Overview

Agenda

- Implicit vs. explicit forms of knowledge
- Knowledge conversion processes
- Skills, Rules and Knowledge
<table>
<thead>
<tr>
<th>Week</th>
<th>Date</th>
<th>Title / Slides</th>
<th>Comments and Links</th>
</tr>
</thead>
<tbody>
<tr>
<td>Week 1</td>
<td>11.10.2007</td>
<td>Knowledge Types and Processes</td>
<td>What is knowledge? What forms of knowledge can we identify? We will discuss some basic definitions and characteristics</td>
</tr>
<tr>
<td>Week 2</td>
<td>18.10.2007</td>
<td>Knowledge Management Strategies</td>
<td>A core of different schools of knowledge management have been proposed by KM researchers. We will discuss selected perspectives and some implications for KM management.</td>
</tr>
<tr>
<td>Week 3</td>
<td>25.10.2007</td>
<td>Knowledge Organization</td>
<td>How can knowledge be organized? We will discuss some basic principles of knowledge organization.</td>
</tr>
<tr>
<td>Week 4</td>
<td>8.11.2007</td>
<td>Broad Knowledge Bases</td>
<td>What kind of knowledge bases exist? We will discuss different types of knowledge bases and representations, such as metadata, wordnets, taxonomies, etc., and their differences.</td>
</tr>
<tr>
<td>Week 5</td>
<td>15.11.2007</td>
<td>Knowledge Acquisition</td>
<td>Knowledge acquisition is the process of transforming knowledge into usable resources.</td>
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<tr>
<td>Week 6</td>
<td>22.11.2007</td>
<td>Knowledge Transfer</td>
<td>How can knowledge be transferred and what factors can influence knowledge transfer? We will discuss time and effort factors.</td>
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</table>

**Preliminary Schedule II**

<table>
<thead>
<tr>
<th>Week</th>
<th>Date</th>
<th>Title / Slides</th>
<th>Comments and Links</th>
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</thead>
<tbody>
<tr>
<td>Week 8</td>
<td>29.11.2007</td>
<td>Organizational Knowledge Management</td>
<td>How can knowledge resources be designed and deployed? We will discuss concepts such as knowledge management, knowledge-based systems, and knowledge representation.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(slides)</td>
<td>Readings: V. R. Baskin and G. Colvard, Knowledge Management: Toward a Taxonomy (1999); R. B. Baskin, Knowledge Management: Toward a Taxonomy (1999)</td>
</tr>
<tr>
<td>Week 9</td>
<td>6.12.2007</td>
<td>Psychology in Knowledge Management</td>
<td>In this class, we will discuss the fundamental psychological concepts in the context of knowledge management, including the psychology of human memory.</td>
</tr>
<tr>
<td>Week 10</td>
<td>13.12.2007</td>
<td>Multimodal &amp; Semantic Retrieval</td>
<td>In this class, we will discuss different forms of semantic annotation and multimedia documents.</td>
</tr>
<tr>
<td>Week 11</td>
<td>10.1.2008</td>
<td>Business Process-Oriented Knowledge Management</td>
<td>In this class, we will discuss different approaches to integrating knowledge management into an organization’s business processes.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(slides)</td>
<td>Readings: TBA</td>
</tr>
<tr>
<td>Week 12</td>
<td>17.1.2008</td>
<td>Agent-Oriented Analysis of Information Systems</td>
<td>What are the requirements for effective information systems? In this class, we will discuss an agent-oriented framework for analyzing information systems.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(slides)</td>
<td>Readings: TBA</td>
</tr>
<tr>
<td>Week 13</td>
<td>31.1.2008</td>
<td>Knowledge-Based Analysis</td>
<td>How can non-technological systems be designed from a knowledge perspective? We will discuss an agent-oriented modeling approach for analyzing knowledge transfer instruments.</td>
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<tr>
<td>Week 14</td>
<td>31.1.2008</td>
<td>Final Exam</td>
<td>No final exam scheduled.</td>
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</table>

Knowledge Management Institute
Motivation [Maier 2005]

Illustration

Context (e.g. knowledge about tickets, implications)

Car is not allowed to go faster than 100

100

1,0,0

knowledge
relation to user/application

link, network with context/experiences

information
relation to meaning

interpret

data
relation to other symbols

structure, order, format

symbol
relation to denominated object/activity

Figure 1. Data, information and knowledge as hierarchy of terms
Motivation [Maier 2005]

- knowledge development/application maps
- communities/knowledge networks
- knowledge process reengineering

organization
(knowledge in social systems)

person
(knowledge bound to individuals)

product
(knowledge as object)

knowledge source map
competence management
personal experience management

knowledge structure map
lessons learned
good/best practices
semantic content management

Figure 1-10. Knowledge management instruments
Motivation

Can you give examples of implicit / explicit information?

What is the difference between implicit and explicit information?

Implicit vs. Explicit Knowledge

naive distinction

Four naive properties of explicit representations [Kirsh1990]:

- **Locality**: visible structures with a definite location
- **Movability**: no matter where in a book a word is to be found, the word retains its meaning, words maintain meaning across time and space
- **Meaning**: words have a definite semantic content
- **Availability**: the semantic content of a word is directly available to cognizers, no translation or interpretation is necessary, immediate readability

Explicit
- Knowledge outside the head
- Examples: A book, a sentence, a piece of code, a database entry

Implicit
- Knowledge inside the head
- Examples: experiences, skills, gut feelings

Information is explicit when it is local, movable, available and when it has a definite meaning.

**BUT...**
Explicit or Implicit?  
[Kirsh1990]

1. Is 5 as the solution to $\sqrt{25}$ explicit in $\sqrt{25}$?
2. Is the $200^{100}$ digit of $\pi$ explicit?
3. Is 3 explicit in $A$: $\{1,5,3,7,4,4\}$?
4. Is the cardinality of $A$ explicit in $A$: $\{1,5,3,7,4,4\}$?
5. Is $(6754, 9629)$ in a matrix of $10,000 \times 10,000$ explicit?
6. Is the answer to „Why does the pop star P!nk perform 4 Non Blondes songs at her concert“ explicit on the web?

Questions: Do we count accessing times as part of the reading process (availability)? Should we differentiate between locating and computing information? What is immediate readability?

Locality  
[Kirsh1990]

Locality: visible structures with a definite location (naive)

Problem: Overly restrictive. Why exclude distributed information? Can information never be explicit on a distributed network?

  e.g. an mp3 file on a distributed peer-to-peer network

What is important is that information can be separated from surroundings by a host system.
Movability
[Kirsh1990]

**Movability**: no matter where in a book a word is to be found, the word retains its meaning (naive)

**Problem:**
- Does 5 in 105 carry the same meaning as 5 in 501?
- „Police police police police police“  
  (*Police who are policed by policemen are themselves policers of policemen*)

**Syntax needs to be taken into account.**

Availability
[Kirsh1990]

**Availability**: the semantic content of a word is directly available to cognizers, no translation or interpretation is necessary (naive)

**Problem:**
What is explicit in a structural sense may not be explicit in a procedural sense.

**Example:**
- A book without index
- Encrypted messages (is „hans“ explicit in „ibot“?)

**We cannot decide what is explicit without knowing in detail how a system works.**
**Meaning**

[Kirsh1990]

**Meaning:** words have a definite semantic content (naive)

**Problem:**

- **polysemous** words (Polysemy)
  - e.g. bank (river bank, financial institution)
- "Then John read him his rights". Who is him?
- A symbol explicitly encodes a certain semantic if a system S can immediately recognize its meaning.

We need to take the semantic context into account.

---

**Implicit vs. Explicit**

[Kirsh1990]

**Four Conditions revisited**

1. The states, structures or processes — henceforth symbols — which explicitly encode information must be **easily separable** from each other (Locality)

2. An ambiguous language may explicitly encode information only if it is **trivial to identify** the syntactic and semantic identity of the symbol. (Movability)

   Trivial: if there is a mechanical process that identifies the relevant property in constant time (independent of the size of the problem instance) or within a given attention span

   **Example:** is a given binary number even or odd?
   **Answer:** Depends on the system's algorithm and the operators attention span to determine it
Implicit vs. Explicit [Kirsh1990]

Four Conditions revisited

3. Symbols explicitly encode information if they are either:
   A) readable in constant time or
   B) sufficiently small to fall in the attention span of an operator
      (Availability)

4. The information which a symbol explicitly encodes is given by
   the set of associated states, structures or processes it
   activates in constant time
      (Meaning)

Implicit vs. Explicit Summarization [Kirsh1990]

“Explicitness really concerns how quickly information can be
accessed, retrieved or in some other manner put to use. It has
more to do with what is present in a process sense, than with
what is present in a structural sense.”

“Representations are inert unless coupled with processes
which interpret them.”

“It is the union of structure and process which can explicitly
encode information.”

Example:
Q: Is the year you started your studies explicit in your Matr. Nr.?
A: Again, this depends on the system’s algorithm and the operators
attention span to determine it
Implications

*What are the implications of the dependencies on*

- Algorithms runtime
- Operator / User attention span

for Software Engineering / Software Engineers?

- Access and processing times determine the extent to which knowledge can be regarded to be explicit
- Different attention spans of different users yield different degrees of explicitness

Tacit, Implicit, Explicit

- Tacit: can not be made explicit
  - Examples: Gut feeling, expert knowledge, etc
- Implicit: not explicit, but can be made explicit
  - Key criteria: time
  - Examples: Why does P!nk perform 4 Non Blondes songs on stage?
- Explicit: easily recoverable and cognitizable
  - According to the four conditions
  - Example: Is any given binary number even or odd?

**But, the ultimate distinction depends on the system processing the information and the operator's attention span**
Types of Knowledge
[Alavi & Leidner 2001]

<table>
<thead>
<tr>
<th>Knowledge Type</th>
<th>Definition</th>
<th>Examples</th>
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</thead>
<tbody>
<tr>
<td>Tacit</td>
<td>Knowledge is rooted in actions, experience, and involvement in specific context</td>
<td>Best means of dealing with specific customer</td>
</tr>
<tr>
<td>Cognitive tacit</td>
<td>Mental models</td>
<td>Individual’s belief on cause-effect relationships</td>
</tr>
<tr>
<td>Technical tacit</td>
<td>Know-how applicable to specific work</td>
<td>Surgery skills</td>
</tr>
<tr>
<td>Explicit</td>
<td>Articulated, generalized knowledge</td>
<td>Knowledge of major customers in a region</td>
</tr>
<tr>
<td>Individual</td>
<td>Created by and inherent in the individual</td>
<td>Insights gained from completed project</td>
</tr>
<tr>
<td>Social</td>
<td>Created by and inherent in collective actions of a group</td>
<td>Norms for inter-group communication</td>
</tr>
<tr>
<td>Declarative</td>
<td>Know-about</td>
<td>What drug is appropriate for an illness</td>
</tr>
<tr>
<td>Procedural</td>
<td>Know-how</td>
<td>How to administer a particular drug</td>
</tr>
<tr>
<td>Causal</td>
<td>Know-why</td>
<td>Understanding why the drug works</td>
</tr>
<tr>
<td>Conditional</td>
<td>Know-when</td>
<td>Understanding when to prescribe the drug</td>
</tr>
<tr>
<td>Relational</td>
<td>Know-with</td>
<td>Understanding how the drug interacts with other drugs</td>
</tr>
<tr>
<td>Pragmatic</td>
<td>Useful knowledge for an organization</td>
<td>Best practices, business frameworks, project experiences, engineering drawings, market reports</td>
</tr>
</tbody>
</table>

How is one type of knowledge converted into another?

Modes of Knowledge Creation
[Maier 2005]

**Tacit knowledge**
- *Socialization*
  - share experiences: training on the job, brainstorming
  - informal gathering
- *Internalization*
  - avoid re-inventing wheels: handbooks, diagrams, learning by doing, stories, studies

**Explicit knowledge**
- *Externalization*
  - communicate intuitive, subjective experiences: metaphors, analogies, physical models
- *Combination*
  - share, integrate knowledge: text/images/audio/video, documents, discussion, formal training & education

**Result:**
- Sympathized knowledge
- Conceptual knowledge
- Operational knowledge
- Systemic knowledge

Figure 1-6. Processes of knowledge conversion (Nonaka/Takeuchi 1995)
What is cognition?

Wordnet:
"The psychological result of perception and learning and reasoning"

Synonym: knowledge

Britannica:
"the process involved in knowing, or the act of knowing, which in its completeness includes perception and judgment. Cognition includes all processes of consciousness by which knowledge is accumulated, such as perceiving, recognizing, conceiving, and reasoning. Put differently, cognition is an experience of knowing that can be distinguished from an experience."

German: Wahrnehmung
Cognitive Load Theory

Intrinsic cognitive load

- Inherent difficulty of information content
  - Example: 23 * 4 = ?

Extraneous cognitive load

- Due to the way the information is presented
  - Example: XXIII * IV = ?

By changing how the information is presented the level of cognitive load may be reduced

External Cognition [Scaife 1996]

Internal representations (mental models)

External representations (text, graphics, etc)

Instead of focusing on internal representations, let's focus on external representations. How can they be modified to improve cognition?

1. Computational Offloading
2. Re-representation
3. Graphical constraining
Computational Offloading [Scaife 1996]

Refers to the extent to which external representations reduce the amount of cognitive effort.

Example: Which nodes do not share an edge?

Textual Representation:

There is a graph with nodes A, B, C, D. There is an edge between A and B. Another line runs from B to C and from A to D. C and D are connected as well.

---

Re-representation [Scaife 1996]

Refers to how different external representations, that have the same abstract structure, make problem-solving easier or more difficult.

Example: Which nodes do not share an edge?

Formal Representation:

[A,B], [C,D], [A,D], [B,C]
Graphical Constraining [Scaife 1996]

Refers to the way graphical elements in a graphical representation are able to constrain the kinds of inferences that can be made.

What kind of graphical constraints are introduced by the graph below?

![Graphical Constraints Diagram](attachment:image.png)

External Cognition [Scaife 1996]

Solvers no longer need to solve the problems entirely in their head but can work them out by interacting with the diagrams.

External Cognition [Scaife 1996]

Examples: Knowledge Visualization

A periodic table of Visualization Methods

http://www.visual-literacy.org/periodic_table/periodic_table.html

Distributed Cognition [Rogers 2005]

The focus is on explicating cognitive systems, which are the interactions between people, artifacts and both internal and external representations.

focuses on the processes that take place in an extended cognitive system. (does not only focus on knowledge „inside the head“)

the explication of the complex interdependencies between people, artifacts and technological systems
Distributed Cognition [Rogers 2005]

Why is this perspective interesting?

It is possible to determine the processes and properties of such cognitive systems more reliably – since they can be observed directly in ways not possible inside a person’s head.

skills and the knowledge produced by distributed processes are the mental residua of the process.

Organizational Work

Organizational work becomes increasingly knowledge intensive and complex. [Eppler 1999]
Distributed Cognition [Rogers 2005]

the distributed cognition approach involves explicating:

• the distributed problem-solving that takes place (including the way people work together to solve a problem)

• the role of verbal and non-verbal behavior (including what is said, what is implied by glances, winks, etc. and what is not said)

• the various coordinating mechanisms that are used (e.g., rules, procedures)

• the various ways communication takes place as the collaborative activity progresses.

• how knowledge is shared and accessed

Distributed Cognition [Walenstein 2002]

Cognition is not a process localized to an individual human mind, but one that is spread out amongst possibly many humans and artifacts.

A cognitive system will operate better or worse depending upon whether the appropriate external artifacts are available, and depending upon how they are designed.

Cognitive support can therefore be understood entirely in computational terms: support is the provision of computational advantage
Cognitive Support [Walenstein 2002]

Thus the cognitive support provided by an artifact is the computational advantage that it provides.

Designing cognitive support can be considered as computational reengineering

**Example:** Calculator, Notebook, Calendar

But what distinct classes of cognitive support exist?

Cognitive Support Classes [Walenstein 2002]

The RODS Framework for Analyzing Cognitive Support

- Reduction
- Optimization
- Distribution
- Specialization
Task Reduction [Walenstein 2002]

- Removing unnecessary steps or unused computations
- Example:
  - Programmer's editor might insist on having the developer re-read every line of code in a program before each and every edit she makes
  - Unnecessary computations being performed
  - Removing these will decrease the amount of cognitive work done

Algorithmic Optimization [Walenstein 2002]

- Relies on the fact that
  - Differences in encoding or procedure can create differences in performance without changing the outcome
  - Information content remains unchanged

- Example:
  - Arabic and roman numbers: Roman numbers require more complex computation (symbol substitution) for most of us
Distribution [Walenstein 2002]

- Divide cognitive work
  - Thereby reduce the work done by each processor
  - Parallelize
  - Cognitive Offloading
- Allows to perform computations that otherwise might exceed the capabilities of one limited processor
- Using external memory
  - Example: Calculator, Type checker

Specialization [Walenstein 2002]

- Make use of specialized cognitive abilities. These are fast, effort-free and execute at least partially in parallel, in contrast to deliberate reasoning which is slow, serial and effortful
- Example: Visual search

<table>
<thead>
<tr>
<th>Formal Representation</th>
<th>Graphical Representation</th>
</tr>
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<tbody>
<tr>
<td>67876 14321</td>
<td><img src="image" alt="Graphical Representation" /></td>
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<td>67876 13243</td>
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<td>78687 69857</td>
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<td>32322 32143</td>
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<tr>
<td>12344 78665</td>
<td></td>
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</tbody>
</table>
Cognitive Support [Walenstein 2002]

- Task Reduction
  - Croft Principle: some functions are easier to compute
  - Substitution Type: substitute simpler tasks for more complicated ones
  - Example (G2O): eliminate unnecessary steps
  - Design Principle: remove unnecessary work, lower task demands

- Algorithmic Optimization
  - Croft Principle: functionally identical algorithms differ in efficiency
  - Substitution Type: substitute equivalent methods, AGTs, or encodings
  - Example (G2O): changing to doubly-linked list, switching sorting algorithm
  - Example (R2O): switching to Roman numerals
  - Design Principle: optimize cognitive processes for task & infrastructure

- Distribution
  - Croft Principle: distribution adds memory or computing resources
  - Substitution Type: substitute external resources for internal ones
  - Example (G2O): caching memory to a hard drive, client-server architecture
  - Example (R2O): writing down a shopping list, automatic constraint checking
  - Design Principle: distribute (i.e., redistribute or offload) data or processing

- Specialization
  - Croft Principle: specialized routines or processes can be more efficient
  - Substitution Type: substitute specialized processes for more general ones
  - Example (G2O): use a GPU for accelebrated graphics card
  - Example (R2O): enable visual search to substitute for “manual” search
  - Design Principle: change representation to make use of specialized hardware

Any questions?

- See you next week!