

Verso il Semantic Web
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The role of ontologies for the Semantic Web

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Summary

- Why ontologies
- What ontologies are (or should be...)
- Ontology quality
- Foundational ontologies

Is the Semantic Web just hype?

Some quotations... (1)

- "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

Two extremely serious examples

- US elections: how many *holes*?
- Twin towers catastrophe:
how many *events*?

...only ontological analysis solves these
problems!!

Some quotations... (2)

- "Lack of technologies and products to *dynamically mediate discrepancies in business semantics* will limit the adoption of advanced Web services for large public communities whose participants have disparate business processes"

Gartner Research, February 28, 2002

A common alphabet is not enough...

- "XML is only the first step to ensuring that computers can communicate freely. *XML is an alphabet for computers* and as everyone who travels in Europe knows, knowing the alphabet doesn't mean you can speak Italian or French"

Business Week, March 18, 2002

Standard vocabularies are not the solution

- Defining standard vocabularies is difficult and time-consuming
- Once defined, standards don't adapt well
- People don't implement standards correctly anyway

Ontology and ontologies

Definitions

- Ontology (capital "o"):
 - a ***philosophical discipline***:
 - The study of "being qua being"
 - The study of what is possible
 - The study of the nature of possible: distinctions among *possibilia*
- An ontology (lowercase "o"):
 - a ***specific artifact*** designed with the purpose of ***expressing the intended meaning of a vocabulary***

Why ontologies in IT?

- Semantic Interoperability
 - Database integration
 - Virtual Enterprises
 - Concurrent engineering
 - e-commerce
 - Web services
- Information Retrieval
 - *Decoupling user vocabulary from data vocabulary*
 - Query answering over document sets
 - Natural Language Processing

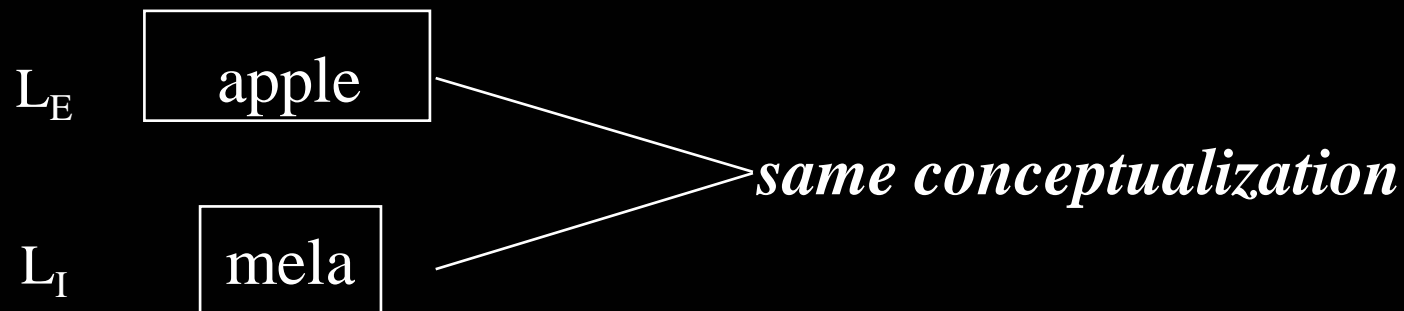
What is an ontology?

- 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]

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 occurrence of a specific **situation**
- Different situations involving same objects, described by different vocabularies, may share the same conceptualization.



Relations vs. Conceptual Relations

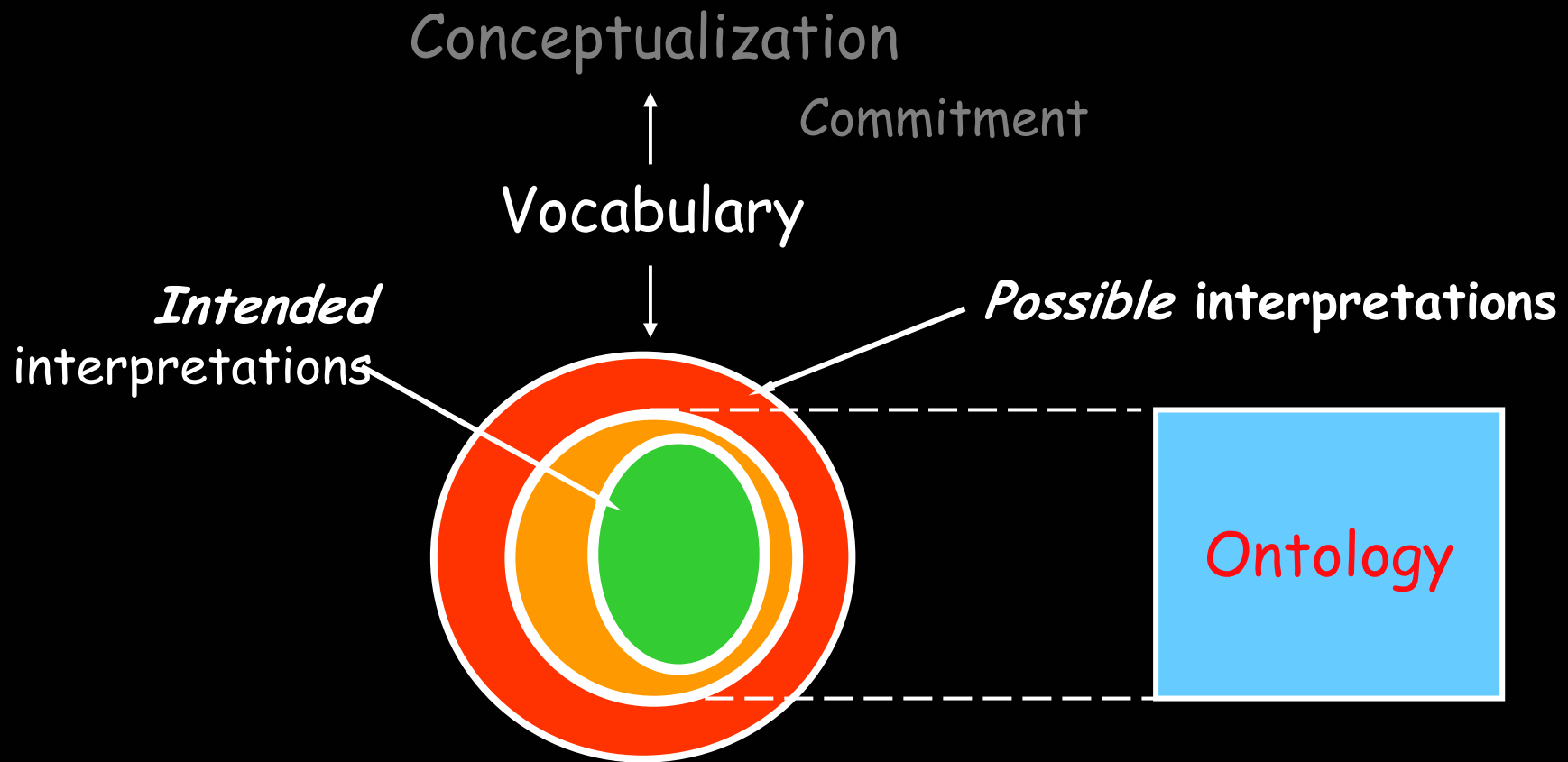
$$r_n \in 2^{D^n}$$

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

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

conceptual relations are defined on a **domain space** $\langle D, W \rangle$

Ontologies *constrain* the intended meaning



Ontologies vs. Conceptual Schemas

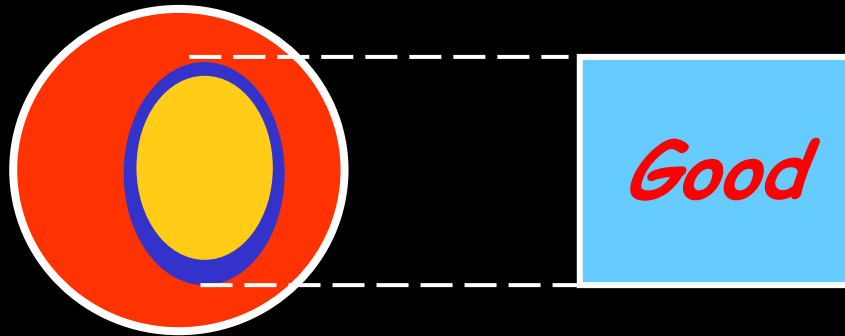
- Conceptual schemas
 - not accessible at run time
 - not always have a formal semantics
 - attribute values are taken out of the UoD
 - only constraints *relevant for update* are specified
 - Risk to be detached from the database itself
- Ontologies
 - accessible at run time (at least in principle)
 - formal semantics
 - *attribute values as first-class citizens*
 - all constraints *relevant for intended meaning* are specified

Ontologies vs. Knowledge Bases

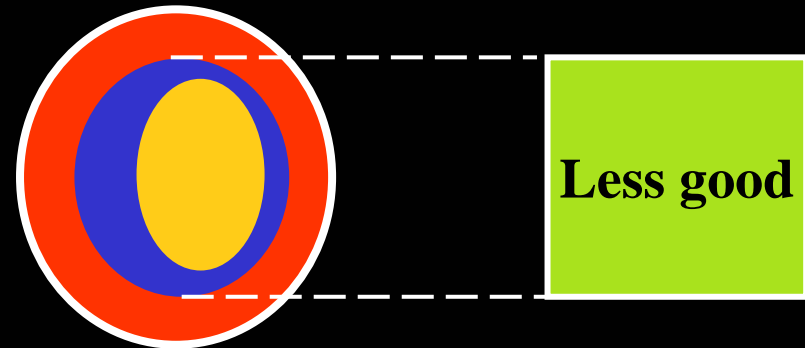
- Knowledge base
 - Assertional component
 - reflects *specific (epistemic) states of affairs*
 - designed for *problem-solving*
 - Terminological component (*ontology*)
 - *independent* of particular *states of affairs*
 - Designed to support *terminological services*

Ontological formulas are (assumed to be)
always valid

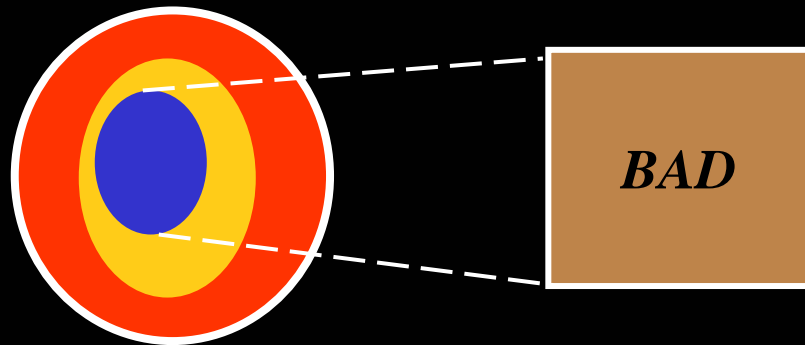
Ontology Quality: Precision and Coverage



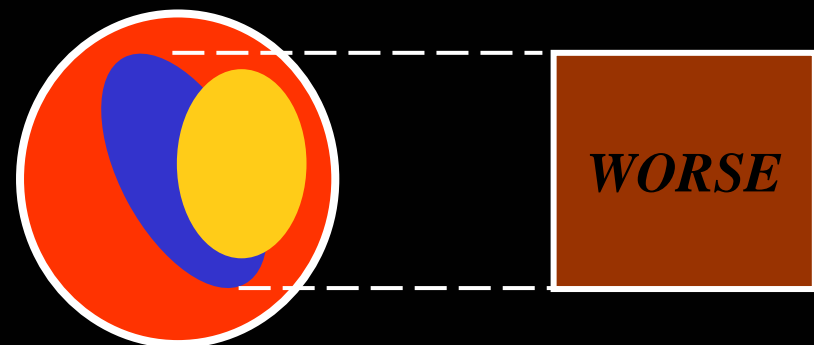
High precision, max coverage



Low precision, max coverage

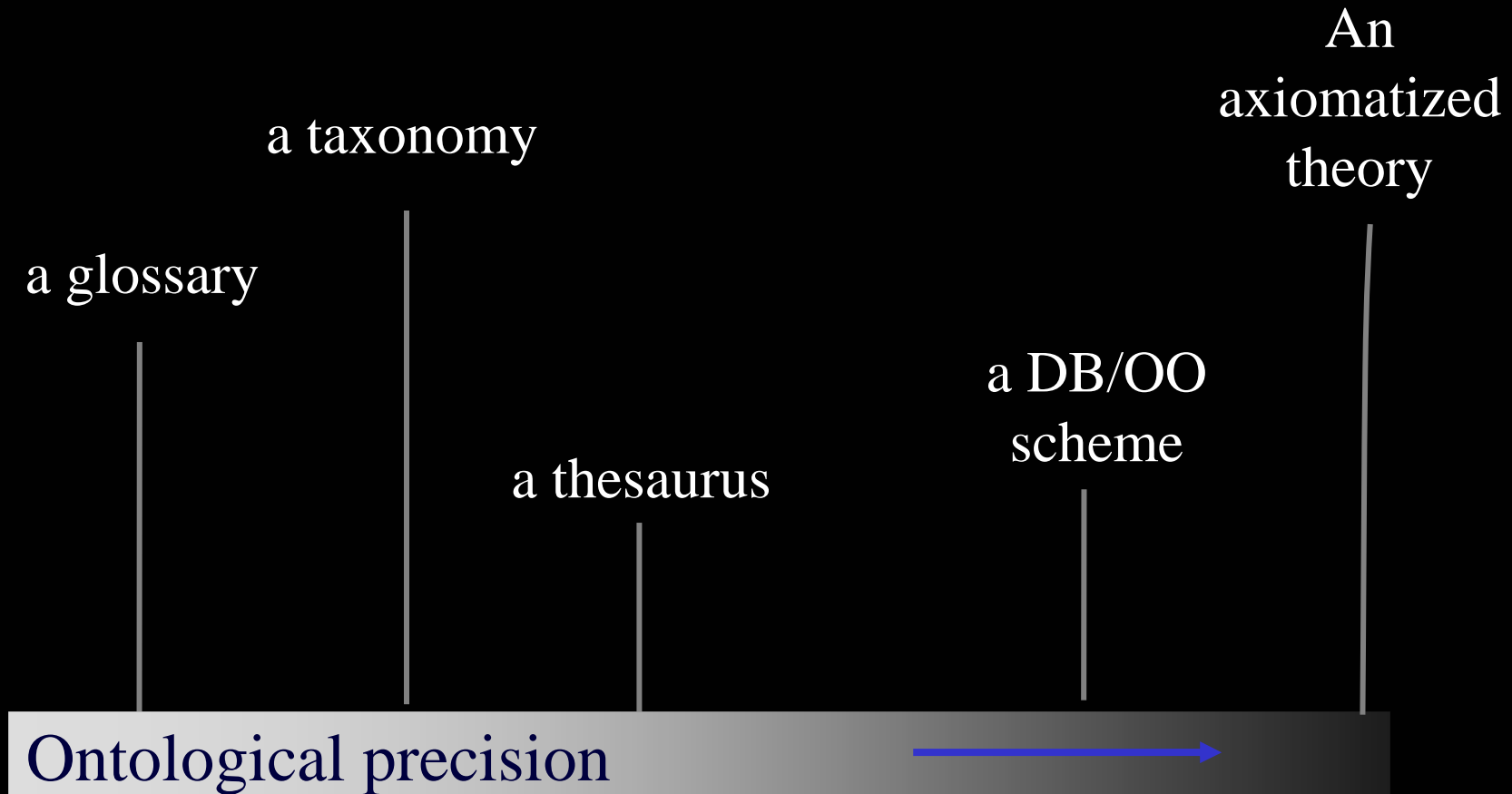


Max precision, low coverage

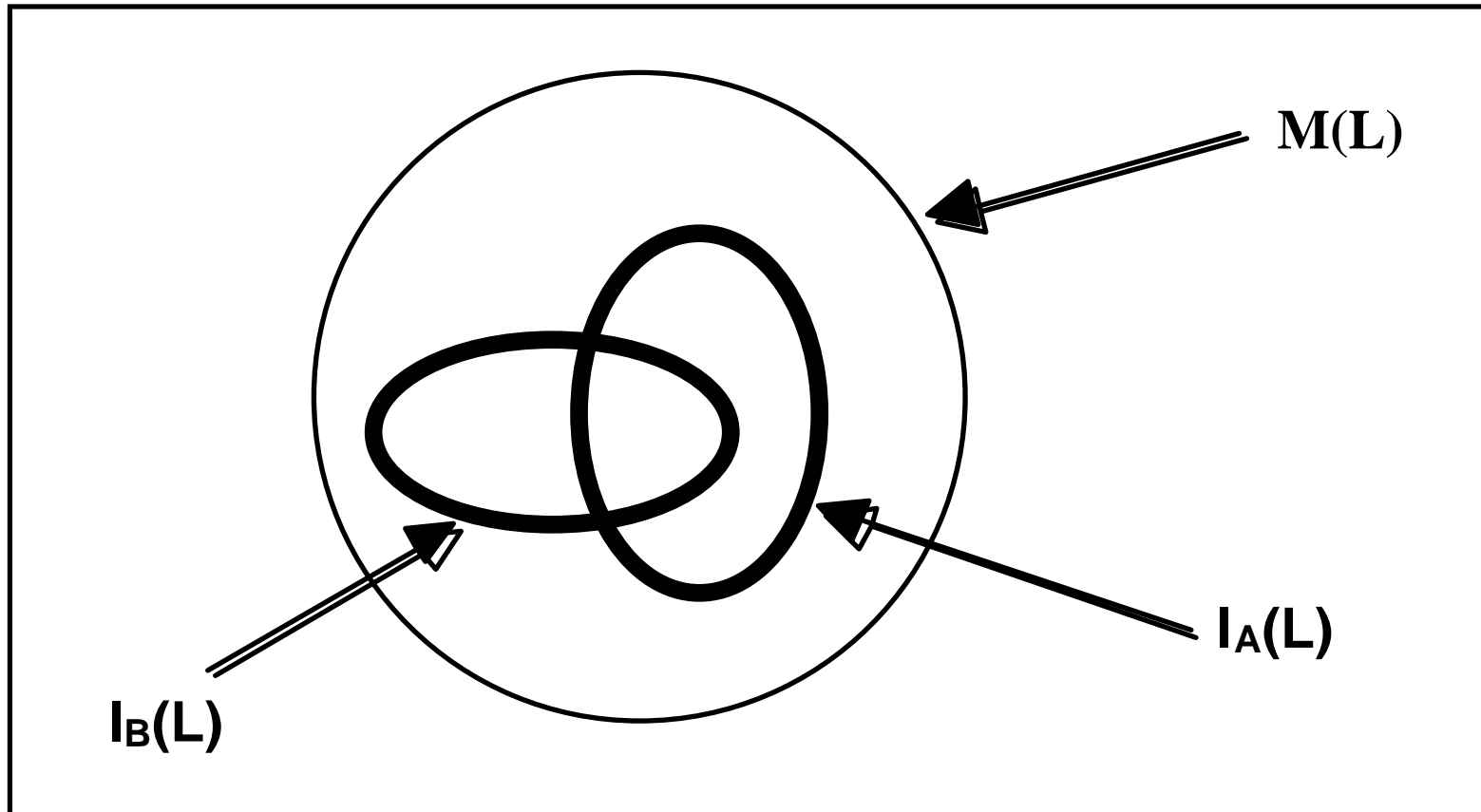


Low precision and coverage

Levels of Ontological Precision

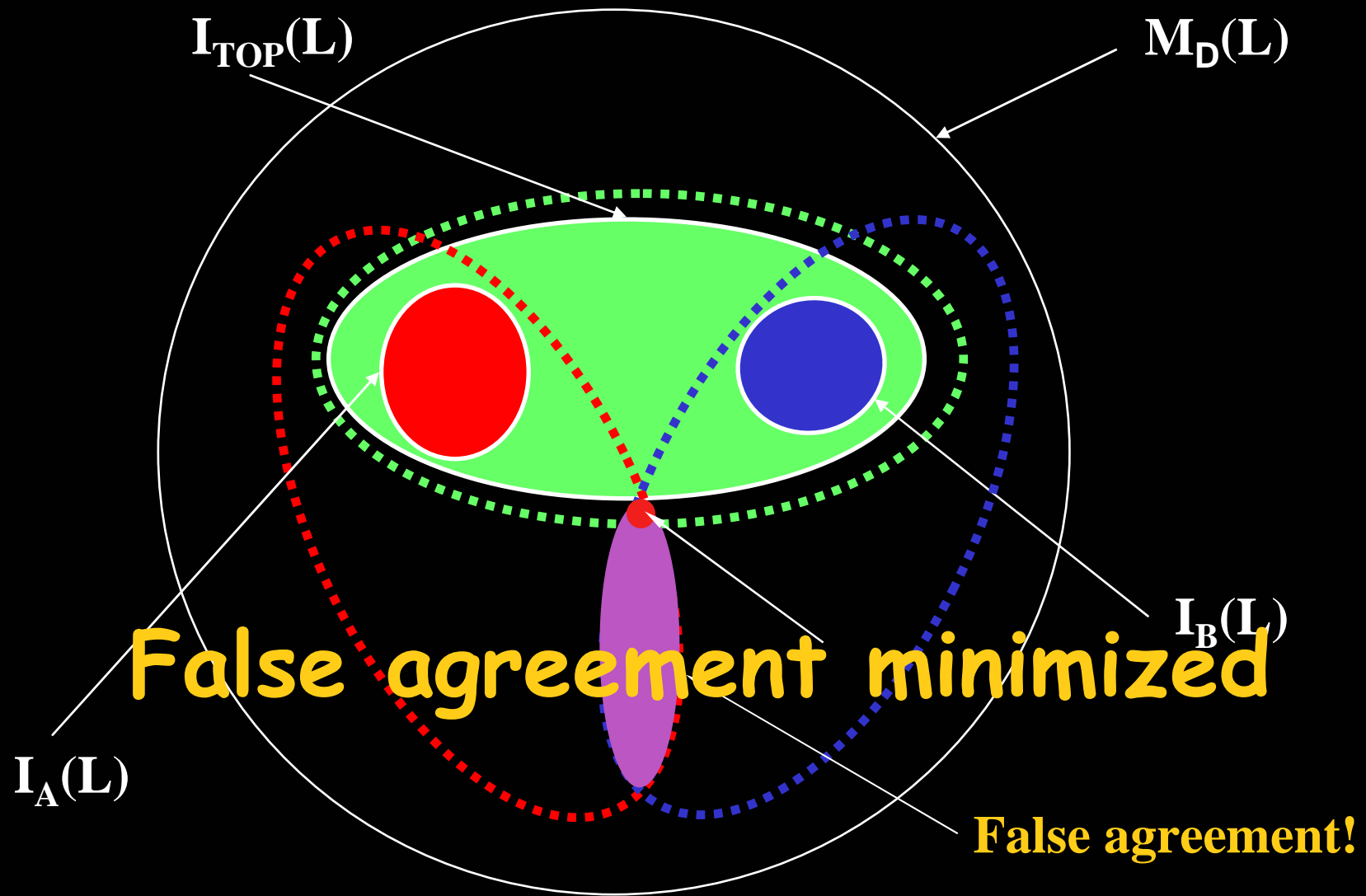


The *Ontology Sharing Problem*



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

The role of *foundational ontologies*



When axioms are not enough

Only one predicate in the language: $on/2$

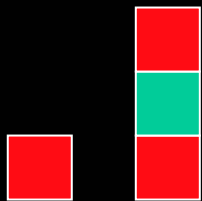
Only blocks in the domain: $\{a, b, c, \dots\}$

Axioms:

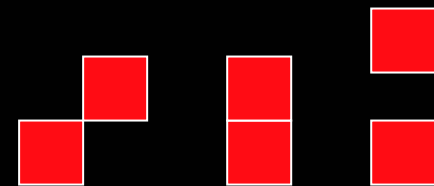
$$on(x,y) \rightarrow \neg on(y,x)$$

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

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



Excluded situations



Collapsed situations

Precision vs. 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
- *Precision*: non-intended *models* are excluded
- *Accuracy*: non-intended *situations* are excluded

Ontology quality

- (Consistency)
- Coverage
- Precision
- Accuracy

We need a rigorous framework for evaluating, comparing, certifying ontologies at the semantic level

Different uses of ontologies

- Simple semantic access *(Processing time)*
 - Intended meaning of terms *known in advance* within a community
 - Lightweight ontologies support only services relevant for the query
 - *Limited expressivity* (stringent computational requirements)
- Meaning negotiation and explanation *(Pre-processing time)*
 - *Negotiate meaning* across different communities
 - *Establish consensus* about meaning of a new term within a community
 - *Explain meaning* of a term to somebody new to community
 - *Higher expressivity* and rich axiomatization needed to exclude ambiguities
 - Only needs to be undertaken *once*, before cooperation process starts

Foundational ontologies

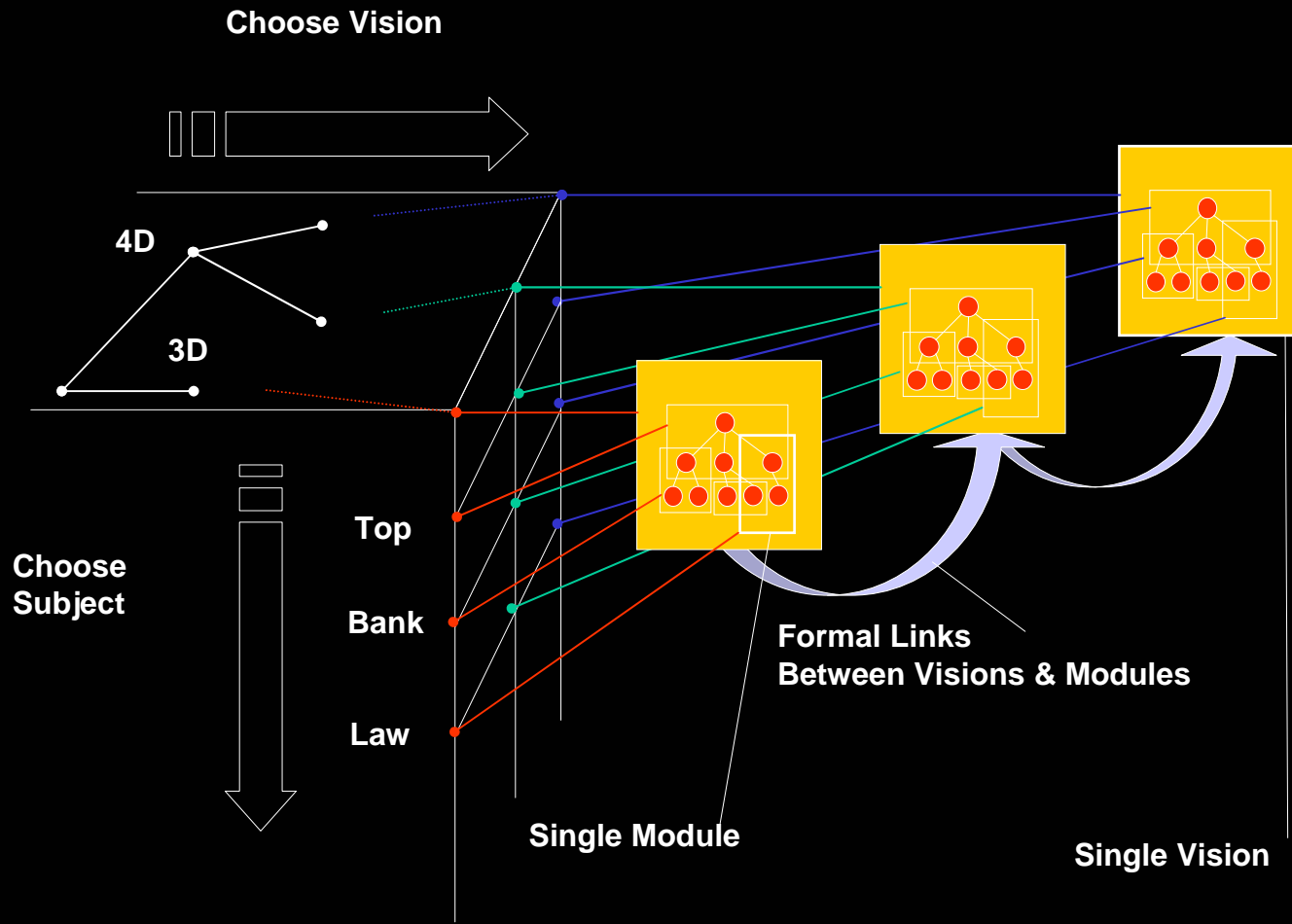
- Provide a *carefully crafted taxonomic backbone* to be used for domain ontologies
- Help recognizing and understanding *disagreements* as well as agreements
- Improve ontology development *methodology*
- Provide a principled mechanism for the semantic integration and *harmonisation* of existing ontologies and metadata standards
- Improve the *trust* on web services

Mutual understanding vs. mass interoperability

The WonderWeb Library of Foundational Ontologies

- No single upper level
- Rather, a (small) set of *foundational ontologies* carefully *justified* and *positioned* with respect to the space of possible choices
- *Basic options* clearly documented
- Clear *branching points* to allow for easy comparison of ontological options)

The WFO architecture



An Interdisciplinary Approach

- Towards a unified *Ontology-driven Modelling Methodology* for databases, knowledge bases and OO-systems
 - *Grounded* in reality
 - *Transparent* to people
 - *Rigorous*
 - *General*
- Based on
 - *Logic*
 - *Philosophy*
 - *Linguistics*

Formal Ontological Analysis

- Theory of Parts
- Theory of Wholes
- Theory of Essence and Identity
- Theory of Dependence
- Theory of Qualities
- Theory of Composition and Constitution
- Theory of Participation
- Theory of Representation

DOLCE

a Descriptive Ontology for Linguistic and Cognitive Engineering

- Strong cognitive bias: *descriptive* (as opposite to *prescriptive*) attitude
- Emphasis on *cognitive invariants*
- Categories as *conceptual containers*: no "deep" metaphysical implications wrt "true" reality
- Clear *branching points* to allow easy comparison with different ontological options
- *Rich axiomatization*

DOLCE's basic taxonomy

Endurant

Physical

Amount of matter

Physical object

Feature

Non-Physical

Mental object

Social object

...

Perdurant

Static

State

Process

Dynamic

Achievement

Accomplishment

Quality

Physical

Spatial location

...

Temporal

Temporal location

...

Abstract

Abstract

Quality region

Time region

Space region

Color region

...

...

The importance of *lexical links*

- *WordNet* used as an ontology
- Links between ontologies and *multilingual lexica*
- Lexical relations vs. ontological relations

Is the Semantic Web just Hype?

- Maybe yes.
- An "ontology vocabulary" is not enough
- Languages based on "semantic" primitives (OWL) are not enough (need for *ontological primitives*)
- ...Unless the deep problems underlying ontology and semantics are attacked under an *interdisciplinary* approach

Europe is well ahead USA here...

Research priorities at the ISTC-CNR Laboratory for Applied Ontology



- Foundational ontologies and ontological analysis
- Domain ontologies
 - Physical objects
 - Information and information processing
 - Social interaction
 - Ontology of legal and financial entities
- Ontology, language, cognition
- Ontology-driven information systems
 - Ontology-driven conceptual modeling
 - Ontology-driven information access
 - Ontology-driven information integration