IT-BASED PURPOSE-DRIVEN KNOWLEDGE VISUALIZATION

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Abstract: Knowledge visualization is currently under investigation from different points of view especially because of its importance for Artificial Intelligence, Knowledge Management, Business Intelligence etc. The concepts and technology of knowledge visualization in the presented research are considered from a purpose perspective which focuses on the interdependencies between different knowledge elements. This way the influence of these elements on each other in every particular situation can be visualized. This is crucial e.g. for decision making.

1 KNOWLEDGE TRANSFER AS THE ESSENTIAL ACTIVITY IN KNOWLEDGE MANAGEMENT PROCESSES

Looking back onto more than ten years of knowledge management history we detected that there is still no universal definition of knowledge management. Some valuable attempts to define knowledge management were made by Probst (Probst et al., 1997), Davenport and Prusak (Davenport/Prusak, 1998), Nonaka and Takeuchi (Nonaka/Takeuchi, 1995), Maier (Maier, 2004) etc. Most of today's accepted definitions describe knowledge management as creation, communication, and application of knowledge. The main goal of knowledge management is therefore to improve these processes. Outgoing from different perspectives and different aims correspondently the descriptions of the activities in the knowledge management process vary significantly. But almost all of them (Bodrow/Fuchs-Kittowski, 2004, Maier, 2004) emphasize knowledge transfer - which is also called sharing, diffusion, exchange, dissemination, or distribution, together with knowledge application as one of the most important activities in the knowledge management process. Below we will use the term transfer synonymously for sharing and exchanging of knowledge as well as for diffusion, dissemination and distribution of knowledge, knowing that sharing and exchange refer to bi-directional processes in opposition to dissemination, diffusion and distribution which represent the uni-directional (knowledge) flow. In respect to the presented research this difference is useless therefore only the transfer term will be applied.

The efficient transfer of knowledge has proven to be a difficult task. In this context the adequate visualization of knowledge can significantly improve its transfer. Therefore in the following analysis we will concentrate on this particular aspect of the knowledge transfer.

2 WHY KNOWLEDGE VISUALIZATION?

A well-known saying, that a picture is worth 1000 words, leads us to the suggestion that the visualization of knowledge can increase the effectiveness of its representation, understanding and consequently of knowledge transfer. Visualization can be considered as a way of internalization (Nonaka/Takeuchi, 1995) of knowledge (transformation from explicit to tacit knowledge). But what exactly do we mean by knowledge visualization? How does it differ from visualization of information or data? Knowledge visualization as opposed to information visualization is a rather new field within knowledge management research. It has received more attention recently due to the business's interests. There are already some attempts to define knowledge visualization. Two examples of such definitions are presented below.

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3 KNOWLEDGE VISUALIZATION TODAY

Following Drosdol (Drosdol/Frank, 2005) knowledge visualization refers to "the result of transformation from information to knowledge, representation of connections and links, designing the space between information elements, development of meaning, creating meaningful structures fitting the contents, helping to generate new knowledge which can be used by people, staff, leaders, decision-makers".

Burkhard (Burkhard/Maier, 2004, Burkhard, 2005, Eppler/Burkhard, 2004) defines knowledge visualization as "the use of visual representations to improve the transfer and creation of knowledge between at least two persons". Moreover he describes the difference between knowledge and information visualization. The latter is not trivially derivable from the presented definition. Information visualization also uses "visual representations to improve the transfer of knowledge", even if its primary goal is to retrieve the information. According to Burkhard's definition it can be considered as knowledge visualization. The recipient (depending on their capabilities) can obtain or perhaps create new knowledge only by getting the visual information. There are many Software-tools that visualize a huge amount of data and information. Experience gathered in this field is very helpful i.e. for development of decision support systems. Obviously the presented definition is too general to be accepted as a definition for knowledge visualization.

Our approach compared to other definitions is not knowledge element-driven, but purpose-driven. It is based on an appropriate application of the different interrelations between the knowledge elements according to the selected purpose. We consider the knowledge element oriented approach as very similar to information or data visualization where the different declared attributes of the particular object can be visualized using graphics and other media. Alternatively we follow the idea, that the most important aspect in visualizing knowledge (especially!) is the multi-valence of explanations for the interdependencies between knowledge elements.

4 HOW DO WE DEFINE KNOWLEDGE VISUALIZATION?

How can we define knowledge visualization from a knowledge management perspective (not from a view of cognitive psychology, pedagogy or graphic design)? Our aim is not to define a visualizing technique (like sketch, diagram, image etc.), but a general proper way for the representation of knowledge using visualization techniques.

If somebody tries to illustrate a solution of a complex (for example business) problem, they do not only visualize single elements of a transferred concept based on its attributes, but also the connections and/or interdependencies of these elements. However it is usually not enough for the recipient to understand the logic of the concept (and to accept the proposed solution). What the recipient needs is an explanation of those dependencies in respect to the task or problem to be solved. Why are the selected elements connected to each other in the considered case or in general? How do these visual dependencies help understand the knowledge to be transferred? Why does the knowledge have to be visualized based on a selected concept (motivation)? How is this visualization going to be helpful for the solution investigated and for other applications? Which role do the skills and preferences of both partners play in the particular knowledge transfer and its visualization?

From our point of view knowledge visualization has to answer these questions to be classified as such. Without explaining the meaning and purpose of the connections between the different visual elements, the visualization loses its value. It reduces to something like data or information visualization – visual representation of abstract data. (Card et al., 1999, Chen, 1999, Chen/Geroimenko, 2003). For instance according Card "information visualization is the use of computer-supported, interactive, visual representation of abstract data to amplify cognition" (Card et al., 1999).

Summarizing the features and perspectives mentioned above the following definition of knowledge visualization can be derived:

Definition:
Knowledge visualization is a set of graphical entities used to transfer knowledge from an expert to a person (or group of persons), which clarifies its complexity and explains the meaning and the purpose of the relevant interdependencies.

Firstly, according to the definition above the sender of knowledge can be both: human or artefact, whereas the recipient from today's perspective can be a single person or a group of persons.
Secondly, the visualization should represent a task or problem to be solved (e.g. business workflow process, structure of a business unit with its responsibilities etc.). This way it provides the answer for the question why the knowledge has to be transferred.
In this research we only consider the dependencies of the first order in the visualized structure (see Figure 1). That means we only analyze the connections (uni- or bidirectional) between different but single elements and not between groups of elements or indirect relations (n-way dependencies).
The connections can be considered from two perspectives:
Why this connection? – What is the purpose of this connection? Why does this connection have to be used? Which problems can be solved based on it?
Which particular dependency or influence is used in this connection? – It should explain the connection between two selected knowledge elements. Accordingly the dependency can be interpreted as a specialization for the more general or strategic formulated purpose of the single connection between two knowledge elements.

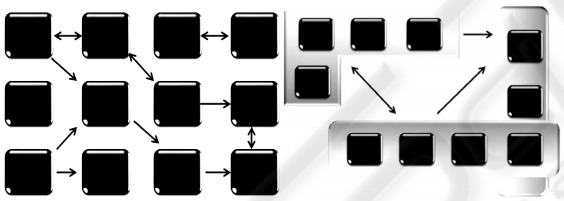

Figure 1: First order and second order dependencies between elements.

According to the previous discussion we can define knowledge visualization formally as

KnowVis = F (E, D, P) where
F is a certain function of
E – a set of knowledge elements (different visual features as tables, charts, nodes of trees, circles etc.)
D – a set of dependencies/influences between knowledge elements
P – a purpose(s) of interdependencies.

From another perspective each dependency can be defined as

$$D = f(e1, e2, s12, s21, p12, p21)$$

Where *e1, e2* are two knowledge elements from E *p12, p21* represent the corresponding purposes *s12, s21* are the strengths of the influence of *e1* on *e2* and vice versa.

One should only concentrate on the most important dependencies between knowledge elements in order to avoid extreme complexity in the visualized structure. Therefore it sounds reasonably that the connections have such attributes as the "strength" of interdependency.

Our concept has something in common with the idea of Novak's concept maps (Novak/Gowin, 1984). Novak defines concept maps as tools for organizing and representing knowledge. They include concepts (enclosed in circles or boxes), and relationships between concepts or propositions. These relations are indicated by a connecting line and a linking word (often a verb).

But the key difference from Novak's to our concept is that each relation in knowledge visualization is provided by the explanation of its purpose. How does this explanation support the whole idea of knowledge transfer?

The choice of visualization technique certainly depends on the type of knowledge transferred and on the recipient's capabilities.

As just mentioned, knowledge visualization should clarify the purpose of the connections between visual entities. This does not mean that the recipient receives only one "right application". The given explanations will contain a description of how the sender would apply this knowledge. Those application suggestions will help the recipient to utilize the best practice by creating his own analogies and associations during his individual decision making. The way in which the obtained knowledge can be applied depends on the effectiveness of the visualization (choice of visual self-describing features, clear dependencies, etc.) and the intellectual (abstract thinking, logical conclusions, experience, etc.) capabilities of the recipient.

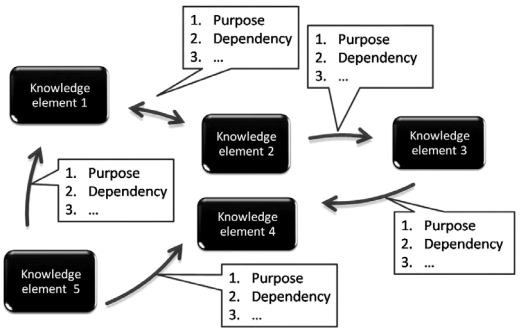

Figure 2: The purpose-driven knowledge visualization metaphor.

An example for purpose-driven knowledge visualizations is presented in Figure 2. The

explanations menus for all connections as shown above can overload the graphic. Therefore they should rather be implemented as context sensitive menu-boxes appearing after a mouse click on the connection to be clarified.

Which advantages can be expected from such visualizations?

Firstly, it is easier for the recipient to understand the knowledge transferred from the sender.

Secondly, this explanation of the dependencies and purposes of the relations will simplify the process of logical and analogical reasoning by the recipient.

5 IMPLEMENTATION

The concept described in this report is currently in realization. The implemented prototype is being investigated in the context of various applications where the knowledge transfer plays an essential role (e.g. different knowledge management systems, e-Learning tools etc.) Its important features are listed below:

- Editor for knowledge elements and n-dimensional connections between them.
- Flexible edition of the facets/attributes of these connections to define the interdependencies between elements.
- Context sensitive visualization of interdependencies within the particular case analyses.
- Activation of the context sensitive pull-down menu with different interdependencies between selected knowledge elements
- Possibilities for generalization as well as for specialization of the solution based on the same concept.

6 CONCLUSIONS

The approach of knowledge visualization described in this paper provides a new basis for knowledge transfer. In contrast to other definitions, in this research knowledge visualization is investigated from the purpose perspective. Following presented purpose-driven approach it is important to extend the usual map of relations between different knowledge elements with explanation of their interdependencies. The implementation of this approach allows context sensitive visualizations of these interdependencies in respect to the purposes of knowledge transfer or tasks under investigation. The clarification of the purposes integrated into the visualization of interdependencies between knowledge elements significantly improves the recipient's understanding and acceptance of the knowledge transferred.

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