Ontology-Driven Conceptual Modelling

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Summary

- Ontology and ontologies
- Formal ontological analysis
- The OntoClean methodology

- Advanced concepts:
  - Re-visiting conceptual modeling notions
  - Comments on BWW approach
  - The DOLCE ontology

What is Ontology?

- A discipline of Philosophy
  - *Meta-physics* dates back to Aristotle
  - *Ontology* dates back to 17th century
- The science of what *is* ("being *qua* being")
- The study of what is *possible*
- The study of the *nature* and *structure* of *possibilia*

What is *an* Ontology?

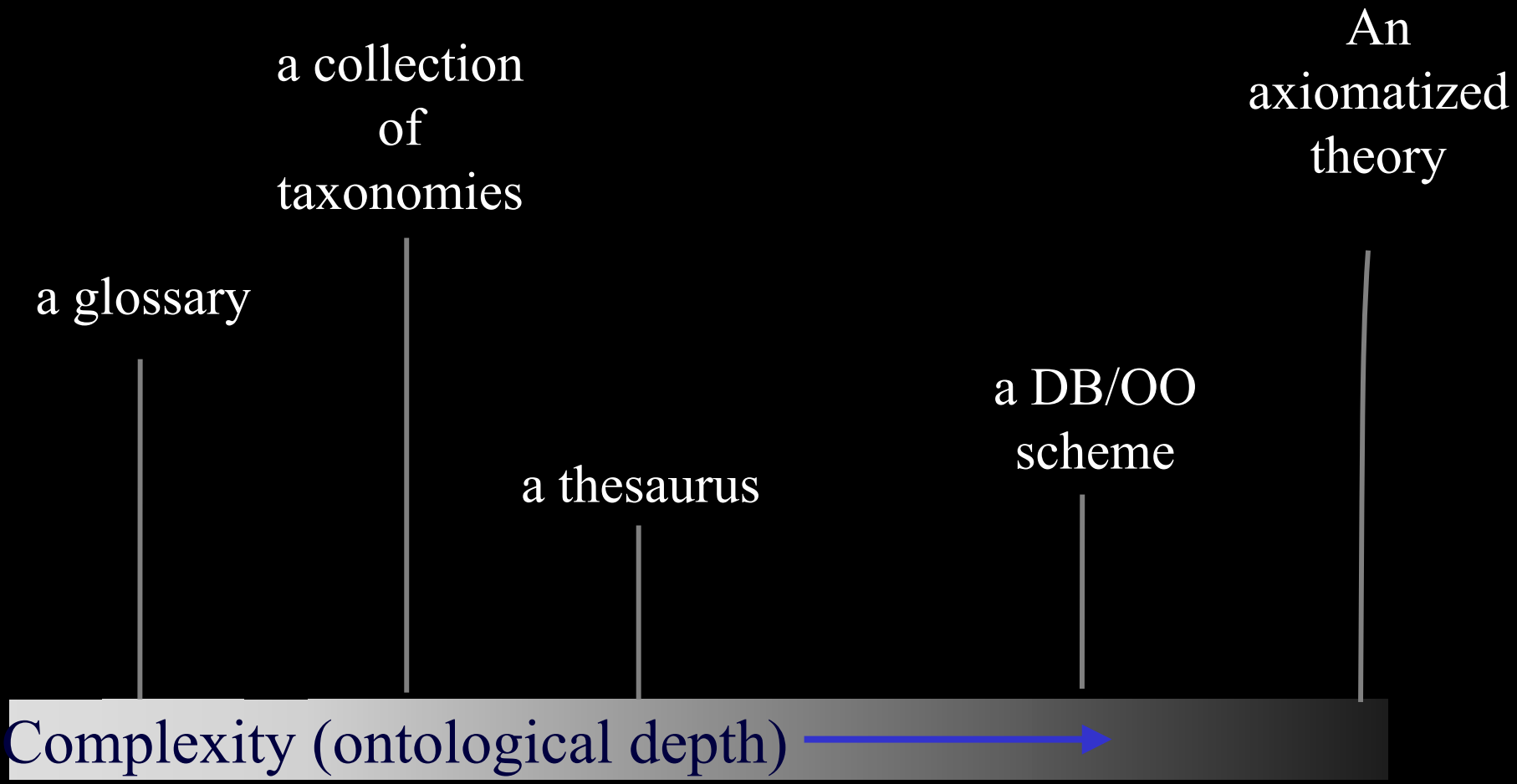
- *A* specific ***artifact*** designed with the purpose of expressing the ***intended meaning*** of a (shared) ***vocabulary***

- *A shared* vocabulary plus a specification (***characterization***) of its intended meaning

"An ontology is a specification of a conceptualization
[Gruber 95]

...i.e., an ontology accounts for the ***commitment*** of a language to a certain ***conceptualization***

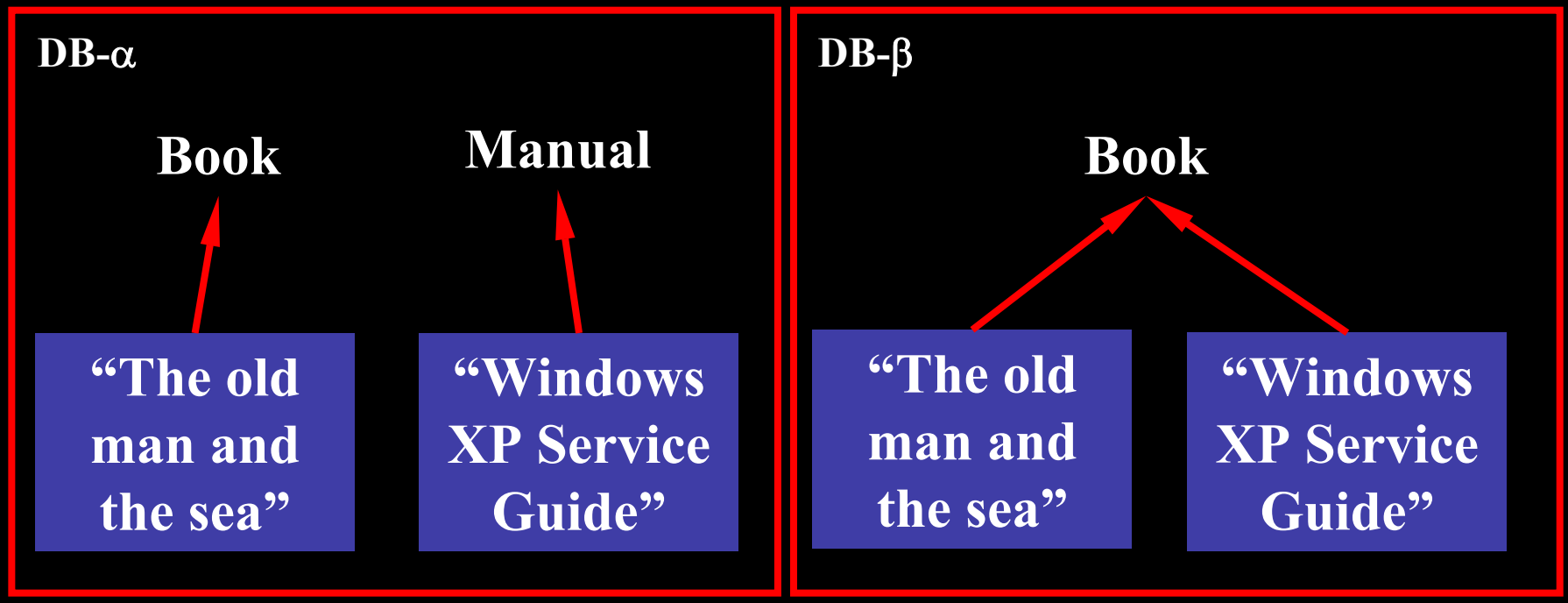
What is *an* Ontology?



Why ontologies?

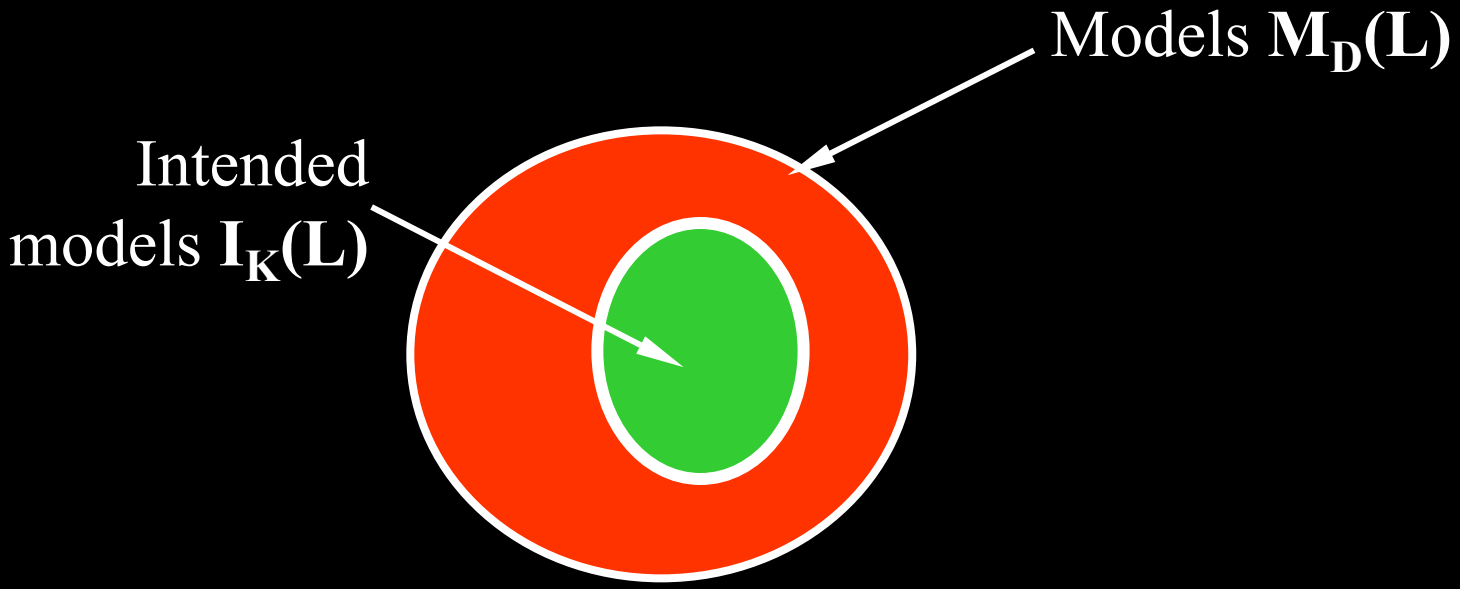
- Semantic Interoperability
  - Generalized database integration
  - Virtual Enterprises
  - *e*-commerce
- Information Retrieval
  - Decoupling user vocabulary from data vocabulary
  - Query answering over document sets
  - Natural Language Processing

Same term, different concept

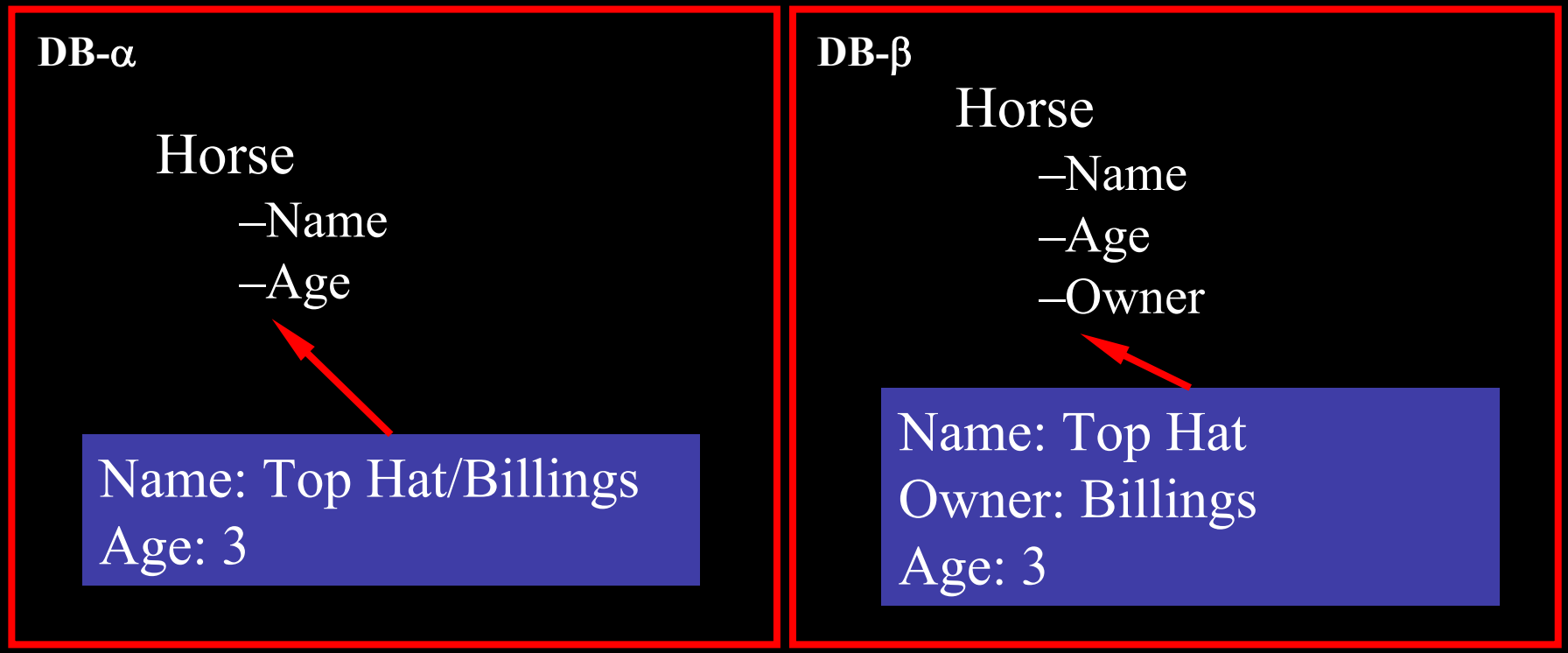


Unintended models must be taken into account during integration

Intended Models

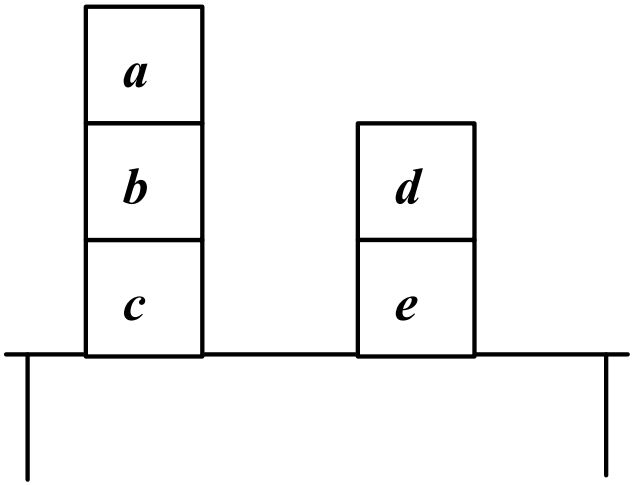


Hidden assumptions behind names



- **DB-α**
  - ***Identity Criteria:*** **Same name**
- **DB-β**
  - ***Identity Criteria:*** **Same name and owner**

What is a conceptualization?

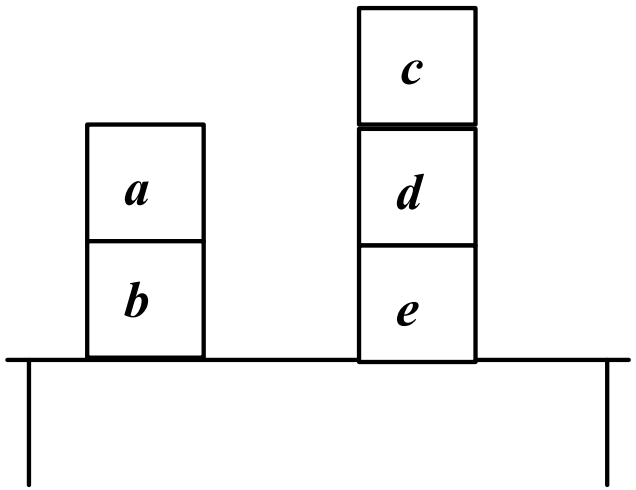


Scene 1: blocks on a table

onceptualization of scene 1 (according to Genesereth&Nilsson

{a, b, c, d, e }, {on, above, clear, table }>

What is a conceptualization?



Scene 2: a different arrangement of blocks

A conceptualization is not a (Tarskian) ***model***!

What is a conceptualization

- Formal structure of (a piece of) reality as perceived and organized by an agent, *independently* of:
  - the ***vocabulary*** used
  - the actual occurence of a specific ***situation***
- Different situations involving same objects, described by different vocabularies, may share the same conceptualization.

Relations vs. Conceptual Relations

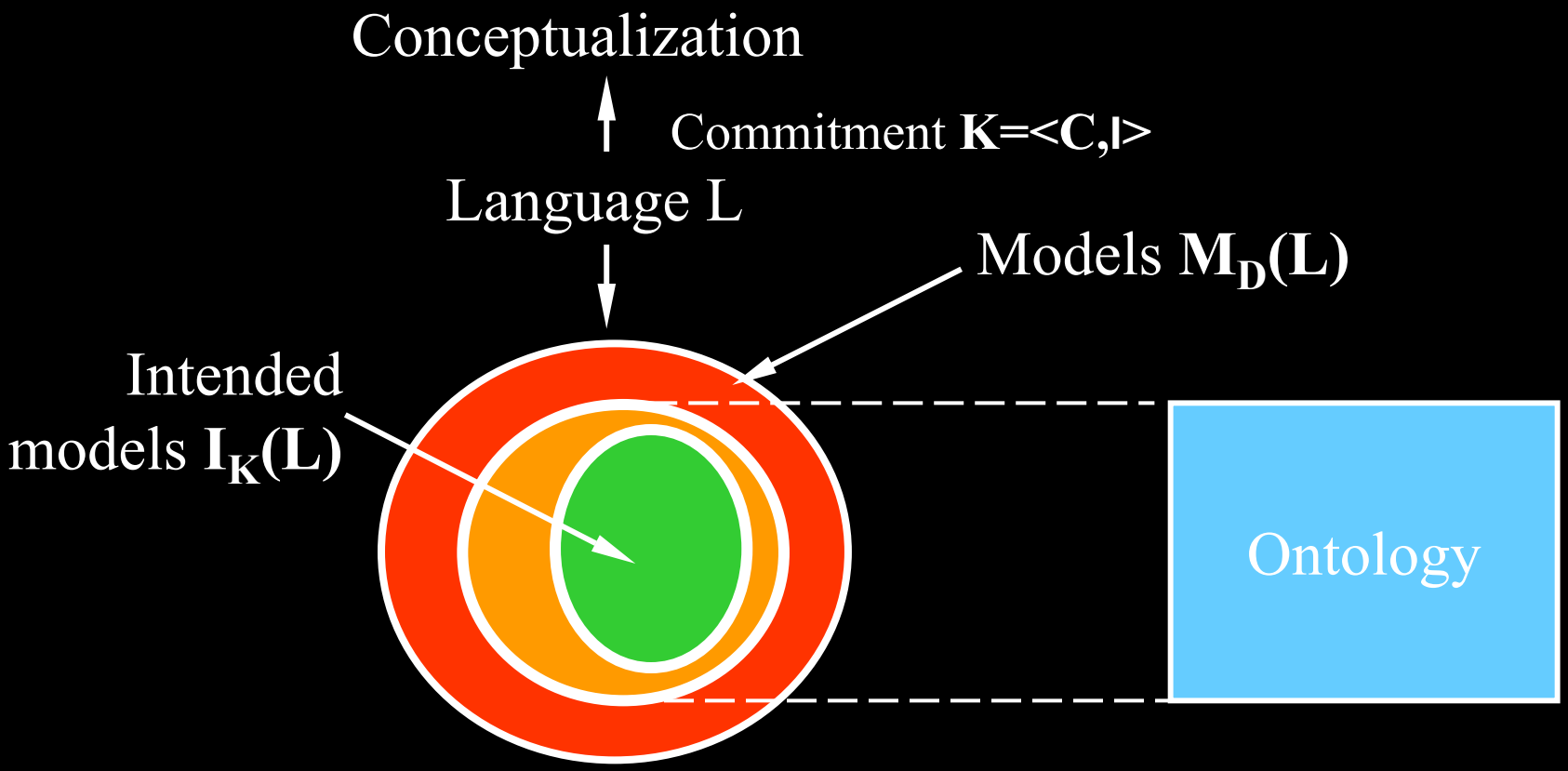
$$r_n \in 2^{D^n}$$

$$\rho_n : W \rightarrow 2^{D^n}$$ *(Montague-style semantics)*

ordinary relations are defined on a ***domain*** D:

conceptual relations are defined on a ***domain space*** <D, W>

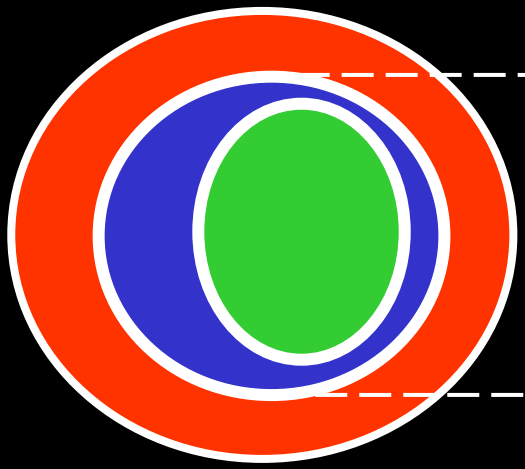
Ontologies *constrain* the intended meaning



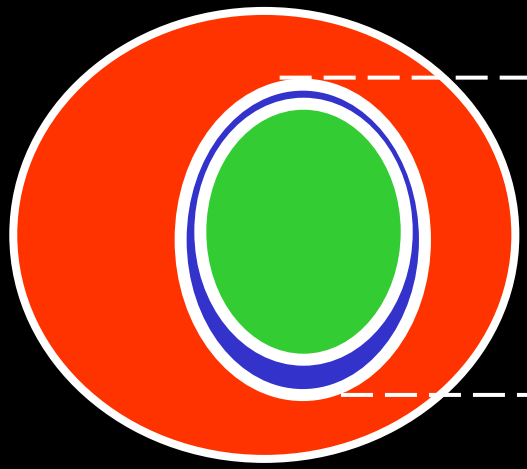
Different uses of ontologies

- Application ontologies (*run time*)
  - offer ***terminological services,*** checking constraints between terms
  - limited expressivity (stringent computational reqs.)
- Reference ontologies (*develop. time*)
  - ***establish consensus*** about meaning of terms (in general)
  - higher expressivity (less stringent computational reqs)
- ***Mutual understanding*** more important than mass interoperability
  - *understanding disagreements*
  - establish *trustable mappings* among application ontologies

Good and bad ontologies

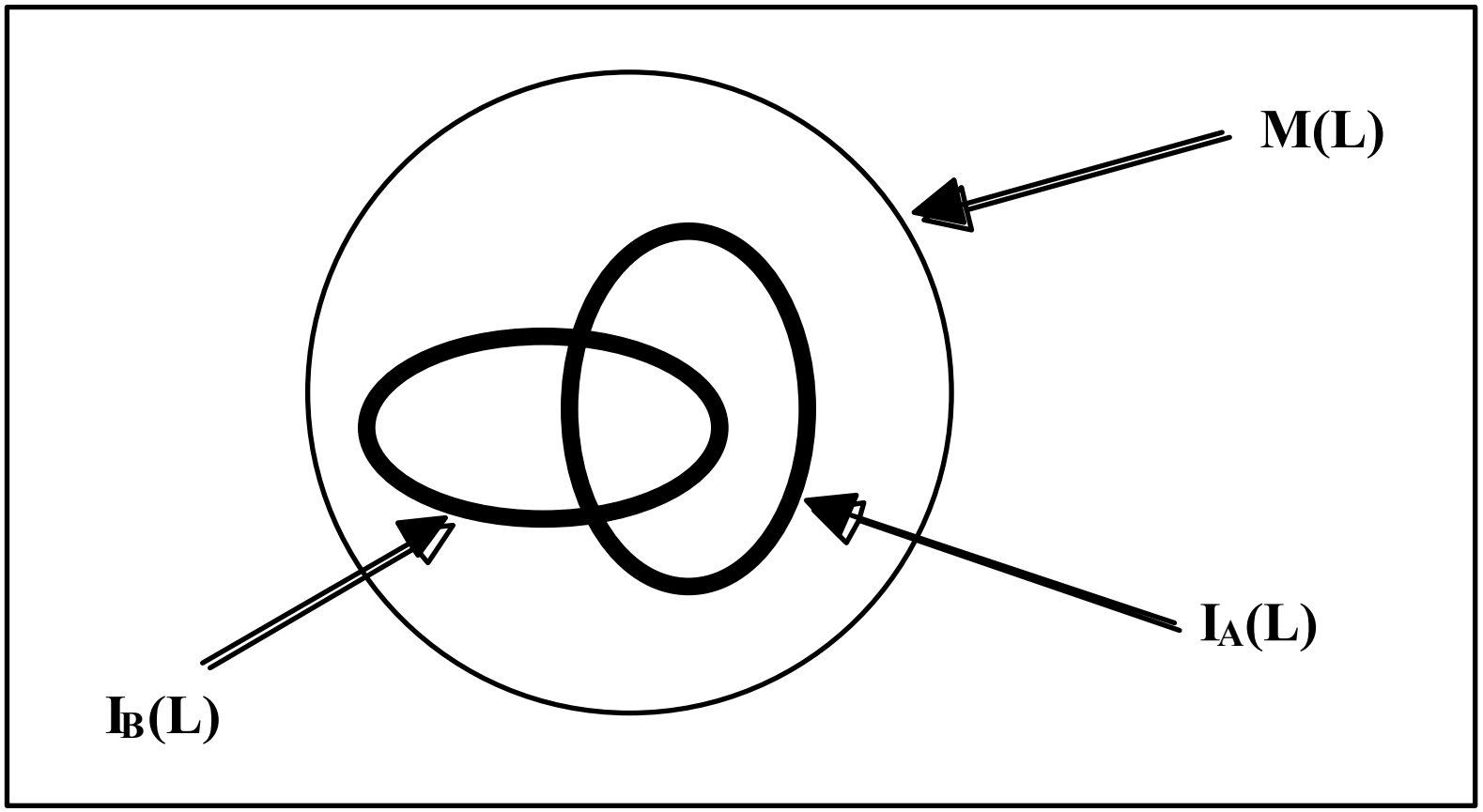


Bad ontology



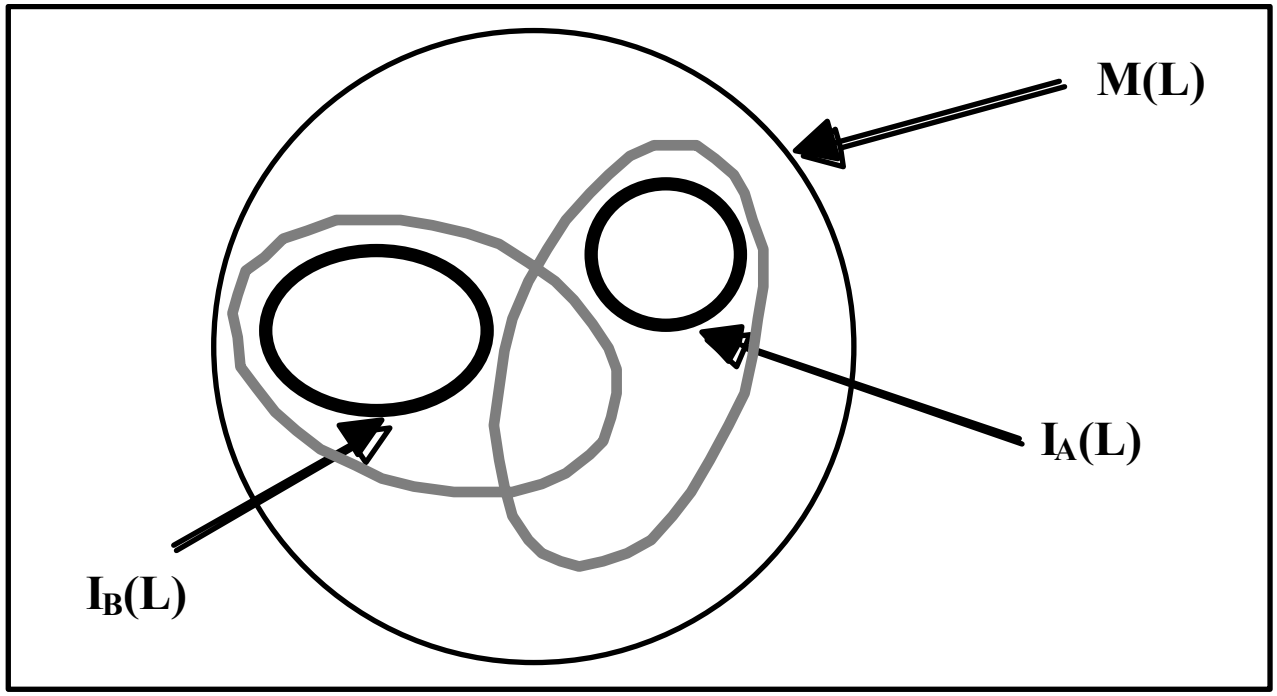
Good ontology

The *Ontology Sharing Problem* (1)



Agents A and B can communicate only if their ***intended*** models overlap

The *Ontology Sharing Problem* (2)



Two different ontologies may overlap while their ***intended*** models do not (especially if the ontologies are not accurate enough)

When axioms are not enough

Let's consider the "on" relationship in the blocks world

Only one predicate in the language: on/2

Only blocks in the domain: {a, b, c, …}

Just one axiom:

$\neg on(x, x)$

Possibly to be replaced with:

$on(x,y) \rightarrow \neg on(y,x)$

Non-intended *models* are excluded, but the intended meaning of "on" for describing *situations* in the blocks world is not captured.

Ontology Completeness and Accuracy

- In general, a single intended ***model*** may not discriminate among relevant alternative ***situations***
  - Lack of primitives
  - Lack of entities
- Capturing all intended models is not sufficient for a "perfect" ontology
- ***Completeness***: all non-intended *models* are excluded
- ***Accuracy***: all non-intended *situations* are excluded
- Accurate ontologies may need an extension of language and domain which is not necessary for run-time purposes

Ontology quality

- Completeness
- Accuracy
- Cognitive adequacy

From Ontologies to Data

- Reference ontology (*development time*)
  - ***establishes consensus*** about meaning of terms (in general)
- Reference application ontology (*develop. time*) [Conc. Model?]
  - *Focuses on a* ***particular application***
  - limited by relevance choices related to a certain application
- Application ontology (Tbox) (*run time*)
  - ***implements*** an ontology for a specific application
  - Describes ***constraints*** between terms to be checked at *run time* (***terminological services***)
  - limited by expressive power of representation formalism
- Database (Abox) (*run time*)
  - Describes a specific (epistemic) ***state of affairs***

A KB includes both

Ontological truths vs. epistemic truths

- Ontological knowledge holds ***necessarily***!
- The semantics of ***generalization*** needs to be refined
  - All the telephones are artifacts
  - All the telephones are black

[Woods 75, *What's in a link*]

Ontologies vs. Conceptual Schemas

- **Conceptual schemas**
  - *Often not accessible at run time*
  - *Usually no formal semantics*
  - *attribute values taken out of the UoD*
  - *constraints relevant for database update*
- **Ontologies**
  - *Usually accessible at run time*
  - *formal semantics*
  - *attribute values first-class citizens*
  - *constraints relevant for intended meaning*

Do we need an ontology of ontologies?

- Not every KB is an ontology
  - *Epistemic* truth vs. *ontological* truth
  - Simulation (predicting behavior) *out of scope*
- Ontologies perform *terminological services*
  - At run-time
  - At developing-time
- Different *computational requirements*
- Different *functional requirements*
  - Whether humans are involved or not
  - Sharing agreements vs. *understanding disagreements*
  - Establishing *trustable mappings* among sources
- **Reference ontologies** vs. lightweight ontologies