A Layered Model for Knowledge Transfer

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***Abstract*— Knowledge transfer is very important to our knowledge-based society and many approaches have been proposed to describe this transfer. However, these approaches take a rather abstract view on knowledge transfer, which makes implementation difficult. In order to address this issue, we introduce a layered model for knowledge transfer that describes the individual steps of knowledge transfer in more detail. This paper gives a description of the process and also an example of the application of the layered model for knowledge transfer.**

Keywords-knowledge transfer; transfer of knowledge; knowledge conversion; impart knowledge.

I. INTRODUCTION

In our knowledge-based society, the relevance of knowledge transfer is increasing. Knowledge management and the understanding of economic coherency can help an organization to handle the challenges of an increasingly fast-evolving environment [1]. The transfer of knowledge from one person to another is of major importance for enterprises [2]. The Socialization, Externalization, Combination, and Internalization (SECI) Model of Nonaka and Takeuchi [3] is an approach that supports organizations in the handling of the important knowledge resource and describes knowledge conversions between internal and external knowledge. However, the SECI Model does not contain precise descriptions of knowledge transfer. This paper aims to introduce a model for knowledge transfer that makes problems emerging during the transfer visible and explainable, and facilitates its implementation through a more detailed and clearer structuring.

This paper is structured as follows: Section II discusses and provides working definitions of data, information and knowledge. Section III discusses existing communications models and Section IV proposes a model of knowledge transfer that aims to reduce errors on each of the knowledge levels. Section V draws conclusions and discusses future directions.

II. DATA, INFORMATION, KNOWLEDGE, CONVERSATION, AND COMMUNICATION

As mentioned by Nonaka [4], the terms information and knowledge are sometimes used interchangeably even though they have different meanings. In her study on the wisdom hierarchy, Rowley [5] pointed out that it is especially important to define the concepts of data, information, and knowledge. Since this paper focuses on the transfer of knowledge, the following section presents definitions to distinguish the terms data, information and knowledge. Having examined various definitions the authors will present their own definitions, which are based on some of the previously introduced ones.

A. Data

Hasler Roumois [6] stated that data consist of symbols that are combined into words by using syntax. The words receive a semantic meaning when they are associated to things. Davenport and Prusak [7] describe data as the raw material for information without an intrinsic meaning. A data set can contain facts about an event or thing. This is also the view of Wormell cited in Boisot and Canals [8] that data are alphabetic or numeric signs that without context do not have any meaning. Rainer [9] characterized data items as "*an elementary description of things, events, activities, and transactions that are recorded, classified, and stored but are not organized to convey any specific meaning*." Ackoff [10] viewed data as "*symbols that represent properties of objects, events and their environment. They are products of observation*." Frické [11] criticized the opinion of those who say that data have to be true, which means that the statement of the data must be true. The following example confirms Frické's criticism: consider a data set containing incorrect or imprecise data, then according to the others this data would not be considered data. Weggeman [12] differentiates between hard and soft data. If the measuring technique and the measurement that created the data are unequivocal, Weggeman describes it as hard data, otherwise the data are softer. Weggeman's classification requires, however, knowledge about the data and the things they represent which is beyond the scope of data, instead part of the scope of information.

1) Definition: data

Data consist of symbols that are combined into words by using syntax. Data are produced by humans or machines. They can be the result of observations of the real world, descriptions of abstract things, or the result of processing existing data. Data cannot be true or false since this decision is beyond the scope of data.

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B. Information

In the definition of information, there are two fundamentally different theories. The more technical approach characterizes information as data where context has been added [13]. In the more philosophical approach it depends on the receiver whether something is information or only data. Hasler Roumois [6] stated that when people recognize the meaning of data and consider their relevance they become information. Similarly, Davis and Olson [14] view information as data that has been processed into a form that is meaningful to the recipient. Dretske [15] noted about information: "*Roughly speaking, information is that commodity capable of yielding knowledge, and what information a signal carries is what we can learn from it. If everything I say to you is false, then I have given you no information*". However, the recipient of the message may receive the meta information that the other person is lying, Dretske stated. Weggeman [12] provides the example that an author will look at his book as information whereas others may consider it initially as a collection of data. It is up to the receiver to consider whether the data are relevant or not. Weggeman argues that data becomes information even if it is irrelevant to the recipient, because the assessment is a form of recognition that leads to information. As stated in the example from Dretske, the recipient may receive meta information. For this analysis the receiver had to compare the message with his personal knowledge base. If he already knew the content, this may lead to reinforcement by the additional confirmation through the message. Therefore, the authors agree with Dretske that the receiver may achieve meta information, but in this case the data does not become information. Rainer and Cegielski [9] described information as organized data that have meaning and value to a recipient.

1) Definition: information

Data becomes information when a person receives data, decodes them, recognizes the meaning and considers them relevant. If the data do not contain anything new for the receiver, the data do not become information. However, they may result in meta information, such as confirmation of the known.

C. Knowledge

For the processing of information the existing knowledge is of crucial importance. Wormell, cited in Boisot and Canals [8], believes knowledge is enriched information by a person's or a system's own experience; it is cognitive based; it is not transferable, but through information we can communicate about it. Dretske represents the relation of information and knowledge as follows: "*Knowledge is identified with information-produced (or sustained) belief, but the information a person receives is relative to what he or she already knows about the possibilities at the source*" [15]. About knowledge Polanyi [16] said: "*I shall reconsider human knowledge from the fact that we can know more than we can tell*". Thus he shows that knowledge has a secret or tacit part and not everything a person knows can be passed. Polanyi describes explicit knowledge, which in turn can be expressed in formal, semantic language, and tacit knowledge, which is personalized and therefore hard to express [17]. According to Nonaka [18] explicit knowledge is knowledge that can be articulated into formal language, such as words, mathematical expressions, specifications and computer programmes, and can be readily transmitted to others. This is in contrast to tacit knowledge, which is personalised and based upon experience, context and the actions of an individual; tacit knowledge resides in individuals who may be unaware that they possess such knowledge. There is also implicit knowledge, which refers to knowledge that is revealed in task performance without any corresponding phenomenal awareness; implicit knowledge is often expressed unintentionally. This characteristic is described as type dimension of knowledge [19]. For this article, the explicit type of knowledge represents the most important knowledge type, because it is the knowledge that can be easily externalized. Weggeman [12] firmly believes that information and knowledge only exist inside the person whereas data can exist outside a person. Davenport and Prusak [7] describe knowledge as bound to a person: "*It [knowledge] originates and is applied in the mind of the knowers*." The transformation from information to knowledge takes place when the information is linked to the existing knowledge through a thinking process [6]. The authors propose the term knowledge base as the collection of all facts, rules, and values which are represented in the brain of a person. Spitzer [20] depicts that through the learning process links are created or dissolved in the brain, which results in changes of the knowledge base. Spitzer [20] points out that messages, which have the quality of relevance and novelty, can be memorized easily.

1) Definition: knowledge

Information becomes knowledge if a thinking process occurs in which the information is linked to the existing knowledge and is stored persistently. The quality of information being relevant and new, insofar as there is a difference to the existing knowledge, encourages the permanent memorization of information. Based on the input by the information, the knowledge base of the person may be extended or restructured.

D. Knowledge Conversion

Nonaka and Takeuchi [3] described the conversation of knowledge in their SECI Model. For this work externalization and internalization of knowledge are of particular importance. Nonaka and Takeuchi describe the internalization as conversion from explicit to tacit knowledge and the externalization as conversion from tacit to explicit knowledge. The authors use the concepts of externalization and internalization with respect to the conversion of data to knowledge and vice versa. Externalization enables a person to converse parts of the personal knowledge base, making them accessible to others. For example, if someone writes down what he knows, everyone except him will refer to this as data. Internalization will happen when a reader receives new knowledge by reading and learning from it.

Transfer and persistent storage require an externalization of knowledge in a recognized and structured language. The various levels of messages are related to levels of semiotics, which are syntactic, semantic and pragmatic. Krcmar [21]

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states that syntax declares the rules according to which characters can be combined to words and which can be combined to sentences. The relation between words and objects represented by the words as the relationship between characters is denoted by semantics. The intention of a person sending words as a message is explained as pragmatic.

E. Communication

The protagonist of systems theory, Luhmann [22], explained communication as a process consisting of three steps of selection. In the first step, the sender decides which information he wants to pass on. In the second step, he selects a single message from many possible messages. In the last step, the recipient selects the information out of the message thereby completing the communication. Based on Luhmann's work, Berghaus [23] describes several results, which can occur if a sender is forwarding a message to a receiver.

- Case 1: The receiver picks up the message and interprets it in the desired way.
- Case 2: The receiver picks up the message but interprets it differently.
- Case 3: The receiver does not recognize the message as a message.

Only one of the three cases achieves the desired result. In this paper the second case and the various reasons for the error in communication will be considered in more detail. The third case plays a minor role as it is assumed that the message is detected as a message because only the messages presented as data are considered.

III. Related Work: Communication Models

A. Schema of Social Communication

Figure 1 shows Aufermann's [24] model for social communication in which two parties are involved. The sender encodes the statement he intends to submit in a message. Therefore, he uses his own character set to encode the message. The message is sent via a medium to the recipient whereby spatial and temporal distance is overcome. When receiving the message the recipient will use his own character set for the decoding of the message.

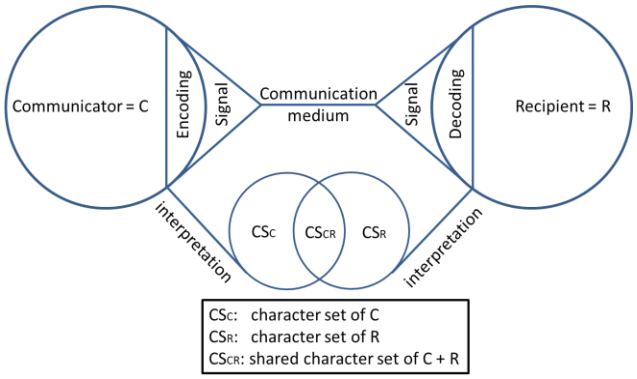

Figure 1. Schema of Social Communication [24] (German)

The model illustrates the important point of the character sets used by sender and recipient and the need to use only those characters that are within the shared character set.

B. A Mathematical Theory of Communication

In Shannon's description of the operation of a communication system, the sender is named "information source" and the receiver is called "destination" [25]. Shannon has investigated the frequency of characters contained in a message, and compared the expected and the actual occurrence of a character. Using the 'entropy' Shannon invented a key figure to measure the information contained in a message. Due to the technical use of the model, specifically the control of missiles, the emphasis is on the transmission of the signal [26]. In addition to Aufermann's schema of social communication, Shannon's model describes the influence of the transmission of a signal by a noise source.

C. Four Forms of Knowledge Conversion

The SECI Model, developed by Nonaka and Takeuchi [3] is focused on the knowledge conversions during knowledge transfer. The description of four conversions takes place at an abstract level showing the particularities of each conversion. However, a detailed description of the individual conversions is missing. Nonaka and Takeuchi describe socialization as a direct knowledge transfer from the tacit knowledge of one person to the tacit knowledge of another person, enabled by action and observation. However, this abstract view does not show exactly how knowledge is transferred in this case. A situation in which socialization happens may arise when master and apprentice work together. Even though the master does not express his knowledge intentionally he externalizes it through his action. Based on the perceived action and the results of action, the apprentice will unconsciously obtain knowledge by internalization.

D. A Hierarchical Modelling Approach to Intellectual Capital Development

Ammann [19] describes knowledge conversions from one person to another, in which the different types of knowledge are taken into account. In addition to the knowledge conversions described in the SECI Model the conversion from latent or conscious knowledge to explicit knowledge is described. Even though Ammann's approach represents knowledge transfer in greater detail, this approach does not give a precise description of how the transmission works.

IV. Model of Knowledge Transfer

A message is a possible way to impart knowledge. The correct interpretation of the message may be prevented by interferences that can affect the message. As described by Shannon the disruption may be caused by a noise source disturbing the medium transmitting the message. In addition to the interferences from the outside that may influence the transport medium, the personal knowledge base of the sender and the receiver may also affect the transfer. The influence

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of the transfer through the personal knowledge of sender and receiver can take place in four layers. The interpretation of the message depends on the elements that are used and whether they are part of the knowledge base of the receiver and equivalent to the elements of the sender's knowledge base.

A. *Layers that Influence the Transfer*

The four layers that influence the transfer of a message from one person to another are code, syntactic, semantic and pragmatic layer. The concept of a knowledge transfer through different layers was influenced by the OSI Reference Model [27]. Figure 2 illustrates the transfer of a message from the sender to the receiver passing through the four layers.

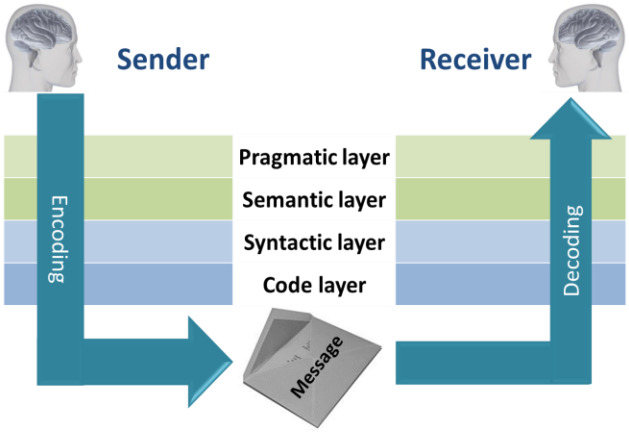

Figure 2. Knowledge Transfer through four layers

1) *Code Layer*

At the lowest level of the layer for transfer is the code. The code consists of symbols or signs that represent the smallest unit, which forms the basis of the higher layers. In the case of written language, which is the focus here, the smallest elements are the characters, σ, taken from an alphabet Σ. In the case of spoken language it would be phonemes, or in sign language gestures.

2) *Syntactic Layer*

The second layer is constituted by the syntax that contains rules for the combination of signs or symbols. In written language, L, the characters σ are combined to form words ω by the use of production rules P.

3) *Semantic Layer*

The third layer contains the semantics that establish the relation between words ω and meaning m. This relation, called semantics s(ω, m), connects the word to its meaning, which can be a real world entity or an abstract thing.

4) *Pragmatic Layer*

The top layer is the pragmatic layer. Pragmatics p(s, c) connects the term represented in semantics with a concept c. The concept contains the course of action and the aims and moral concepts that are represented in the human brain. They influence the thinking and acting of the sender.

B. *Process of a Knowledge Transfer via Messages*

The premise of the following example is the desire of a person, called sender, to communicate something to another person, called receiver. Even if the model is general, the focus is on the written notification.

1) *Sender: Pragmatic Layer*

The core of the message is represented in the pragmatic layer. The aims and moral concepts of the sender do not only affect the externalization of the message, but also the assumptions he makes about the receiver.

2) *Sender: Semantic Layer*

This layer contains all words ω and their relation to the objects. The sender must choose appropriate words that are available in his personal knowledge base. Appropriate means, not only the term which fits best, but also which refer to the knowledge of the recipient.

3) *Sender: Syntactic Layer*

This layer contains the rules P according to which the sentences and terms are made. The words ω chosen to carry the meaning are wrapped in sentences.

4) *Sender: Code Layer*

To transfer the message as written communication the sender has to write the words ω by using characters σ that are part of an alphabet Σ of a language.

5) *Transfer: Message*

The communication medium (e.g. letter, email) transmits the data from the sender to the receiver.

6) *Receiver: Code Layer*

The receiver will view the message and read the characters σ, if he knows them. In the case where the message contains characters from an alphabet unknown to the receiver, the transfer might be disrupted. With only small deviations of the used characters a reconstruction might be possible, otherwise it can lead to misinterpretation or stop the decryption.

7) *Receiver: Syntactic Layer*

The receiver will compose the characters σ to words ω and sentences if they are part of a language L he knows. As in the decoding of the code small difference can be compensated under favourable circumstances, otherwise misinterpretation or stopping the decryption are the consequences.

8) *Receiver: Semantic Layer*

Almost simultaneously with the combination of words and sentences the receiver will put the terms in relation to the things for which they stand. The more the receiver knows the context and the sender of the message, the easier it is to capture the meaning of the text.

9) *Receiver: Pragmatic Layer*

In a final step the receiver will interpret the message in relation to his own aims and values. The things the receiver knows about the sender as well as the assumptions regarding the receiver that are influenced by the sender's own values and aims, play an important role in the decoding of the message.

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C. Influence of Overlapping Knowledge

Knowledge about the receiver is an important requirement for a successful and lossless transfer of a message. The better the sender knows the receiver, the easier he can encode the message. A proper encoding of the message can be done by using elements that exist identically in the personal knowledge base of the sender as well as in the personal knowledge base of the receiver. If the receiver is unknown, only assumptions can be made to support the selection. The other way around it is easier for the receiver to decode the message if he knows the sender of the message very well. Figure 3 visualizes the overlapping of the knowledge in different layers.

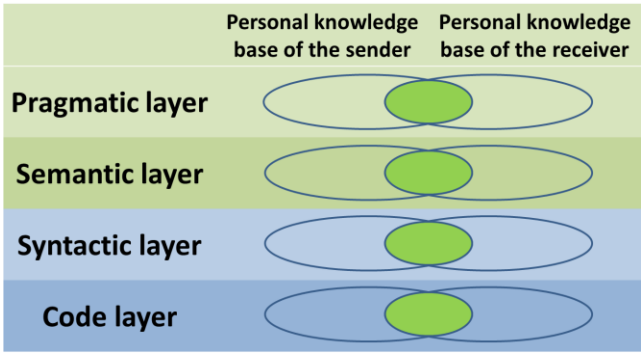

Figure 3. Overlapping Knowledge

D. Example of Knowledge Transfer

A challenge in knowledge transfer is the different knowledge base of sender and receiver. In companies, this situation may occur when a business analyst explains a modelled process to a technician in a department. The business analyst, an expert in business process modelling (BPM), will interview the employees of the department to review the department's processes. During the interview he will make notes and sketches, which he subsequently transfers to business process models.

The business analyst will show and explain the modelled processes to the departmental employees to check that everything has been modelled properly so that model and practised processes are consistent. When explaining the model to the technician, the business analyst must take into account that the technician might not have (sufficient) knowledge of a business process modelling language. We assume that the business analyst and the technician speak the same language and have had similar schooling. Consequently, symbols that exist in their knowledge base are nearly equal although the business analyst might know additional symbols such as those used in the business process modelling languages. This consensus also occurs in the syntactical layer, which contains rules to build words, and the semantic layer, where things are represented through words. The largest differences in the knowledge base are probably found in the pragmatic layer. The basic concepts of aim and moral, that are shaped by education, culture, and environment, may be similar for both. However, the business analyst might have a larger knowledge base in the respective aims and concepts of BPM, while the technician might have a larger knowledge base in the respective aims, processes, and concepts of his special field.

The business analyst, after seeing that the technician has not mastered a business process modelling language, will avoid using terms and concepts unknown to the technician. When explaining the model, the business analyst will introduce the necessary symbols, terms, and concepts to explain the process. He can try to use simple explanations and he can bring in additional information that facilitates the interpretation of the message. The interpretation of the symbols is dependent on the knowledge base of the interpreting person. The interpretation can be facilitated by restrictions; in this example, the terms used for the process are terms from the domain of the department as well as from BPM. The context the terms are used in thereby facilitates the correct interpretation of the process.

V. Conclusion and Future Directions

Knowledge transfer is affected by many different parameters. Because of the relevance of knowledge transfer, it is important to understand the impact of the different parameters. The sociologists Luhmann and Aufermann deal with communication aspects but they neglect the issue of implementation. Shannon's model focuses on the technical implementation but is restricted to the layers of code and syntax. The model of Nonaka and Takeuchi deals with organizational knowledge and knowledge conversion, but the practical transmission is not considered in detail. Ammann describes knowledge conversions in more detail. However, this model is still too abstract to facilitate implementation. The approach presented in this paper addresses these issues by introducing a model with different layers. The intention behind introducing the layers is to reduce errors on each of the knowledge levels. Thus the process of knowledge transfer is divided into several steps, which can be examined separately. This makes it easier to detect and identify errors and facilitates the prevention of misinterpretation.

The model is to be used for knowledge transfer in the area of business processes. The important knowledge of a company, describing the procedures for the production of products and services, is incorporated in business processes. Due to the fact that business processes represent important corporate knowledge they are an interesting area of application. With respect to the description of the various levels of the model, an appropriate representation will be used. The application of the model on business processes aims to reduce errors both in modelling and analysing business processes.

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