Applying a Layered Model for Knowledge Transfer to Business Process Modelling (BPM)

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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 structures 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. The example is located in the area of business process modelling. Business processes contain the important knowledge describing the procedures of the company to produce products and services. Knowledge transfer is the fundamental basis in the modelling and usage of business processes, which makes it an interesting use case for the layered model for knowledge transfer.**

Keywords-knowledge transfer; knowledge conversion; impart knowledge; business process modelling.

I. Introduction

This paper presents an approach that describes the transfer of knowledge. It extends the original paper "A Layered Model for Knowledge Transfer" [1] with an example in the area of business process modelling. The application in the area of business process modelling pursues two goals. First, the example intends to make the mode of operation of the layered model for knowledge transfer apparent. Second, the application in the area of business process modelling is to show how the layered model can be used in solving real problems in modelling of business processes.

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 [2]. The transfer of knowledge from one person to another is of major importance for enterprises [3]. The Socialization, Externalization, Combination, and Internalization (SECI) Model of Nonaka and Takeuchi [4] 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 describes an application of the layered model for knowledge transfer in the area of business processes. Section VI draws conclusions and discusses future directions.

II. Data, Information, Knowledge, Conversation, and Communication

As mentioned by Nonaka [5], the terms information and knowledge are sometimes used interchangeably even though they have different meanings. In her study on the wisdom hierarchy, Rowley [6] 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 [7] 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 [8] 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 [9] that data are alphabetic or numeric signs that without context do not have any meaning. Rainer [10] 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 [11] viewed data as "*symbols that represent properties of objects, events and their environment. They are products of observation*." Frické [12] 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 [13] differentiates between hard and soft data. If the measuring technique and the measurement that created the data are unequivocal, Weggeman describes them 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.

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 [14]. In the more philosophical approach it depends on the receiver whether something is information or only data. Hasler Roumois [7] stated that when people recognize the meaning of data and consider their relevance they become information. Similarly, Davis and Olson [15] view information as data that has been processed into a form that is meaningful to the recipient. Dretske [16] 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 [13] 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 [10] 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 [9], 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*" [16]. About knowledge Polanyi [17] 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 [18]. According to Nonaka [19] 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 [20]. 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 [13] firmly believes that information and knowledge only exist inside the person whereas data can exist outside a person. Davenport and Prusak [8] 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 [7]. The authors propose the term knowledge base as the collection of all facts, rules, and values that are represented in the brain of a person. Spitzer [21] depicts that through the learning process links are created or dissolved in the brain, which results in changes of the knowledge base. Spitzer [21] 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 [4] 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 [22] states that syntax declares the rules according to which characters can be combined to words and these 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 [23], 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 [24] 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 [25] 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.

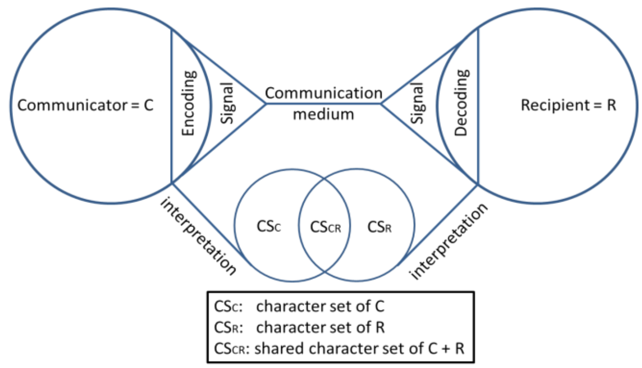

Figure 1. Schema of Social Communication [25] (German)

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" [26]. 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 [27]. 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 [4] 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 [20] 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 knowledge transfer. The influence 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 [28]. Figure 2 illustrates the transfer of a message from the sender to the receiver passing through the four layers.

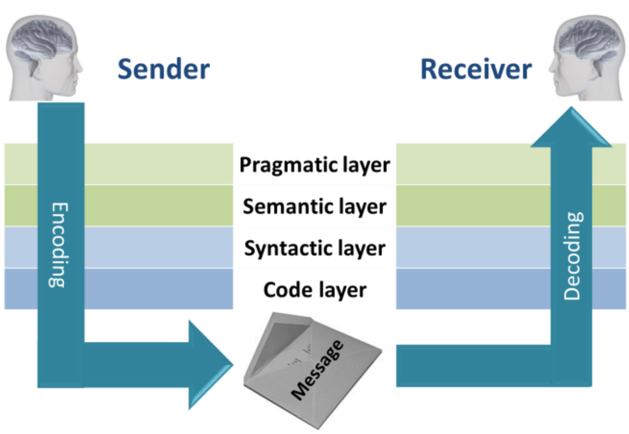

Figure 2. Knowledge Transfer through four layers

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 units, which form 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 semantic term s 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 sender and receiver.

B. Process of a Knowledge Transfer via Messages

The aim 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 that fits best, but also that refers 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. Again, the sender must choose the words in compliance with the words known by the recipient.

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 differences 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.

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.

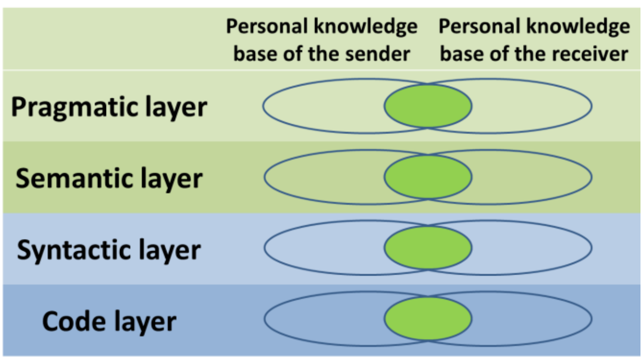

Figure 3. Overlapping Knowledge

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.

E. Supporting the transfer of the message

The prevention of transmission errors as well as misinterpretation of the message is crucial for the knowledge transfer. The dissemination of knowledge in the form of written language uses characters to form the message. The message shall not only contain plain text but also data types. Data types are object descriptions, which define and cluster objects of the same kind. This implies that all objects of a type have the same value range and usability. This supports the accurate decoding of the message, because the knowledge about the data type restricts the room for interpretation. Prerequisite for the use of data types is that sender and receiver know the data types used in the message. Through the use of data types the message can be mapped corresponding to the layers of the model. Although the message can contain only data, a part of the logic necessary to extract the meaning, can be embedded by the use of data types.

V. Application in Business Process Modelling

We apply the model 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 this fact they are an interesting area of application. Furthermore, the modelling of business processes normally requires bidirectional communication. An exemplary application of the layered model for knowledge transfer is presented using the example of a business process for the procurement of goods. The business process for procurements is a process that is used in almost every producing company usually with small company-specific adjustments. Event-driven Process Chain (EPC) diagrams will provide a basis for the graphical representation of the business process.

A. *Event-driven Process Chains*

The EPC diagram was invented by Scheer [29] and consists of events and functions interconnected by a control flow. Functions are rectangular symbols that represent a performance to achieve a desired result. Events are hexangular symbols that represent a situation that triggers a function and they are used to represent the result of a function. The control flow can be split and merged by the use of a logical connector such as AND, OR, and XOR [30].

Another basic symbol used in the EPC is the role showing who is performing a function. If further symbols, standard or company-specific, are added to the EPC it becomes an enhanced Event-driven Process Chain (eEPC). Common used symbols are resources such as system, data base, and document, which can be connected to functions by an information flow indicating the input or output of a function. EPC is a semi-formal modelling language especially for the functional representation of business processes. EPCs are widespread, at least in Germany and supported by various tools [31].

B. *Process: Procurement of Goods*

Figure 4 shows the business process for the procurement of goods modelled as an EPC diagram. The process starts when the event “goods required” occurs. The event can be activated by a material requirement planning in an enterprise system such as SAP as well as by a manual requirement planning carried out by a human. The first activity of the business process is the function “perform order” where an order is created for the purpose of covering the demand. This process step, undertaken by a procurement manager, results in an order with an order number including all relevant details. At this point the process splits and is waiting until the events “goods arrive” and “bill arrives” occur. The AND symbol splitting the process is a logical AND which illustrates that both following events will occur. An important rule for modelling processes states that the logical connector that splits the process must also be used for merging.

Once the goods arrive a logistic employee will accept the goods and check the delivery in compliance with the order number. The result of the goods received is that the inventory of goods is increased by exactly the number of delivered goods. The invoice checking runs in parallel as soon as the bill arrives and triggers the event “bill arrives”. Following this event the “invoice checking” is performed by a financial accountant. Here, the data of the invoice are matched with the expected data, which are based on the order. The data of the invoice are entered into the system. Here the process is merged again visualized by a logical AND symbol. When used for merging the process the AND requires all inputs to be true until the process can continue. As soon as both parallel process flows are completed a financial accountant performs the payment. Result of this function “perform payment” is that the supplier obtains the money and the company’s bank account is decreased by the same amount. The process is completed by this cash transfer and ends with the event “order completed”.

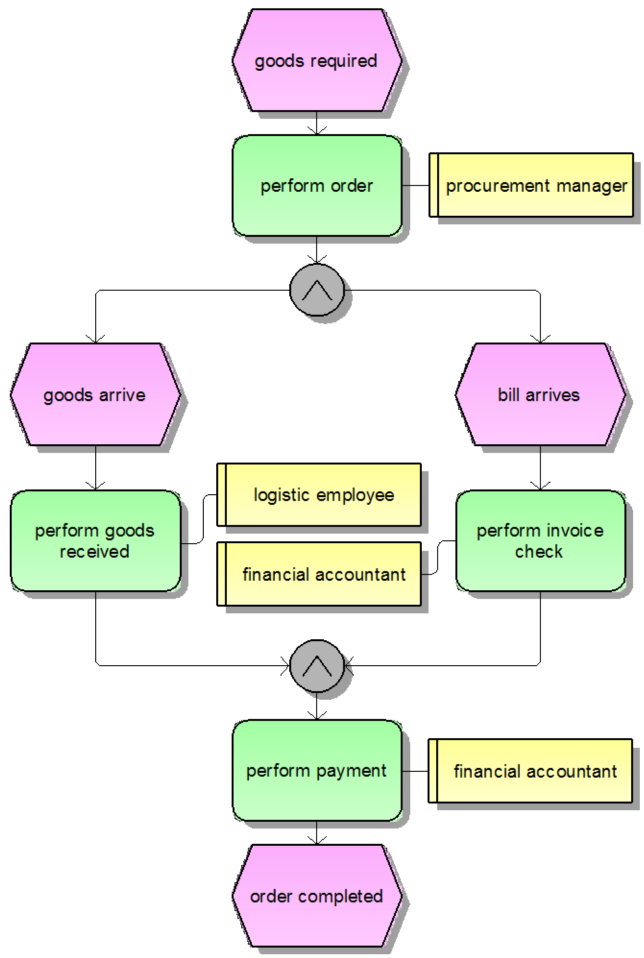

Figure 4. Procurement of Goods

C. *Fragmentation of the process*

The process shown in Figure 4 provides an insight into the operational sequence. Due to the simple graphical representation in EPC it is easy to understand and therefore suitable for discussions with department specialists. However, the limited amount of symbols restricts the accuracy of the representation. While the sequence with the splits and merges is precisely described by the control flow and its logical operators, details of functions and events are expressed by comments or, if supported by the tool, by additional attributes.

When we consider the modelling language EPC with respect to the layered model for knowledge transfer we can derive the following statements. The code layer contains the symbols used in the EPC diagram as well as the language in which the process is modelled. The syntactic layer contains the rules for the EPC diagram and the rules of the natural language. The semantic layer contains the connection between the words or symbols and its meaning. Because of the simple representation the precise representation depends mainly on the wording. More precise descriptions are almost impossible as the annotation of the used words is not possible. The pragmatic layer is almost not affected by the EPC. Exceptions may be additional symbols, e.g., a symbol representing the output of a process. However, the pragmatic is affected by the natural language used to describe the process and the knowledge base of the person modelling the process and the person who reads it.

The simple notation of EPC leads to a lack of precision in the semantic and pragmatic layer of the knowledge transfer. To achieve the goal of a better and ideally lossless communication in the area of business processes the descriptions concerning the semantic and pragmatic layer need to be enhanced. To achieve a better representation on the semantic and pragmatic layers the authors have decided to use frames. Every function and event in the business process will be represented as a frame.

According to Sowa [32] the frames specified by Minsky [33] are a more precise and implementable representation of the schemata. The schemata were first mentioned by Aristotle to categorize the elements of his logical arguments. Sowa [32] stated that Kant and Bartlett advanced Aristotle's schema but their definition remained too immaterial. Minsky defined a frame as a data structure to represent a consistent situation. The frame can be complemented with attributes to describe the application of the frame, the following action, or alternative actions. Minsky [33] characterizes the frame "*as a network of nodes and relations*". Minsky pointed out, that a frame has several layers and the top levels represent the true characteristics of the frame. Lower levels contain terminals that store specific data about the instance. Those instances often constitute sub- frames. With the frames Minsky intends to create an approach that imitates the human thinking in the aspect of creating pattern and apply them to new situations. He points out that a new frame often is an imperfect representation, which is gradually refined. This is facilitated by a loose coupling that enables replacement of assignments to slots.

The application of frames intends to enhance a function with a precise description. Frames allow describing a situation and changes of this situation. When used for functions the frame enables a precise description of the performance and thereby a representation of the pragmatic layer. Frames provide the opportunity to create nested structures, which allows an efficiently representation of complex situations. The inputs and outputs of functions and events, represented as frames, are described in a formal way. This aims to verify interfaces and make suggestions for modelling based on the interface verification. In addition, the semantic description should help to clarify the properties of the input and output objects. The objects describing the application of a function and the objects that represent the inputs and outputs of the function can be represented as frames too. According to Minsky they are called terminals and constitute "slots" where the data are saved. Based on the usage of the word "terminal" in computer science for an entity that cannot be further broken down, the authors will refer to the terminals of the frame as slots. Each slot can contain an object describing the characteristics of the function or an object representing an input or output of a function. Each of these objects needs to be further broken down until the costs for the break down is higher than the gained benefit. When a further break down is not possible or not reasonable anymore the object has reached the state of a terminal symbol.

D. *Complement the Process*

The procurement process shown in Figure 4 is composed of symbols. The symbols can be divided into function, event and logical operators. So far the features that distinguish the different types of symbols are name, shape and colour. To meet the requirements and to improve the matching of the process model with the different layers of the layered model for knowledge transfer, every function and event must be represented as a frame. The top level of such a frame contains the following slots: The frame has a name and a unique identifier (ID). The slot symbolType allows a distinction between events and functions. Both contain slots to capture all the inputs and outputs. The inputs contain everything that must be available before the corresponding object can operate. The results contain the outcome of the corresponding object. In addition to this, functions can contain slots that enclose objects describing the application of the corresponding function. Events have a slot for description instead of the one for application. Every object in the slot of a symbol can be a sub-frame itself. Thus, any level of description accuracy can be achieved.

The possibility to increase the detail depth arbitrarily is very important when applied to business process modelling. Business processes can be modelled in different levels of detail. Usually an organization decides how many levels are available for modelling and categorizing the processes.

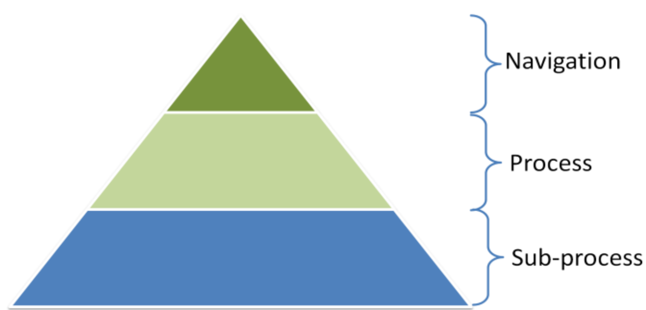

Figure 5. Process hierarchy [34]

Figure 5 displays an illustrative process hierarchy. According to Schmelzer and Sesselmann [31] the highest level constitutes a process landscape that contains the main processes with a high degree of abstraction. The upper levels in the process hierarchy aim to provide a navigation through the organizations processes. The levels below contain the business processes where sequence and execution of actions are described. A further detailing of business processes leads to the level of sub-processes. On this level the course of action is described for the sub-processes.

The need for different levels of abstraction is also highlighted by Kramer and Roovers in Scheer [34]. They argue that the need is caused by different requirements within the organization. Managers require a broad view to govern the processes and employees ask for guidance through the processes. If all these different views are implemented in a process environment the complexity requires filters to prevent an excessive demand caused by too many process models.

E. Specification of a Function

The navigation hierarchy is often put into practice by using value-added chain diagrams. However, for this paper the focus is on EPC and thus the lower levels of the hierarchy. The process shown in Figure 4, described as an EPC diagram, can be classified in the process layer of the process hierarchy. When describing the application of a function with inputs/outputs the next deeper level of the process hierarchy becomes visible. While normally this is accomplished by a drill down, in our model the refinement is done by representing the symbol as a frame. Figure 6 shows a frame structure for the representation of a function.

Frame name		
Slot	**Type**	**ValueType**
Slot1	<int>	ID
Slot2	<string>	name
Slot3	<symbol>	symbolType
Slot4	Dictionary<key, DB>	storages
Slot5	Dictionary<key, object>	input
Slot6	Dictionary<key, object>	application
Slot7	Dictionary<key, object>	output
Slot8	Dictionary<key, DB(object)>	outputStorage

Figure 6. Frame Structure

The frame name will contain the name of the function as shown in the EPC diagram. In order to represent a symbol in a modelling tool it is necessary to provide a unique name, in our example the ID as an integer. The name of the function is stored in another slot as string. All relevant inputs assigned to the functions are stored in a dictionary. Every object can be added to the dictionary as a pair of values, one contains a key the other the object itself. The use of keys enables a fast retrieval of objects stored in a dictionary. Moreover, dictionaries are very flexible, so it is not necessary to know the exact number of objects that the dictionary should contain. The description of the function, which describes the use and application of the function and the outputs, are also stored in a dictionary. The description objects used in the slots can be sub-frames or terminals. In Figure 6, the description objects, represented in the rows, are described by the "ValueType".

1) Caching

A deeper look at the representation of inputs and outputs in functions and events highlights another issue. When the inputs and outputs of every function and event are described, the amount of necessary inputs and outputs increases rapidly. This is caused by passing on the input / output objects, even if they have no influence on the current process step. This passing on might be necessary if an process step on the end of the process requires an input that is not used by the preceding process steps but which is available from the beginning. Referred to our example process this might be account information, which are recorded in another process but used to perform the payment. This passing on of inputs and outputs has a negative effect on the reusability of the functions.

To solve this problem the authors suggest using storage, as it is also used in the eEPC diagram, to cache the object and reuse it in another process step. Such storage could be a data base system, in a less automated landscape a manual storage such as an address book or a conceptual storage.

2) Application to the Event Perform Order

In the following the business process "Procurement of Goods" will be enhanced by using frames to refine the description of functions and events. The process starts with the event "goods required" shown in Figure 7. This event contains a human readable description and the output: "RequirementQuantityGoods". This output is a sub-frame that contains a 'requirement' for a 'quantity' of 'goods'. The output of the event "goods required" is also the input for the first function "perform order". Figure 8 shows the function "perform order" represented as a frame.

Goods Required		
Slot	**ValueType**	**Value**
Slot1	ID	1
Slot2	name	"goods required"
Slot3	symbolType	event
Slot4	input	
Slot5	Description	"This event occurs when the demand for goods is greater than the available quantity"
Slot6	output	1, RequirementQuantityGoods

Figure 7. Frame: Goods Required

Perform Order		
Slot	**ValueType**	**Value**
Slot1	ID	2
Slot2	name	"perform order"
Slot3	symbolType	function
Slot4	storages	1, SAP_6
Slot5	input	1, RequirementQuantityGoods; 2, SupplierPriceGoods
Slot6	application	1, CreateOrder
Slot7	output	1, OrderNumber
Slot8	outputStorage	1, SAP_6(OrderNumber)

Figure 8. Frame: Perform Order

As shown by the figure above, the function has another input, which is required for the application. However, the input "SupplierPriceGoods" is not an output of the previous event. This second input is a sub-frame that contains a 'supplier' and a 'price' for the 'goods'. If this input cannot be delivered by the previous function there must be another way to supply it to the function. At this point, the storage is used.

Data that are used by many processes of a company are commonly stored in a central storage. For our example process this storage is an enterprise resource planning (ERP) system, the SAP ERP system (SAP_6). Enabled by the connection to this storage, mapped in slot 4 of the frame, the function can search for the required data and use them if available. To make this perfectly clear, the connection described here is not a connection to the real SAP server in the company. It is, however, a representation of the real storage and the data that are stored there.

Order		
Slot	**ValueType**	**Value**
Slot1	ID	201
Slot2	order number	000213736
Slot3	description	"An order is a legally binding request for goods to a supplier and contains a unique order number. "
Slot4	necessary elements	1, goods; 2, supplier; 3, customer; 4, price; 5, delivery date; 6, date of order
Slot5	Transaction code	"ME21N"

Figure 9. Frame Order

The data in the storage are used as input for a function or are created as output of a function. The description of the application is contained in slot 6. The function "perform order" contains the sub-frame "CreateOrder". Depending on the purpose the process model is used for, the frame could contain further descriptions for persons or computers. Descriptions for persons may contain instruction manuals, transaction codes to perform the action at the system or a list with all required inputs and created outputs. For machine processing it may contain code that can be execution directly by a computer. Output of the function is the sub- frame "Order", which is output for the next process step but also stored in the storage SAP_6. Figure 9 shows the "Order" frame with its slots. The properties stored in the slots are chosen with the target to create understanding of the object and to facilitate a later implementation in software.

F. *Modelling Support, Analysis, and Optimisation*

The application of the layered model for knowledge transfer aims to support both, modelling and usage of the business process model. The modelling should benefit by automatic syntax checks, verifying the model against the modelling rules. However, such syntax checks are already implemented in various modelling environments. Furthermore, the modelling environment should generate recommendations for the subsequent process step if an appropriate element exists in the database. An important point for this suggestion is constituted by the descriptions of the outputs of the current process step. The system will analyse the process and search for a suitable subsequent process step with matching inputs. Accordingly the system will suggest the object found during the search to the modeller where the conformity of the interfaces is indicated in percent. Thus, the modeller can make the decision whether to use the suggested element, which might be a function or an event.

It has to be considered that process models pursue different targets. For process models used as work instruction the semantic annotation and enhanced descriptions can constitute a benefit. So, for example, the components of an order, used in the "process procurement of goods", can be looked up as illustrated by Figure 9.

For the optimisation of a process the description of inputs and outputs as well as the description of the application are of great importance. Based on this various optimisation approaches could be undertaken.

VI. Conclusion and Future Directions

Knowledge transfer is affected by many different parameters. Due to 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 a practical 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 its implementation. The approach presented in this paper addresses these issues by introducing a model with different layers.

The application of the model focuses on the transfer of knowledge by using written language as a medium. While the description of knowledge transfer is not very precise in the approaches of Nonaka and Takeuchi our approach goes more into detail. The further refinement of the knowledge transfer, during the externalisation and internalisation intends to create a profound understanding about the process of knowledge transfer. Another 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 application of the layered model for knowledge transfer in the area of business process management shows one possible area of application. The different knowledge base of the person modelling the process and the employees in a department running the process constitutes a challenge for both, modeller and employee. Due to the more detailed description of the process by using frames, which integrate the semantic and the pragmatic layer, this challenge is addressed.

In this paper, the authors presented a layered model for knowledge transfer and applied it to the area of business process modelling. However, at this stage the application of the model is a theoretical model; the application is still to be proven. Therefore, the next step will be to develop a prototype application for modelling of business processes and run a validation. Goal of the investigation will be to determine the effect on the modelling and the analysis of business processes through the use of the layered model for knowledge transfer.

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