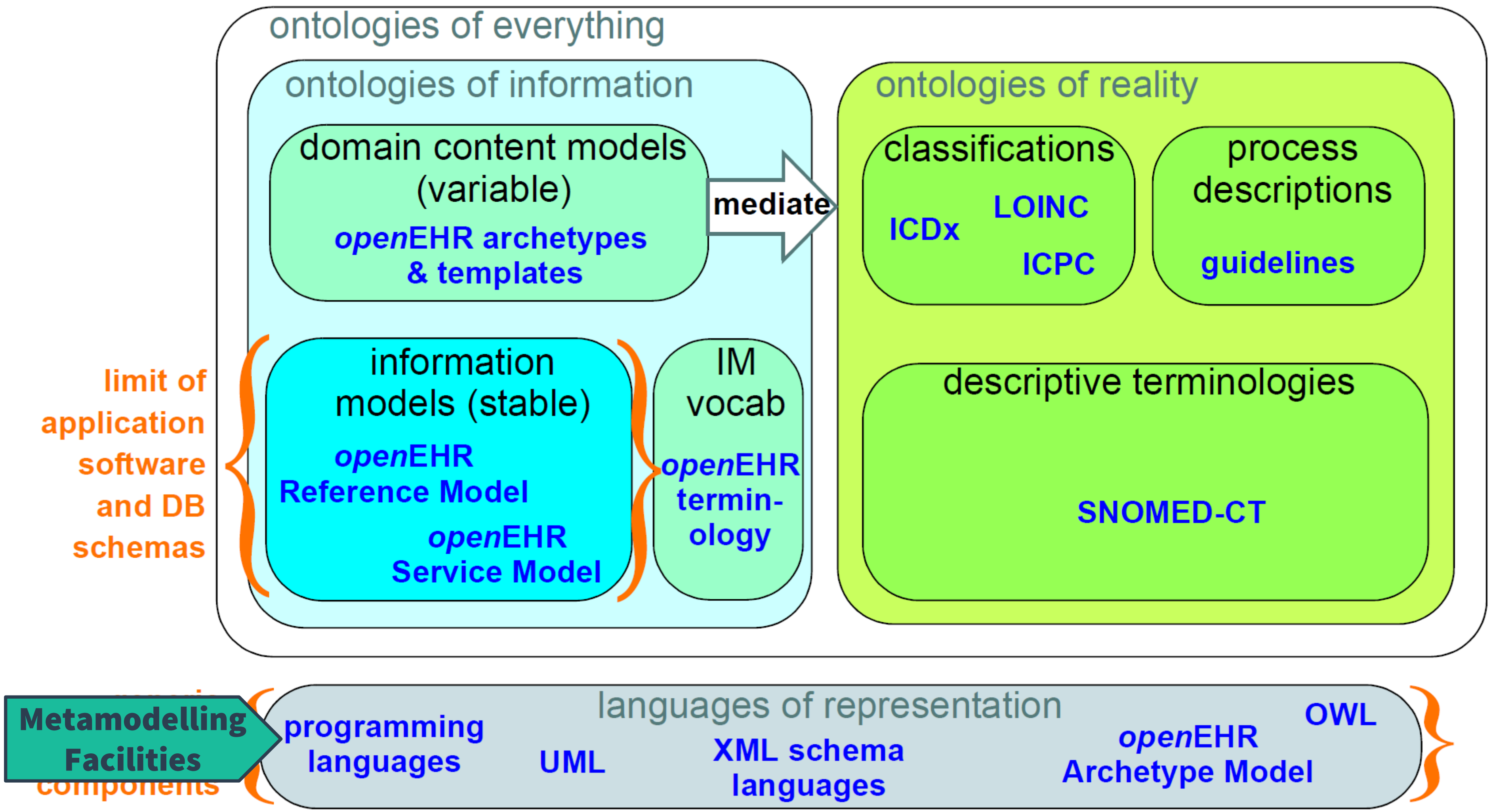

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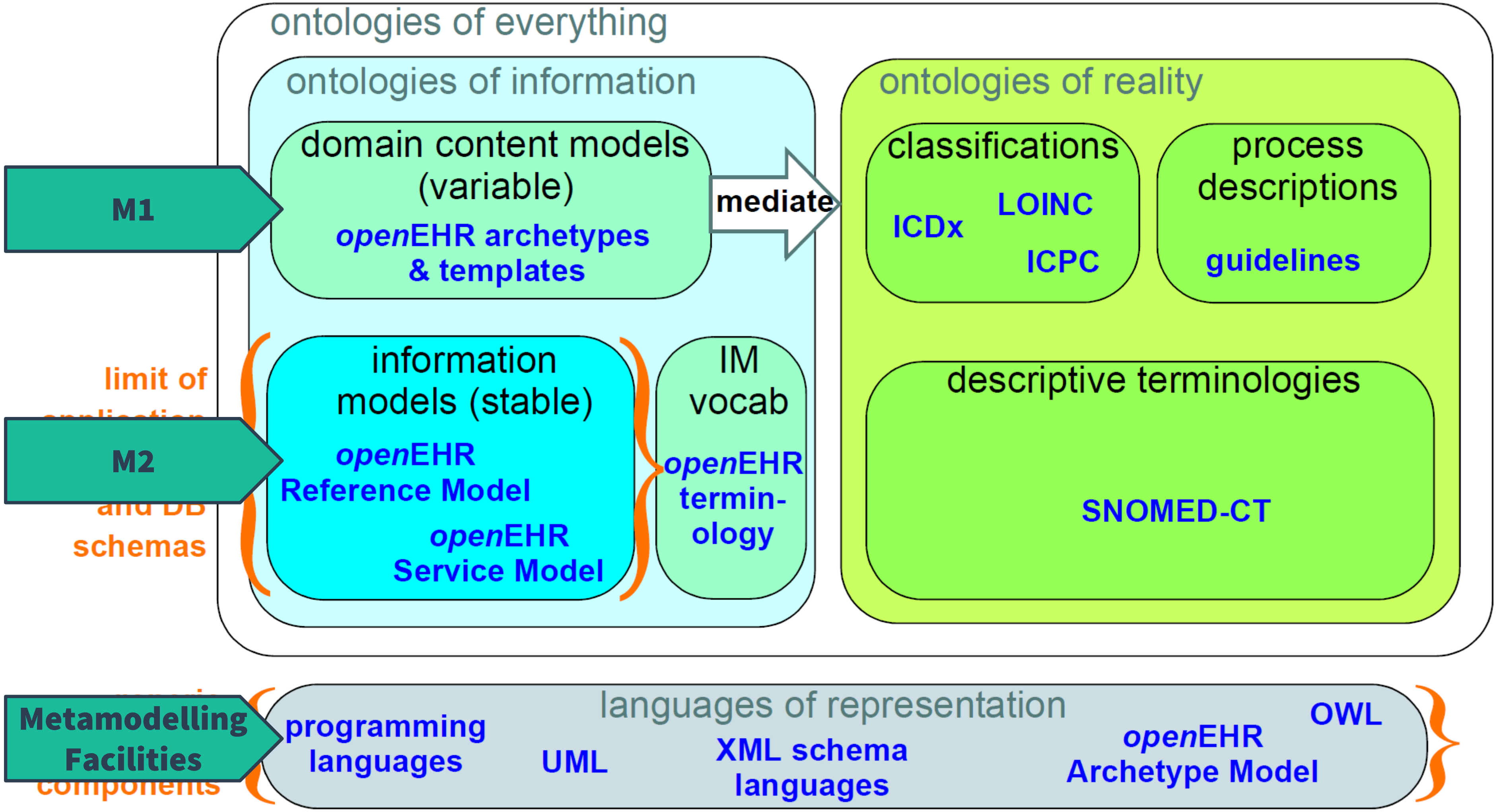

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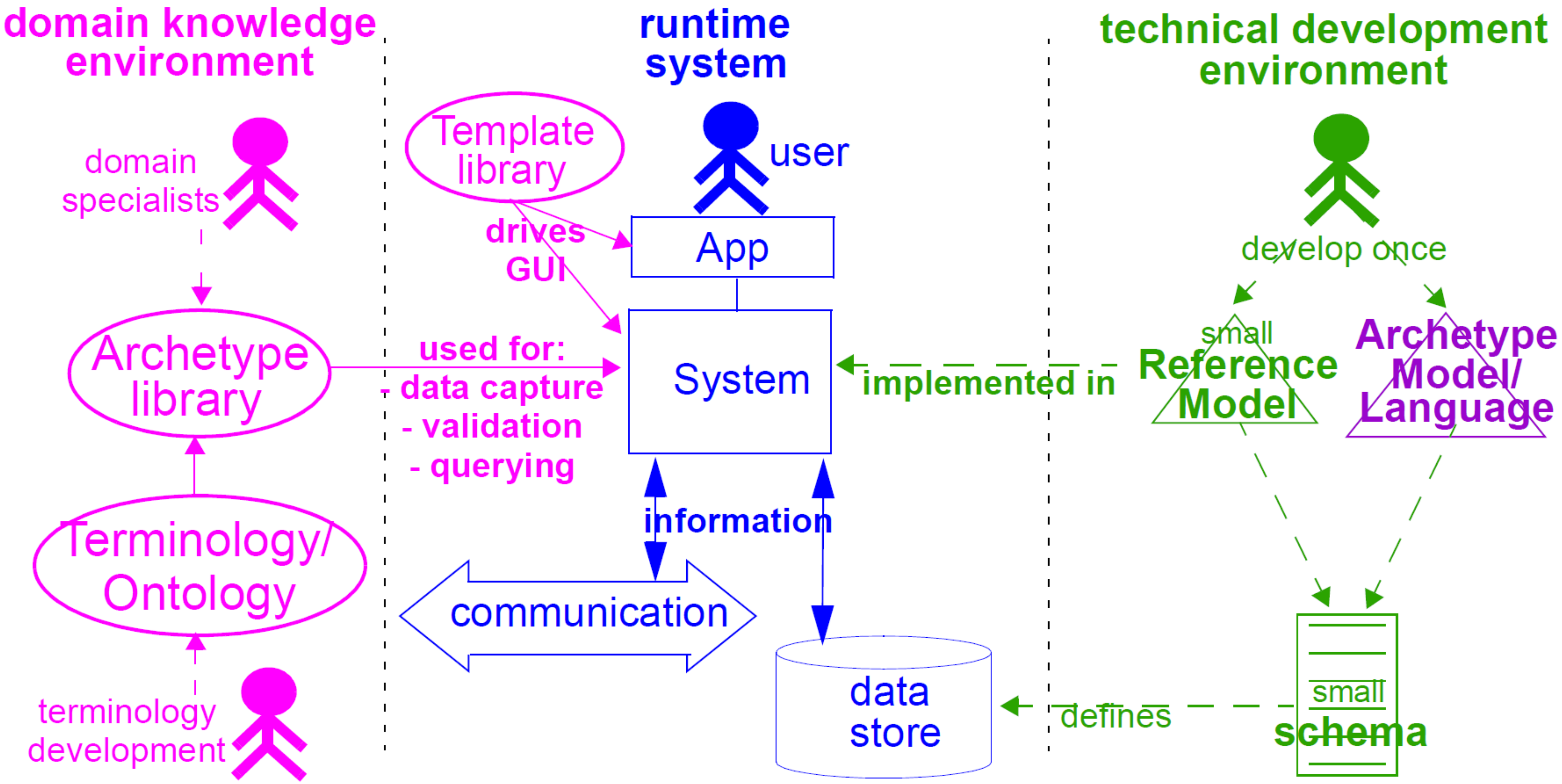

Conclusions

- **Multi-Level Modelling**
  - Potency
  - Orthogonal Classification Architecture
- **Design Patterns**
  - Type-Object Pattern
  - Dynamic Features
  - Dynamic Auxiliary Domain Concepts
  - Relation Configurator Pattern
  - Element Classification
- **Discussion**
  - When to use multi-level modelling?