Transforming Information into Value

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The Role of Ontologies and Taxonomies in Knowledge Technologies

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Knowledge Technologies
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Paradigm of Declarative Programming

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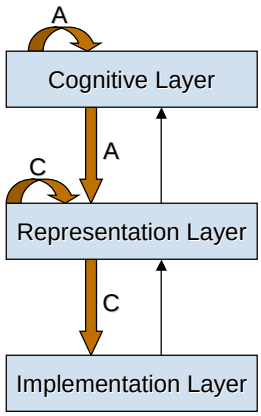
- All types of programs (can) contain knowledge.
- Imperative programs (C, C++, Java, …):
  implicit representation of knowledge (hidden in algorithms)
- Declarative programming:
  - Program operations are **not** defined step by step
  - Instead: Facts and laws are represented
  - Consequences are drawn by the system itself
- Knowledge-based systems are written in declarative programming languages

3 Layer Model of Knowledge-Based Systems (KBS)

- Cognitive Layer
  - rational
  - informal
- Representation Layer
  - logical
  - formal
- Implementation Layer
  - data structures
  - programs



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Formal and Informal Knowledge Representation

The concepts *formal* and *informal* are not absolute:

- Knowledge is formal with respect to some system if the system is able to process this knowledge in an adequate way (to react, to initiate some action etc.)
- Otherwise the knowledge is informal with respect to the system, i.e., the knowledge is merely a set of symbols with no meaning to the system

In particular, knowledge may be formal with respect to a human (e.g., a lawyer) but informal to the interpreter of the language Prolog

For a human, to be informal does not mean useless

Computer systems need the knowledge represented in a way which is formal with respect to this system

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Semiformal Systems

***Semiformal* systems have formal and informal parts. They are concerned with**

- The structure in which knowledge units are organized: This is usually formal (e.g. a list, a labelled graph, etc).
- The knowledge units themselves:
  - Formal
    (e.g., executable programs,
    elements of a formal representation language)
  - Informal
    (e.g., comments for the user in natural language)

Semiformal systems are useful for:

- The development of formal systems as intermediate products
- Interactive systems for the needs of the human

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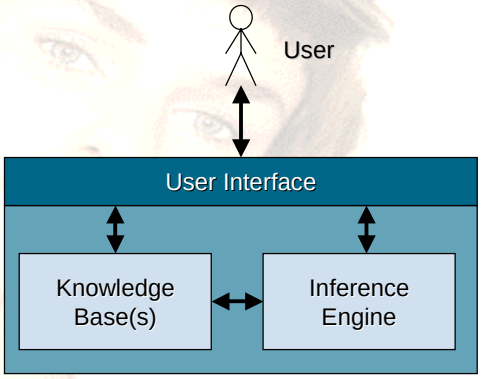
Structure of a KBS in Its Simplest Form



Optional Components:

- Explanation component
- Learning component
- Component for special computations
- Interfaces for special users

Inference Engine:

- May be complex
- May be made up of sub components

Main characteristic is the separation of the knowledge base(s) and the inference engine

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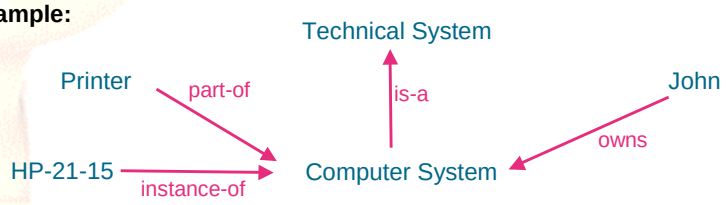
Semantic Nets

… are typical examples of semiformal knowledge representations

… are intended to represent (binary) relations

Taxonomies (hierarchy of concepts) are special cases of semantic nets

Example:



The intention of this semantic net is clear to the human due to the vocabulary used

Definition of Ontology

***ontology* := explicit specification of a shared conceptualization**

- Conceptualization:
  - Abstract model of some area of interest (domain) by identifying *relevant* concepts of that domain
  - Consists of:
    - Relevant concepts of a domain
    - Relations between concepts
    - Axioms about these concepts and relations
- Explicit:
  - Types of concepts used and constraints are explicitly defined
- Shared:
  - Ontology captures consensual knowledge
  - Ontology is not private to some individual
  - Ontology is accepted by a group

Types of Ontologies [Studer]

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Light-Weight Ontologies (e.g., semantic nets/Topic Maps)

- Concepts, atomic types
- Is-a hierarchy among concepts
- Relationships between concepts

Heavy-Weight Ontologies (e.g., OIL/DAML)

- Cardinality of constraints
- Taxonomies of relations
- Axioms/semantic entailments of various tastes
  - Expressiveness
    (description logics, horn, first order logic, higher order)
  - Inference systems

Case-Based Reasoning

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A doctor remembers past patient records

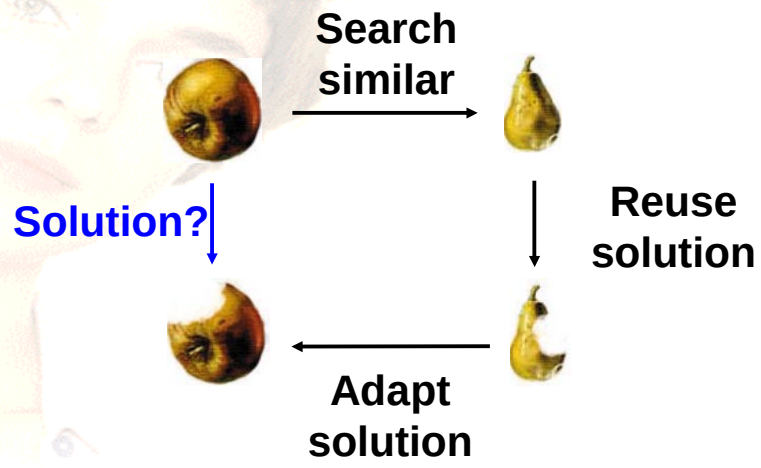
An advocat argues by precedence

An architect reuses designs of existing buildings

A sales agent explains a new product by referring to satisfied customers

A service technician remembers a similar defect from another machinery

Case-Based Problem Solving



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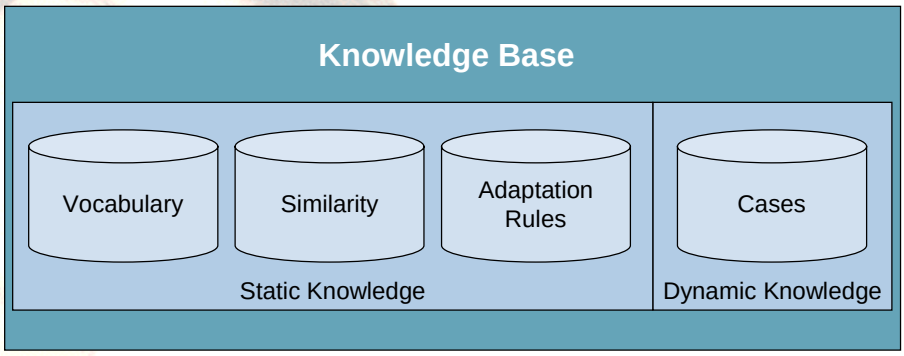
Knowledge Containers of CBR Systems [Richter]



Knowledge can be transferred between containers!

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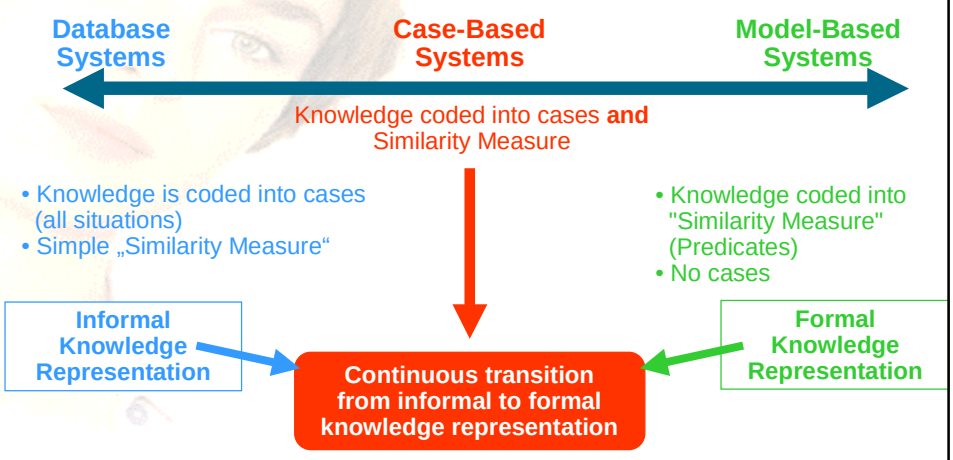
Case-Based Reasoning Systems



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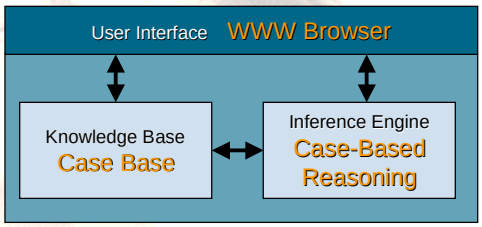
empolis orenge – A Case-Based Reasoning System



orenge

Inferences:

- Similarity-based retrieval
- Completion of queries and cases (Inference using rules)

Optional components

- orenge:explain
  - Explanation component
  - Explains why a hit is relevant
- orenge:caseBuilder
  - Learning component
  - Insertion/Indexing of new cases
- orenge:dialog
  - Component for special computations
  - Intelligent dialog based on principle of "Information Gain"
- orenge:script, orenge:rules
  - Interface for special users
  - Freetext / form / mixed input
  - Automatic recognition of user preferences
    - Example: Low price means price-consciousness → Price becomes important criterion for relevance rating

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