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MBOPS: Towards A ***M***ultidimensional ***B***usiness ***O***ntology based-***P***remodeling ***S***ystem

Sonya Ouali*, Mohamed Mhiri, Faiez Gargouri

MIR@CL Laboratory, Technopark of Sfax : Tunis Road Km 10 BP. 242, 3021 Sfax, Tunisia

Abstract

In this paper, we propose a Multidimensional Business Ontology based-Premodeling System (*MBOPS*). Its knowledge-oriented core ensures an easier use and share for unambiguous business process modeling. Furthermore, the proposed (*MBOPS*) guarantees a good understanding level for the modelled-domain familiar designers as well as the modelled-domain non-familiar designers thanks to a Multidimensional business ontology. In order to evaluate the proposed (*MBPS*) and demonstrate its effectiveness, we choice the breast cancer treatment protocols as an applicative field.

Keywords: Framework, Business ontology, Knowledge Dimension, Business rules, Semantic relationships, Protege, Breast cancer;

1. Introduction

Business process modeling requires an exhaustive description of its components. It should be based on a finite number of concepts that explain the related semantic depending to the domain to be modeled thanks to the added value that knowledge can bring to well describe business. The use of ontology seems to be a relevant way to explicitly present business knowledge in order to help users, in their tedious task, to find relevant knowledge corresponding, each time, to modeling needs. Moreover, the ontology is increasingly used for modeling knowledge. It provides a theoretical and practical basis for robust modeling of a domain [1]. Additionally, it improves the exchange of operational concepts from one study to another in the same domain of interest. The ontology describes clear and consistent semantic links between terms implicitly

* Corresponding author. Tel.: +216-22386401.
E-mail address: sonyawali@hotmail.fr

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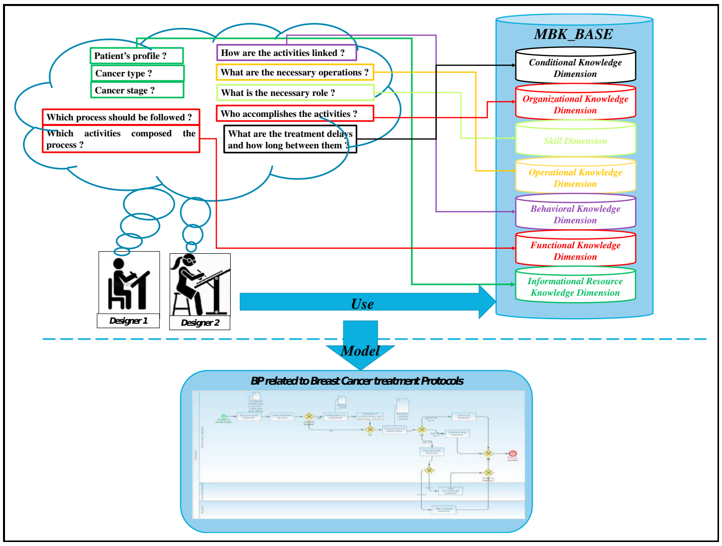
defined in a domain. It is used to provide a semantic reference of a field by describing their concepts and their relationships [2]. In the same spirit, this paper deals with an ontology-based approach that the objectives is to provide an easy way for designers to make their tasks. Indeed, we propose to extend the business process life-cycle in adding a pre-modeling step that takes place just before the design step. In such an additional step/phase, we suggest a set of knowledge organized around the three-main business process perspectives to provide for designers exactly the needed knowledge. In the literature, there are several works use ontology to model specific domains such as [3] and [4]. These works are not generic and they do not deal with different dimensions of business knowledge, so they can not be consistent in our field.
The present paper is organized as follows. Section 2 gives a scoop of the application domain which relevant to a very delicate one. Section 3 presents our contribution which is decomposed in two main directives: (i) Multidimensional Domain-Specific Ontology construction and (ii) Business Rules elaboration. Section 4 demonstrates the proposed framework MBOPS. Section 5 discuses some related work. Finally, a conclusion is provided in section 6 with a number of suggestions for future work.

2. Motivating Example: Breast Cancer (BC) treatment protocols

Information and Communication Technologies (ICT) practically take part in all business domains. Healthcare domain, which is considered one of the largest business domains in the world, was also benefits from the ICT impact especially as it is a large-speciality domain. Since nothing is more precious than a human life, in this section, we choose to treat a real practical scenario that touches the human life. It is cancer, more precisely breast cancer which is classified as a dangerous disease. The analysis and the treatment protocols of such a disease require a large actors from different specialities. Referring to the American Cancer Society (ACS),[1], breast cancer treatment processes are characterized by highly dynamic, unpredictable, complex and highly intensive knowledge actions. Knowledge have a particular interest because an evil knowledge use can has a very expensive result especially when talking about the loss of a human life.
The overall care process of the women with breast cancer is composed of several sub-processes which made up of a succession of many actions in the form of medical analysis and evaluation situations involving various delicate specialities. It calls up very important and heterogeneous knowledge types. Many medical information and knowledge related to results of clinical exams and hospitalization reports are used and created during these BPs. For a specialist or a domain expert, to predict a case-specific breast cancer treatment protocol process, is not awfully a hard task but, in reality, the predicted process does not perforce be the same of that of another specialist. Indeed, this variety can led to several problems of knowledge sharing and reuse. So, *how is the case of a non specialist that has as task to model such a complex process ?*
Our prominent objective is to identify, make visible, preserve, share and generate the different dimensions of medical knowledge for modeling the medical care process of patient with BC. This lead to resolve the semantic ambiguity in business process modeling since modelers can have fuzzy visions to the activities linking (which activities should be chosen) and even to assign the activity to the appropriate actors (How can accomplish one activity?)
In the matter that a woman remarks that there is a change in her breast shape, the process of BC treatment will be triggered. A breast cancer specialist discusses with her, relevant to her situation, about the protocols of BC treatment and makes the appropriate treatment decision. Related to the decision, the patient participates in a clinical trial and here a medical report check must be performed. In accordance with the results of medical reports, there are three choices related to some conditions (i) no treatment at all, (ii) stop the treatment, (iii) takes a treatment. In the last case, sub-processes can take place involving different actors. Chemotherapy treatment involves a chemotherapist or medical oncologist, radiation treatment involves radiation oncologist, surgical treatment involves a surgeon and other treatments. As an example, in the above description, for the activity related to choice a treatment, the modeler can allocate it to a chemotherapist, medical oncologist or radiation oncologist. Here, three different roles can be constructed in the business

[1] www.cancer.org

Fig. 1: Modeling requirements of Breast Cancer Treatment Protocols.

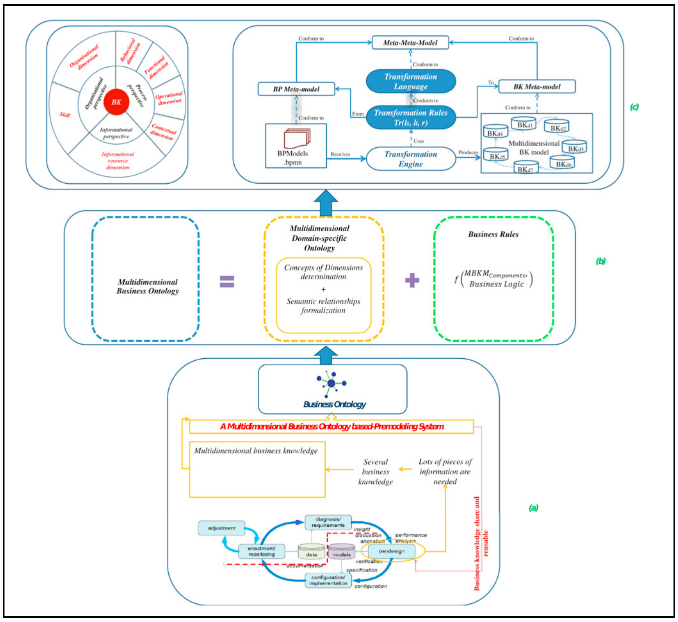


process model to lead to semantic ambiguity in answering the question of textit "Who executes what?" The multidimensional proposed approach helps modelers to separately have the needed piece of knowledge, intending to shut off the semantic gap between the modeling requirements and perception of process modelers.

3. MBO: A Multidimensional Business Ontology

Business processes play a crucial role in the organizations given that they represent the manner in which work is organized, coordinated, and focused to produce a valuable product or service. In fact, to be more competitive and to react as fast as possible to the clients' requirements, the organizations give more importance to the management of their business processes. Indeed, the business process management (BPM) refers to methods, techniques, and tools that support the design, management, and analysis of business processes that are the different levels of BPM life cycle [5]. In addition, when treating with these levels, designers must deal with many pieces of information in order to well represent the activities to improve the overall performance of the organizations. Furthermore, the key-idea is to create business process models so as to be share and reusable when needed. In this way, problems of understanding are provided because designers have not the same visions and ideas. Simply, they have different skills, manner of understanding and explaining given that this is graved in their memory and their work habits. In fact, this diversity of skills and manner can product lots of problems in an understanding level. Hence, our approach is considered as a solution to limit modeling problems. Figure 2 summarizes the main issue and the presents the proposed solution. The key objective of our proposed solution is to facilitate the designer's tasks by making at their disposal A Multidimensional Business Ontology based-Premodeling System (*MBOPS*). The core of the MBOPS is a Multidimensional Business Ontology (MBO) since ontology provides a much appreciated-semantic significance for specific domain, thanks to their ability to share and reuse pieces of knowledge. Business domain is such a delicate domain. [6]. In the scope of the ontology, the main role is to describe knowledge using terms definitions and axioms related to a specific domain that has ever been investigated and analyzed for conceptual modeling [7]. MBO is divided into two phases as demonstrated in figure 2. Phase 1 addresses the construction of a multidimensional domain-specific domain and phase 2 addresses business rules elaboration. Concerning the first phase, business process models are employed to capture business knowledge and divide them into dimensions organized around the business process key-perspectives. To formally present these dimensions, a model to model (M2M) transformation is applied to formalize concepts of each dimension and

Fig. 2: The Proposed Approach.



express the existing relationships between [8]. These multi-dimensions are responsible to represent different pieces of work. Summing up, the MBO is a combination between a multidimensional domain ontology and a set of business rules.

Definition 1 : Multidimensional business ontology is defined as a set of formal definition of multidimensional domain-specific ontology (MDO) and a set of business rules (BR). MDO represents dimensions of knowledge related to a specific domain. BR is a reasoning resulting from MDO components expression in function with business logic [9].

$$MBO ::= \sum(MDO, BR)$$

Constructing a domain specific ontology from scratch by hand, or from textual description is not such an effortless task to realize, especially when talking about multi-dimensional knowledge. For this purpose, existing business process models are an interesting support to extract the key business concepts and to explicit the exiting relationships.

3.1. Multidimensional Domain- Specific Ontology

A domain ontology or domain-specific ontology, as Gruber was defined it, is a collection of vocabularies and the specifications of the conceptualization of a given domain. By definition, the domain ontology provides to model a specific domain describing a part of the world. It represents the particular meanings of terms as they apply to that domain [10].

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As it is on view in figure 2(b), MDO is split-up to two key-directives. Determination the dimension concepts and formalization the semantic relationships. The capture of, both, concepts and relationships based on BP models, MDO should be presented as a model. In this direction, when processing existing business process models, several dimensions of business knowledge can be retrieved. Each of which carries significations so as to clarify the business process modeling. In this matter, seven dimensions of business knowledge are defined [8] notably, the organizational dimension, the informational dimension, the functional dimension, the operational dimension, the conditional dimension, the behavioral dimension and finally the skill. These dimensions are organized around the three-key business process perspectives as it is depicted in figure 2(c).

$$BK = \{Fun\_K,\ Op\_K,\ Beh\_K,\ Con\_K,\ Org\_K,\ SK,\ InfR\_K\ \}$$

In essence, a transformation has been proposed in [8] founded on a model to model transformation in proposing a Multidimensional Business Knowledge Model (MBKM). The MBKM represents each dimension with their related business concepts. So, the transformation had been based on a mapping among a set of BPMN models to determinate their MBKM corresponding in a meta-modeling level [11] as it is depicted in figure 2(c).
Definition 2: MBKM is defined as a set of Business Knowledge (BK) that are, in turn, a set of business concepts (BC) and a set of semantic relationships (SR).

$$MBKM = \textstyle\sum_{i=1}^{n} BK.$$
$$BK = \textstyle\sum_{j=1}^{m} BC + \sum_{k=1}^{l} SR$$

Semantic relationships (SR) have an important role as much as the business concepts due to their logical-link description between the different concepts. The SR determination is absolutely logic and semantic task for which a misunderstanding of the business domain can lead to many modeling problems. In this matter, flowing the same directives of BC determination, we opt to a model to model transformation based on the BPMN existing models. Besides, referring to the BPMN meta-model, the connecting objects especially the sequence flow on the one hand, and on the other hand, the flow objects are the key elements of which we have used to detect the semantic relationships. In studying the BPMN elements, we have remarked that each element has one or more incomingport and one or more outgoingport except some event types like start event and the end event. For that, in referring to the description of the elements' ports, each outgoing port is closely related to an incoming port and vice versa. In follows, we outline some semantic relationship determination.

- *Event corresponding semantic relationship:* Concerning the Event, in this research, we have chosen to be limited to respectively present the start and the end event related semantic relationship among the 51 types of event in the BPMN.
  E is an event, Bc is a business concept, Se is a Start event, Se is an end event and act is a business process activity. If the Event E has only an outgoingPort then E is a Start Event SE.

  If the Se.outgoingPort is corresponding an act.incomingPort then
  Create a Semantic Relationship SR where the SR.name is "*Trigger*".
  The SR.source element (Domain) is the BC related to Se and
  The SR.target element (Range) is the BC related to act.
  SR is $\mathrm{BC}_{Se}\,Trigger\ \mathrm{BC}_{act}$

  If the Event E has only an incomingPort then E is an end Event Ee.

  If the Ee.incomingPort is corresponding an act.outgoingPort then
  Create a Semantic Relationship SR where the SR.name is "*End*".
  The SR.source element (Domain) is the BC related to act and
  The SR.target element (Range) is the BC related to Ee.
  SR is $\mathrm{BC}_{Ee}\,End\ \mathrm{BC}_{act}$

- *Sequential semantic relationship:* The business process elements are related together using connecting objects. Moreover, the key connecting-object element is the sequence follows which are defined as substantial links within a process. The Sequence flow ensures the connexions between the BPMN elements,

whether between activities themselves, activities and gateways and even gateways themselves. Based on the same principle of the communicating port in addition to a specific sequence flow description (targetRef and sourceRef), we outline the manner in which the SR is de terminated.
act is a business process activity and SeqF is a BPMN sequence flow.

If SeqF.targetRef is related to act then For all activities in the process do
If act_i.outgoingPort = SeqF.sourceRef And act_{i+1}.incomingPort = SeqF.targetRef then
create a Semantic Relationship where SR.name is "*Follow*"
The SR.source element (Domain) is related to the $BCact_{i+1}$
The SR.target element (Range) is related to the $BCact_i$
SR is $BCact_{i+1}$ *Follow* $BCact_i$

3.2. Business Rules

The execution of business logic is missing in MDO, which makes it a static representation of specific business concepts and their relationships. The business logic is expressed throughout a set of business rules [12]. Business rules are high-level structured declarations that provide a good way to constrain, control and influence a business aspect. Also, that can decrease or increase the risk impact, and even, make rational decisions [13]. In bellow, we have chosen to simply present different segments of business rules separately to facilitate their presentation, their readability, and their understanding. Table 1 resumes some business rules.

4. MBOPS: A Multidimensional Business Ontology based-Premodeling System

Implementation. At this level, we depict the implementation phase of the proposed environment which mainly contains three modules for which we will detail their operation, defining the technical choices of their realization, and the used API. MBOPS is a design-helping system dedicated to business process designers. MBOPS, based on business ontology, gives a business vision semantically clear and rich. As figure 3 depicts, it is a three-module system that the first one is Filling Ontology, the second is Rule execution and the third is Premodeling of BP.

- *Filling Ontology module*: The main functions of this module are access to the population interface of concepts from the process perspective, from the organizational perspective and equally from the informational perspective. The purpose of the module, with the various interfaces, allows designers to add new instances as they go when they consult MBOPS for the modeling of their business processes. Indeed, the process of filling in the knowledge base interface starts with choosing the business process perspective, secondly, selecting the knowledge dimension, and third, choosing the concept that the designer wants to add. For implementing new instances to the ontology, we have chosen Protégé [2] that is automatically applied in this module. Protégé, is considered as the most used ontology editing environment that provides the ontology management notably the ontology building [14]. It provides an easy way to create new classes, manage instances and even define properties [15]. Java and API-JENA are applied to implement this module[3].
- *Rule Execution module*: The main function of this module is to access to the list of business rules already defined in order to allocate for each dimension the possible logic combination, as an example the list of activities with the necessary role to carry out each activity. The used language to execute this module is the SWRL (Semantic Web Rule Language) [4]. SWRL is a W3C standardized language

[2] https://protege.stanford.edu/
[3] https://jena.apache.org/
[4] http://www.w3.org/Submission/SWRL/

Table 1: Example of the Business Rules.

Rule	SWRL Syntax	Description
R1	activity(?a)∧ realized_ by(?a, ?act)∧ actor(?act)∧ have_ skill(?act,?r) → necessite(?a, ?r)	If an activity (a) is realized by an actor (act) and the actor plays a specific role (r) then the activity (a) necessitates the specific role (r) to be accomplish
R2	informational_ resource (inf?)∧ used_ by(?inf, ?act)∧ realized(?act, ?a) → participate(?inf, ?a)	If an informational resource (inf) is used by an actor (act) that consumes it to realize an activity (a) than the informational resource (inf) participates to accomplish the activity (a)
R3	activity(?a)∧ is_ linked(?a, ?cor)∧ unconditionnal_ coordination_ pattern(?cor) ∧ be_ linked(?a, ?b)→ followed(?cor, ?b)	If an activity (a) is linked to an other activity through an unconditional coordination pattern (cor) than the unconditional coordination pattern (cor) is linked to an activity
R4	provoke(?c, ?a)∧ is_linked(?a, ?cor) ∧ activity(?a)∧ conditional_ coordination_ pattern(?cor)∧ be_*linked*(?a,?b) → is_ coordianted(?cor, ?b)	if a condition (c) provoke an activity (a) and this activity is linked through a conditional pattern than this coordination must be connected to an other activity
R5	activity (?a)∧ realized_ by (?a, ?act)∧ actor(?act)∧ use(?act, ?inf)∧ infromational_ resource (?inf) → consume(?a, ?inf)	if an activity (a) is realized by an actor (act) that use an informational resource (inf) to accomplish his work than the activity consumes the informational resource
R6	belong(?a, ?p)∧ begin(?p, ?e)∧ start_event (?e) → caused(?e, ?a)	if an activity (a) belongs to a process (p) and this process begins with a start event (e) than this event caused an activity
R7	provoke(?a, ?e)∧ end_ event(?e) ∧ is_ linked(?a, ?cor) → followed(?cor, ?e)	if an activity (a) which provoke an end event (e) and it is linked with a (conditional or unconditional) coordination pattern than the coordination pattern is followed by an end event
R8	atomic_ activity(?at)∧ equivalent(?at, ?o)∧ trigger(?o, ?c)∧ condition(?c) → provoke(?c, ?at)	if an atomic activity (at) is equivalent to an operation (o) and this operation triggers a condition (c) than the activity provokes the condition

that allows at defining OWL rules (Web Ontology Language) [5] concepts to provide deductive reasoning capabilities [16]. In this research, Pellet reasoner has been used to run the rules since it is an inference engine. Its role is to deduce the implicit knowledge that is not explicitly expressed in the ontology and to check the coherence of the ontology.

- *Pre-modeling module*: This module tacitly summons the two above modules. It allows the designers to compose their business process models by choosing the event that triggers the process. With simple clicks, the designers select the necessary activities that construct the process with an automatic allocating of the adequate skill necessary to perform each activity, obviously, based on the logical reasoning already made. The result of the combination of the chosen iterations will be transformed to generate

[5] http://www.w3.org/TR/owl2-overview/

Fig. 3: MBOPS Implementation Architecture.

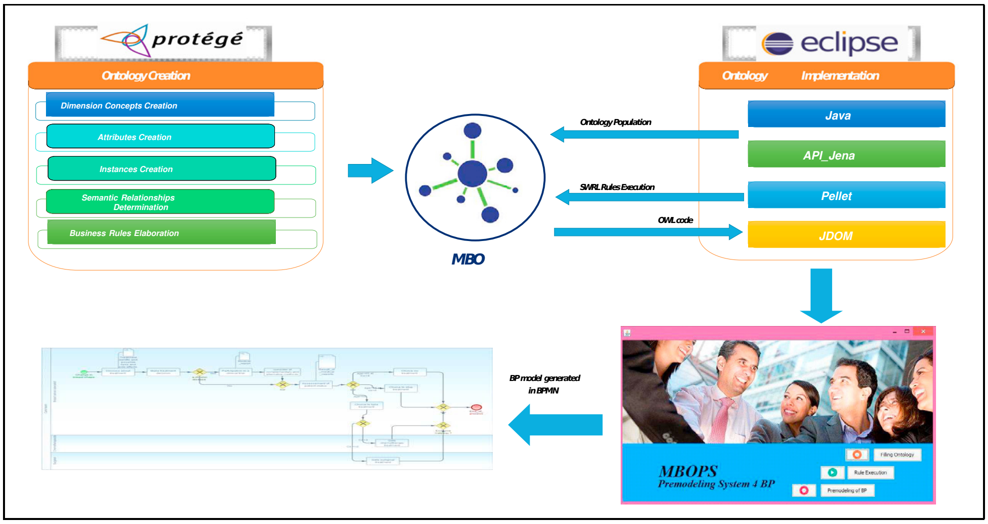
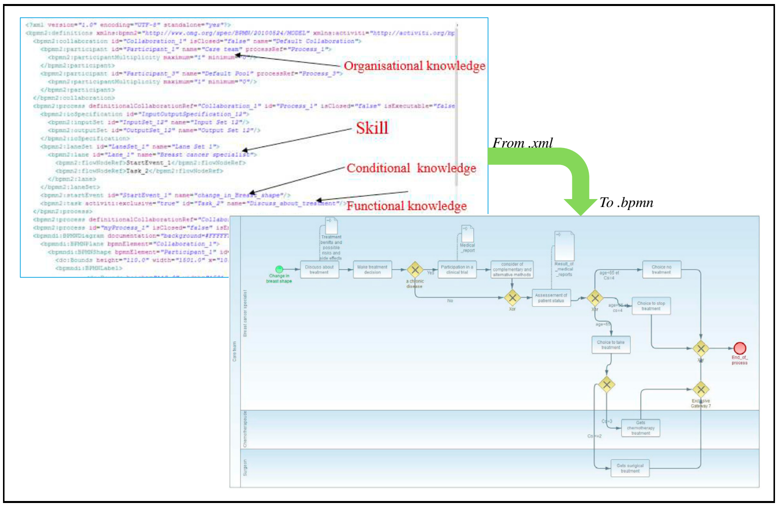


Fig. 4: The generated model.



a file respecting the BPMN format. To do so, the used language is the API JDOM [6]. In this spirit, figure 4 represents the generated model.

Evaluation To ensure the performance of the MBOPS, two-possible evaluations can be performed, whether comparing the resulted models against a collection of processes describing the breast cancer treatment protocols or through direct verification established by medical experts. In regard to the pre-modeling module, we are interested in evaluating the argument made by the ontology and its ability to meet the designer's needs to accomplish its task of modeling by giving as much as possible the right guidelines. In this context, we present a three-part assessment: a quantitative assessment, a syntactical assessment, and a qualitative assessment. Concerning the quantitative assessment, it is related to an MBO evaluation, which gives us the

[6] https://API.JDOM.org/

Table 2: MBO quantitative assessment.

Evaluation Metrics	MBO
No. of concepts	35
No. of object properties	32
No. of instances	80
No. of SWRL rules	28

following numbers in terms of instances for each concept of the populated ontology. The table 2 depicts some numbers in this direction. Concerning the syntactical assessment, the generated model had been executed throughout specific BPM software without errors. Regarding the qualitative, we made use of an oncologist to assess the model generated through our MBO.

5. Related Work

Researches related to business process modeling did not cease ever through the years. The most emphasized interest is that of business process modeling quality improving. Indeed, researchers had been focused their studies on treating the semantic hidden behind the business process models. For that, several approaches had taken part to resolve the modeling ambiguities that designers can meet during the design phase of the business process life-cycle [17]. These ambiguities have two formats whether structural or semantic. Concerning the structural pitfalls, several studies had succeed to resolve this issue but did not succeed to resolve the semantic pitfalls [21] and [22]. On the other hand, other studies had succeed in treating the semantic issues, but their efforts still limited to improve the business process model semantics as an example, we can cite [23], [24] and [25]. Ontologies had evenly contributed to resolve the semantic issues by focusing on domain knowledge modeling for business process management, as an instance, we can cite [26] and [7]. Despite the efforts made in this direction, these researches had, on the one hand, succeed to partially resolve the semantic pitfalls and, on the other hand, unfortunately, they had contributed to facilitating the automation and the verification of the business process models rather than the task of designing them. In this regard, we believe that our solution is unique because it is a bi-directional solution since it deals with, both, structural and semantic ambiguities: structural ambiguities are treated by ensuring an automatic generation of the model and semantic ambiguities are treated by making available at the disposal of the designers a multidimensional business knowledge base.

6. Conclusion and Future Work

The difference of the designers skills and their ability to understand and describe real phenomena, leads to several ambiguities. In this work, we proposed an ontological approach to create a multidimensional business knowledge base so as to help, at an early stage, business process designers in their tasks. Building an ontology for a vast domain as a whole, such is the case of the medical domain, is not straightforward, but likewise we envisaged to build a multidimensional business ontology starting from existing business process models by determining the business concepts and likewise the determination of the semantic relationship. In this spirit, we equally proposed a set of business rules that describe the business logic whose their role is to guarantee the reasonable allocation of the business concept and the semantic relationship. Indeed the MBO has been evaluated using three-type evaluation (i) syntactical, (i) qualitative and (iii) qualitative. Besides, we proposed MBOPS as a framework to ensure the performance of the proposed solution and we chose as an application domain the processes related to the breast cancer treatment. As a future direction, we envisaged, on the one hand, to not be limited to the basic elements of BPMN but to proceed to the treatment of the extended elements of BPMN in order to determinate new semantic relationship. On the other hand, from a practical view, we envisaged to generalize the MBO to support other medical domains.

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