University of Applied Sciences and Arts Northwestern Switzerland
School of Business

Knowlege in Processes - Introduction to Knowledge-Based Systems

Why is knowledge important for (Italian) companies?

What is the problem with knowledge?

Discussion: What is knowledge work?

- Give examples of knowledge work
- Explain, why you regard this work as knowledge work.

Some categories of knowledge work

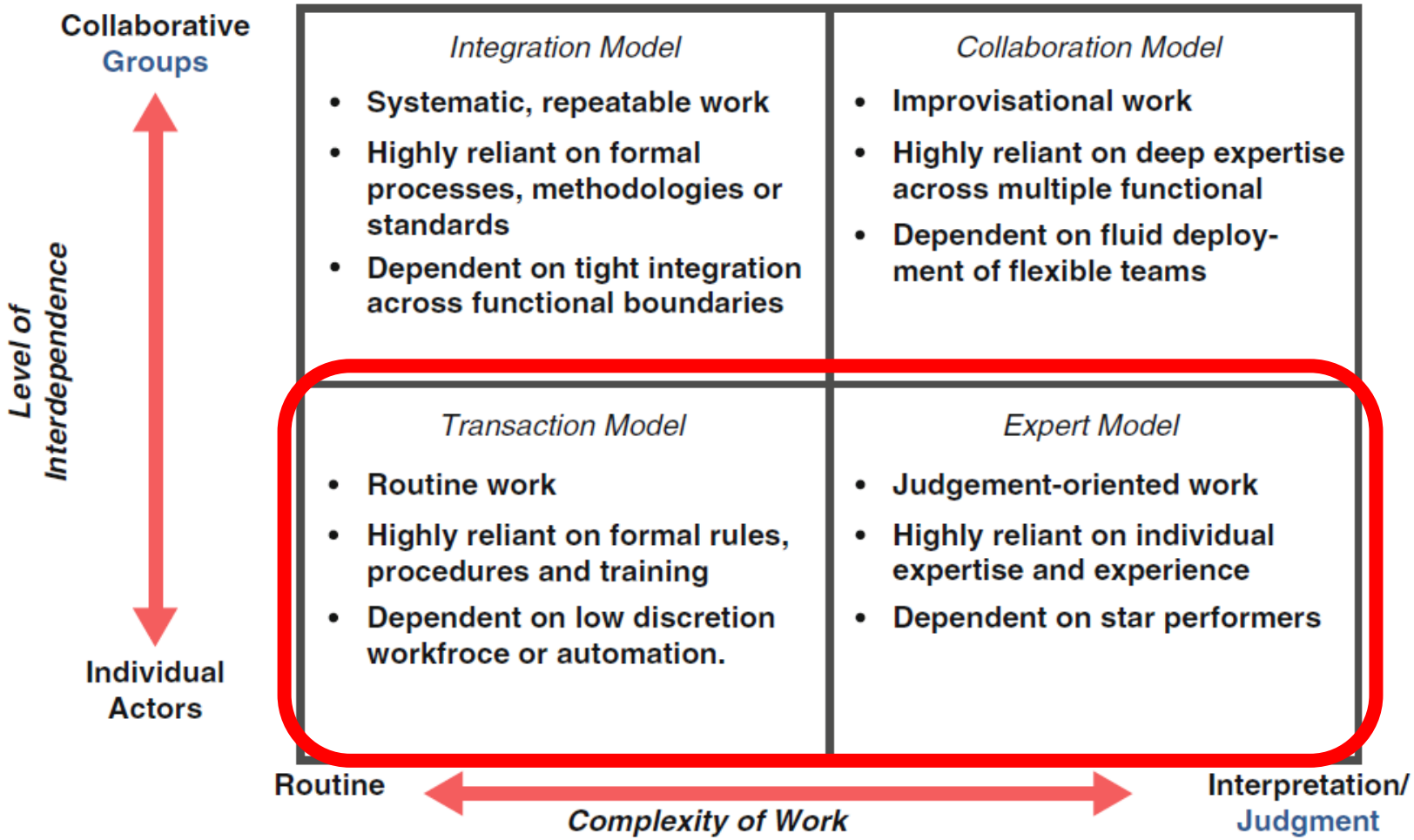
- Decision-Making
  - Making a choice between different alternatives.
- Diagnosis
  - identification of the nature and cause of something, e.g. a disease or a failure in a machine; (can be a prerequisite for solving a problem)
- Problem Solving
  - Finding solutions to a problem satisfying specified goals, e.g. treatment of a disease
- Design
  - construction of an artifact (object or a system), satisfying a set of requirements, subject to constraints
- Configuration
  - special case of design activity, where the artifact is assembled from instances of a fixed set of component types
- Planning
  - organizing activities to achieve a desired goal

Application of Knowledge

Examples from the Car Rental Company

- Decision-Making
  - Choose between different offers for new cars
- Diagnosis/Problem Solving
  - Find the failure if the engine of the car does not start
- Configuration
  - Select equipment for new cars
- Planning
  - Scheduling of cars so that they are at the branch
- Information Retrieval
  - Find all documents with regulations about international drivers licences

Types of Knowledge Work according to (Davenport 2010)



(Davenport 2010)

Process-orientation for Knoweldge Workers according to (Davenport 2010)

Transaction workers. Need to understand the flow of their work and the knowledge needed to perform it, but rarely have time to consult guidelines or knowledge sources. Process flow can be added into IT applications (workflows) bringing required information to the worker.

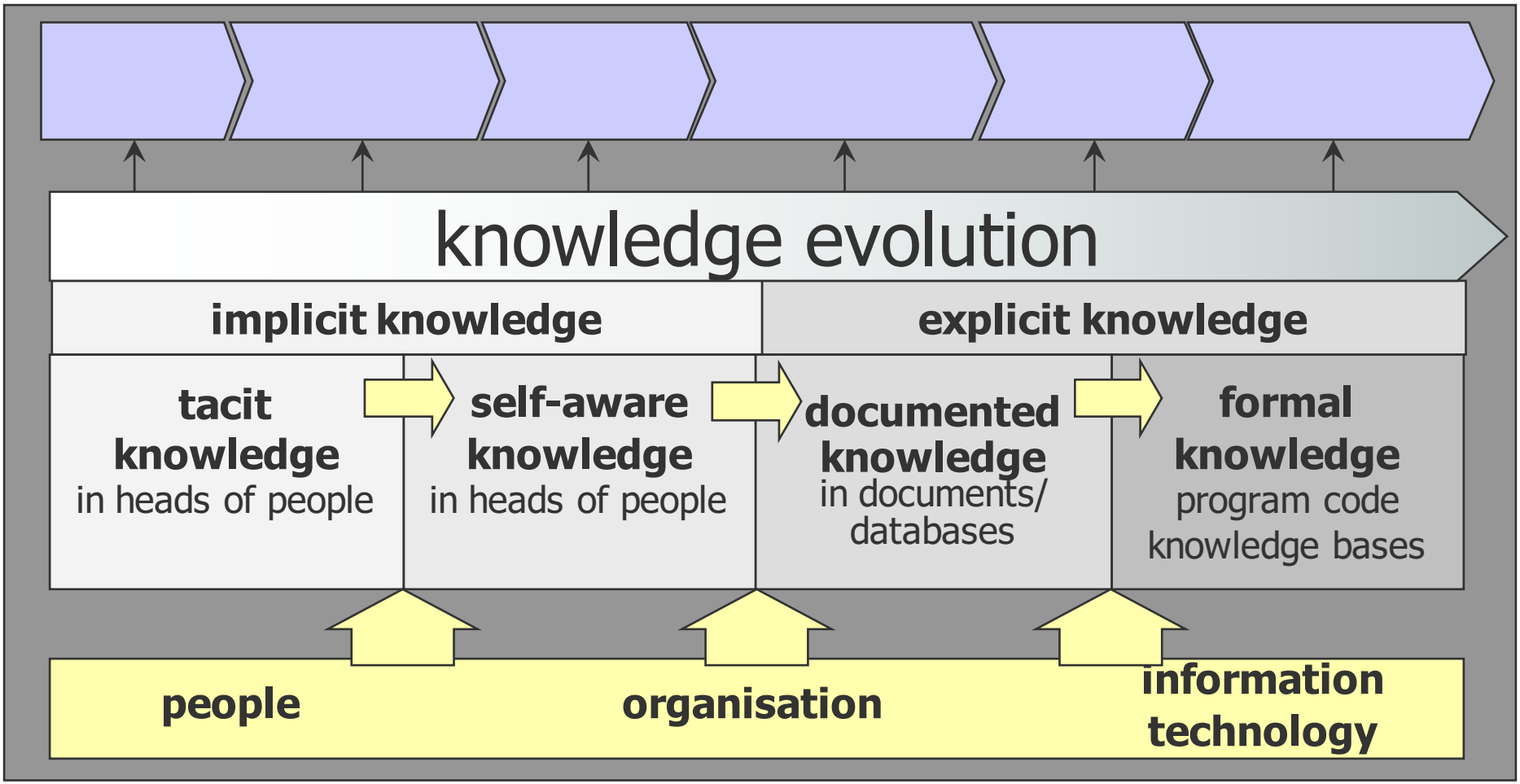
Integration workers. It is possible to articulate the process to be followed, e.g. by "standard operating procedures". Workers typically have enough time and discretion to consult the description.

Expert workers. High autonomy and discretion in the work. Expert knowledge work can be improved by providing templates, sample outputs, and high-level guidelines instead of specifying detailed process models.

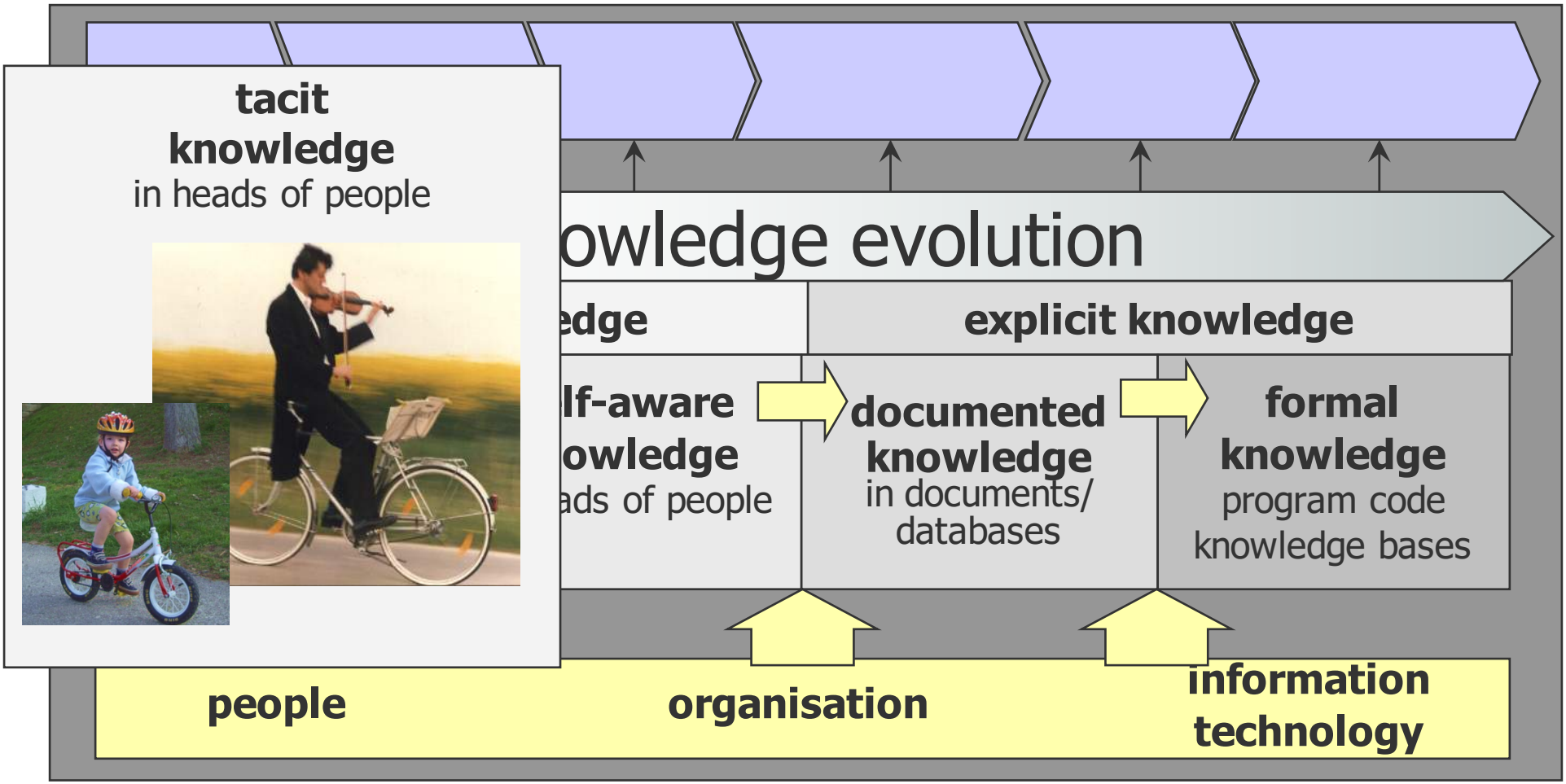
Collaboration workers. If external knowledge and information are necessary to do the job, they must generally be made available through repositories and documents

(Davenport 2010)

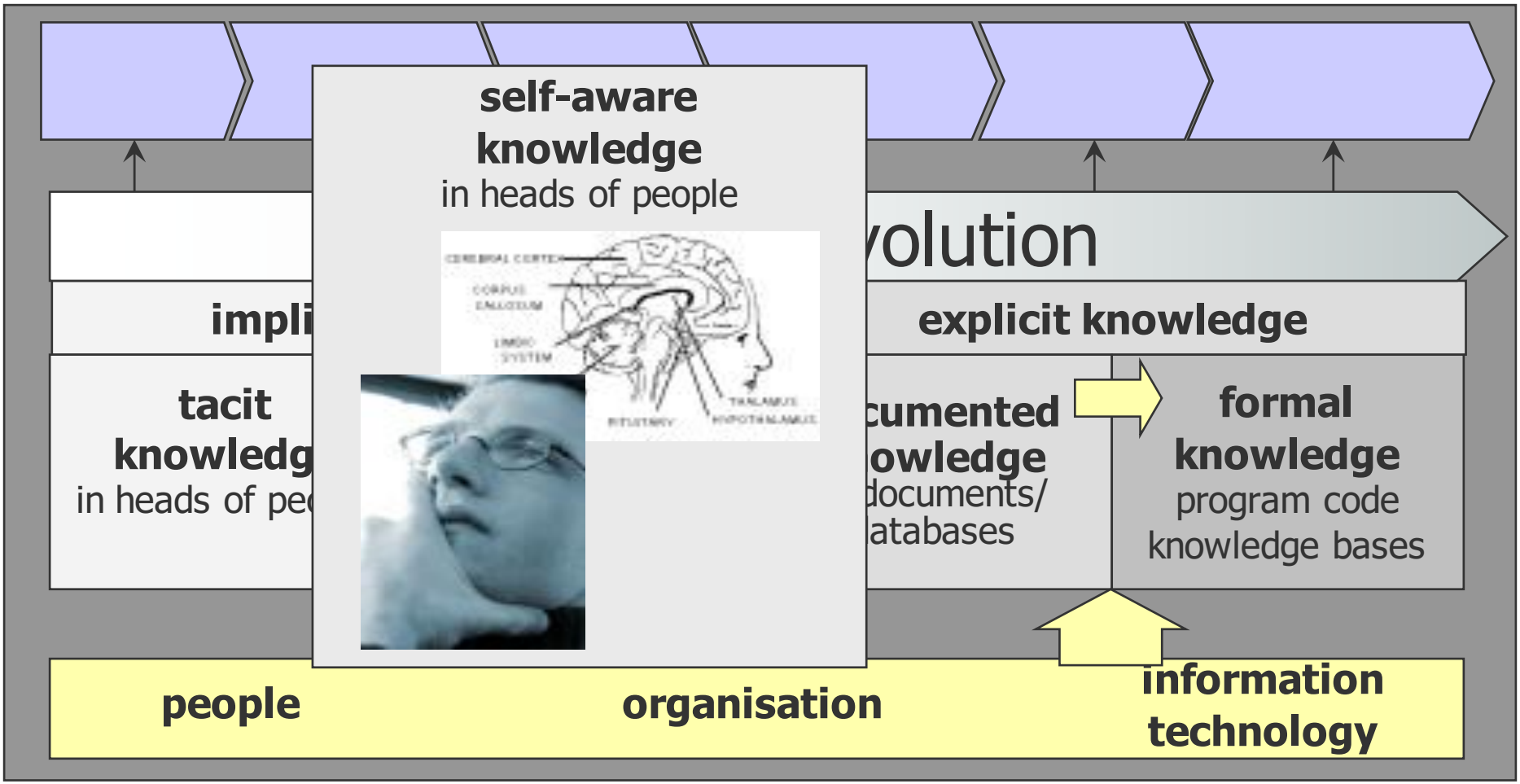
Knowledge in Enterprises



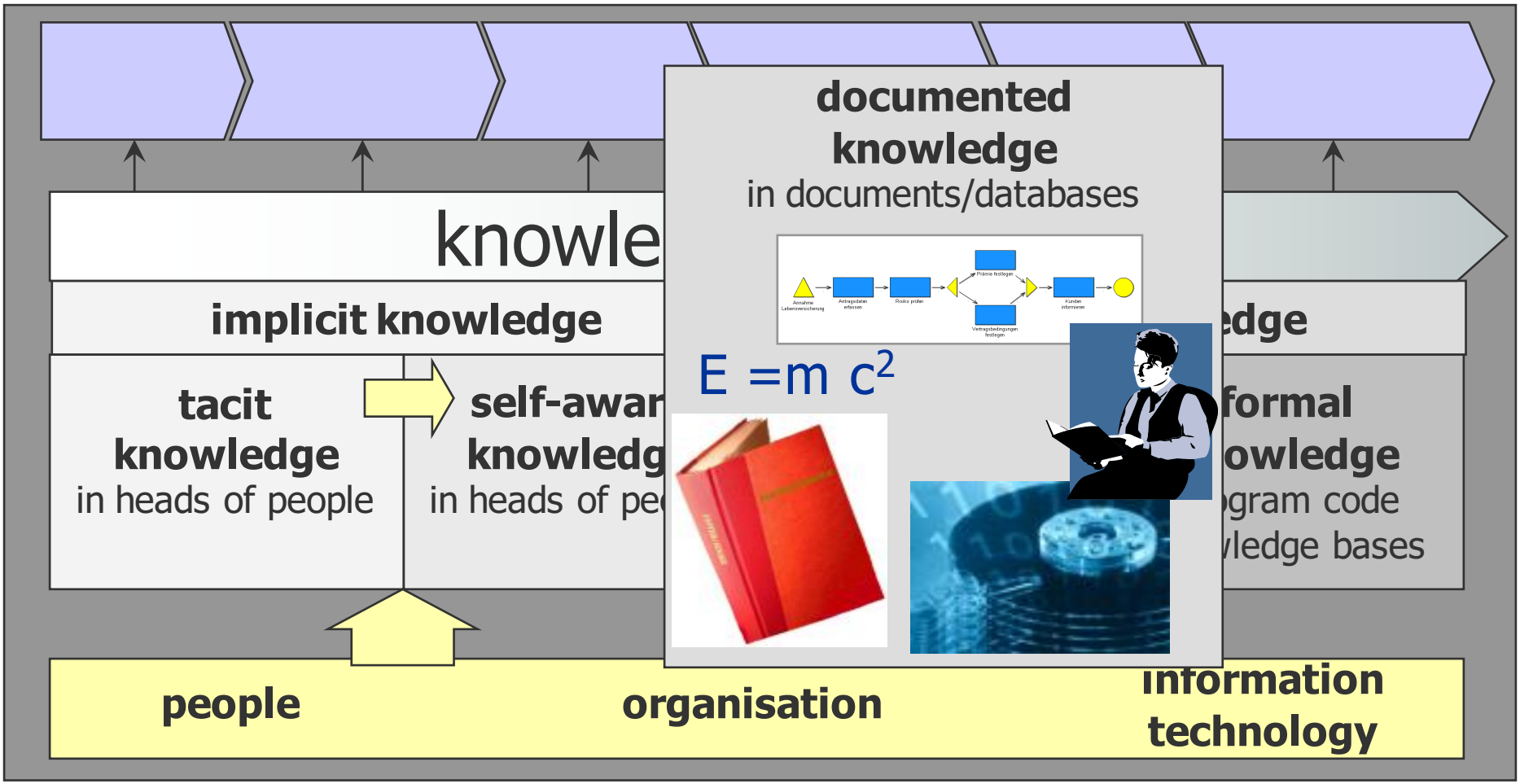
Knowledge in Enterprises



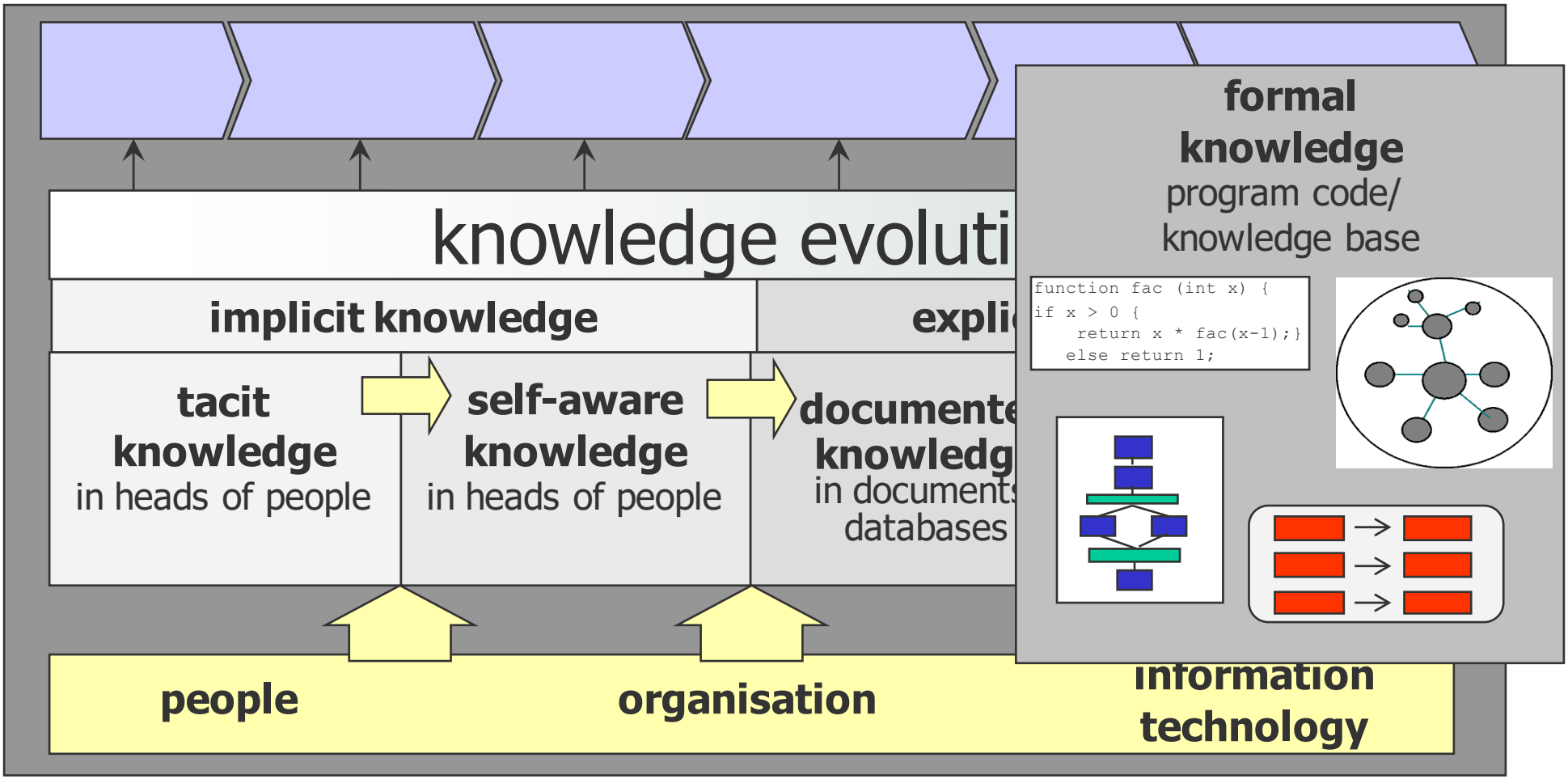
Knowledge in Enterprises



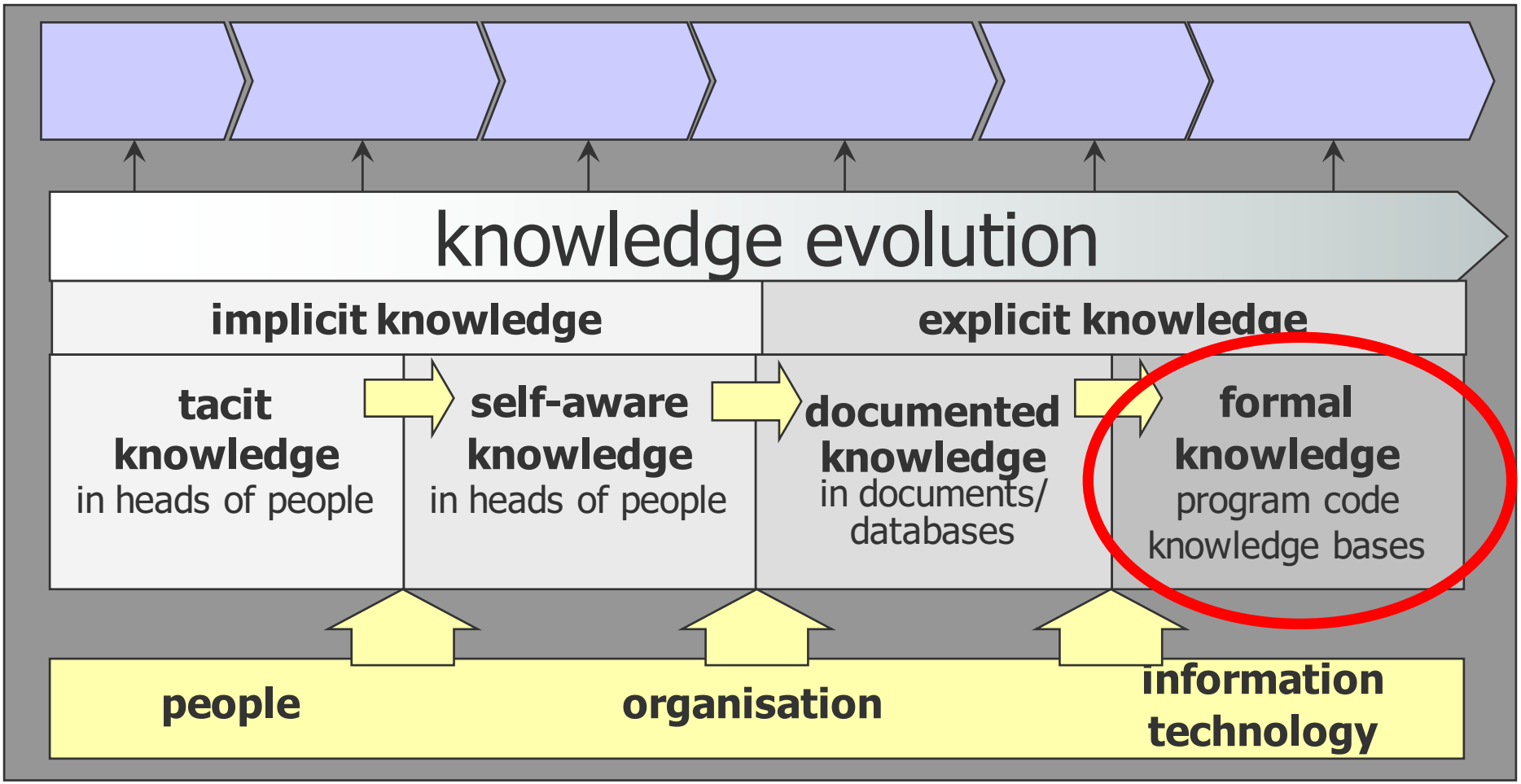
Knowledge in Enterprises



Knowledge in Enterprises

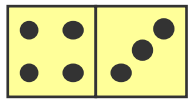


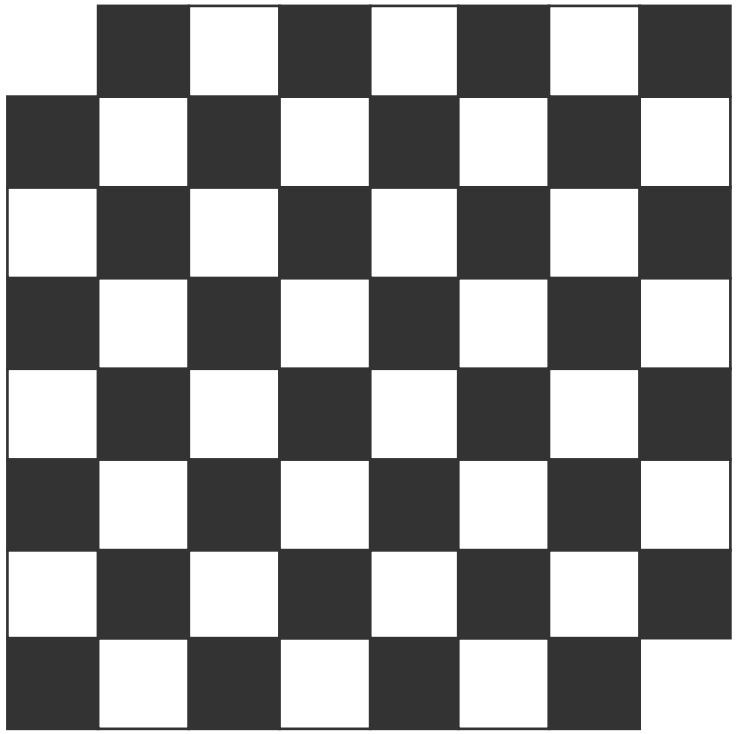
Knowledge in Enterprises



Problem Solving: Example

Placing a domino on a chess board





- Given a chess board where two opposite corners are missing
- A domino covers two adjacent field
- Is it possible to cover all fields of the board with dominos?

Expert Systems

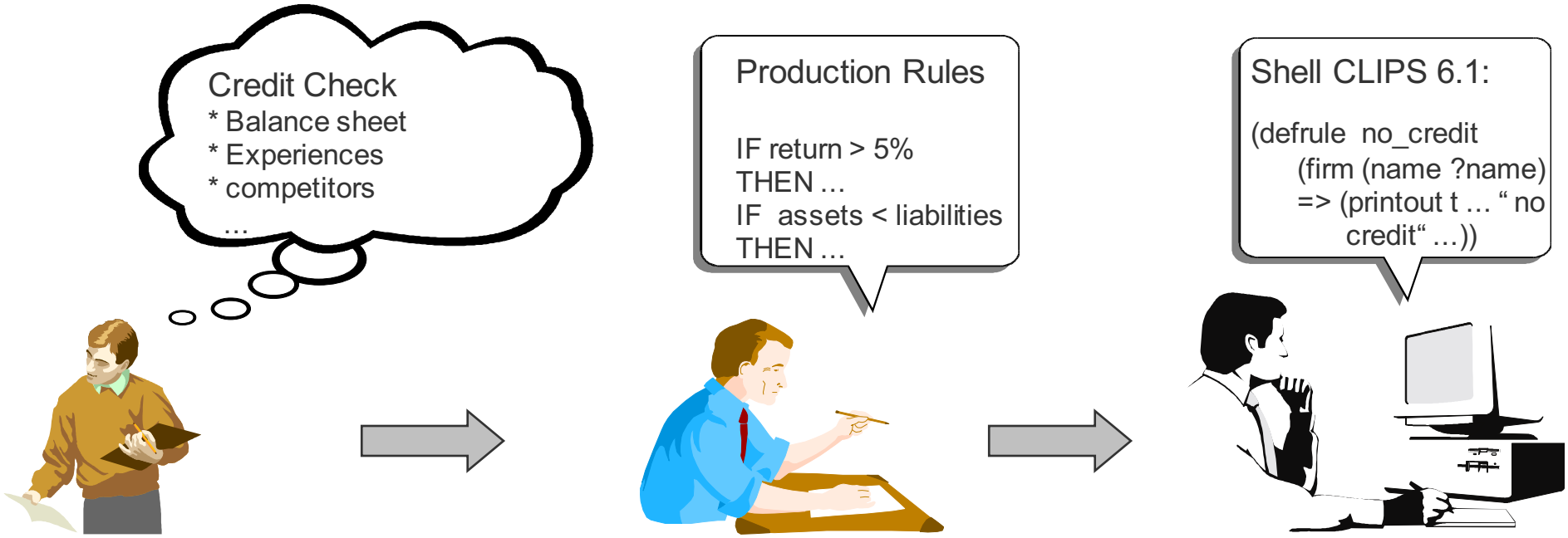
- *„An Expert System is an intelligent computer program that uses knowledge and inference procedures to solve problem that are difficult enough to require human expertise for their solutions.“*
  (Feigenbaum 1982)
- The term „knowledge-based systems“ is often used synonym for „expert systems“. It makes clear that the system has an explicit knowledge base.

Knowledge Layers

Knowledge can exist on different layers:

- Cognitive layer:
  colloquial statement of thoughts; problems are getting modelled, but still not formalised.
- Representation layer:
  Formalisation of thoughts in a representation formalism (e.g. production rules, ontologies)
- Implementation layer:
  Formalisation has progressed so much, that the sequence is possible on a computer

Layers of Knowledge-Based Systems



Cognitive Layer

Formulation of thoughts - No formally modelled

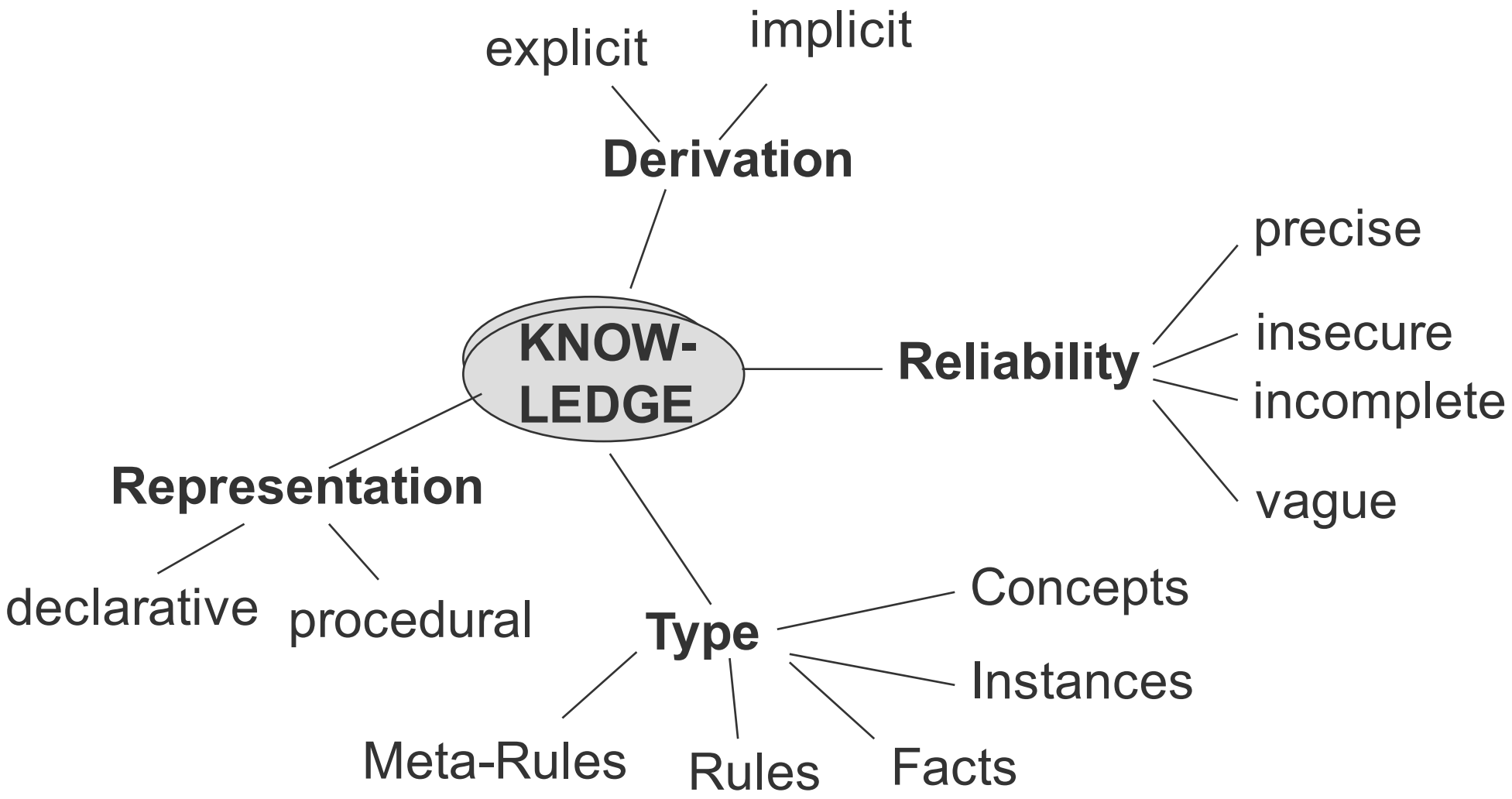
Representation Layer

Selection of a representation formalism

Implementation Layer

Selection of a software tool

Classification of Knowledge

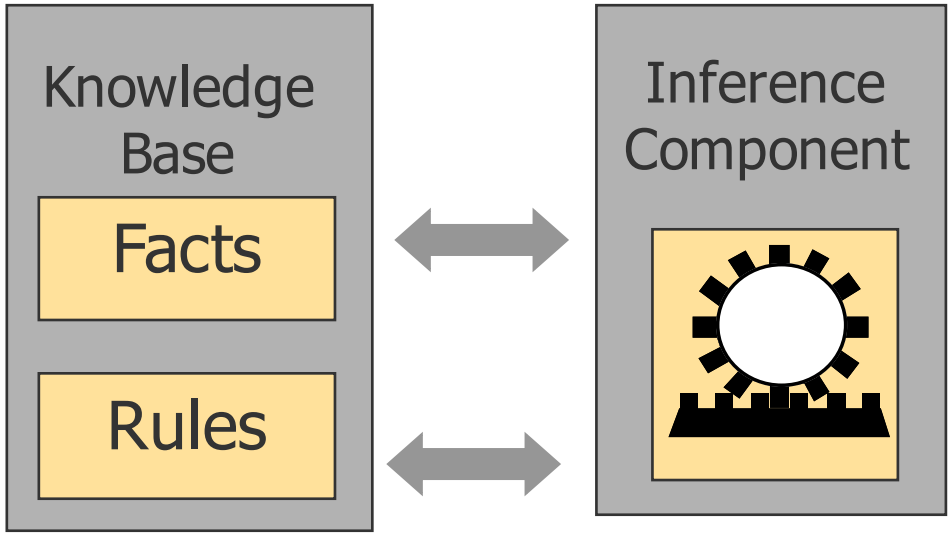


Reliability of Knowledge

- Exact knowledge:
  - „It is raining."
- Uncertain knowledge:
  - „I believe it will not rain tomorrow.“
- Incomplete knowledge (knowledge not complete, but strongly delimitated):
  - „The temperature ist between 10 and 15 degree Celsius“
- Vague knowledge (interpretation-dependent knowledge):
  - „The weather is good."

Rule-based Systems

- Rule-based Systems consist of
  - Rule base
  - Fact base
  - Inference engine



- Rules are of the form
  - IF <antecedent> THEN <consequent>

Different Types of Rule-based Systems

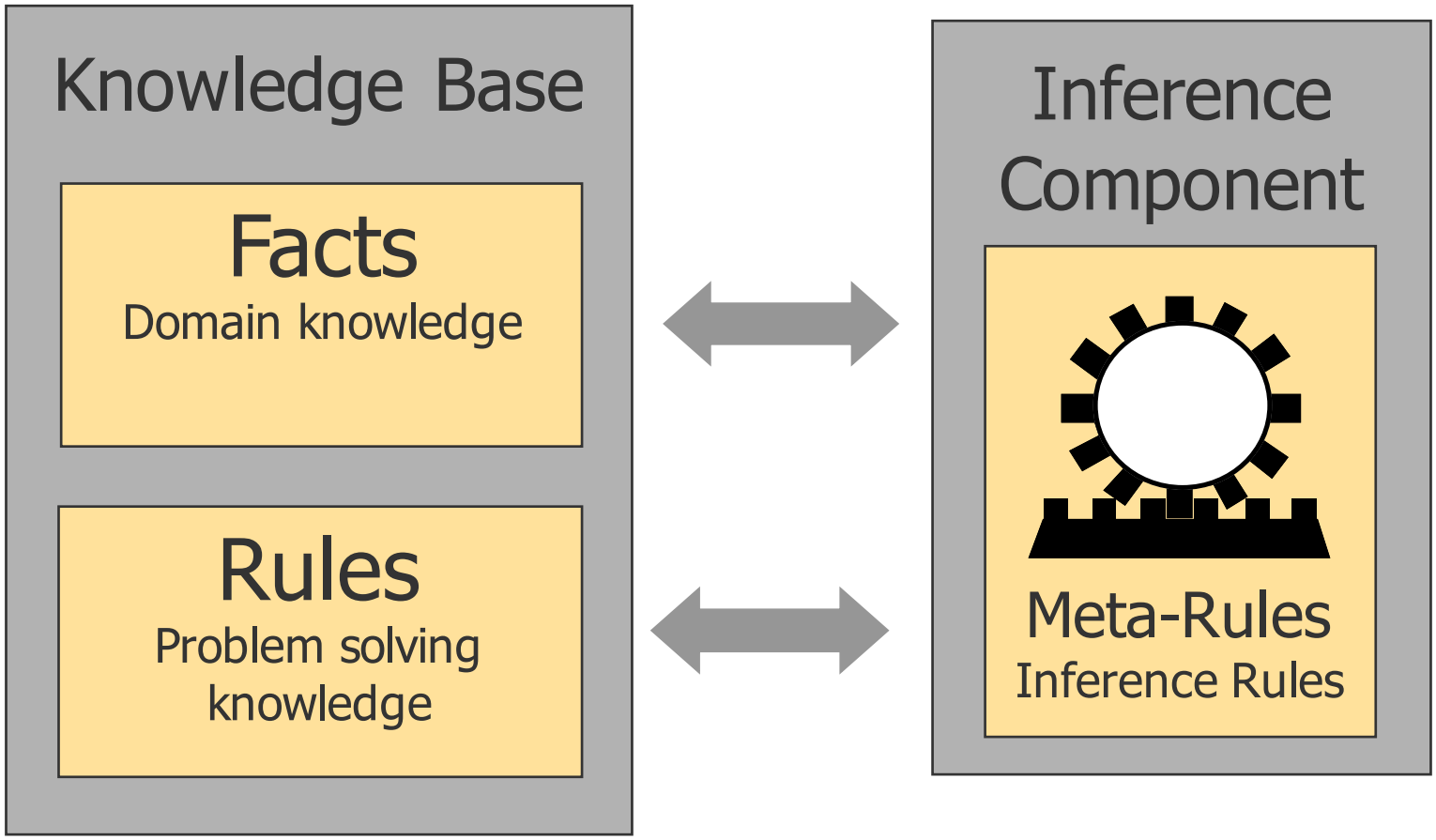
- Condition-Action Rules (Production Rules)
  - <consequent> is a set of actions
  - <antecedent> is a set of conditions
  - Example:
    IF car X has been sold THEN delete X from the catalogue
- Logical rules
  - <antecedent> and <consequent> are formulas of first-order logic
  - IF … THEN is equivalent to implication
  - Example:
    IF X is a man THEN X is mortal

Representation of Rules

There is a large variety of rule representations:

- decision tables
- decision trees
- graphical representation
- textual representation
  - logical formulas
  - Structured English
  - „Code“

Knowledge-Based Systems (Rules & Facts)



Types of Knowledge

- Facts: statements about reality
- Rules: General proposition about relations or procedure that are valid under specific conditions (e.g. in an „if ... then“-form“)

Examples:

- Fact:
  - Socrates is human
- Rule:
  - All humans are mortal

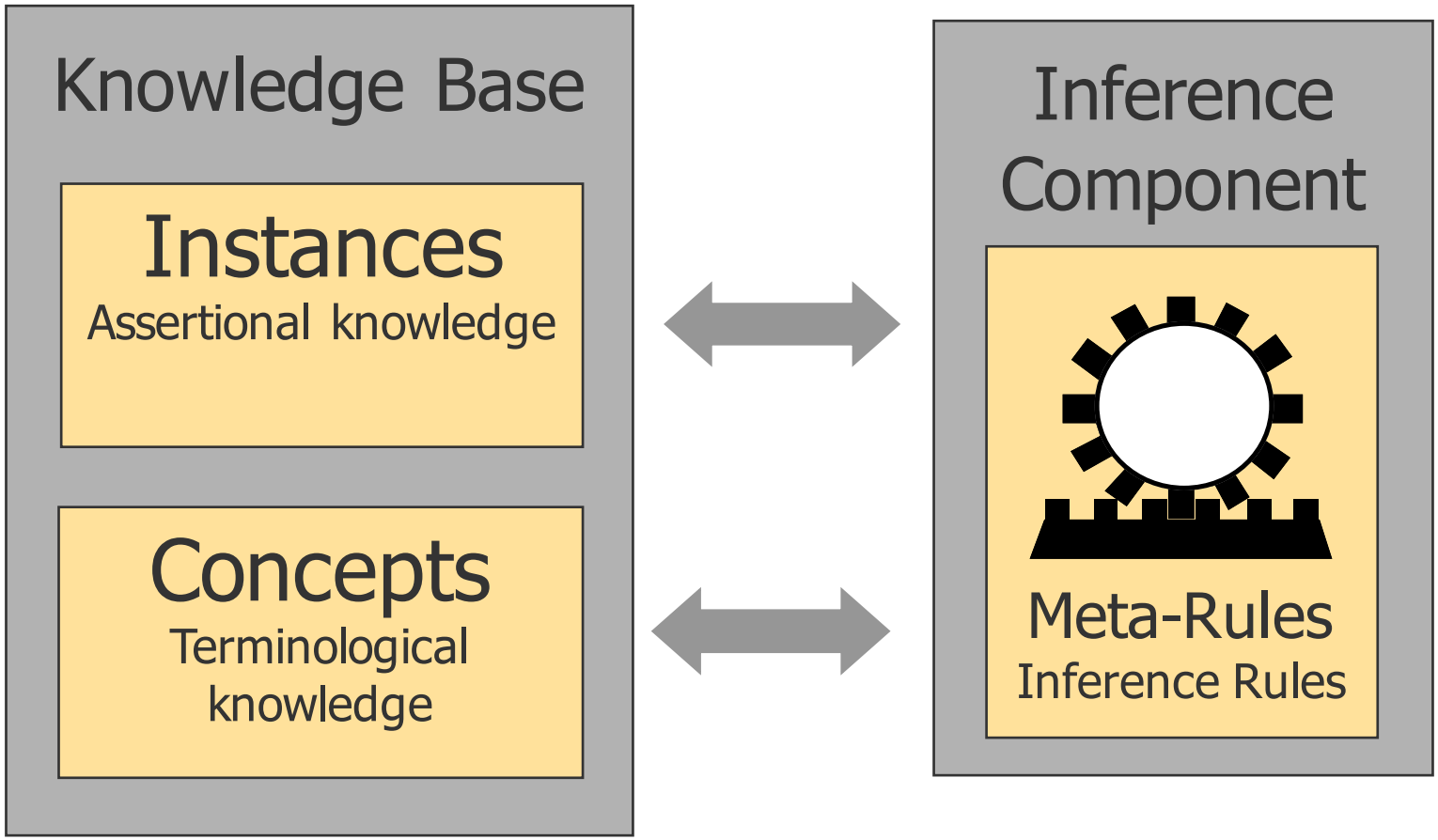
Derivation

- Explicit knowledge:
  - knowledge which is filled away in the knowledge base (static knowledge)
- Implicit knowledge:
  - not explicitly stated in the knowledge base
  - is determined from facts by application of rules
- *Derivation = Inference = Reasoning*
  - New knowledge is generated from existing one: Making implicit knowledge explicit

Sokrates is human.
All humans are mortal.

Sokrates is mortal.

Knowledge-Based Systems (Concepts and Instances)



Types of Knowledge

- Instances: statements about reality
- Concepts: General proposition about relations that are valid under specific conditions

Examples:

- Instance (instance of):
  - Socrates is human
  - "Socrates is an *element* of the set of all humans"
- Concept (subclass of – "is a"):
  - Humans are specializations (is-a) of Mortal Beings
  - "Humans are a *subset* of the set of all mortal beings"

Derivation

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Sokrates is human.
Humans are specializations (is-a) of Mortal Beings.

Sokrates is mortal.

Meta Rules

- Meta Rules …
  - implement the Inference
  - control the application of rules/concepts
  - are part of the Inference Engine
- Meta Rules can be general, e.g.
  - If all conditions of a rule are satisfied then add the conclusion to the knowledge base
  - If more than one rule can be applied use the most specific one
  - First check whether the

… or domain specific

- For underwriting in health insurance, first apply the rules that deal with the health conditions and then check for the credibility of the applicant

Example of a Declarative Knowledge Base

father(peter,mary)
father(peter,john)
mother(mary,mark)
mother(jane,mary)

---

father(X,Y) AND father(Y,Z) → grandfather(X,Z)
father(X,Y) AND mother(Y,Z) → grandfather(X,Z)
mother(X,Y) AND father(Y,Z) → grandmother(X,Z)
mother(X,Y) AND mother(Y,Z) → grandmother(X,Z)
father(X,Y) AND father(X,Z) → sibling(Y,Z)
mother(X,Y) AND mother(X,Z) → sibling(Y,Z)

X, Y, Z are variables,
Names starting with lowercase letters are either
- *constants (peter, mary, john, jane)*
  or
- *predicates (father, mother, grandfather, grandmother, sibling)*

The rules can be used to
- Derive all grandparent and sibling relationships (forward chaining)
- Answer questions about relationships (backward chaining)

Purpose of Reasoning

- Classification
  Determine the group (class) for an element
- Diagnosis/Problem Solving
  Classification but also ask questions to explore more information
- Decision-Making
  Variant of Classification or Diagnosis
- Configuration
  Assemble a complex device out of small parts
- Design
  Develop new Solutions (e.g. artefacts)
- Planning
  Plan a combination of actions to reach a goal
- Information Retrieval
  Retrieve information with knowledge support
- ...

→ support the different kinds of knowledge tasks

Declarative vs. Procedural Knowledge

- *Declarative knowledge*: The representation of knowledge is independent of an inference engine
- *Procedural knowledge*: The representation of knowledge determines its use, e.g. representing actions, order/flow of tasks, updating knowledge

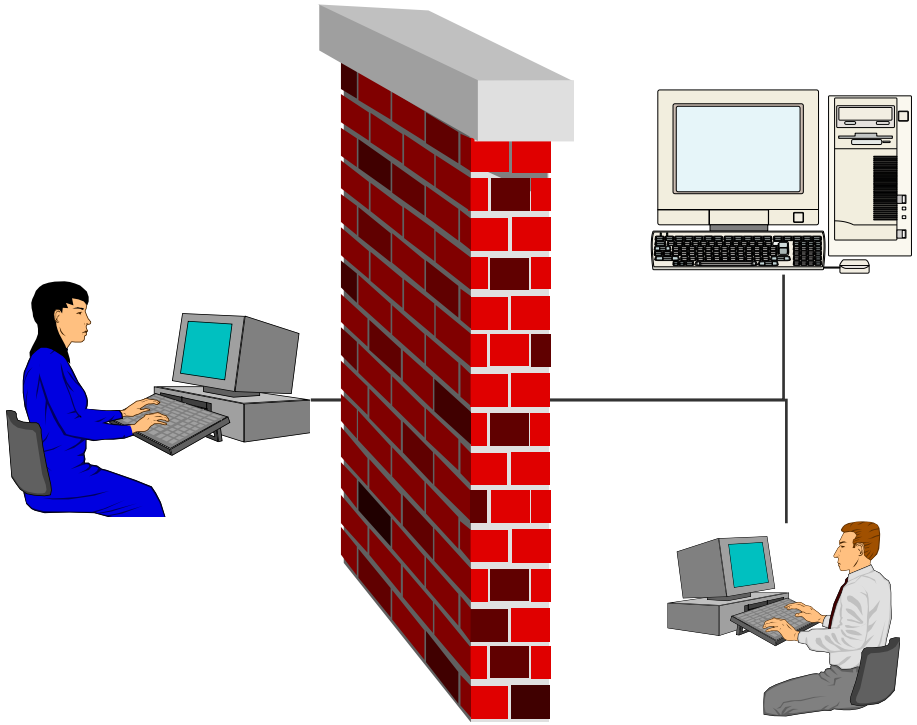
  if a car reaches the traffic light
  and the traffic light has switched to red
  then hold at the stop line

  if account balance is X
  and deposit is Y
  then account balance is X + Y

Paradigms of Knowledge Processing

- Symbolic Systems:
  - Logic Systems:
    - Representations: logical formulas
    - Derivation of knowledge: Inference (Deduction)
  - Non-Logic Systems:
    - Representations: condition-action rules
    - Derivation of knowledge: Inference
  - Fuzzy Systems:
    - Representation: linguistic formulated knowledge
    - Derivation of knowledge: Approximate conclusion
- Subsymbolic Systems:
  - Neural Networks
    - Representation: units, weights between units
    - Derivation of knowledge: Connotation

Are Machines Able to Think? – The Turing-Test



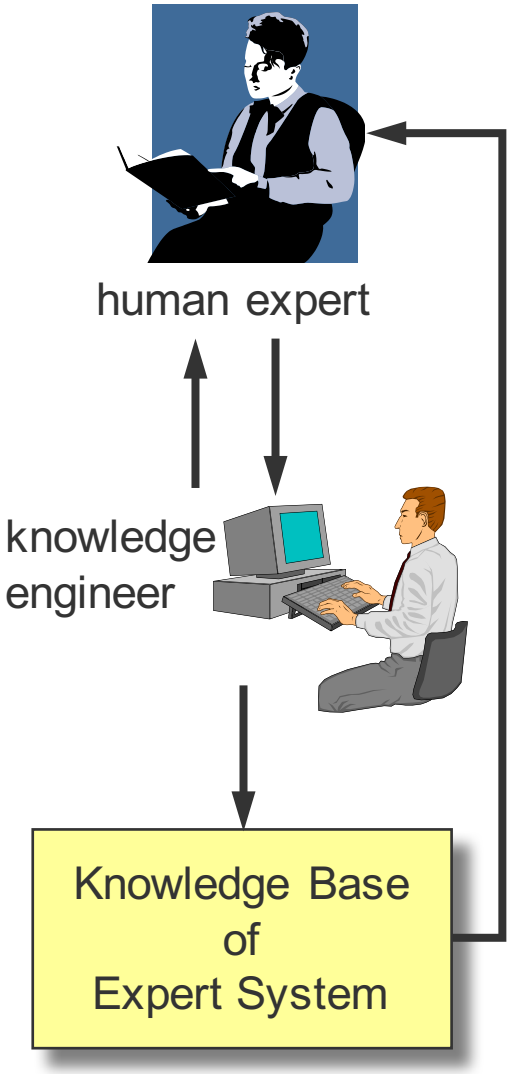
- Are Machines able to think?
- In order to find an answer to this question, the English computer pioneer A. Turing developed 1950 the so-called Turing-Test
- Test arrangement:
  - Room A: interviewer
  - Room B: Computer and Human
- The interviewer asks questions from different fields aiming to discover whether the computer or the human has provided the answer.
- The computer has passed the Turing-Test, if the interviewer cannot say who answers the questions, the computer or the human.

How can you acquire the knowledge?

How to get the knowledge

- Knowledge Engineering
  - Knowledge from human expert is extracted and formalized
  - Can be supported by an knowledge engineer
- Business Intelligence
  - Extract knowledge from data
    - Data is used as a basis for decision making
  - Quantitative and qualitative data analysis
  - Identify relationships, correlations, patterns or anomalies in data

Knowledge Engineering

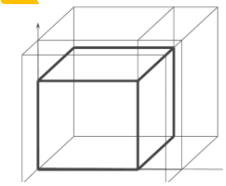
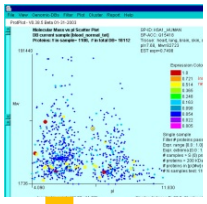


- Knowledge Engineering is the process of
  - building and
  - maintaining

  knowledge-based systems or intelligent agents
- *"Knowledge Engineering is an engineering discipline that involves integrating knowledge into computer systems in order to solve complex problems normally requiring a high level of human expertise."*[1)]
- Sources of knowledge
  - Human experts
  - Documentation

1) Feigenbaum, E., and P. McCorduck. (1983). The Fifth Generation. Reading, MA: Addison-Wesley

Business Intelligence: Getting knowledge from data

	strategic	***operative***
Questions	• What are our goals? • Are we reaching our goals? • If not, where is the problem?	• Which customers are interested in the new product? • Which tasks need how many efforts?
Analyses	 *measure, aggregate, visualise*	 *Ad hoc queries, OLAP*
		 *find patterns (data mining)*

dimensional modelling

ETL *ETL* *IE*

raw data

ETL = Extract, Transform, Load
IE = Infromatin Extrction
OLAP = Online Analytic Processing

Business Intelligence and decision making

- Fact-based decisions are based on information
- BI supports decision making by providing information, usually in the following way:
  - the human decision maker (HDM) formulates the decision problem
  - the HDM identifies the questions that need to be answered in order to take an informed decision
  - the HDM consults a BI tool to get the answers, e.g. by querying or browsing information source or from reports or dashboards
  - the HDM uses the answers to take an informed decision

Source: H. F. Witschel