Laboratory for Applied Ontology

Institute of Cognitive Science and Technology
Italian National Research Council

Ontological Analysis

1 - Introduction

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Summary

- Content: what ontological analysis is about
- Meanings and signs
- The emergence of ontologies in AI
- What are (computational) ontologies

1. Focusing on content

The focus of ontological analysis: from form to *CONTENT*

- The key problems
  - content-based information access *(**semantic matching**)*
  - content-based information integration *(**semantic integration**)*

- To approach them, content must be studied, understood, analyzed ***as such***, independently of the way it is represented.

- Computer technologies are not really good for that...
- …and users of computer systems are often ***confused by technology***

Ontologies: a ***magic solution?***

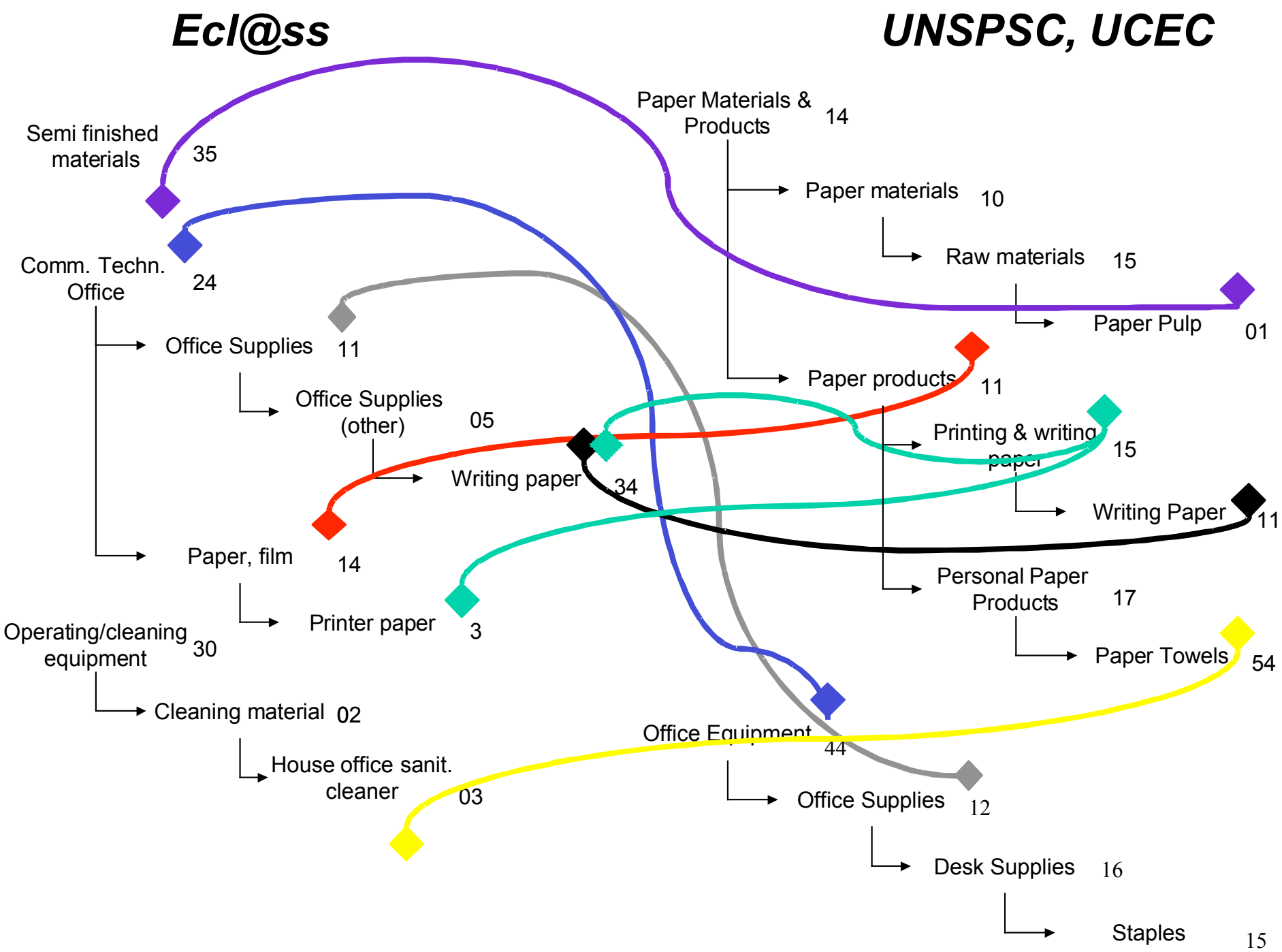
No ontology without ***ontological analysis!***

The problem: subtle distinctions in meaning

"Trying to engage with oo 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


Ecl@ss
UNSPSC, UCEC
Semi finished materials 35
Comm. Techn. Office 24
Office Supplies 11
Office Supplies (other) 05
Paper, film 14
Writing paper 34
Printer paper 3
Operating/cleaning equipment 30
Cleaning material 02
House office sanit. cleaner 03
Paper Materials & Products 14
Paper materials 10
Raw materials 15
Paper Pulp 01
Paper products 11
Printing & writing paper 15
Writing Paper 11
Personal Paper Products 17
Paper Towels 54
Office Equipment 44
Office Supplies 12
Desk Supplies 16
Staples 15

Subtle distinctions in meaning...

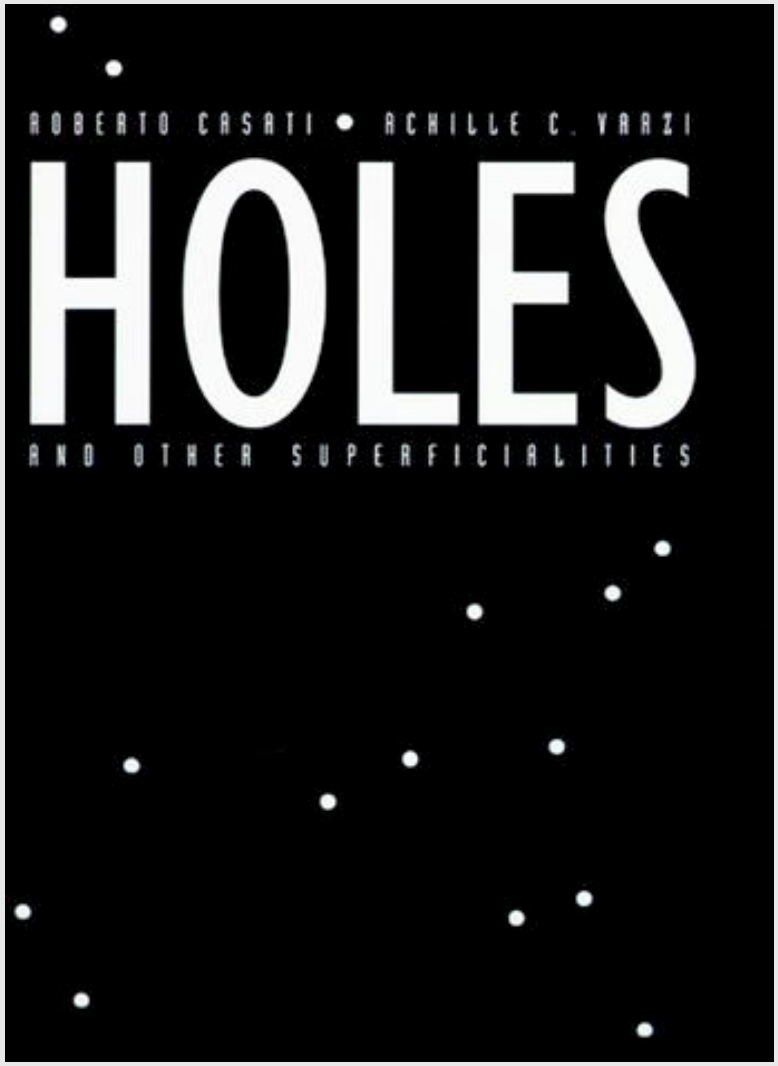
- What is an ***application*** to a public administration?
- What is a ***service****?*
- What is a ***working place***?
- What is an ***unemployed person***?
- What is a ***customer****?*
- What is a ***passenger****?*
- Can ***organizations*** make actions?
- What is a ***document****?*
- What is a ***contract****?*
- What is a ***spare part****?*
- What is a ***missing part****?*
- What is a ***hole****?*

Where subtle distinctions are important

- 2000 US Presidential elections: is there a ***hole***?
- 2001 twin towers catastrophe: how many ***events****?*

…only ***ontological analysis*** solves these problems!!

The ontology of holes



Books by Roberto Casati and Achille C. Varzi (MIT Press):

- Holes and other superficialities
- Parts and places

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 glossaries can help, but...

- Defining standard vocabularies is ***difficult and time-consuming***
- Once defined, standards ***don't adapt well***
- Heterogeneous domains need a ***broad-coverage vocabulary***
- People don't implement standards correctly anyway
- Vocabulary definitions are often ***ambiguous or circular***

Do we know what to REpresent?

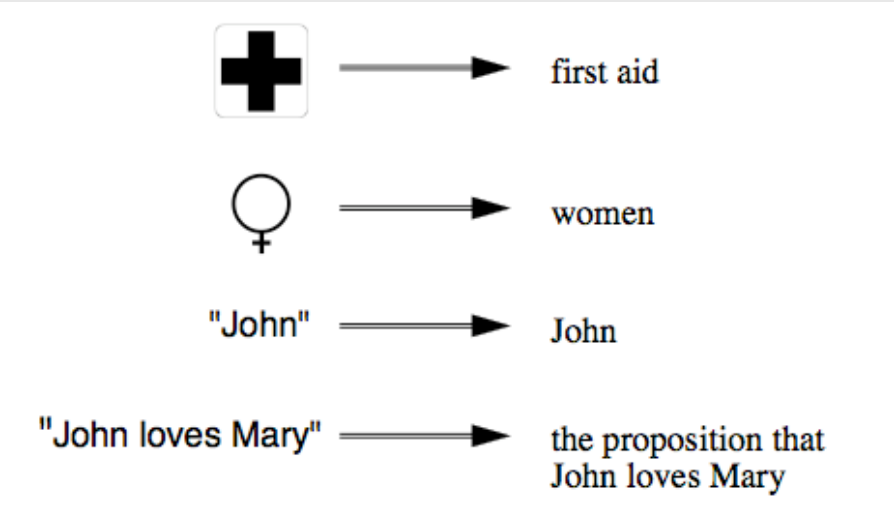
- ***First*** ontological analysis,
- ***THEN*** knowledge representation…

Unfortunately, this is not the current practice…

2. Meanings and signs

Signs and their content

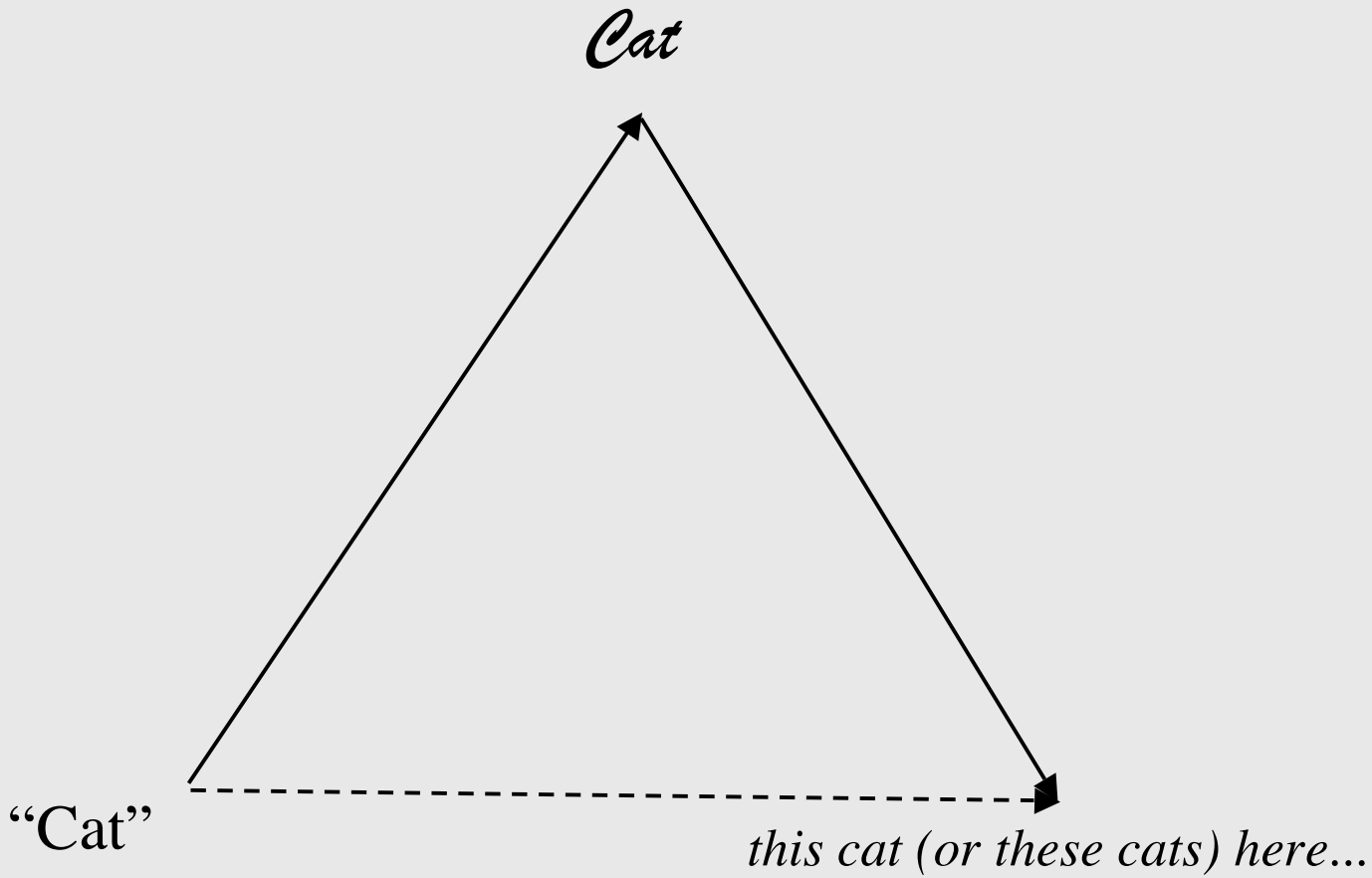
- Sign kinds in Peirce:
  - icon: **analogic** association with content
  - indexes: ***causal*** association
  - symbols: ***conventional*** assotiation



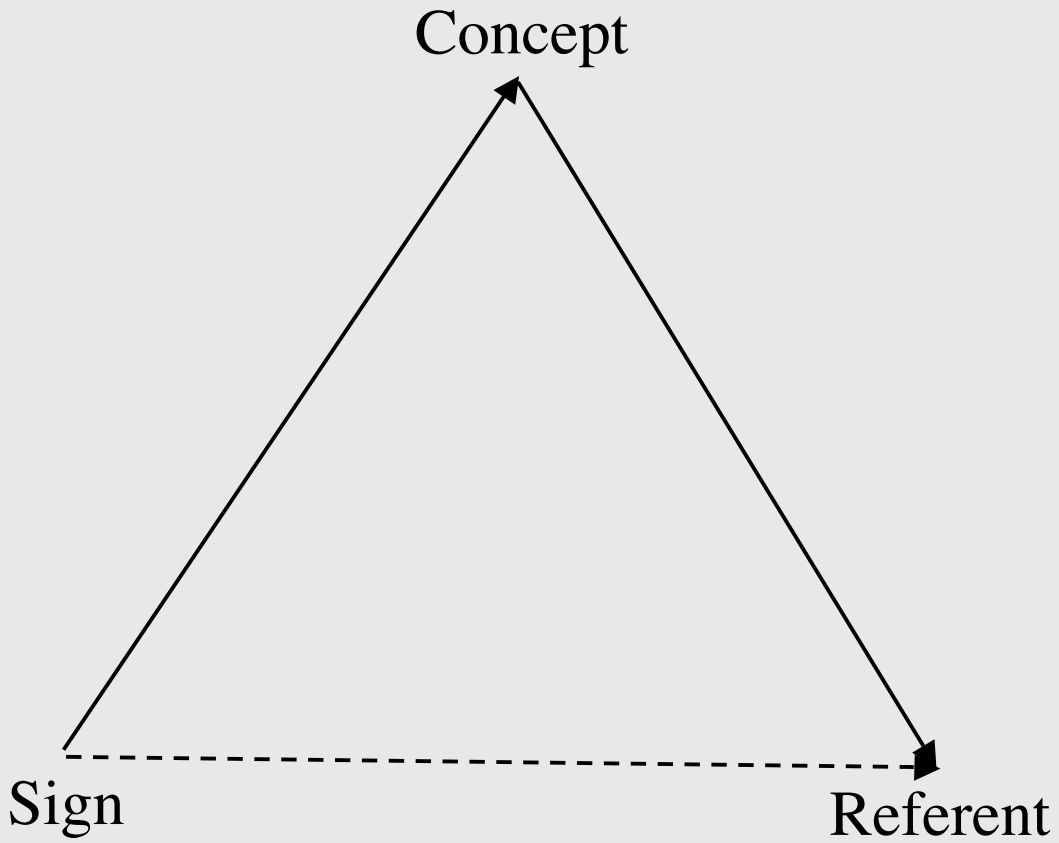
Signs and concepts

- 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



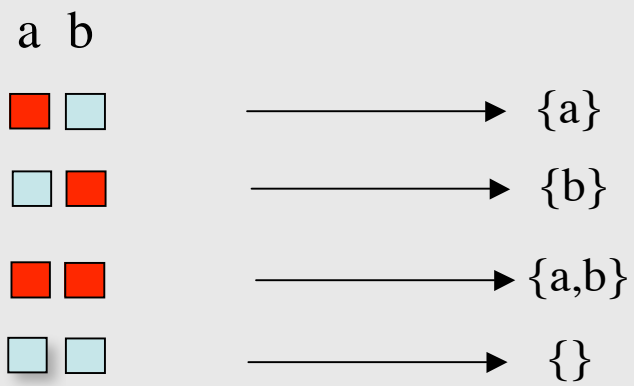
The triangle of meaning - 2



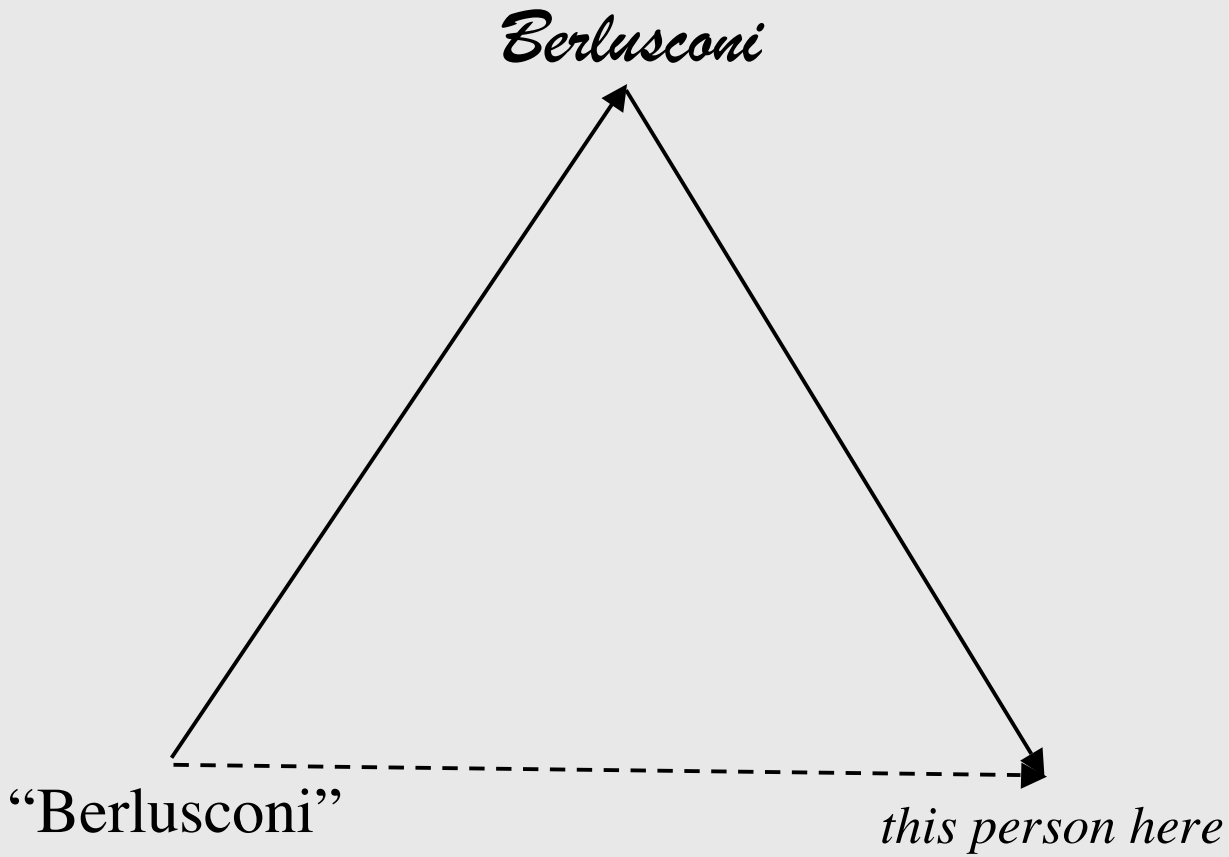
Intension ed extension

- 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***

An example: the concept of *red*



The triangle of meaning - 3



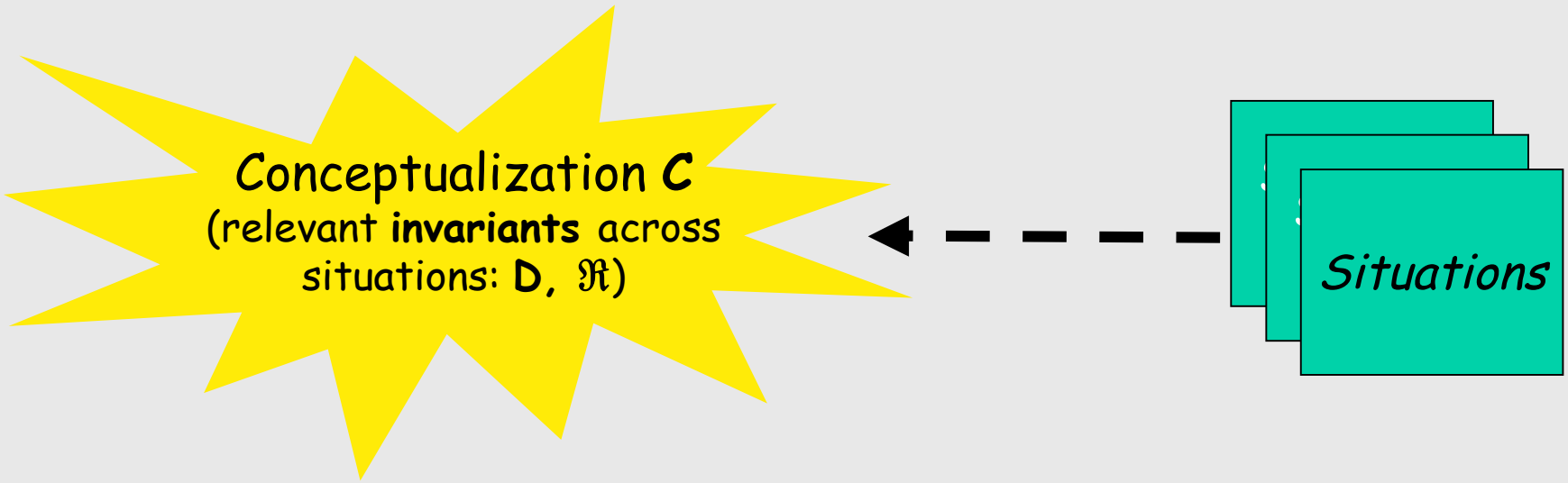
Again on intension and extension

- Concepts with zero extension
  - square circle, unicorn (different cases!)
- Concepts with same extension and different intension
  - equilateral triangle and equiangular triangle
  - president of Council of Ministers and president of Milan (*definite descriptions)*
  - morning star and evening stars

Concepts, properties, and relations

- By means of concepts, we ***ascribe*** properties and relations to things. We can say that concepts *describe* properties or relations.
- Concepts describing relations are also called ***conceptual relations:***
  - *friend-of, father-of...*
- Conceptual relations are NOT sets of tuples! Their extension is a set of tuples.

From experience to *conceptualization*



D : cognitive domain

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

What is a *conceptualization?* A cognitive approach

- Humans isolate ***relevant invariances*** from physical reality (quality distributions) on the basis of:
  - Perception (as resulting from evolution)
  - Cognition and cultural experience
  - Language
- A set of ***atomic stimuli*** (input pattern) is associated to each situation
- Synchronic level: ***spatial invariants***
  - Unity properties are *ascribed* to input patterns: topological and morphological wholes (***percepts***) emerge
- Diachronic level: ***temporal invariants***
  - ***Objects***: equivalence relationships among input patterns belonging to different situations
  - ***Events:*** unity properties are ascribed to percepts patterns belonging to different situations

3. The emergence of ontologies in AI

The emergence of ontologies in AI
(a very short story)

- The old days:
  - Semantic networks based on conceptual primitives
  - A progressive ***ontological neutralization*** of AI languages:
    - from conceptual primitives to *epistemological primitives*
    - the move towards ontologically neutral formalisms (DLs)
  - The short ***commonsense summer***
- The New Wave:
  - 80's: knowledge ***sharing*** and reuse
  - 90's: enterprise ***integration***
  - 2000: ***semantic*** web

The same problems are still there!

Representation vs. Reasoning

- Representation comes first!
- The very task of representation (i.e. ***modelling***) is left to the user
- AI researchers focus more on the ***nature of reasoning*** than in the ***nature of the real world***

Essential ***ontological promiscuity*** of AI?
(Genesereth and Nilsson 1987)

The need to focus on content

- Philosophers have generally stopped short of trying to actually specify the truth conditions of the basic atomic propositions, dealing mainly with the specification of the meaning of complex expressions in terms of the meanings of elementary ones. ***Researchers in artificial intelligence are faced with the need to specify the semantics of elementary propositions*** as well as complex ones.

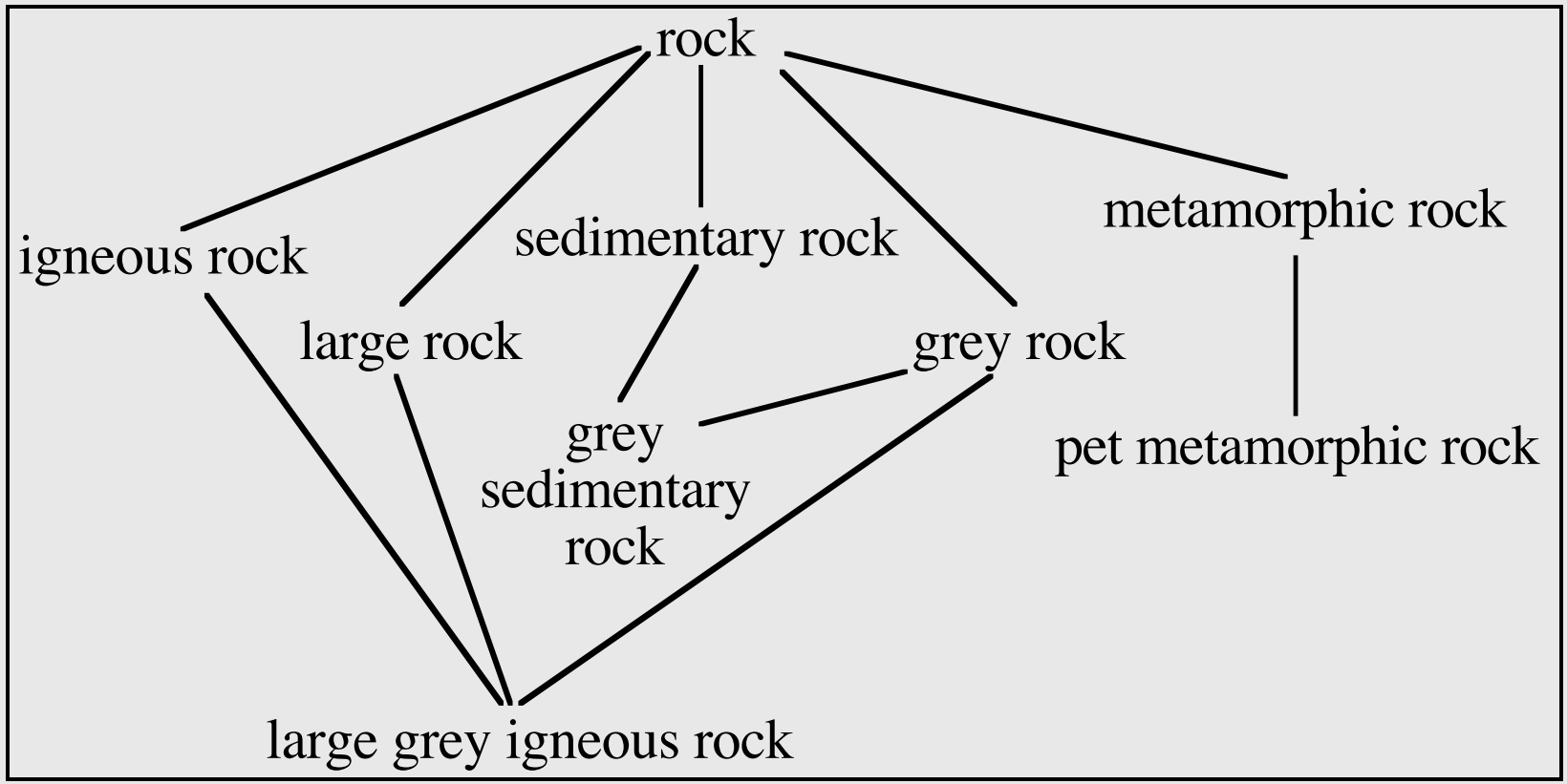
  [Woods 1975]

- The majority of work in knowledge representation has been concerned with the technicalities of relating predicate calculus to other formalisms, and with the details of various schemes for default reasoning. There has been almost an aversion to addressing the problems that arise in actually representing large bodies of knowledge with content. The typical AI researcher seems to consider that task to be 'just applications work'. But there are deep, important issues that must be addressed […]: What ontological categories would make up an adequate set for carving up the universe? How are they related? What are the important things most humans today know about solid objects? And so on. In short, we must ***bite the bullet***.

  [Lenat&Guha 90] (our italics).

Kinds, roles, attributions

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)