Knowledge Dimension in Business Process Modeling

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Abstract. Business process models can be represented as stand-alone models and as a par-of a system of models. In the case of the system of models the business process model elements can be a part of other models that are included in the system of models. Each model that relates to the business process via its element can be regarded as a dimension of the business process. Thus the organizational structure model (performer model), goal model, decision model, location model, and other models represent a particular dimension of the business process. One of the dimensions that have not yet evolved into a model that could be easily related to the business process is knowledge dimension. The problem resides in the not fully agreed-upon understanding of the relationship between such notions as data, information, and knowledge. The concept of information code allows to look closer at knowledge dimension of the business process and to clarify several issues with respect to this dimension and its proper place in business process model representation.

Keywords: data, information, knowledge, business process model.

1 Introduction

The period of distrust in business process model based approaches due to unsuccessful re-engineering efforts in the previous century is over; and business process re-engineering again becomes an important topic in scientific literature [1-4]. However, it is worth to remember that business process engineering have to be a holistic approach and take into consideration various aspects of the business system, including organizational and individual knowledge [1-5]. In order to provide new means for the analysis of relationship between the business process and organizational knowledge we propose to include knowledge dimension in the business process model.

In business process modeling languages such as IDEF0, IDEF3, EPC diagrams in ARIS tool, GRAPES BM in GRADE tool, UML 2.0 activity diagram, and BPMN 2.0 data, information and material flow is often represented by the same symbols and without any unambiguous definitions of these concepts. On the other hand, knowledge modeling languages (KMDL, GPO-WM, PROMOTE, and RAD) allow to model knowledge, but do not address process logic to full extent and thus lose the possibility to represent data. Currently, from the point of view of various ways how data, information and knowledge are used in organizations, the following features of business process modeling languages are not yet fully supported in any of the above mentioned languages:

- Possibility to separate information and data during business process modeling
- Opportunity to identify the owner of data, information and knowledge
- Possibility to identify, plan, and manage knowledge of the role required for participating in a particular activity and linking this knowledge to competence model
- Possibility to evaluate the amount of lost organizational knowledge if a person – owner of knowledge – leaves the organization. i.e., to identify which tacit knowledge in this case should be transformed into explicit knowledge, such as documents, rules, systems, etc.
- Opportunity to improve understanding about the knowledge usefulness, validity and relevance for particular activities in a process
- Opportunity to enable competence requirements management and proactive training based on a process reengineering impact analysis.

We have already tried to address these issues with respect to BPMN notation in our previous work [6]. This lead to the introduction of specific symbols for data, information and knowledge objects. Experiments with the notation revealed that the relationship between the phenomena behind the symbols is somewhat unclear in the modeling process. Therefore in this paper we focus on analysis of this relationship by investigating intersection of modern information theory assumptions and knowledge management definitions of information and knowledge. The results obtained and their application for different business process modeling languages, as well as a template of activity representation with visible knowledge dimension are presented and discussed in this paper.

In Section 2 we ponder over the terms data, information, and knowledge and come to the conclusion that the use of information codes as a supplementary term helps to clarify relationship between previous three terms. We use all four terms to define information interaction in homogenous and heterogeneous environments. In section 3 we analyze information interaction in the context of business process modeling languages. In Section 4 the template of business process model activity with visible knowledge dimension and example of its use are represented. Section 5 consists of brief conclusions and points to the research for analysis of knowledge dimension of business processes.

2 Constituents of knowledge dimension

Data, information and knowledge are terms that are widely used, but still have no commonly agreed definitions. Data are usually associated to database, knowledge most often is associated to human beings while information is freely used in both cases. In this work we do not discuss various interpretations of the above mentioned terms deeply [7, 8, 9-11]. We focus on the relationship between data, information and knowledge and rely upon the following observations and assumptions:

1) Knowledge is located in the knowledge holder (natural or artificial)

2) Knowledge in the knowledge holder (e.g., human brain) has a particular structure which may be regarded as a “mental model”. The “mental model” can be natural or artificial, tacit and externalized, implicit and explicit
3) Any business process involves a knowledge process which is performed by a natural or artificial knowledge holder
4) If several knowledge holders are involved in the business process, - data, information, and knowledge exchange between them is possible. This exchange differs from the exchange of other substances as it is asymmetric: the amount of given information may differ from the received one; and the knowledge holder by giving information does not lose knowledge on the basis of which the information was provided.

To obtain a holistic and at least semi-formal view of the relationship between data, information, and knowledge we use theory that shows that in information exchange a substance called information codes is involved [7], i.e., information exchange is accomplished via information codes.

Suppose the knowledge holder (object O_1 provides some information codes T_1 to another knowledge holder (object O_2). The state transition in O_2 which receives this information is illustrated in Fig. 1. In the first phase, the object O_2 receives particular information code Ic_1. To perceive the code the object needs a particular “linguistic” device that can recognize the code. (E.g., if the code is information in English, it can be recognized if there is a “device” that can handle English). The received code is transformed into data Δd. Thus *data are functional values of information codes* which correspond to new parameters of object state obtained in interaction with another object.

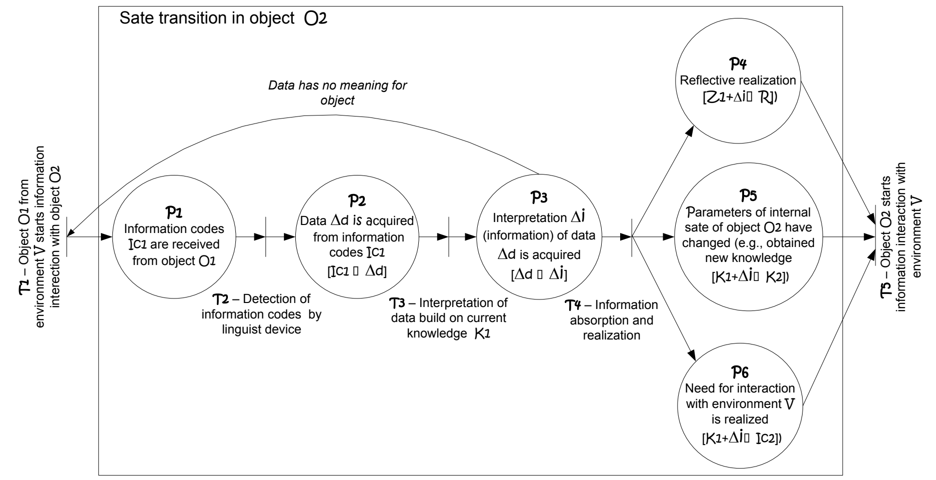

Fig. 1. State transition in knowledge owner when information codes are received.

In the next phase the object O_2 decides upon the meaning of obtained data Δd that is subjective interpretation of Δi by current knowledge of K_1 of O_2 taking into consideration M_1 – the set of its current needs or goals. According to [8] structured and processed data is information that is time dependent (relevant only in a given point of time) and correct with respect to the processed data set. In general, the amount of received information can be calculated as difference between knowledge after data interpretation and knowledge before interaction with object O_1: $\Delta i = Z_1 - Z_2$. It can be regarded as a measure of reduction of uncertainty for choosing actions in order to achieve particular goals M_1 [12].

Information exists from the moment data is interpreted till the moment when the information has been absorbed or included in mental model of the object. As a result of information absorption the content or structure of mental model (including procedural and declarative knowledge which is stored in it) can be changed.

In the final phase realization of obtained information Δi takes place and it can lead to changes of internal state parameters of object O_2 or/and to the next cycle of interaction with environment. There can be several overlapping options of realization: (1) a reflective action: $K_1 + \Delta i \rightarrow R$; (2) if the object starts the next cycle of iteration with object (-s) from its environment, object O_2 delivers appropriate set of information codes: $K_1 + \Delta i \rightarrow Ic_2$: (3) if object changes its internal state, its mental model can change, under certain conditions obtaining new knowledge: $K_1 + \Delta i \rightarrow K_2$. According to [13] *knowledge is reasoning about data* that is stored in object's "mental model" in order to promote action, problem solving, decision making, learning, and teaching. Knowledge is a higher organizational level of data that allows their specific interpretation. Requirements to data organization level can differ from a simple grouping of the data to complicated data hyper-structures.

Thus according to [7] a single cycle of information interaction between object and its environment is divided into three sequential phases: (1) object receives information codes from its environment, (2) obtained codes are interpreted, and finally (3) information is realized (reflected upon, absorbed, put into action). In Fig. 2 a simplified example with two objects (process performer that is analyst and document that includes interview protocols) is shown. The analyst performs the activity of analyzing as-is business process model. Perceived information codes are realized as new knowledge about actual business processes in the company.

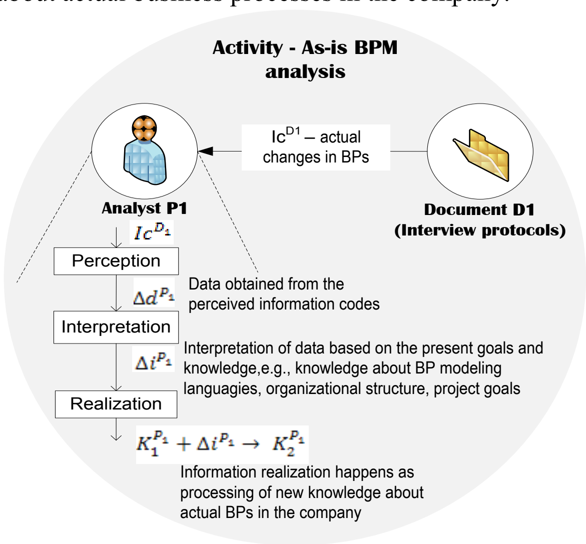

Fig.2. A simplified example of an activity.

The performer of a business process can receive information codes in three different ways, namely, from human, from active artificial object, and from passive artificial object. Depending on the situation the interchange of information codes can take place in homogenous (human-human, IS-IS) or heterogeneous (human-IS, IS-document, human-document) environments. In Fig. 3 and 4 internal changes of knowledge holders are illustrated. A in Fig. 3 shows information code interchange and new knowledge (natural or artificial) development in homogenous environment (on the left: human-human and on the right: computer system-computer system). Fig. 3 B illustrates how natural or artificial knowledge holder interacts with the passive knowledge holder (document). Figure 4 illustrates heterogeneous environment with two different types of knowledge holders. The interchange and knowledge development can proceed differently depending on the level of intelligence of the artificial knowledge holder (from the left to right: without data interpretation means; with data interpretation means only, and with learning ability).

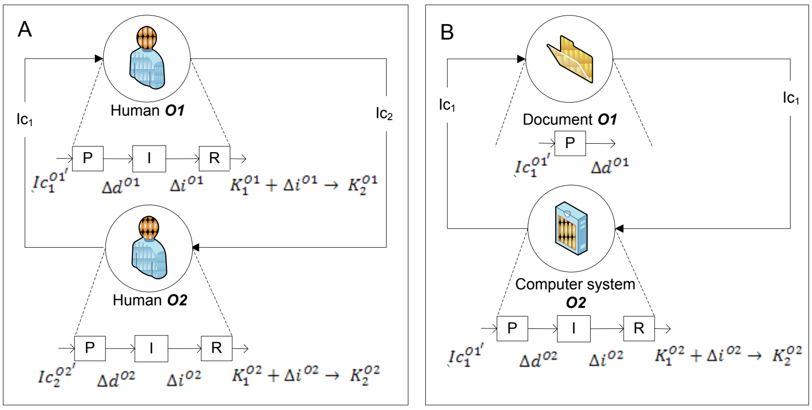

Fig. 3. A- Information interaction in homogenous environments; **B** - Information interaction between active knowledge holders and passive knowledge (P – perception, I – interpretation, R – realization).

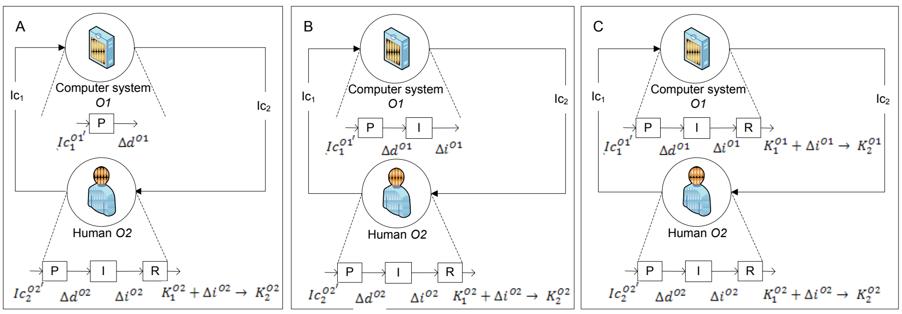

Fig.4. Information interaction in heterogeneous environment (among active objects) (P – perception, I – interpretation, R – realization).

The above analysis of information interaction shows that changes in knowledge are initiated by perception of particular information codes. Thus for representing the knowledge dimension it would be necessary to show knowledge before and after perception of information codes as well as coded information itself. The potential of contemporary business process modeling languages in this regard is examined in the next section.

3 Information exchange in business process context

In our previous work [6] we analyzed different attempts to include knowledge dimension in business process modeling and knowledge modeling languages and we proposed to integrate knowledge-oriented modeling language KMDL [14] and BPMN notation [15]. In that work three different objects: knowledge objects, information objects and data objects were used. However, further experiments with the integrated notation showed that it is difficult to distinguish between data and information objects. Theoretical issues discussed in the previous section clarify the reason behind this difficulty. It shows data rather as an internal than external phenomenon of the knowledge holder and interchange of perceivable knowledge is accomplished via information codes. None of the approaches analyzed in [6] took into consideration information codes and therefore are not directly applicable for representation of knowledge dimension in the way it is described in the previous section. On the other hand knowledge modeling approaches analyzed in [6] are not used very often; therefore in this work we consider "ordinary" business process modeling languages in order to see how appropriate they are for inclusion of knowledge dimension. The following business process modeling languages were analyzed: GRAPES BM – in GRADE tool [16], EPC diagrams in ARIS [17], IDEF 3 [18], IDEF 0 [19], UML 2.0 activity graphs [20], and BPMN 2.0 [15]. The languages were analyzed from the following two points of view (1) possibilities to represent data and knowledge (Table 1); (2) possibilities to represent process logics (Table 2). Both views are important for representation of static and dynamic aspects of knowledge in individual knowledge holders and in the process as a whole. In the Table 1 and 2 "-" means "does not support"; "-/+" means "somewhat supports"; "+" means "inclusion is possible"; "++" means "almost fully supports", and "+++" means "supports fully".

Table 1. Representation of inputs, outputs and resources

Criteria	GRAPES BM	ARIS EPC	IDEF 0	IDEF 3	UML 2.0	BPMN 2.0.
Input/output [data]	+	+++	+	-	+	++
Input/output [inforamtion]	+	+++	+	-	+	++
Input/output [knowledge]	-	+/-	-	-	-	-
Resource [knowledge]	-	-	-	-	-	-
Resource [human]	+	++	+	-	-	+
Resource [artificial]	+	+	+	-	-	+
Resource [data store]	+	+	-	-	+	-

Table 2. Representation of process logics

Criteria	GRAPES	EPC	IDEF 0	IDEF 3	UML 2.0	BPMN
Process management	-/+	-/+	+	-	-/+	-/+
Controls	-/+	-/+	+	-	-/+	-/+
Decision points	+	+	-	-	+	+
Control flows	+	++	-	+++	++	+++
Events	+	++	-	+/-	+	+++

From the point of process logics the best options are BPMN and ARIS EPC. The least feasible is IDEF0, which lets to assume that this language has to be extended if taken as a basis for the representation of knowledge dimension.

4 Representing knowledge dimension transparently

In this section we propose one possible way how to represent an activity with knowledge dimension. We strive to show the proposed ideas graphically. It is not yet a new business process modeling notation. The representation is based on IDEF0 notation. IDEF0 was chosen as the basis for activity template, because it gives an opportunity to distinguish between controls (relates to knowledge holder's goals (see Section 2), inputs/outputs (received and produced information codes), and resources (knowledge in the holder). However, it must be admitted that IDEF0 notation is not the most suitable for representing logic of the process, therefore, in our further research we intend to combine it with other notations that give more means for control and decision points modeling. The activity template and example of its use are represented in Fig. 5 and 6.

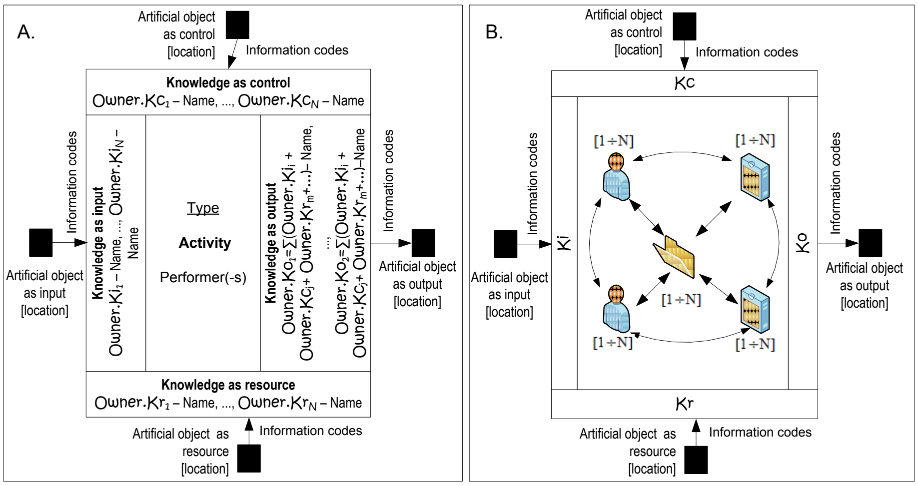

Fig. 5. Activity with a knowledge dimension: A: activity template; B: activity zoomed in (this information is not presented in the template).

Each *Activity* (Fig. 5 A) corresponds to one of different combinations of interaction between human, computer systems, and documents as shown in Fig. 2-4. Social processes among performers inside the activity are not represented (Fig. 5 B). The activity template has the following attributes: *Activity name*, *Performers of the activity* (human or artificial (computer) system). For knowledge intensive activities there is an additional attribute *Type* with possible values Socialization, Externalization, Combination, and Internalization. These attributes and their values are visually positioned in the central part of the template. The central part is surrounded by four blocks that correspond to four types of knowledge, namely: control knowledge *Kc*, input knowledge *Ki*, output knowledge *Ko*, and Resource knowledge *Kr*. This is knowledge that is inside the knowledge holders (natural and/or artificial) participating in the activity and can be referred to as tacit knowledge. Each block of the tacit knowledge can be linked to particular artifacts: input artifacts *I*, output artifacts *O*, resource artifacts *R*, and control artifacts *C* which in essence are information codes perceived by tacit (natural or artificial) knowledge of the performers of the process. Each block *Kc*, *Ki*, *Ko*, *and Kr*, of the template can be related to particular concepts of the representation of organizational "mental model", if such is maintained. To illustrate the proposed template an activity of logical data model development process is illustrated (Fig. 6). The development process starts with an As-is business process model analysis when the analyst reads two documents: current business process model and an interview protocol. As a result of this activity the analyst should obtain new knowledge about actual business processes.

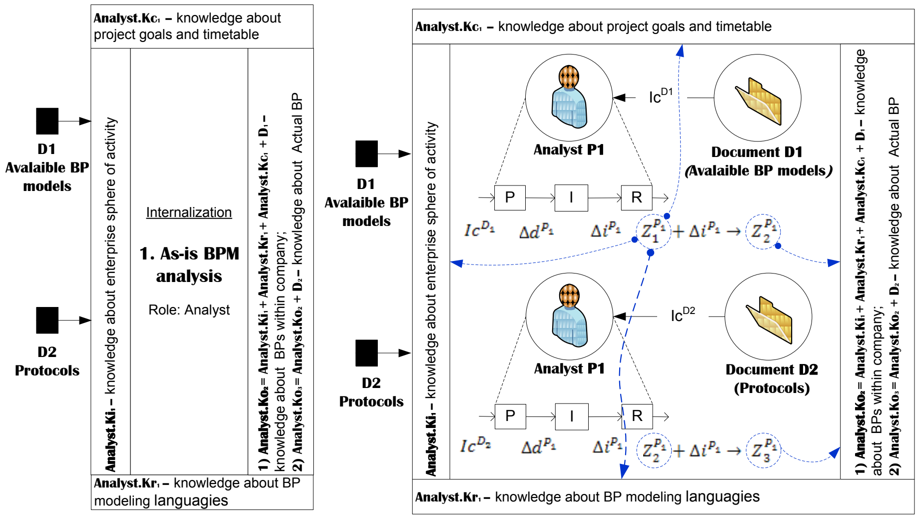

Fig. 6. Example of an activity represented by the template (on the left). What happens inside of it is illustrated on the right.

6 Conclusions

In business process reengineering it is important to have a holistic view of the enterprise. Since organizational knowledge is an essential aspect of an enterprise, there is a need for transparent linkage between the business process model and organizational and individual knowledge. In order to achieve this transparency the paper proposes a new activity template that gives visual means to relate business process to organizational knowledge and to analyze knowledge circulation in a business process. The model presented in the paper is in its experimental stage. Analysis of possibility to introduce it to different business process modeling languages is the next step of the research presented in the paper. Additionally we consider interviewing experts who routinely use business process modeling languages and notations in order to investigate how they presently capture knowledge.

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