

A Proposal to Model Knowledge in Knowledge-Intensive Business Processes

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Abstract: This paper addresses the topic of modeling tacit knowledge across business processes. Some approaches exist to cover that issue but none is really satisfying. Therefore a new approach is proposed, which is based on more than ten years of experience with the Knowledge Modeling and Description Language (KMDL). The new approach suggests to differentiate knowledge in professional insight, experience and context and to describe the degree of ability to articulate and generality.

1 INTRODUCTION

This paper addresses the topic of modeling tacit knowledge across business processes. Some approaches exist to cover that issue but none is really satisfying. Therefore a new approach is proposed, which is based on more than ten years of experience and also overcomes the deficits of existing approaches.

One of the often used definitions of tacit knowledge is based on Davenport's set of criteria that consists of information, professional insight, values, experience and context (Davenport and Prusak, 1998; Gronau, 2012). Conventional approaches for the differentiation of knowledge types like Polanyi (1966) or for the differentiation of the handling of knowledge like the SECI model (Nonaka and Takeuchi, 1995) see tacit knowledge only bound to humans. That might be too narrow in the light of new cyber-physical systems as self-organizing and decision-capable technical entities (Lee et.al, 2014; Gronau, 2015). In the future at least some of the competencies to make decisions will lie with technical actors.

Digitalization, virtualization and the Internet-of-things force great changes in the roles of the employees and the technical actors. Machines and factory units collect data from their environment with the help of sensors, process these data and act in the environment using mechanical actuators. Data will be sent to information systems, which receive, process

and forward them. This is an analogy to the human information processing. Processing includes the use of information following predefined rules and a predefined space of alternative solution paths (Inference), and the creative development of facts and solutions additionally to predefined structures with a not predetermined result (intelligence, cf. Turing, 1950).

Knowledge as a „goal-oriented netting of information“ (Rehauser & Krcmar, 1996) allows that actors to act and to decide. It helps to prepare decisions and is an important component to generate competencies. The netted information contains data with semantics and data with a certain syntax. Human as well as technical actors are able to proceed signs, data information and knowledge with existing technology. Therefore it might be useful to see also the technical entities as potential bearers of knowledge. While value creating processes become more and more interwoven with cyber-physical systems, some of the concepts developed for person-bound knowledge also can be used for a machine's knowledge. Especially the aspects of professional insight in a specific domain and the experience are candidates for a transfer from man to machine. Experience for instance can a machine gain and process by using a case-based-reasoning system.

Another problem occurs when the usage of knowledge in teams is investigated. This kind of knowledge cannot be characterized with the criteria

given by Davenport, because most of these criteria are only suitable for one human.

What makes the difference between subjective knowledge and explicable and more objective knowledge? It is the context, in that the information is announced and it is the value that may be very different for two humans looking at exactly the same piece of information. Therefore the authors of this contribution see information as an extreme occurrence of knowledge. During the process of explication the context was reduced and the value propositions were omitted.

One of the modeling techniques that is able to represent knowledge bound to persons is the Knowledge Modeling and Description Language (KMDL®). Its development started more than ten years from now. In that time a lot of experience was gained, especially in the areas of software development, product development, innovation processes, quality management and other areas (Gronau, 2012). Based on these experiences the authors suggest to differentiate knowledge following the criteria of professional insight, experience and context and to look at generality and ability to articulate for each of these criteria. The following sections describe this proposal in more detail.

2 THE TERM KNOWLEDGE

Stemming from the complexity of the term knowledge the necessity occurs to differentiate in knowledge types and knowledge dimension. The supposedly most often used differentiation discriminates between tacit and explicit knowledge. The tacit dimension was first described by Polanyi and addresses parts of the personal knowledge, which are neither to be scribed nor to be articulated. *„Although the experts (...) can indicate their clues and formulate their maxims, they know many more things than they can tell, knowing them only in practice, as instrumental particulars, and not explicitly, as objects.“* (Polanyi 1958, S. 88)

Tacit knowledge is „personal, context specific and very difficult to communicate“ (Nonaka and Takeuchi 1995, p. 72). Contrarily explicit knowledge can be distributed in a formal and systematic language. Tacit knowledge can be seen as a synonym of embodied and procedural knowledge (Meyer and Sugiyama, 2007, p. 26).

Davenport and Prusak (1998, p. 5) deliver a so-called pragmatic definition of knowledge: *„Knowledge is a fluid mix of framed experience, values, contextual information, and expert insight*

that provides a framework for evaluating and incorporating new experiences and information. It originates and is applied in the minds of knowers.“

Knowledge is seen as very difficult to articulate and also person-bound. It is based on information but cannot be equaled with it. To make the term knowledge more comprehensible, Davenport and Prusak (1998) refer to six key components: experiences, ground truth, complexity, judgment, rules of thumb and intuition, values and beliefs.

Explicit and tacit (some authors use the wrong term of „implicit“) knowledge are defined by pointing out the difference in processing these two knowledge types. Explicit knowledge can be transferred by communication, by numbers, pictures or language. It can be processed, altered and learned together (Willke 2001; Franken and Franken 2011, p. 33).

Lam (2000) has given a description of knowledge that refers not only to qualities but also to the organizational context: The encoded knowledge has an existence independent of persons and can be stored in handbooks, data bases, rules of conduct etc. and can be seen as organizational explicit knowledge (see also Blackler, 1995). The embedded knowledge to the contrary cannot be transferred objectively but is socially constructed, captured in organizational cultures, language systems etc and used and shared by the members of the organization. Different types of knowledge are differentiated in the realm of organizational knowledge:

- encultured knowledge, which is shared by the members of the organization and transferred by socialization (Sackmann, 1991; Kogut and Zander, 1992)
- event knowledge that is concerned to events in the lifetime of the organization (Vlaar et al, 2007)
- procedural knowledge about processes and connections (Fischer, 2008).
- embodied knowledge describes the dimension of individual tacit knowledge. It is bound to persons and can only be created by experience (Polanyi, 1966; Blackler, 1995; Nonaka and Takeuchi, 1995).

Franken and Franken (2011, p. 30) say that knowledge is something immaterial, difficult to describe, but with great influence on human acting. It has to be distinguished between the real world on the one hand and the immaterial world of knowledge on the other hand, which exist in the human brain as a result of experiences and learning, leading to mental patterns. In this way knowledge is developed as an individual construction from the interaction with the real world (Franken and Franken, 2011, p. 31).

Rehauser and Krcmar (1996) denote knowledge as an individually modeled reality, which is generated by the bearer of knowledge under the influence of her own perspective. Knowledge allows to act and the artifacts created during the action cause a change in the real world, induced by the individual person.

Summarizing it can be reasoned that the term “tacit knowledge” encompasses a broad area of different characteristics. This makes its transfer into a model, which is necessary to get a grip on knowledge processes and knowledge conversions, very difficult. In the following sections the deduction of such a model in the context of KMDL is presented.

3 DEDUCTION OF A CONCEPT FOR THE MODELING OF KNOWLEDGE

Starting with the different characteristics of the term tacit knowledge a classification is necessary as a first step. First knowledge can be classified following the definition of Davenport and Pruzak (1998, p. 5). Following them knowledge consists of experience, values, context information and professional insight.

Experiences stem from a practical engagement with a certain topic. Professional insight is the intellectual penetration of an area of content. Values are generated by socialization procedures and are shared conjointly. They are deeply embedded into one’s personality. On the other side context information is the picture of an observation. This observation can relate to an object, a person, a topic of the environment or a self-observation.

Existing approaches that recognize these differentiations and the relations between the components are rare (Hinkelmann et al, 2002; Heisig, 2000; Allweyer, 1998; Gronau and Froeming, 2006). Following the guidelines of proper modeling (Becker et al, 1998) the possibility and usefulness of every component has to be judged. The six requirements are relevancy, correctness, economic feasibility, clearness, comparability and systematic construction.

The question of relevancy was solved by selecting criteria and justify their selection above. The other requirements are combined to judgment criteria.

The requirements correctness and economic feasibility are merged into the criterion ascertainability. Ascertainability states whether components of knowledge can be grasped objectively true and whether this is possible with reasonable effort. A modeling of a component of knowledge is

only possible if this component can be captured by an observer or by self-observation.

The requirements clearness and comparability are combined into the criterion intersubjective comparability. The intersubjective comparability also is important to be able to compare certain model statements and to be able to model the transfer of knowledge.

These components of knowledge can be captured and compared in different degrees of easiness, as seen in Table 1.

Table 1: Judgment of easiness of modeling.

Component	Ascertainability	Intersubjective comparability
Professional insight	++	++
Experience	++	++
Values	o	--
Context	+	+
++ very good, + good, o no statement possible, - bad, -- very bad		

Professional insight, for instance in the shape of formal education, can be captured by certificates or the documentation of training periods. These are also comparable very good, by certificate degrees, age of knowledge etc.

Experience can be captured objectively by documenting core areas of action or by self-judgment. Although distortions are possible, typically the results are mostly correct. Also an intersubjective comparability is given, when durations, frequency or intensity of actions are compared between different knowledge bearers.

Values are very difficult to capture due to their often un-reflected anchoring in the human consciousness and their very subjective character. Also an intersubjective comparison between values is not possible, because it is very difficult to create a hierarchy of values or to compare the value systems of two humans. A pure description of equal or different values is not suitable for the modeling purpose. Another argument is that the dissemination of values in an organization occurs over time and is of long duration, therefore not usable in the context of process-oriented knowledge management. Properties of values that are relevant for decisions can be modeled in the context component.

The context component can be captured in a sufficient manner when the usage environment is described or observed. Although the context can be

compared inter-subjectively, different interpretations or perspectives can occur.

Following those thoughts, values cannot be modeled sufficiently. The remaining components to model knowledge objects are therefore professional insight, experience and context.

Knowledge seldom can be assigned only to one single component. The judgment of the context typically uses experience. Capturing of professional insight is done within a context and the collection of experience only works when professional insight is available. Therefore these components have to be inspected together depicting the knowledge of person, an item or a status.

Beside the differentiation of knowledge components to be able to model the use and the transfer of knowledge more information is necessary. For a more detailed description the knowledge dimensions of Spinner (2002) can be used. He differentiates the shape, expression, content and validity dimensions.

Table 2: Judgment of modeling of knowledge dimensions.

Component	Ascertainability	Intersubjective comparability
Shape	++	++
Expression	+	+
Content	+	--
Validity	-	+
++ very good, + good, o no statement possible, - bad, -- very bad		

The shape dimension indicates the generality of knowledge on a scale between particular and general. The expression dimension depicts the degree of articulation and has the polar characteristics tacit and explicit. The content dimension indicates how much information lies in the knowledge, between nearly and highly informative. The validity dimension shows how much the knowledge is backed by facts or scientific results. This dimension has the polar characteristics of hypothetical and apodictic.

Again the dimensions can be checked with their degree of ascertainability and intersubjective comparability to judge the transfer into knowledge modeling (Table 2).

Following Table 2 we can see that especially the dimensions of shape and expression are suitable to integrate into modeling. The content dimension cannot be compared inter-subjectively, due to different prevalent knowledge and different interest

in the subject. The content dimension is therefore different between two persons and during different points in time. Additionally no judgment of the value propositions of the bearer of knowledge is intended, especially because it is very difficult to measure a value proposition. Nevertheless the authors want to state that the attached value remains an important part of the description of person-bound knowledge.

Further on the validity dimension is difficult to capture on an individual level. Whether some element of knowledge is hypothetical or rock solid cannot be determined in most cases.

The concentration of the two remaining dimensions allow a more detailed description of knowledge. Both dimensions can be applied on the components so that a 2x3 matrix is constructed (Table 3).

Table 3: Characteristics of a knowledge object.

	Professional insight	Experience	Context
Ascertainability	[0,1]	[0,1]	[0,1]
Generality	[0,1]	[0,1]	[0,1]

Professional insight, experience and context are judged referring to generality and ascertainability by the bearer of the knowledge with values from 0 to 1.0 means, there is no expression of this characteristic while 1 means there is a maximal expression of this characteristic. For the dimensions it means as follows:

Ascertainability:

- 0 - not articulable, real tacit knowledge
- 1 - completely articulable

Generality:

- 0 - particular, only useful in a single instance
- 1 - commonly useful

Instead of the suggested numbered scales also other scales are possible, so for instance pure yes-no-depictions or judgments like low - medium - high.

Using these six characteristics, a very detailed differentiation of a knowledge object can be processed. Therefore it is suggested to use this new knowledge object while modeling with KMDL (Figure 1).

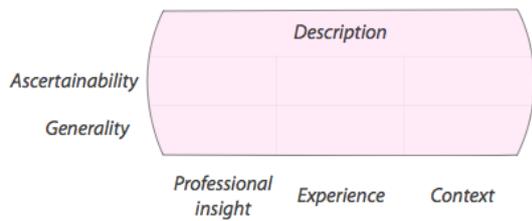


Figure 1: Knowledge object in KMDL.

After introducing the multi-dimensional of knowledge objects a differentiation between knowledge and information objects can be omitted. Therefore in the activity view of MDL only knowledge objects are shown and the information objects move to the process modeling view to assure comparability to other BPM modeling approaches.

An additional advantage lies in the better ability to interpret the conversion of knowledge. This is explained using two examples:

Example 1: ERP usage in chemical industry

An expert of ERP systems in the chemical industry can articulate her knowledge with a degree of ascertainability of 0.85. Under some circumstances she will get her knowledge about that topic from books and journal essays, but not only from practical experience. Therefore she has a great ability to articulate but a quite limited experience.

Example 2: Vegan food

Now the same expert from example 1 shall speak about vegan food. Due to missing personal experiences but because the ascertainability of the expert her knowledge can be assessed, Low values for generality mean that her knowledge is not very useful for others, although she is able to articulate it quite good.

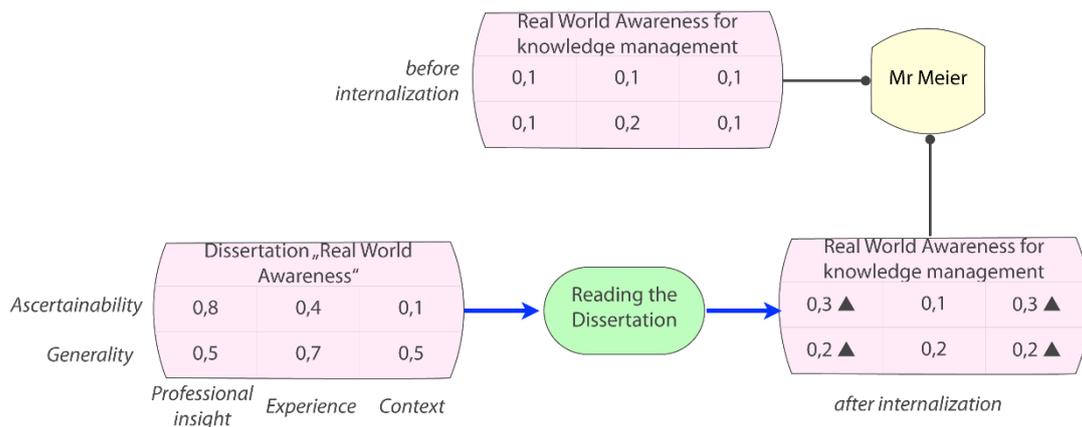


Figure 2: Modeling of internalization of knowledge.

Beside the better representation of the knowledge of certain actors in the process also the knowledge conversions externalization, internalization socialization and combination can be represented better. The modeler has to decide about his point of observation and about the purpose of the modeling beforehand. By comparing the scale expressions of the bearer of the knowledge object before and after the conversion also an increase of knowledge can be measured - clearly a real advantage against other modeling approaches!

In Figure 2 an internalization is depicted using the newly developed knowledge object. Not the transfer of knowledge from the printed dissertation to the knowledge of the bearer is of interest here but the increase of the bearer's knowledge about the topic before and after reading the dissertation. This can be seen that in four of the six characteristics of a knowledge object an increase took place and only two characteristics remain unchanged.

4 CONCLUSIONS

Modeling the occurrence of knowledge is the decisive key to be able to recognize potentials for the improvement of knowledge-intensive business processes. For this purpose a differentiation of knowledge is very important. This paper proposed a framework to capture only these dimensions of knowledge which can truly being captured during modeling.

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REFERENCES

- Allweyer T, 1998. Knowledge Management with ARIS Models. In: Scheer A-W: ARIS - From Business process to the application system (in German), Heidelberg
- Becker J, Rosemann M; Schuette R, 1995. Guidelines of proper modeling (in German). In: *Wirtschaftsinformatik* (37) 5, 435-445.
- Blackler F, 1995. Knowledge, Knowledge Work and Organizations: An Overview and interpretation; in: *Organization Studies*, 16(6),1021-1046.
- Davenport T, Prusak L, 1998. Working knowledge: How organizations manage what they know, Harvard Business School Press, Boston.
- Fischer M, 2008: Organizational learning in Corporations with extreme performance pressure (in German). In: Pawlowsky P; Mistele P (Eds.): High performance management (in German), Wiesbaden: Gabler,111-131
- Franken R, Franken S, 2011. Integrated knowledge and innovation management (in German). Wiesbaden: Gabler.
- Gronau N, 2015. The influence of Cyber-Physical Systems on the creation of production systems (in German). *Industrie Management* 3, 16-20
- Gronau N, Heinze P, Weber E, 2012: Conversion- and Transformation-Oriented View on Knowledge Flows. In: Gronau N (ed): Modeling and Analyzing knowledge intensive business processes with KMDL - Comprehensive insights into theory and practice, Berlin, 249–268.
- Gronau N, Fröming J, 2006: A semi-formal modeling language to describe knowledge conversions (in German). In: *Wirtschaftsinformatik* (48) 349-360.
- Heisig,P, 2002. GPO-WM - Method and tool for process oriented knowledge management (in German). In: Abecker A, Hinkelmann K, Maus H, Mueller HJ(eds.): Process-oriented Knowledge management (in German), Berlin Heidelberg, New York, 47-64.
- Hinkelmann K, Karagiannis D, Telesko R, 2002. PRO-MOTE - Method and tool for process oriented knowledge management (in German). Abecker A, Hinkelmann K, Maus H, Mueller HJ (eds.): Process-oriented Knowledge management (in German), Berlin Heidelberg, New York,
- Kogut B, Zander U, 1992. Knowledge of the Firm: Combi-native Capabilities and the Replication of Technology; in: *Organization Science*, Vol. 3, No. 5 (August), 383-397
- Lam A, 2000. Tacit Knowledge, Organizational Learning, and Societal Institutions: An Integrated Framework. *Organization Studies*, vol. 21 (3), 487-513.
- Lee J, Bagheri B, Kao H-A, 2014. A Cyber Physical Systems Architecture for Industry 4.0-based Manufacturing Systems. *Manuf Lett* 3, 18–23
- Meyer B, Sugiyama K, 2007. The concept of knowledge in KM: a dimensional model", *Journal of Knowledge Management* (11) 1, 17 - 35
- Nonaka I, Takeuchi H, 1995. The knowledge creating company: how Japanese companies create the dynamics of innovation. New York: Oxford University Press, 284
- Polanyi M, 1966. The tacit dimension. Garden City, Doubleday
- Polanyi, M, 1958. Personal Knowledge: Towards a Post-Critical Philosophy. University of Chicago Press, Chicago,IL.
- Rehauser J, Krcmar H, 1996. Knowledge Management in the corporation. In: Schreyoegg G, Conrad P (eds.) *Management research 6: Knowledge Management*. Berlin, 1-40
- Sackmann S, 1991: Uncovering Culture in Organizations; in: *Journal of Applied Behavioral Science*, 27, 295-317
- Spinner HF, 1994. The knowledge order. A guiding concept for the third order of the information age (in German) Opladen
- Turing AM, 1950. Computing machinery and intelligence. *Mind*, 433-460.
- Vlaar P, Van Den Bosch F, Volberda H, 2007. Towards a Dialectic Perspective on Formalization in Interorganizational Relationships: How Alliance Managers Capitalize on the Duality Inherent in Contracts, Rules and Procedures; in: *Organization Studies*, Vol. 28, 437 - 466
- Willke H. 2001. Systemic Knowledge Management (in German). Stuttgart. 2. edition.