Knowledge Engineering for Business Process Modeling

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Abstract: The process is the pivot of the business modeling. Thus, the goal of modeling is to present the main flows exchanged with the internal and external environment. Indeed, there are several pieces of information that take place throughout the process life cycle, from design to execution. Behind these pieces of information, there is a lot of business knowledge that should be acquired to improve the quality of such a modeling. The aim of this paper is to manipulate the business knowledge when developing modeling perspectives. For this reason, our solution consists in proposing an ontological approach to create a Multidimensional Business Knowledge base (*MBK_BASE*) to help the designers of the business process with their tasks. In this way, on the one hand, we outline an overview of our proposed solution by relating it to other research. In fact, we define the main business concepts and we describe some semantic relationships which are expressed with the descriptive logic. On the other hand, we give an illustrative case study related to the treatment choice process of a patient with breast cancer in order to demonstrate the applicability of our solution.

1 INTRODUCTION

Research Context. As it is already known, the business domain is one of the most complex domains to model. For this reason, organizations attach more importance to their Business Process Management (BPM), which plays a crucial role in the improvement of their performance (Gábor and Szabó, 2013). Therefore, a clear business process modeling is at the heart of the major challenges of the BPM, given that this modeling enables to describe the sequence of different activities and the way they are connected in giving a complete description of a model called: *Process Model* (PM). In fact, this description is not an easy task because it requires a better understanding and an effective management of the business process. However, the description of the same sequence of activities, more than one PM is required since this description is strongly related to the different views of the designers and the used modeling language. Indeed, in the literature, there are several methods and techniques which support the modeling of business process such as UML (Unified Modeling Language), BPMN (Business Process Modeling Notation) and many others (Recker et al., 2009). Thanks to these standards, business processes are more understood by a large public, but, what about knowledge?

Knowledge is gravitated in the memory of the designers and figures in their habits and their daily tasks. For this reason, the use of knowledge can be considered as the most important thing when modeling a business process because it deals with many different pieces of information that differ from one sector to another and from one participant to another. Furthermore, it is necessary to express knowledge and make it in the disposal of the designers.

The problem being arisen in this paper is *"how we can present this knowledge and enable the designers to benefit from their use at an early stage?"*

Our solution is to propose an ontological approach to construct a Multidimensional Business Knowledge BASE (*MBK_BASE*) which is an original way to decompose business knowledge by the perspectives of the business process. Besides, such a base provides a clear presentation and an easy use of exactly the needed dimension of knowledge.

Organization of the Paper. The remainder of this manuscript is organized as follows. Section 2 provides some preliminaries which revolve around the business process modeling and knowledge engineering. Section 3 highlights the studies and projects related to our positioning. Section 4 exposes the basics of our proposed approach. Section 5 presents an illustrative case study so as to explain the utility of our

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proposed solution. Finally, section 6 concludes the paper and suggests some future research studies.

2 MOTIVATIONS

Research in the business process modeling does not stop due to the high speed of technological development and the already increasing customers' demands for efficient improvements of products and services. Indeed, one of the most important research objectives is to support a business process with semantic level. Such a level has a crucial impact on the improvement of the business process BP through a better understanding. In what follows, we present two preliminaries in order to put our work in its research context.

2.1 Business Process Modeling

In recent years, organizations have been increasingly competitive using great dynamics and complex processes. Furthermore, to respond to their customers' requirements, organizations think more seriously about their business process management (BPM). In this context, BPM is defined in (Dumas et al., 2013) as: "the art and science of overseeing how work is performed in an organization to ensure consistent outcomes and take advantage of the improvement opportunities". Moreover, the crucial role of the BPM is to manage the chains of events, activities and decisions so as to add value to the organization. Chains of events, activities and decision are simply represented in a business process.

The business process is not a new term. In fact, it has several definitions in literature, such the one of (Harrington, 1991), (Hammer and Champy, 1993), (Weske, 2007) and (Gernert and Köppen, 2006). However, the most popular definition is that of (Coalition, 1996) which states that a business process is "a set of one or more linked procedures or activities which collectively realize a business objective or policy goal, normally within the context of an organizational structure defining functional roles and relationships". Indeed, business process modeling lies in the heart of the BPM given that its objective of the business process modeling is to give a clear graphical presentation taking into account the smallest details so as to facilitate its understanding. However, modeling is not a simple task in a business domain characterized by a diversity of concepts and used terms. Therefore, several process modeling languages and notations emerged with the aim of assisting enterprises with the documentation and presentation of their processes. These notations describe the business process and take into account the functional, organizational and informational ways (Rosemann and vom Brocke, 2015),(van der Aalst, 2013) (Indulska et al., 2009). In this context, we can mention the most prominent notations, such as the BPMN (Business Process Modeling and Notation), the UML (Unified Modeling Language) especially through the activity diagram, the Petri net, the EPC (Event driven Process Chain) (La Rosa et al., 2013) and (van der Aalst, 2013). However, the BPMN is considered as the de facto standard approved by ISO/OSI (Model, 2011). BPMN is defined by OMG in order to make the understanding of the business processes easier for business analysts and technical developers. At the semantic level of modeling the business processes, PMs are as understood as their graphical presentations using these standards and notations. This semantic level aims at limiting the ambiguities using different terms. In fact, several studies had been carried out in this context, more precisely in expressing knowledge, which results in the appearance of knowledge engineering.

2.2 Knowledge Engineering

To make anything more understood, the only way is to give it a meaning, which is called the *semantics*. However, this is not an easy task to do given that the semantics is expressed throughout the knowledge term. Furthermore, Knowledge is tightly related to the thoughts which are hard to extract. Literature provided several definitions of knowledge. We have chosen to give definitions we think they are the most significant in our field of research. For instance, knowledge is defined as "true and justified beliefs" (Nonaka and Takeuchi, 1995), "a mix of experiences, values, contextual information and expert insight that provides a framework to evaluate and interpret new experiences" (Jablonski and Bussler, 1996), "ability to act in a given context" (Sveiby, 1997). In addition, managing knowledge highly depends on its forms. Knowledge has many forms; tacit, explicit, declarative, procedural, conditional, individual and collective. The most popular ones are the tacit and explicit. On the one hand, the explicit form is generally described across a set of symbols -like words, forms . . . - which formally express it (Evans et al., 2015). Its access is not such a difficult task because it can be articulated, codified and stored in some supports. On the other hand, tacit knowledge, is defined as the meta-resources emanating from the thought, the reflection, or the experience of the human mind (Van den Berg, 2013). Therefore, its access is as difficult as the explicit form.

The process of capitalizing and constructing a knowledge base is called Knowledge Engineering (KE). KE deals with knowledge acquisition, representation, validation, inferencing, explanation, and maintenance. The business field, like several research fields, had benefited from the KE. Indeed, to construct a business knowledge base, the KE process should pass by some major phases:

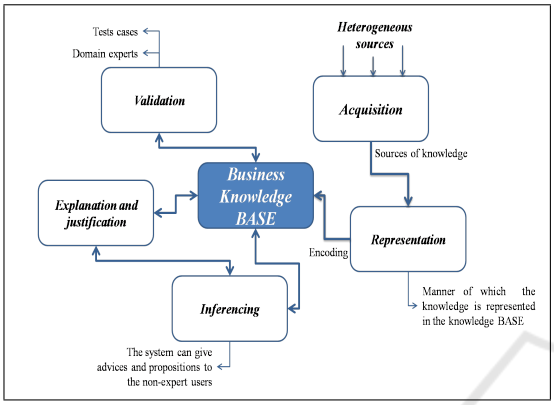

Figure 1: Principe of the construction a Business Knowledge Base.

- Knowledge acquisition: based on heterogeneous resources, this step enables us, on the one hand, to identify the tacit knowledge and, on the other hand, extract the business concepts which appear to be useful to find business knowledge. Today, lots of theoretical and applied research studies are still being conducted in this field (Wagner et al., 2002).
- Knowledge representation: this step aims at preparing a knowledge map and encoding it in the business knowledge base.
- Knowledge validation: there are two successive ways to validate or verify knowledge. The first one consists in applying test cases. After that, the obtained results are shown to the experts of the domain to verify their conformity with the reality.
- Inferencing: this step consists in using the stored knowledge to enable the system to give advice and propositions to different types of users.
- Explanation and justification: this step consists in making knowledge available to be used in answering the queries.

Thereby, to support and exploit the semantics of information through structuring and encoding its meaning in order to describe and characterize information for the purpose of enhancing its processing, this can be accomplished by the application of techniques called semantic technologies (Sheth and Ramakrishnan, 2003). Ontology can be considered as the most understood semantic model because it serves for capturing and formalizing the meaning like a conceptual schema (Antoniou et al., 2005). Basically, ontology is defined as a conceptualization of a domain of interest (Gruber et al., 1993), (Daconta et al., 2003). Due to the richness of its expressiveness and also its semantic formalization high degree, the use of ontology is a core element for knowledge engineering.

3 TOWARDS A SYSTEM THAT HELPS DESIGN A BUSINESS PROCESS

As previously mentioned, the business process modeling is the most important field in the BPM which helps graphically visualize the activities and tasks of the business process for a better understanding. To give a complete model of the business process, it is necessary to follow a cyclic methodology called a business process lifecycle which consists of a set of phases, starting with a *diagnosis/requirements* phase, passing by a *configuration/ implementation* phase, an *enactment/monitoring* phase until arriving at an *adjustment* phase (Lodhi et al., 2011). This business process lifecycle is recursive given that each phase can have similar phases during its lifecycle. In what follows, we briefly describe the lifecycle based on the modeling phase. In the *diagnosis/requirement* phase, it is necessary to define which business processes are the best to achieve the fixed objectives. In this way, these objectives and requirements must be described in more detail. The output of these phases is a detailed plan about the goals of a business process in taking into account the important changes to be carried out.

In the *design* phase, the main thing be considered is the analysis of the business process key-perspectives which are the process perspective, the organizational perspective and the informational perspective. The first one aims at describing the activities involved in the process, which operations are encapsulated in and wherewith are they linked between them. The second aims at structuring the business process actors and authorizing them, in taking into account their skills, to perform tasks making up the process. However, the third aims at defining the structure of the documents and data required and produced by the process. Therefore, a good analysis of the business process perspectives conducts the designers to define the inputs, describe the procedure, extract the business

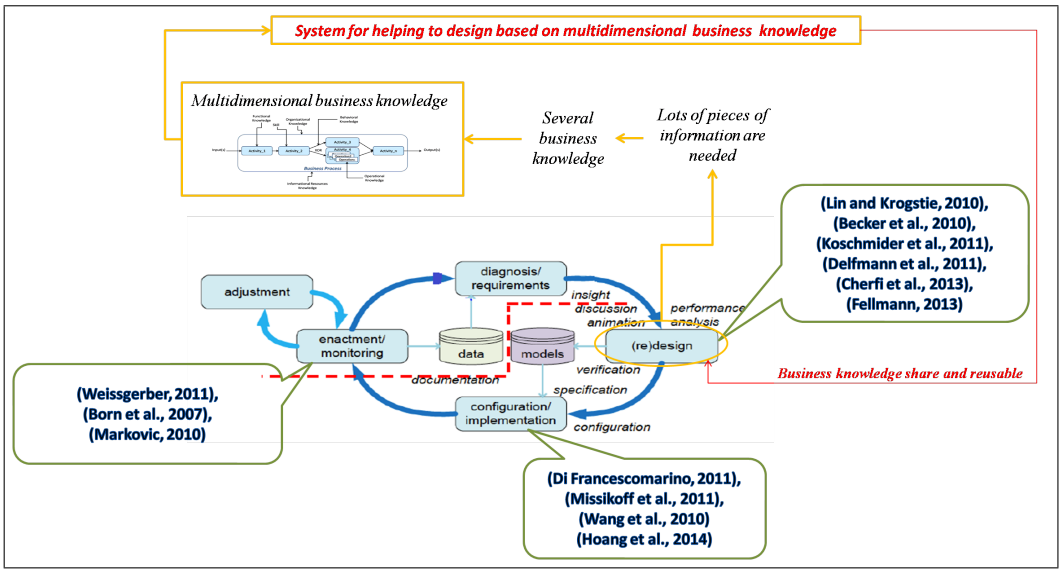

Figure 2: Work related to the business process Lifecycle and our positioning.

rules, ensure the resource allocation, define the role mapping and take into account the required changes. In this phase, the designers must explicitly specify the involved elements of the business process to give a detailed design model to the implementation phase. In this way, we distinguish a strong need for their knowledge. Thereby, this makes knowledge an essential element to be used especially when the processes are conceptualized and designed from scratch.

The *configuration/implementation* phase is widely dependent on the description of the language of the models in such a way that business processes are supported with the Information Technology (IT). This phase is considered as a mapping between the process needs and requirements. On the one hand, and the IT service, on the other hand, with the objective to provide Business- IT support since an output of the business processes is executed with the help of information systems. Moreover, the information systems are equally used on an evaluation and monitoring levels. After implementing and configuring the designed business processes, it is necessary to enact and adjust them when needed. The idea here is not to redesign the processes or to create a new software, but to adapt or reconfigure these processes to make them conform to the reality and fulfill the requirements and the objectives of the organization.

On modeling business processes, several pieces of information are needed during the business life cycle from design to execution and monitoring. Indeed, behind these pieces of information, there is a great deal of knowledge which makes business processes more understood and clearer. Knowledge is not usually explicit because it is closely related to the mind and thoughts of the people in general, and to the designers, in our context. In this way, we can say that business process modeling is highly dependent on the designers' knowledge. In fact, due to different experiences, intellectual levels and skills, the designers have not the same knowledge given that they have different abilities to understand, to describe the reality and make decisions about the choice of the concepts and details to be modeled. However, for one business process, several models can be retrieved resulting in any ambiguity. This has an impact on the quality of the models and later, on their shareability and their reuse. In addition, the designers' knowledge is closely related to the business process perspectives. Therefore, we can say that business knowledge is a set of different pieces of knowledge related to the different parts of the business process, like the activities, how their are linked, who performs them and which skills are required. In this way, we define business knowledge as a set of dimensions and proposes of a multidimensional model to link each dimension with the main business process concepts. Consequently, our contribution is to create a system based on a multidimensional business knowledge to help the designers of the business process to guaranty the reuse and the sherability of knowledge. This contribution is considered as a phase of pre-modeling. Figure 2 clarifies the main directives of our contribution and its positioning in relation to the business process lifecycle. Many efforts have been made on the semantic level in the business process context, with its different lifecycle phases proposed in literature. In this context we elaborate them by phases. For instance, concerning the phase of design (modeling), there are (Lin and Krogstie,

2010), (Becker et al., 2010), (Koschmider et al., 2011) and (Delfmann et al., 2011). While (Cherfi et al., 2013) and (Fellmann, 2013) who treated not only the design phase but also the analysis one. Concerning the analysis phase, we mention (Di Francescomarino, 2011), (Missikoff et al., 2011), (Wang et al., 2010) and (Hoang et al., 2014) and with the execution phase (Weissgerber, 2011), (Born et al., 2007) and (Markovic, 2010). In short, we believe our solution is currently unique, not only in trying to be substituted at a pre-modeling phase but also to take into account all the dimensions of business knowledge in a coherent framework. In fact, this is made possible thanks to the use of Ontology.

4 KNOWLEDGE ENGINEERING FOR BUSINESS PROCESS MODELING: AN IMPLEMENTATION OVERVIEW

Our contribution is to help business process designers with their tasks by putting at their disposal a Multidimensional Business Knowledge BASE (MBKBASE) for the purpose of guaranteeing their shareability and their reuse. For this reason, we have decomposed our proposal solution into many bricks as it is demonstrated in figure 3.

4.1 Business Concept Definition

The business process modeling requires an exhaustive description of its components. It should be based on a finite number of concepts. In this context, starting with a set of heterogeneous inputs, such as graphical representations of the business process, like the BPMN models, the activity diagrams (UML), the EPC models and many others, we notice that there are a lot of different used terms. This diversity leads to many ambiguities and does not contribute to improve the BP modeling. Actually, it requires a pre-treatment to define the relevant information by eliminating the redundancies and ambiguities. Furthermore, a definition phase of the business concepts is necessary so as to limit and regroup the similar expressed pieces of information under only one significant business concept. Table 1 presents a glossary of concepts related to the business domain.

Table 1: Business concepts.

Concept	Description
Process	A sequence needed to make an output (product or service) while using a set of resources: physical and human
Activity	part of the business process with a well-defined order. There are two kinds of activities: atomic activity and composite activity
Operation	Results of actions to perform an activity
Coordination Pattern	link between two or more activities. It can be a conditional pattern or an unconditional one.
Condition	The fact triggers one or more activities
Actor	Someone who performs an activity by applying some techniques and has many skills. It can be a person, a machine or a software
Informational Resource	Materials and tools used by an actor to make his business

4.2 Business Knowledge Modeling

After the definition of the business concepts, the second phase aims, as its name indicates, at modeling business knowledge. In fact, we define *Business Knowledge (BK) as a set of knowledge dimensions that serve to better understand processes and especially to facilitate the modeling of tasks for designers*. Based on this definition, we identify seven dimensions of BK, namely, organizational knowledge dimension, informational resource knowledge dimension, functional knowledge dimension, operational knowledge dimension, conditional knowledge dimension and finally behavioural knowledge dimension. Indeed, the aim of this phase is, on the one hand, to segment the business knowledge since such knowledge has a large meaning and, on the other hand, to allocate the defined business concepts to each BK dimension. Hence, this phase is decomposed into two steps, the *business knowledge classification* and the *business knowledge formalization*. In the first step, we elaborate more than one dimension, like organizational knowledge, functional knowledge, operational knowledge, behavioral knowledge, skills, informational resource knowledge and contextual knowledge. These dimensions had been well expressed by

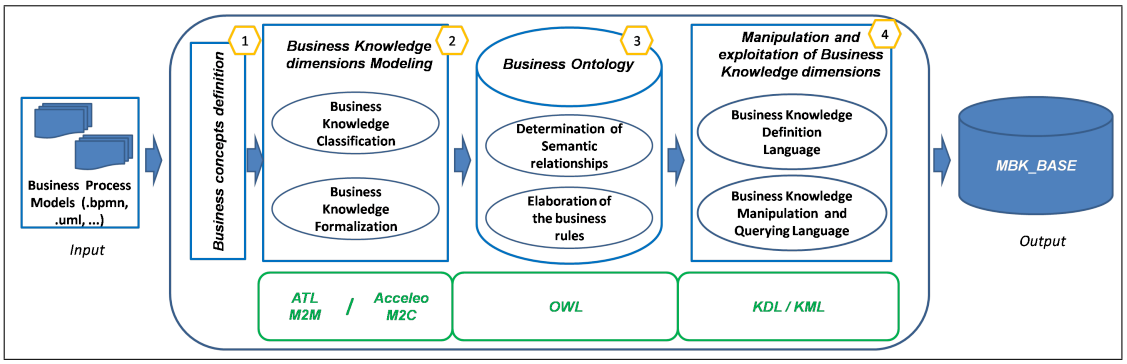

Figure 3: The proposed approach for representing the multidimensional Business Knowledge.

(Ouali et al., 2016). They have been presented around the main-key perspectives of the BP. Moreover, we have linked each dimension with the main related business concepts. Concerning the second step, we had elaborated an algorithm that permits to construct a multidimensional business knowledge model with the idea to automatically, generate the skeleton of the business ontology, defining the business knowledge dimensions and, their related business concepts. In this way, the used languages are, first, the model to model (M2M) transformation throughout the ATL in order to build the multidimensional business knowledge model. This model is later used to be transformed into an owl code throughout a model to text (code) (M2T) transformation using the Acceleo as a code generator.

4.3 Business Ontology

As it is already known, ontology is increasingly used for modeling knowledge. In addition, it provides a theoretical and practical basis for robust modeling of a domain (Andersson et al., 2006). It improves the exchange of operational concepts from one study to another in the same domain of interest. In the literature, there are several research studies that used ontology to model a specific domain, such as (Tétreault, 2012) and (Yessad and Labat, 2011). The skeleton of our business ontology is the result of the business knowledge modeling phase. In fact, the construction of our business ontology is summarized in three principle directives which are:

- First, the definition of the business concepts related to the corresponding business dimensions.
- Second, the determination of the semantic relationships and their modeling.
- Third, the elaboration of the business rules.

The first directive is automatically done as it has been mentioned previously, that is the output of the business knowledge modeling phase. The second one consists in clearly and consistently describing the semantic links between the business concepts. The objective of this modeling is to describe the behaviour of a process in terms of activities, operations, informational resources, conditions, transitions and actors. The process execution depends on the execution manner of these business concepts. The semantic relationships between these business concepts are described by many rules. In this way, we have two kinds of relationships: inter-perspective relationships (relations that match concepts and are not from the same business knowledge perspective) and intra-perspective relationships (relations that match concepts and appear in the same business knowledge perspective). In fact, we present some of them which are expressed in the *Descriptive Logic* (Baader et al., 2009).
As an example of the intra-perspective relationships, we can mention:

- "*is composed*": this relationship models the composition of concepts. The concept process is composed of more than one activity and each activity is composed of more than an operation.

  $\texttt{Process M >=1 is composed Activities} \sqcap \texttt{Activity >=1 is composed Operations}$

  And as an example of the inter-perspective relationships, we can mention:

- "*consume*": the activity consumes one or more informational resources.

  $\texttt{Activity M >=1 consume Informational Resource}$

- "*realized by*": this relationship models the semantic link between the activity and the actor: the activities are realized by at least one actor.

  $\texttt{Activity M> = 1 realized by Actor}$

- "*trigger*": the operation triggers one or more condition.

  $\texttt{Operation M> = 1 trigger Condition}$

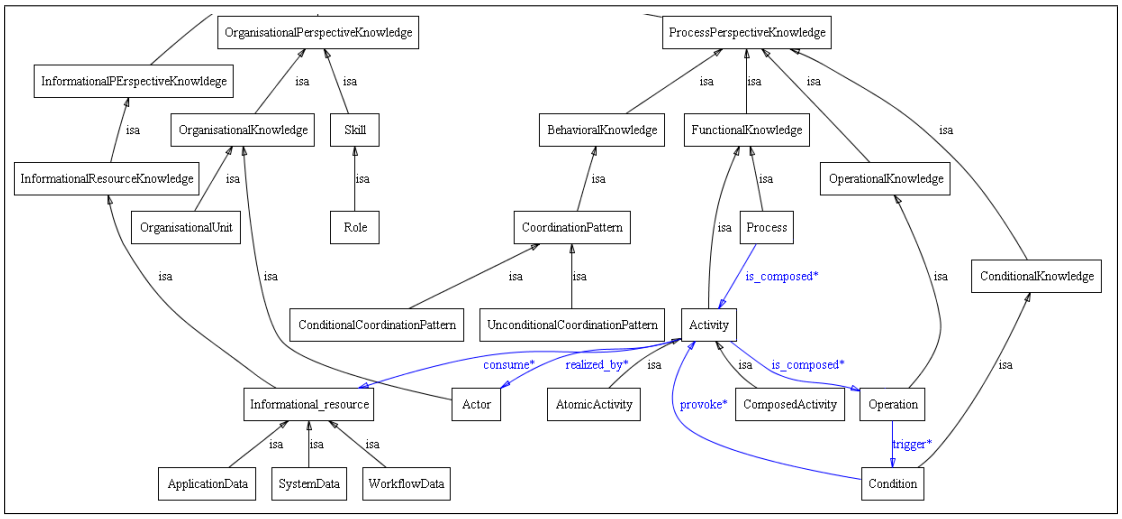

Figure 4: Fragment of semantic relationships in the Business Ontology.

- "*provoke*": the condition concept provokes exactly one activity

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Condition M> = 1 provoke Activity M
<= 1 provoke Activity
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These semantic relationships are expressed in a general way to implicitly describe the semantic reference of the manner by which business concepts are linked to one another (Wache et al., 2001). Hence, figure 4 shows a fragment of the business knowledge dimensions which are clearly represented with their related business concepts and some semantic relationships. In fact, these semantic relationships have a crucial role by elaborating the business rules with the aim of separating the application code from the business knowledge (Omrane et al., 2011).
After constructing of our business ontology by enabling the designers to benefit from a multidimensional business knowledge base, the final step is the manipulation and the exploitation of the business knowledge dimensions. For this reason, our objective is to elaborate a Business Knowledge Definition Language (BKDL) and a Business Knowledge Manipulation and Querying Language (BKML). The objective of these languages is to ensure simple operations with an easy syntax to respond to complex queries.

5 ILLUSTRATIVE CASE STUDY

To illustrate the performance of our system, we have opted for the healthcare domain to illustrate and evaluate the importance of the MBK_BASE with regard to its applicability and capability to give the needed knowledge dimension. In fact, we have chosen the healthcare domain since it is one of the most complex domains to model due to its delicateness. Since, in one process, many activities figure in applying many actors which work together to guarantee a high treatment quality for the patients. Cancer is a part of this complex domain. Moreover, its treatment needs sharing knowledge because there is an interaction of lots of healthcare professionals with many specialities who are located on different sites. On this side, while a business process designer creates a PM for one patient with breast cancer, he needs to have answers to many questions (Q1 $\cdots$ Q10) since he is not a healthcare specialist, as it is shown in figure 5. In fact, the performance of our MBK_BASE is to make the needed piece of knowledge available (that is what we call the *dimension*). This will be made possible by consulting the MBK_BASE throughout one of the business knowledge dimension. For this reason, our case study is conducted in a real clinical scenario in the context of women with breast cancer. The description of the process of making the good treatment decisions is taken from an American Cancer Society (ACS)[1]. To observe the practical applicability of our proposed MBK_Base, we illustrate in the figure 6, a PM writing using the *BPMN2 modeller*, enriched with a set of MBK. During our experimentation, we have identified different dimensions related to each business concept. For instance, we add, on the one hand, an organizational knowledge dimension related to the actors of the first activity "Discuss about to treatment options" and, on the other hand, a skill dimension which is important in allocating the activity to the adequate actor. Furthermore, the third activity in the process of the choice of the breast cancer treatment is related to a condition. Therefore, we

[1] www.cancer.org

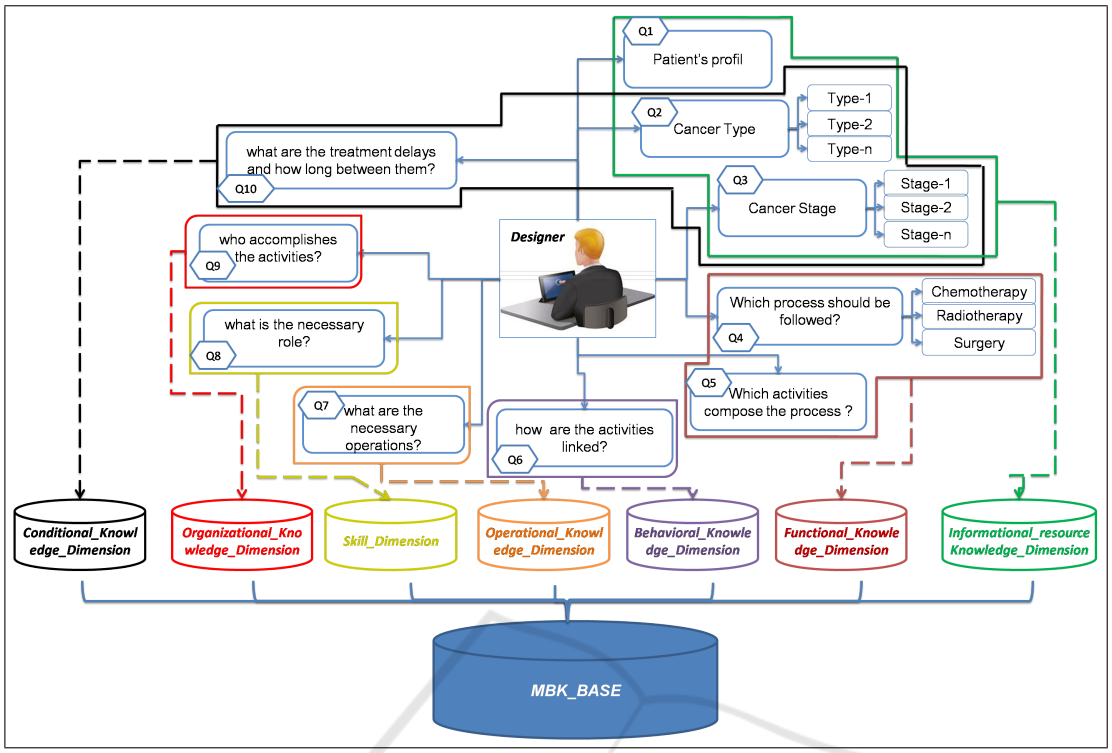
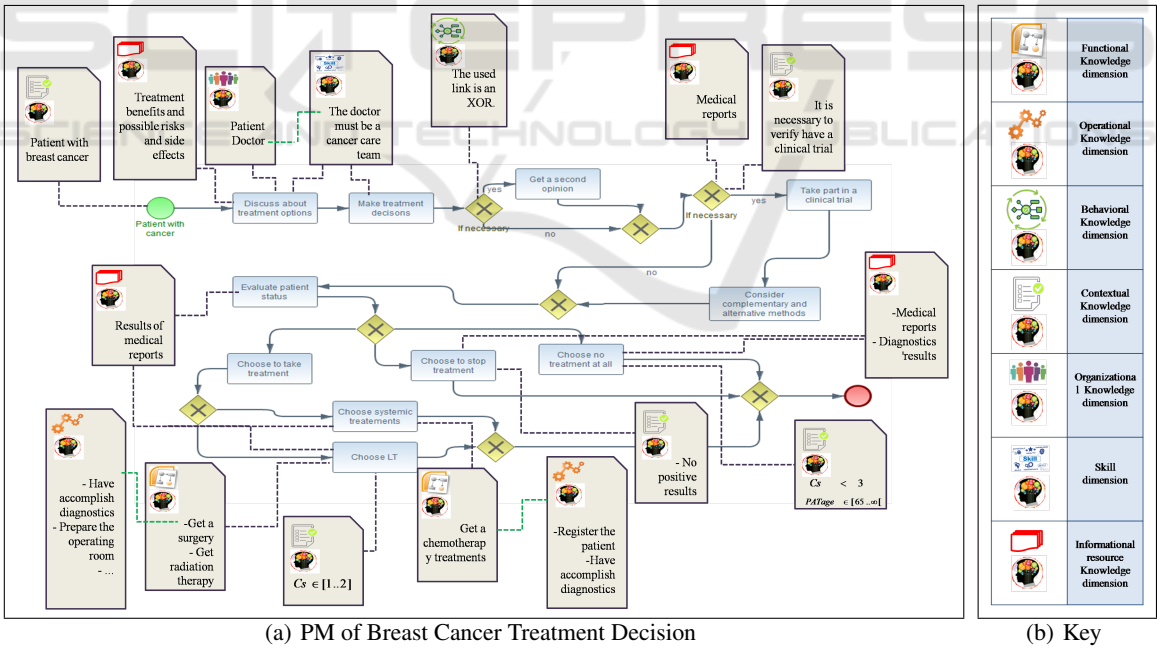


Figure 5: Illustrative case study related to the PM of patients with breast cancer.



(a) PM of Breast Cancer Treatment Decision (b) Key

Figure 6: Some of used MBK in a PM of a patient with cancer.

integrated a behavioral knowledge dimension, to conduct the designer to make the good link between the activities. The fourth activity is preceded by both a condition ”if necessary”, which elicits a contextual knowledge dimension, and an informational resource knowledge dimension ”medical reports”. The activity ”Choose no treatment at all” requires contextual knowledge and informational resource knowledge dimensions. The first one is related to the knowledge of the cancer stage (Cs) and the patient’s age (PATage).

Concerning the second one, it is related to the medical reports and the diagnostics's results. Actually, if cancer is at an early stage, the activity "Choose LT (Local Treatment)" is the appropriate choice. For this reason, a contextual knowledge dimension is recommended to explain this condition. Indeed, in this case, the same activity applies a functional knowledge dimension to describe a set of composed activities of getting surgery and/or radiation therapy. Moreover, it is necessary to present an operational knowledge dimension to specify the main executed operations related to the surgery or the radiation therapy.
It can be concluded that, the aim of this illustrative case study is to show how multidimensional business knowledge can figure in the design of a PM. These dimensions contribute to facilitate the design tasks.

6 CONCLUSION AND PERSPECTIVES

On concluding this paper, we give an overview of some preliminaries in which our research work is subscribed. In addition, we presented our contribution in relation to the research studies that focused on the semantic expression of the business process modeling. Thus, we organized them in three categories around the business process modeling lifecycle phases. Furthermore, we explained the different steps of our approach by presenting their principle directives and some of their results. To validate our proposed solution, we elaborated an illustrative case study related to one of the most complex domains, which is the healthcare domain, especially the cancer one. In fact, our choice is related to the process of treatment decision. For this purpose, we presented a set of business knowledge dimensions that are necessary for a clear understanding of the process.
Regarding the suggested future studies, firstly, we plan to accomplish the implementation of the prototype to support the business knowledge ontology. Secondly, we plan to simplify the proposed language of definition, manipulation and querying the ontology because, such a language must be based on a clear syntax without ambiguity to express complex queries with simple operations.

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