First Interdisciplinary Summer School on Ontological Analysis

Introduction to Applied Ontology and Ontological Analysis

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Applied Ontology: an emerging interdisciplinary area

- Applied Ontology builds on *philosophy*, *cognitive science*, *linguistics* and *logic* with the purpose of understanding, clarifying, making explicit and communicating ***people's assumptions*** about the nature and structure of the world.

- This orientation towards ***helping people understanding each other*** distinguishes applied ontology from philosophical ontology, and motivates its ***unavoidable interdisciplinary nature***.

ontological analysis: study of
content (of these assumptions) ***as such***
(independently of their *representation*)

Ontological analysis and conceptual modeling

Conceptual modeling is the activity of ***formally*** describing some aspects of the ***physical*** and ***social*** world around us for the purposes of ***understanding*** and ***communication***

(John Mylopoulos)

Focusing on content

Do we know what to REpresent?

- ***First*** analysis,
- ***THEN*** representation…

Unfortunately, this is not the current practice…

- Computer scientists have focused on the ***structure of representations*** and the ***nature of reasoning*** more than on the ***content*** of such representations

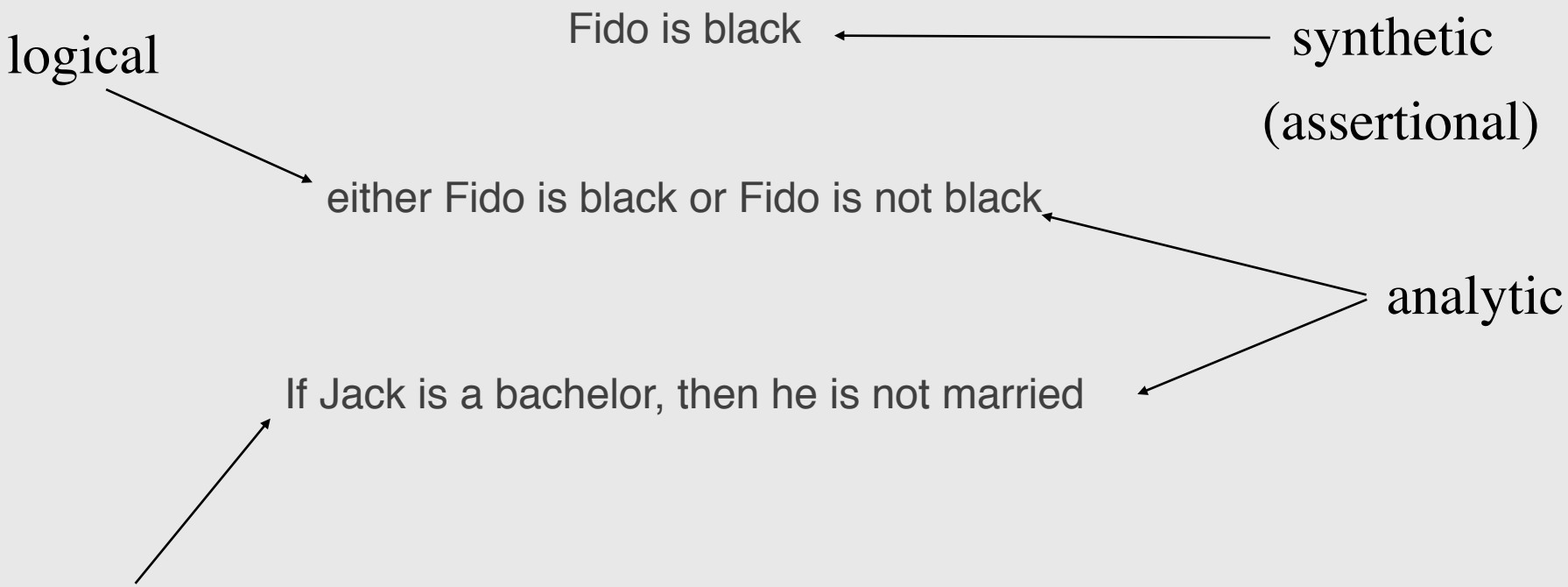
Essential ***ontological promiscuity*** of AI: any agent creates its own ontology based on its usefulness for the task at hand (Genesereth and Nilsson 1987)

No representation without
ontological analysis!

Logic is neutral about content

...but very useful to describe the formal structure (i.e., the *invariances*) of content

Kinds of knowledge



Terminological knowledge is about relationships between ***terms*** and ***concepts***

The problem: subtle distinctions in meaning

The e-commerce case:

"Trying to engage with too many partners too fast is one of the main reasons that ***so many online market makers have foundered***.

The transactions they had viewed as simple and routine actually involved many ***subtle distinctions in terminology and meaning***"

Harvard Business Review, October 2001

Subtle distinctions in meaning...

- What is an ***application*** to a public administration?
- What is a ***service****?*
- What is a ***working place***?
- What is an ***unemployed person***?

The key problems

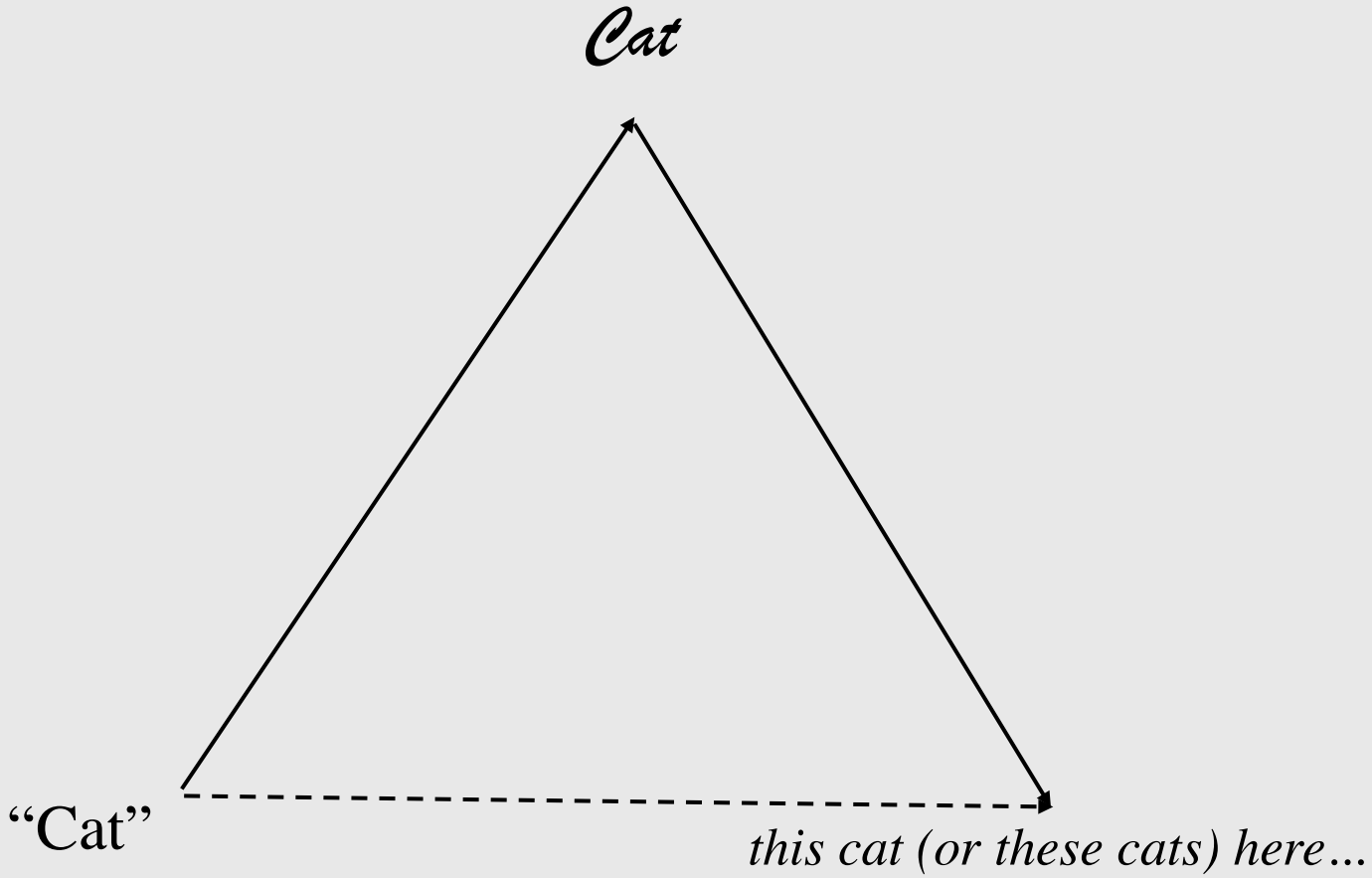
- content-based information access *(**semantic matching**)*
- content-based information integration *(**semantic integration**)*

Signs and concepts

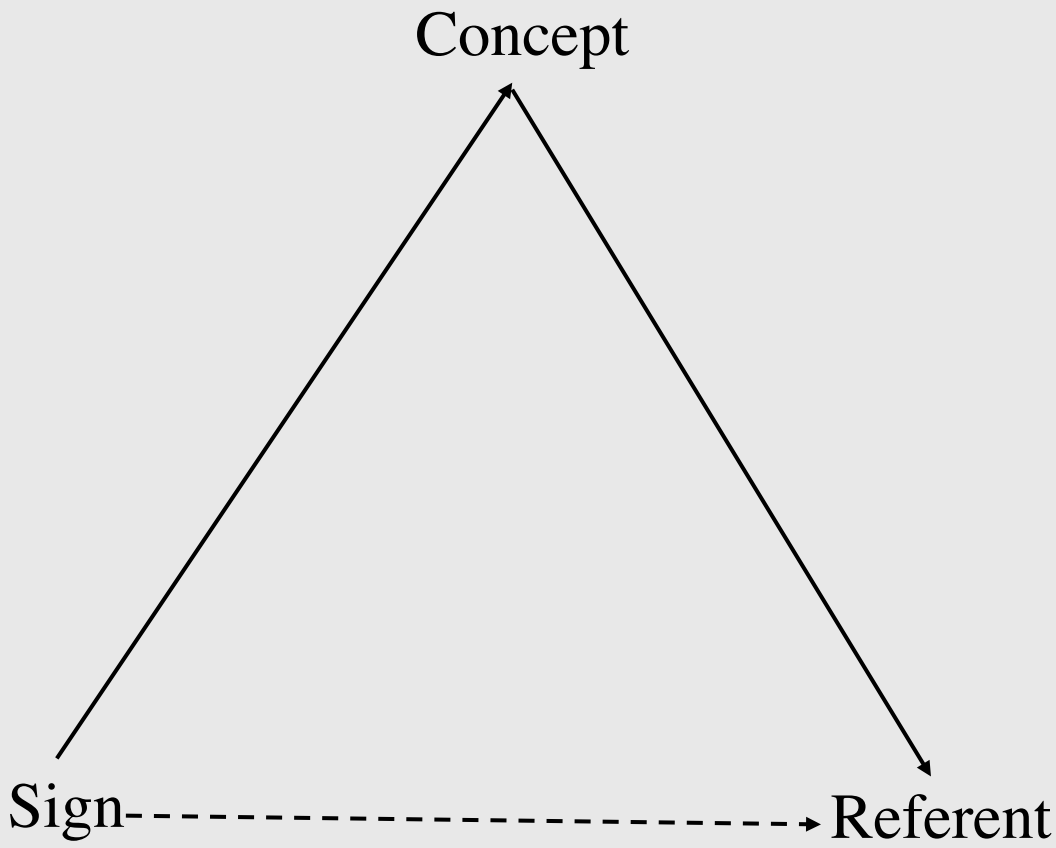
Signs and concepts

- Episodic memory vs. semantic memory:
  - we memorize both specific ***facts*** and general ***concepts***
- But what is a ***concept****?*
- What does it mean to represent it?

The triangle of meaning - 1



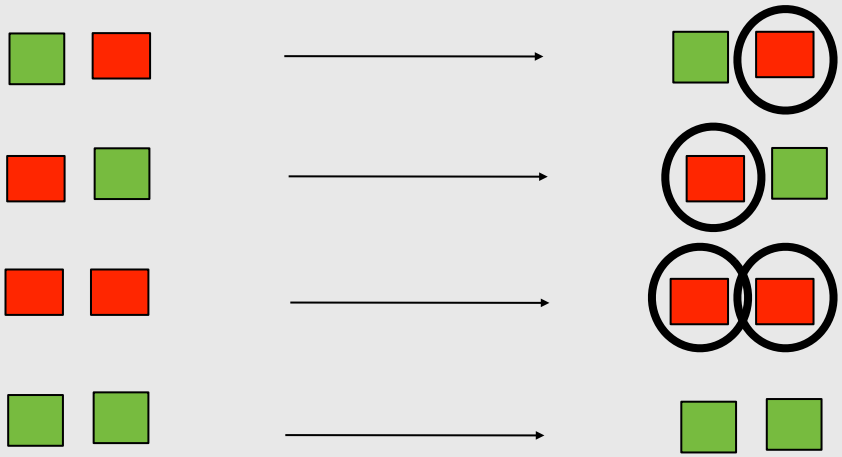
The triangle of meaning - 2



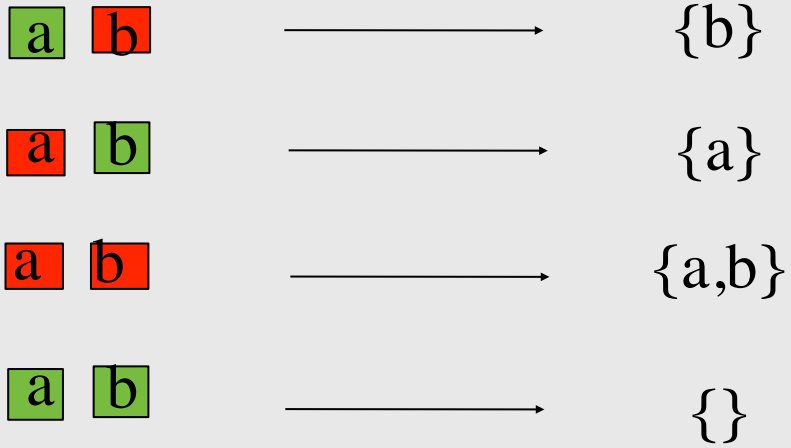
Intension ed extension

- Intension (concept): part of meaning corresponding to general principles, rules to be used to determine reference (typically, abstractions from experience)
- Extension (object): part of meaning corresponding to the effective reference
- Only by means of the ***concept*** associated to the ***sign*** “cat” we can correctly ***interpret*** this sign in various ***situations***
- The sign’s referent is the result of this interpretation
- Such interpretation is a ***situated intentional act***

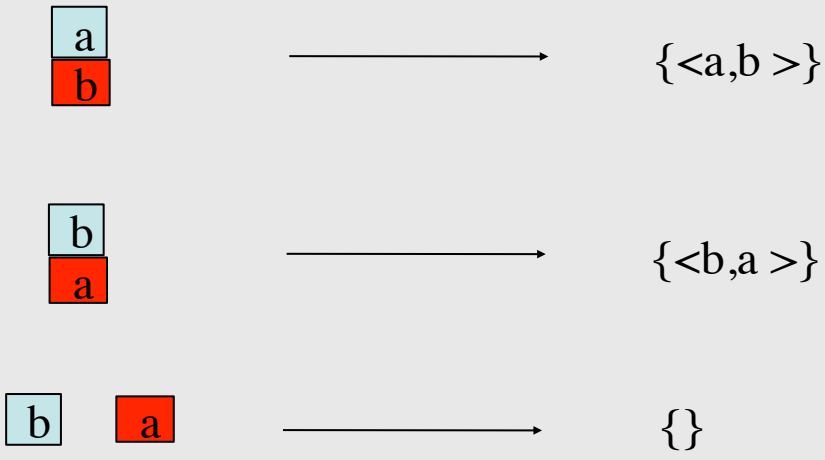
Example 1: the concept of *red*



...assuming a constant *conceptual domain*



Example 2: the concept of *on*



Concepts, properties, and relations: terminology issues

- Non-relational concepts are often called ***properties***
- Relational concepts are often called ***(conceptual) relations***

What is an ontology

Philosophical ontologies

- ***Ontology***: the philosophical discipline
  - Study of ***what there is*** (being qua being...)
    ...a liberal reinterpretation for computer science:

    content *qua* content, *independently of the way it is represented*

  - Study of the ***nature*** and ***structure*** of "reality"
- ***A (philosophical) ontology:*** a structured system of entities assumed to exists, organized in categories and relations.

Computational ontologies

Specific (theoretical or computational) artifacts
expressing the ***intended meaning*** of a ***vocabulary***
in terms of ***primitive*** categories and relations describing
the ***nature*** and ***structure*** of a ***domain of discourse***

...in order to account for the competent use of vocabulary in real situations!

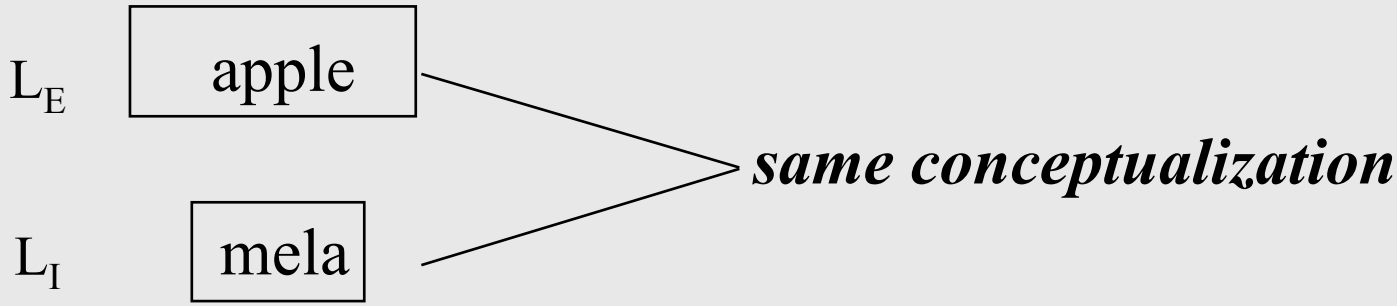
Gruber: "Explicit and formal specifications of a ***conceptualization***"

Computational ontologies, in the way they evolved, unavoidably mix
together philosophical, cognitive, and linguistic aspects.
Ignoring this ***intrinsic interdisciplinary nature***
makes them almost **useless**.

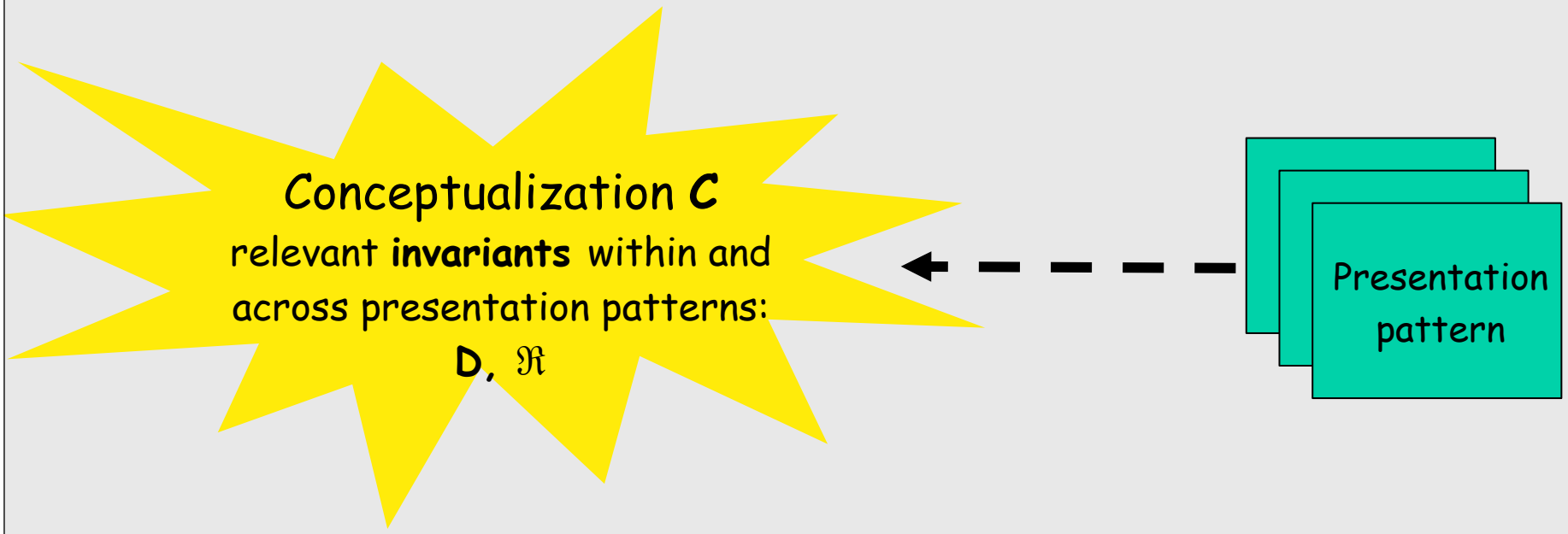
What is a conceptualization

- 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.

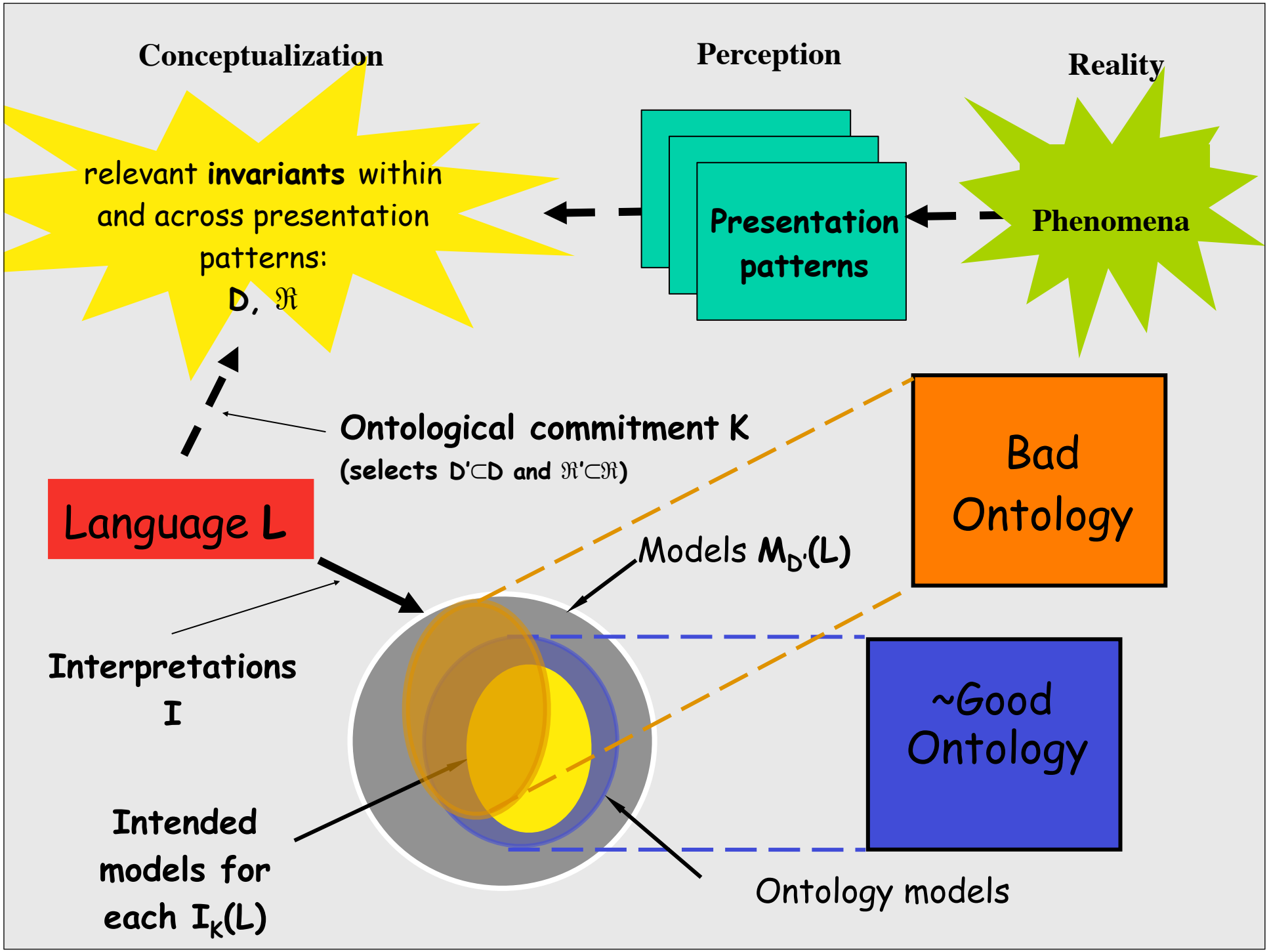


From experience to *conceptualization*

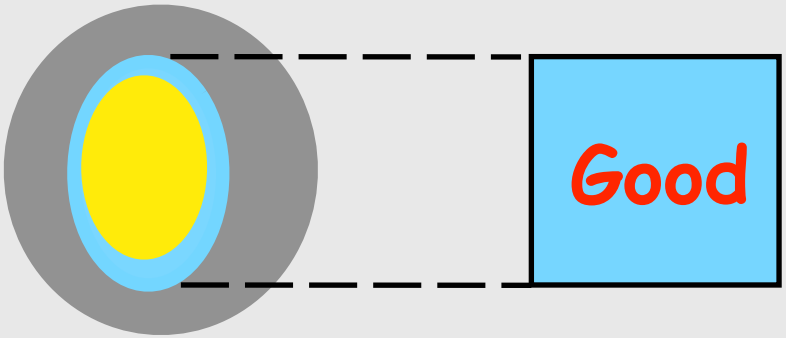


D : cognitive domain

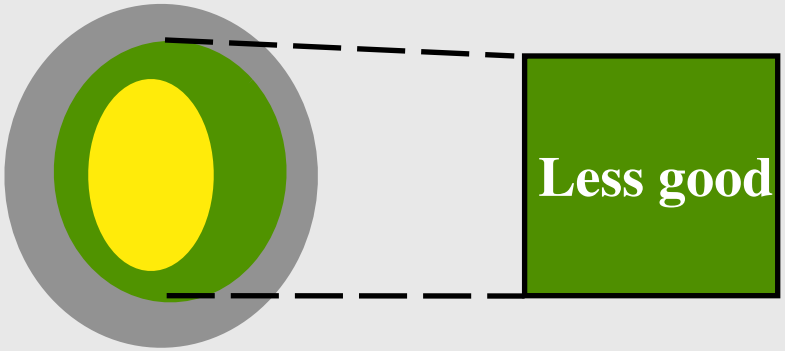
ℜ : set of *conceptual relations* on elements of D


Conceptualization
Perception
Reality
relevant invariants within and across presentation patterns: D, ℜ
Presentation patterns
Phenomena
Ontological commitment K
(selects D'⊂D and ℜ'⊂ℜ)
Language L
Models $M_{D'}(L)$
Bad Ontology
Interpretations I
~Good Ontology
Intended models for each $I_K(L)$
Ontology models

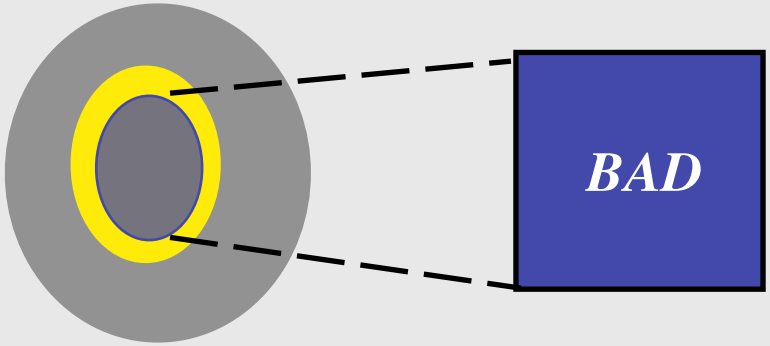
Ontology Quality: Precision and Correctness



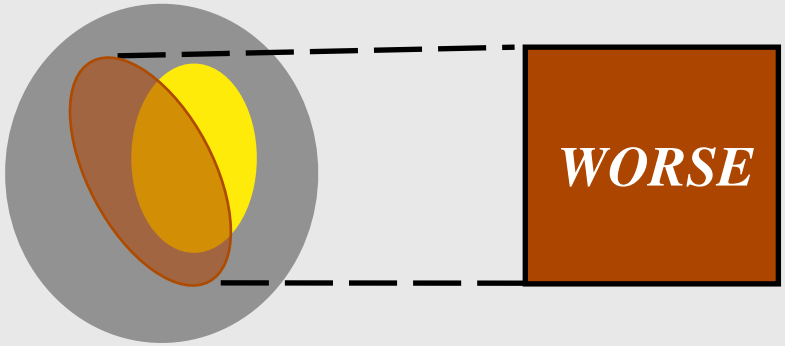
High precision, max correctness



Low precision, max correctness

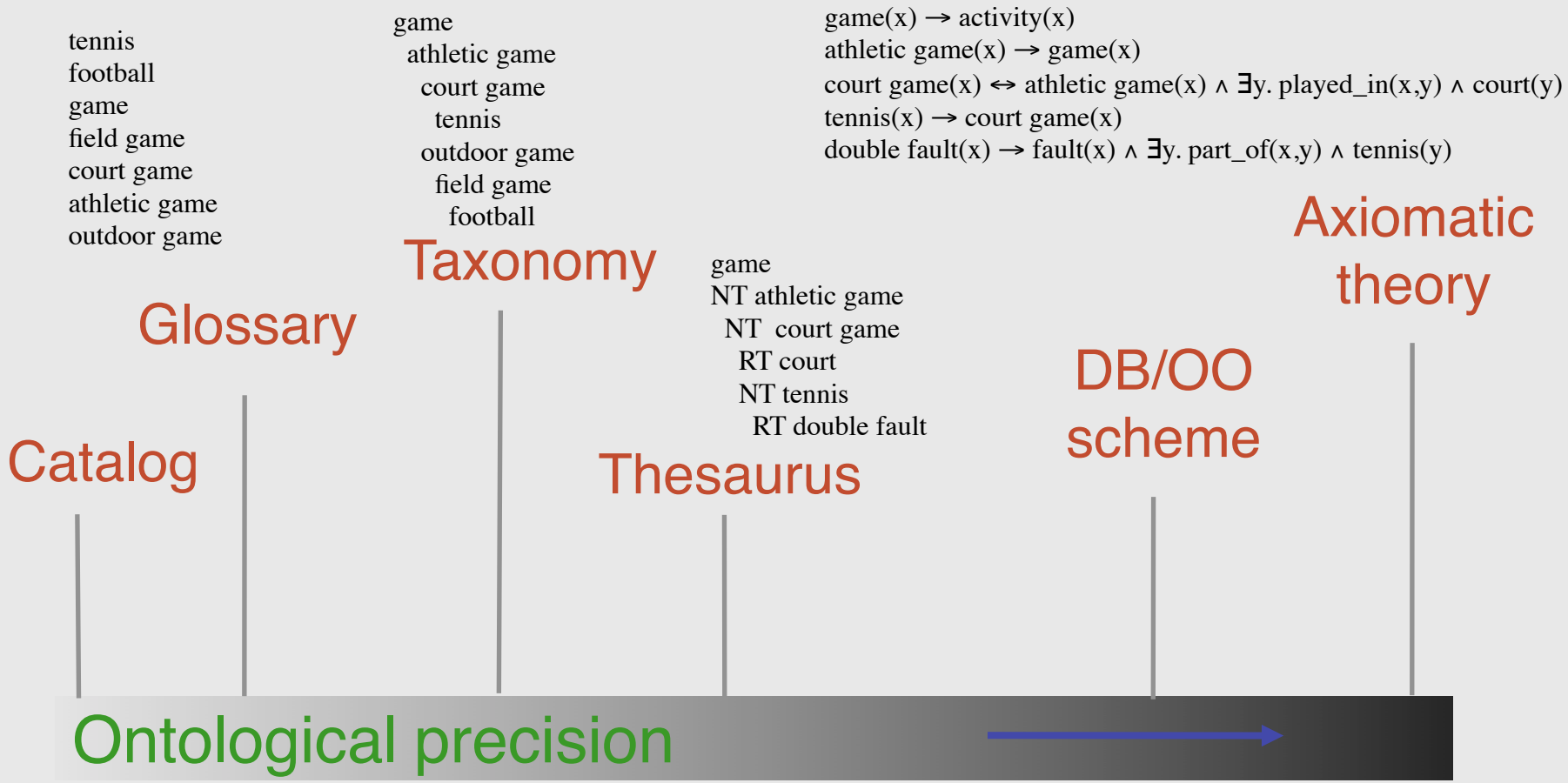


Max precision, low correctness



Low precision, low correctness

Levels of Ontological Precision



Why ontological precision is important

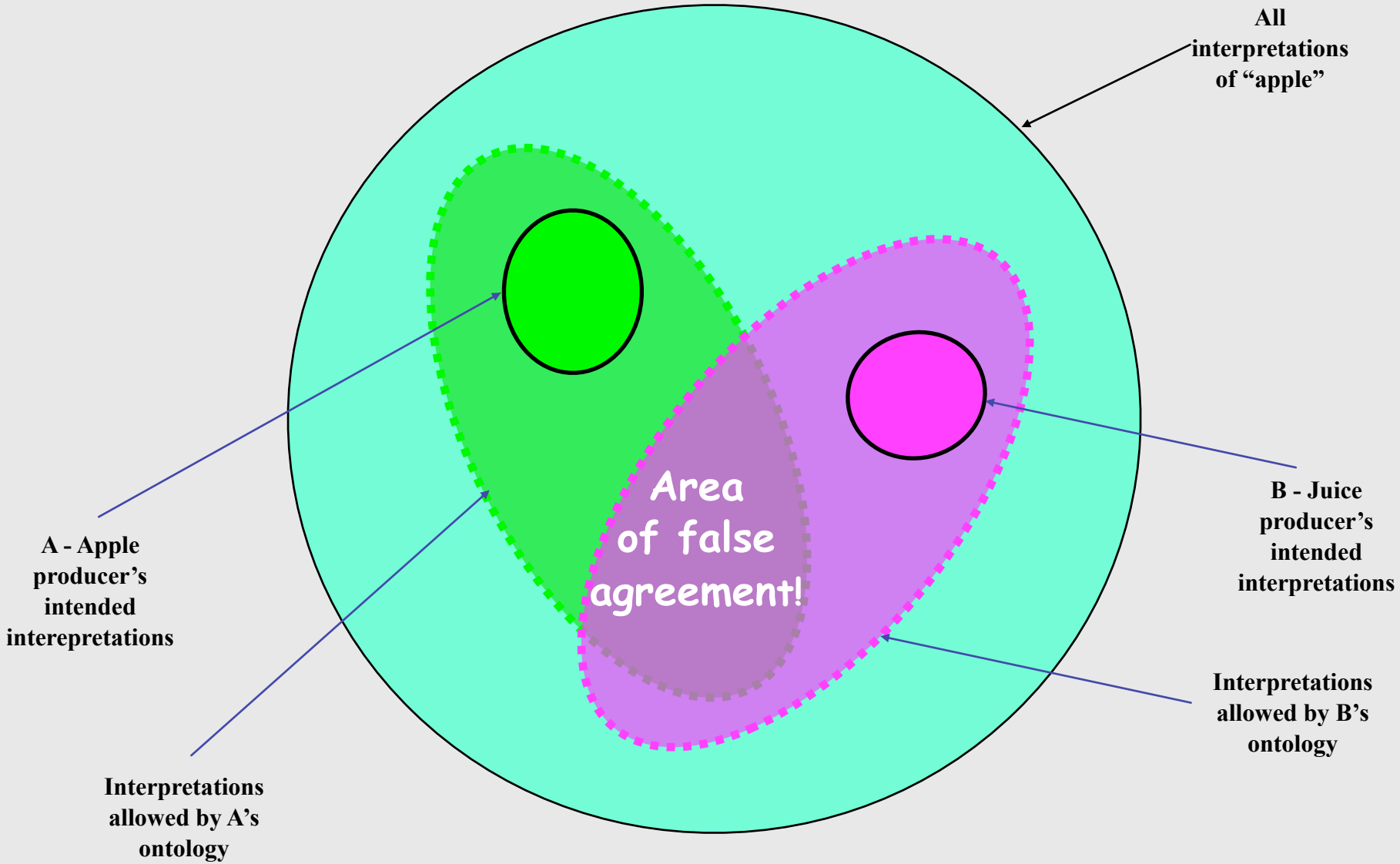
Database A: keeping track of fruit stock

Variety	Quantity
Granny Smith	12
Golden delicious	10
Stark delicious	15

Database B: keeping track of juice stock

Variety	Quantity
Granny Smith	12
Golden delicious	10
Stark delicious	15

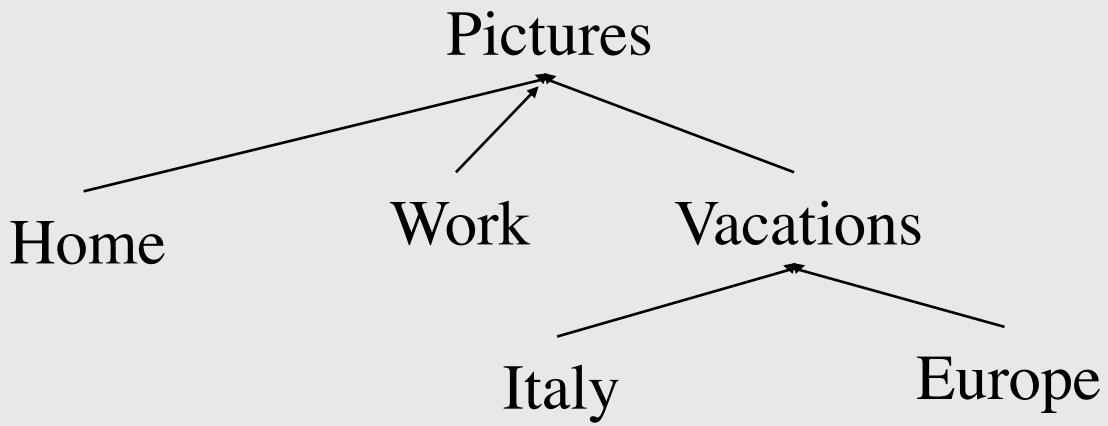
Why ontological precision is important



When is a precise (and accurate) ontology useful?

1. When *subtle distinctions* are important
2. When *recognizing disagreement* is important
3. When *careful explanation and justification* of ontological commitment is important
4. When ***mutual understanding*** is more important than interoperability.

Ontologies vs. classifications (1)



What's the ***meaning*** of these terms?

What's the meaning of arcs?

Ontologies vs. classifications (2)

- Classifications focus on:
  - ***access***, based on pre-determined criteria (encoded by ***syntactic keys***)

- Ontologies focus on:
  - ***Meaning*** of terms
  - ***Nature*** and ***structure*** of a domain

Ontologies vs. Knowledge Bases

- Knowledge base
  - Assertional component
    - **reflects** ***specific (epistemic) states of affairs***
    - designed for ***problem-solving***
  - Terminological component (*ontology*)
    - ***independent*** of particular ***states of affairs***
    - Designed to support ***terminological services***

Ontological formulas are (assumed to be)
invariant, necessary information

The two fundamental scenarios for semantic integration

1. *Same domain, same terminology, same conceptualization:* e.g, different processes within a very small, family-managed enterprise (everybody does everything)

2. *Same domain*, *shared terminology*, *different conceptualization*: e.g., different branches of a big company with a strong organization structure..

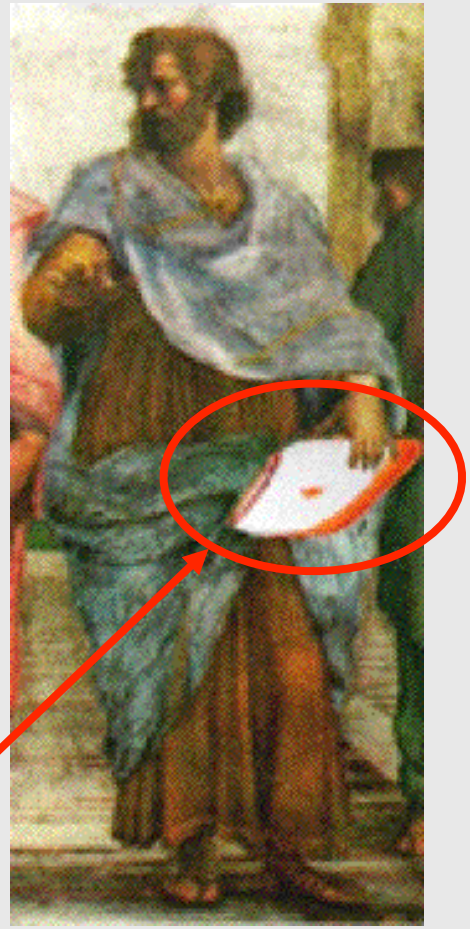
Computational ontologies have been born for 2, but, they are actually used for 1: ***just shared*** *data schemes*. The result is the so-called "**data sylos**" **effect.**

A single, imperialistic ontology?

- An ontology is first of all ***for understanding each other***
  - ...among people, first of all!
  - not necessarily for thinking in the same way
- A single ontology for multiple applications ***is not necessary***
  - Different applications using different ontologies can co-exist and co-operate (not necessarily inter-operate)
  - ...if linked (and compared) together **by means of a general enough basic categories and relations (*primitives*)**.
- If basic assumptions are not made explicit, any imposed, common ontology risks to be
  - seriously mis-used or misunderstood
  - opaque with respect to other ontologies

The formal tools of ontological analysis

- Theory of Parts (Mereology)
- Theory of Unity and Plurality
- Theory of Essence and Identity
- Theory of Dependence
- Theory of Composition and Constitution
- Theory of Properties and Qualities



The basis for a common ontology vocabulary

Idea of Chris Welty, IBM Watson Research Centre, while visiting our lab in 2000

Formal Ontology

- Theory of ***formal distinctions and connections*** within:
  - entities of the world, as we perceive it (***particulars***)
  - categories we use to talk about such entities (***universals***)
- Why ***formal****?*
  - Two meanings: ***rigorous*** and ***general***
  - Formal logic: connections between truths - neutral wrt ***truth***
  - Formal ontology: connections between things - neutral wrt ***reality***
- ***NOTE:*** **"represented in a formal language" is not enough for being formal in the above sense!**
- ***Analytic ontology*** may be a better term to avoid this confusion

The Ontological Level

From the logical level to the ontological level

- Logical level *(no structure, no constrained meaning)*
  - $\exists x\,(\mathrm{Apple}(x) \wedge \mathrm{Red}(x))$
- Epistemological level *(structure, no constrained meaning)*:
  - $\exists x{:}apple\ \mathrm{Red}(x)$ *(many-sorted logics)*
  - ~~$\exists x{:}red\ \mathrm{Apple}(x)$~~
  - a is a Apple with Color=red *(description logics)*
  - ~~a is a Red with Shape=apple~~
- Ontological level *(structure, constrained meaning)*
  - Some structuring choices are excluded because of ontological constraints: Apple carries an ***identiy condition***, Red does not.

Ontology helps building "meaningful" representations

The source of all problems: (slightly) different meanings for words

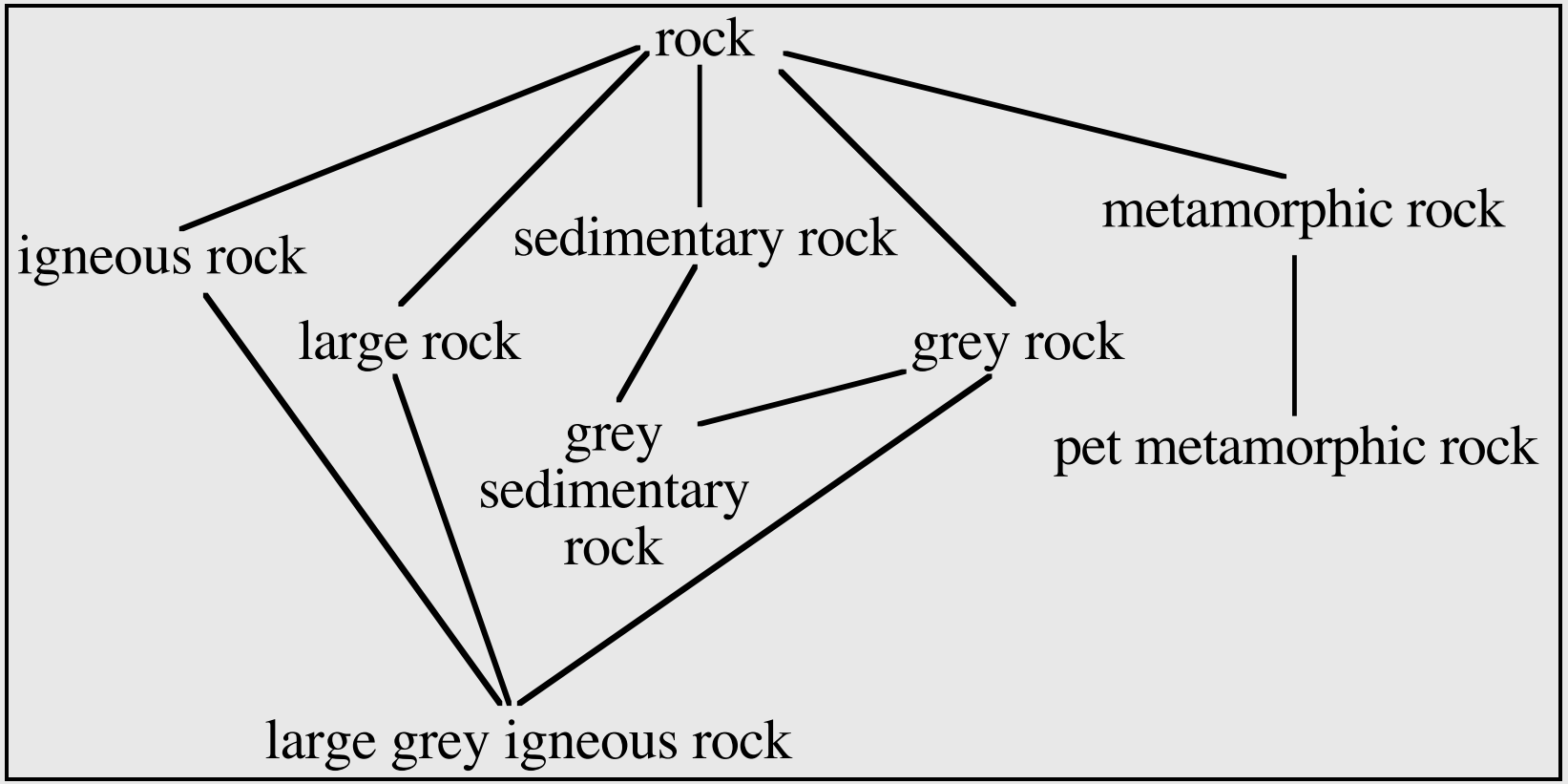
- A (simple-minded) painter may intepret the words “Apple” and “Red” in a completely different way:
  - Three different reds on my palette: Orange, Appple, Cherry
- So an expression like ∃*x:red* Apple(*x*) may mean that there is an “Apple” red.
- Two different ontological assumptions behind the Red predicate:
  - adjectival interpretation: *being a red thing* doesn’t carry an identity criterion (uncountable)
  - nominal interpretation: *being a red color* does carry an identity criterion (countable)

Formal ontological distinctions help making *intended meaning* explicit

Ontological analysis can be defined as the process of ***eliciting and discovering relevant distinctions*** and relationships bound to the very nature of the entities involved in a certain domain, ***for the practical purpose of disambiguating terms*** having different interpretations in different contexts.

Terminological competence - kinds of properties

How many rock kinds are there?



[From Brachman, R ., R. F ikes, et al. 1983. "Krypton: A Functional Approach to Knowledge Representation", *IEEE Computer*]

The answer

- According to Brachman & Fikes 83:
  - It's a **dangerous question**, only "safe" queries about analytical relationships between terms should be asked
- In a previous paper by Brachman and Levesque on ***terminological competence*** in knowledge representation [AAAI 82]:
  - "an *enhancement mode transistor* (which is a *kind* of transistor) should be understood as different from a *pass transistor* (which is a *role* a transistor plays in a larger circuit)"
- These issues have been simply ***given up*** while striving for logical simplification and computational tractability
- The OntoClean methodology, based on formal ontological analysis, allows us to conclude: ***there are 3 kinds of rocks*** (appearing in the figure)

Terminological competence - kinds of relations

- Woods' "What's in a link?" (1975):

  JOHN

  HEIGHT: 6 FEET

  KISSED: MARY

- "no longer do the link names stand for attributes of a node, but rather arbitrary relations between the node and other nodes"
- different notations should be used

Kinds of attributes

JOHN

HEIGHT: 6 FEET

RIGHT-LEG: LEG#1

MOTHER: JANE

KISSED: MARY

intrinsic quality

part

role

external relation

We need different primitives to express ***different structuring relationships*** among concepts

We need to represent ***non-structuring relationships*** separately

Current description logics tend to collapse **EVERYTHING**!

The Ontological Level

(Guarino 94)

Level	*Primitives*	*Interpretation*	*Main feature*
Logical	Predicates, functions	Arbitrary	Formalization
Epistemological	Structuring relations	Arbitrary	Structure
Ontological	**Ontological relations**	**Constrained** (meaning postulate s)	**Meaning**
Conceptual	Conceptual relations	Subjective	Conceptualization
Linguistic	Linguistic terms	Subjective	Language dependence

IAOA
International Association for Ontology and its Applications

From the Statute

"The Association is a non-profit organization the purpose of which is to promote interdisciplinary research and international collaboration at the ***intersection of philosophical ontology, linguistics, logic, cognitive science, and computer science***, as well as in the applications of ontological analysis to ***conceptual modeling, knowledge engineering, knowledge management, information-systems development, library and information science, scientific research, and semantic technologies*** in general."

IAOA: a unique combination of key aspects

1. Interdisciplinarity
2. Cooperation between academy, industry, and communities of practice (with an eye on education)
3. Scientific authoritativeness
4. Openness
5. Legal status
6. Transparent governance

A new journal: ***Applied Ontology***

Editors in chief:

Nicola Guarino
ISTC-CNR

Mark Musen
Stanford University

IOS Press

Amsterdam, Berlin, Washington,
Tokyo, Beijing

www.applied-ontology.org

Now indexed by ISI and Scopus.
Impact Factor: 1.105

A bit of history - Community building initiatives

- 1993: 1st Int. workshop on Formal Ontology & Information Systems
- 1998: 1st FOIS conference
- 2002: Ontolog forum
- 2005: Applied Ontology (IOS Press)
- 2005: ECOR, NCOR, JCOR...
- 2006: First public discussion on an ontology association at FOIS (Baltimore)
- 2008: Public assembly at FOIS (Saarbrucken)
- 2011: IAOA Summer Institute on ontology of processes
- 2011: Applied Ontology gets official ISI recognition
- 2009-2012: Several focused conferences (FOMI, WOMO...)
- 2012: IAOA permanent co-organizer of Ontology Summit

- In parallel: various *consortia* focusing mainly on Semantic Web

Vote NOW for IAOA EC renewal!

The challenges of ***interdisciplinarity, language and cultural diversity, openess, and interoperability***

Working at (and in…) the ***interfaces*** among different

- Disciplines
- Cultures
- Languages
- Socio-technical systems

…is **HARD**!

- Anyway, these are the main challenges of modern, global, networked society
- Ontologies are certainly intended to address such challenges, and ultimately can contribute to ***mutual understanding***, ***social awareness*** and ***collaborative participation*** to the huge socio-technical system which is modern society

A new discipline (or science) is emerging?

Maybe.

See the history of Psychology, Systems Engineering...

See recent proposals for Web Science, Services Science…

For sure, a ***humble***, truly interdisciplinary approach is needed, focusing on letting new ideas, approaches, methodologies emerge from the ***mutual cross-fertilization*** of different disciplines.

That's why we organised this summer school.