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Extending BPMN Business Process Model with SBVR Business Vocabulary and Rules

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Abstract. Despite the fact that business process (BP) modeling has its long-lasting traditions in various areas of application, this discipline remains in the constant process of improvement and issue-solving. The possibilities of synergy among business process models and business vocabularies and rules are analyzed in this paper. We emphasize the existing gap between business process modeling and specification of business vocabularies and rules. Such a situation may lead to misunderstandings while reading and interpreting business models and also miscommunication issues within and among the organizations. Some of these issues could be resolved by realizing the integration of BP modeling standards with business vocabularies and rules. The paper presents some argumentation to back such statements. Later, basic principles of the approach for BPMN (Business Process Model and Notation) Business process model integration with SBVR (Semantics of Business Vocabulary and Business Rules) business vocabulary & rules are presented and briefly described in this paper.

Keywords: business process; business process modeling; business vocabulary; business rule; SBVR; BPMN; information systems development.

1. Introduction

Competitive and progressive organizations are always on the move – they seek to adapt their organizational policies and procedures to constant changes of the environment. The main success factor of this adaptation is the ability to control processes within the organization. Business process management (BPM) is the core discipline, which allows one to analyze, model, simulate, document and execute these business processes [1]. According to Recker et al. [2], BPM is a top business priority nowadays. It enables the adoption of business processes to the goals of the organization increasing the effectiveness of its activities and ensuring sustained benefits. Next to BPM, Information Systems Development (ISD) is yet another area where BP modeling found its application, and the last decade's hype of various model-driven automation solutions for ISD, especially MDA-based, have finally imprinted BP modeling in ISD life cycle.

There is quite a number of definitions for the term "business process"; in this paper, it is defined as a set of related activities (or tasks) that must be performed together to produce a defined set of results (products or services). Business process is understood as a complex element, performance of which requires the identification of goals, organizational structure, responsibilities, outside agents or customers, data, equipment and other resources. One of the ways to eliminate such complexity is to use BP modeling. Fourth generation BP modeling standards [3] enable users not only to design and see these models from the different points of view, such as organization structure, reciprocity of BP, choreography etc., but also to use this information in other BPM activities, e.g. simulation, computerization or process execution. All this becomes possible because of the formal background of such standards.

One of the newest standards among business process modeling languages is Business Process Model and Notation (BPMN) developed by OMG group [4]. It represents the objects of the real world and seeks to eliminate the existing gap between modeled real world business processes and computerized processes; moreover, it narrows the communication gap between business people and IT experts. According to the researches carried out by different

scientists and practitioners, BPMN models the dynamics of business processes in a very proper way, however, there are some critical aspects of business that still need to be improved in BPMN-based business process modeling – from our point of view, extensive integration with business vocabularies and constraints should be among the top priorities here.

For this reason, BP modeling should be extended with new features for the identification (and, possibly, modeling) of such business entities as business terms, facts and constraints. Business constraints describe the conditions of BP execution with different level of complexity (restrictions, initiations, inhibitions) [5]. Basically, the term "constraint" falls under the broader understanding of so called business rules (BR), which define the semantics of business concepts, reactions to business events, constraints and preconditions on tasks and activities, as well as the rights and obligations of business actors. In other words, business rules guide and constrain various aspects of business, including the sequence and timing of activities [6].

The semi-structured interviews and the global survey made by Recker [7] confirmed that business people and IT professionals indeed have a great need to specify business rules in their process models. Nowadays, a common practice is to define business rules separately with a very loose (if at all) synchronization with business process models, goals and other formal models of the actual organization. Practice shows that BR are usually defined in a form of unstructured natural language and augment other models, including business process models, in a form of comments [8]. It obvious that such unstructured business knowledge cannot be passed to the next stages of BPM (e.g. for business process model execution) or communicated unambiguously within or outside the organization.

Several authors have offered their methods (Section 2.5) how to integrate business rules with BP models. However, some unsolved issues still remain, e.g. the absence of business vocabulary to synchronize business terms in such models [9], the absence of consistent integration of the extended BP models with the whole BPM life cycle, the lack of guidance on how BR must be identified and captured, moreover, the definition of business rules in real business environments becomes too complex for business experts to handle [10]. The main driving factor for the business rules and business process models integration is to let business experts define BR by themselves and at the same time to ensure that these constraints will be formal and integrated enough to pass them to the next stages of BPM life cycle. In this paper, some basic principles of the method for SBVR (Semantics of Business Vocabulary and Business Rules) business vocabulary & rules integration into the BPMN BP model are presented. With support of certain computerized tool, such a method ensures the synchronization of BP model with formally defined business vocabulary & rules and allows one to perform consistent transformations of the extended BP model to the next levels of BPM or ISD.

The paper is structured as follows: Section 2 presents a brief overview of the existing challenges and trends in the area of BP modeling and the basic philosophy behind the business rules; also, certain aspects of BP modeling and BR integration in the context of OMG's Model Driven Architecture (MDA) [11] are discussed in Section 2. Later, the existing issues in this area are identified and linked to the Section 3 where the principles of the proposed method are presented and discussed. Section 3 is composed of two subsections addressing two basic stages of the method. Conclusions and future work are presented in the Section 4.

2. Integration of business vocabularies & rules with business process models: background and premises

2.1. Challenges of Business Process Modeling (with regard to Business Vocabularies & Rules)

Business process modeling is the first stage of BPM Life Cycle. The other stages are System configuration, Process enactment and Diagnosis. These are the names of the BPM life cycle stages given by van der Aalst [12], and it should be mentioned that the stages can be named differently by different authors; nevertheless, the true meaning behind the names remains the same. Process modeling is a common technique which is widely used within organizations to identify, accumulate, structure, visualize and perceive the knowledge behind business processes and to use that knowledge for very different purposes within the life cycle of BPM as well as ISD. The models are not only the background for simulation, but they also increase the understanding of the business, its goals, allow to prepare technical requirements if it is necessary, experiment with the integration of new concepts in the processes etc. [13], [14].

Probably one of the main challenges of BPM is to ensure the compliance of the modeled processes to the processes of the real world. The user can choose the level of abstraction of the processes under scope. A process can be modeled on the high level of abstraction, however, in most cases there is a need in detailed, formal specification of such process showing its decomposition and relationships with other elements of the whole business model.

In order to prepare a detailed business process specification, a user has to work with both static and dynamic aspects of the process. While talking about processes, modeling of activities (tasks), control flows, decision points and other artifacts representing dynamic aspect always plays a major role. However, static aspect cannot be left aside either as this is where the main business entities, their structure, relationships and constraints are specified, and that is what forms the core of a Business vocabulary. At this point one

basically faces two interrelated issues that exist in the common practice of BP modeling today:

- There are no tools and techniques that would allow one to identify and formally specify business entities during the dynamic aspect modeling process, i.e. well-structured business vocabularies (static aspect) are left aside from the processes (dynamics of the business model);
- During the business process modeling, there is also no possibility to formally and fluently specify business constraints that incorporate business entities from such vocabularies and are enforced on the business processes that are being modeled. Usually, if at all, such constraints are presented as some loose, natural language-based textual comments next to some element of the business process model.

In other words, the most effort is mostly put into dynamic aspect of the model and this is the right thing to do, however, all the common practices of business process modeling lack the ability to formally define business vocabularies & rules and associate them with particular elements of business process models in the same modeling environment. In its turn, this negatively affects the possibilities to extensively use such business process models in other activities of BPM or even ISD (assuming that BP model is a starting position in the ISD life cycle).

After defining these issues the answer comes on itself – there is a must to integrate business vocabularies & rules with business process models and assure some computer-aided support for it. Some work [6], [10], [15] has already been done in this direction and it will be briefly overviewed further in this paper.

2.2. BPMN – OMG's standard for business process modeling

While talking about graphical modeling standards in general, the acronym of Object Management Group (OMG) and the whole set of its well-known standards comes into mind first of all. Not that long ago OMG had quite poor positions in the area of business process management and in business process modeling in particular – probably the only suitable solution for that matter was UML with quite limited extension possibilities. However, on the second half of last decade OMG released a whole set of its initiatives such as BMM, BPDM, BPMM which allowed OMG to gain some firm grounds and acknowledgement in BPM community. Of course, the most widely cited, implemented and practically used OMG's BPM standard is BPMN (Business Process Model and Notation) [4].

The primary goal of BPMN is to provide a notation that is understandable by various people with very different expertise: business analysts who model real world business processes, IT experts who are responsible for the implementation of the processes, and finally business people who will manage and monitor these processes or work according to the given instructions (expressed via business process models). The main diagram of BPMN is a Business Process Diagram (BPD), which allows defining the process, its execution circumstances, some simple constraints, responsible actors and also to simulate the modeled process [4].

Despite the solid performance of BPMN, Unified Modeling Language (UML) is also quite widely used for business process modeling purposes, especially in IT projects. Even though UML is a graphical modeling language that can be and still is used to model processes, its basic area of application is information systems modeling [16]. Highly extensible UML 2.0 (and its newer versions) in some cases can also be treated as a disadvantage because it does not formalize the semantics of its extensions, i.e. newly added concepts, which are used in BP modeling, thus leading to incomplete or even incorrect models [17]. Compared to BPMN, information systems modeling-oriented standards (like UML, IDEF) also lack sufficient expressiveness; moreover, such languages hold a number of concepts, constructions and rules that can be treated as excessive for business process modeling needs [18].

Analysis of Bunge-Wand-Weber ontology [19] also showed that compared to other BP modeling languages BPMN covers the largest amount of real world concepts and is well-understood and accepted by business experts [17], [19]. The survey made by Wahl and Sindre [21] also indicated that BPMN is clearly understandable and well-suited for business process modeling. According to the survey of BPMN application in companies [7], the main reasons of using it are: documentation of organization; redesign of the organization; knowledge management; supporting continuous process management; requirements specification for software development.

Also, BPMN fluently integrates into Model Driven Architecture, which is quite a buzzword in so many R&D discussions at the moment. Needless to say that MDA is widely accepted standard by CASE tools developers, and that encourages the use of BPMN even more. Integration of BPMN into MDA is achieved via the meta-meta-model (Meta Object Facility – MOF), which is common with other OMG modeling standards, and is supported by OMG's constant efforts to integrate their standards on all levels of IS development. From MDA perspective, BPMN diagrams are a part of system's Computation independent model, also known as Business model.

It should be noted that the advent of BPMN forced other standardization organizations such as Workflow Management Coalition to revise and incorporate their standards with BPMN [7]; this gives additional credits for broader and more intensive adoption of BPMN in various areas of application.

2.3. SBVR – OMG's standard for modeling business vocabularies and rules

Depending on the area of application, business rule (BR) concept has quite a number of definitions. In the context of this paper, we will define BR as a logical statement that defines or constrains some aspect of the business in the concrete situation [15]. Despite the chosen definition or BR classification schema, Business Rules Manifest [22] defined that a BR has to possess certain characteristics – it has to be atomic, precise, declarative, reasonable, complete, substantial, consistent, accessible, traceable and business oriented. Yet again, this may seem somewhat arguable depending on the area of practical application of BRs; however, the argumentation of BR Manifest is out of the scope of this paper and will not be discussed further.

Speaking of areas of practical application of BR one should mention business process management, information systems development [23], [24], semantic technologies [25], artificial intelligence technologies [26] etc. Naturally, business rules are being expressed in a variety of forms and languages depending on the selected area – one can find rules buried straight into information system's executable code or database triggers [27], expressed in executable rule language of some business rules management system (such as FICO Blaze Advisor or IMB Ilog) [28] or simply written down as unstructured natural language text. It must be pointed out that neither of these forms is suitable for the use on the level of business process modeling, and this is exactly the place where business rules should be identified and formally specified by business experts or system analysts. At this level, business rules must be specified in a language, which is: well-structured and formal enough so that one could specify rules unambiguously and use these specified expressions in model transformations, rule exchange, execution and other activities alike; easily comprehensible and usable by business people who are the true owners of BR.

Practice shows that business people and even information systems developers tend to express business rules in some natural language statements followed by some loose list of common terms and definitions. During the last decade, people from Business Rules community (http://www.brcommunity.com) such as R. G. Ross, B. von Halle and other scientists and practitioners tried to formalize the way business rules had to be gathered and specified [8], [15], [29]; however, all these efforts neither brought a significant impact on the common practice of BR specification nor they bridged the gap which existed between business process modeling and business rules specification.

By that time, OMG joined forces with many from BPM and BR communities and in 2008 released "Semantics of Business Vocabulary and Business Rules" (SBVR) standard [30], which was welcomed by both business and IT sectors. The vision SBVR is to express business knowledge in a controlled natural language, which would be unambiguous and understandable to humans as well as computer systems.

From the MDA perspective, business vocabularies and rules (constraints) have to be defined at CIM level of MDA, i.e. in parallel with business process modeling. Indeed, both BP management and BR management focus on the improvement of organizational efficiency and effectiveness, but as technologies they have evolved separately [31]. Needless to say that formal "Business process model ↔ Business vocabulary & rules" (BP↔BV/BR) integration methods as well as their implementations are very welcomed.

SBVR is fully integrated into the OMG's Model-Driven Architecture via Meta Object Facility (MOF) or Eclipse Metamodeling Framework (EMF). Few years ago, our research group finished a state-funded R&D project *VeTIS*[1], which resulted in some theoretical as well as practical outcome. The main practical result of the project was *VeTIS* tool [32], which realized automated transformations of SBVR specifications (i.e. Business Vocabularies and Rules) written in SBVR Structured English into SBVR 1.0 XMI format and subsequently – into the UML class models with OCL constraints (in EMF UML 2.1.2 XMI). The project showed that it is possible to integrate SBVR with other OMG standards and make business knowledge transformations not only in theory but also in practice. This was yet another reason to choose SBVR over other business rules specification languages to integrate with BPMN. More argumentation on this subject is presented in Section 2.4.

2.4. Current situation in the area of BP↔BV/BR integration

Over the last decade, business rules became a very relevant subject in the area of BPM. Many come to an agreement that BPM and BRM should not be treated as competing but rather as complementary technologies Business rules are now acknowledged as a critical component in BPM R&D activities, due to the need to ensure the maximum flexibility and configurability of business process execution/monitoring solutions. Of course, modern standards-based BP↔BV/BR solutions could be implemented in many more areas of practical application [32], [34] (Fig. 1).

In order to effectively integrate business vocabularies & rules with BP models, the compatibility of BR and BP concepts must be assured. Early experiments to integrate business rules and business processes started few decades ago. One of the first research works on this subject was some business rules methodology published by Krogstie et al. in 1991 [35]. Later, there were a number of various BP-BR

[1] Lithuanian State Science and Studies Foundation High Technology Development Program Project "Business Rule Solutions for Information Systems Development (*VeTIS*)". Download *VeTIS* tool from www.magicdraw.com.

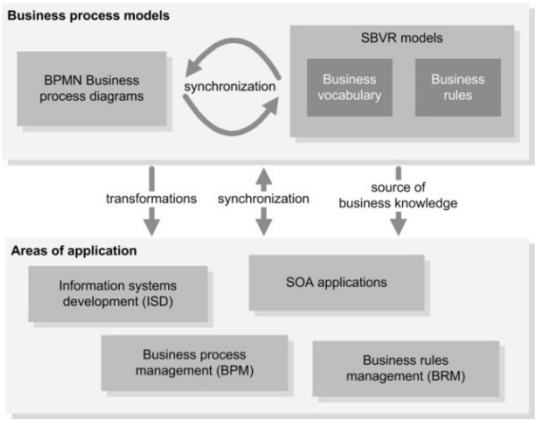

Figure 1. Basic areas of application for the BPMN Business process diagrams enriched with SBVR business vocabularies and rules

integration-oriented research initiatives undertaken in various areas of application [36], [37]. However, taking into account the scope of this paper, research works of the most interest were undertaken after the advent of OMG's business modeling-oriented standards (BPMN and SBVR in particular). Vanthienen and Goedertier proposed an approach to implement SBVR business rules into business processes management life cycle using a service-oriented architecture (SOA) [6], [366]. They presented the architecture, which consisted of three layers: business rules and business process layer, services and components layer, application layer. Ali et al. [38] described business rules as separate model used as an integral component of BP modeling; business processes were defined, arranged and are directly depending on the business rules model. Milanović et al. [39] offered to integrate BPMN with R2ML. They developed a new modeling language rBPMN (Rule-based Process Modeling Language). The main idea of this proposition was to extend some existing elements of BPMN with the BR property. Zhao et al. [40] analyzed semantic programing language (SPL) to facilitate the orchestration of semantic web services (SWS). They offered a method to integrate BR and business processes using SWS.

The latest research made by Muehlen et.al. [19] confirmed that BPMN has more accurate adequacy to the concepts of the real world processes, compared to Petri Nets, IDEF3 and EPC (Event-driven Process Chains). The background for this analysis was Bunge Wand Weber (BWW) ontology [41]. The same analytic principles were used to identify the over-lapping of business rules standards (SBVR, SRML) with Petri Net, IDEF3, EPC and BPMN. The results showed that combinations of BPMN with SRML and BPMN with SBVR provided users the best represen-tation power of business processes with minimum overlap [31]. Another fact mentioned in their investi-gations is a common organizational practice to write business rules in a form of textual annotations in business process models. However, business people as well as other interested parties have to get used to model these constraints using appropriate BR standards to increase the effectiveness of BR in various application areas.

The research brought by the authors of this paper is closely related with the work of Muehlen et al. as both groups of authors try to integrate BP and BR concepts in a single business process diagram and also interpret these two as equally important, fully manageable concepts. The research presented in this paper can be viewed as a certain augmentation to the Muehlen et al. approach in order to eliminate some of the yet existing issues presented in Section 2.1 and also to present some implementation aspects of such approach.

3. Basic principles of BPMN business process model integration with SBVR business vocabularies & rules

3.1. Mapping of BPMN and SBVR meta-models

Basically, there are few possible ways to realize the integration between models, which are based on two different meta-models:

1. Merge together the existing meta-models into one base meta-model and use it for the development of new merged models;
2. Select one of the existing meta-models and enrich it with the required meta-elements referable to the second meta-model. A link among newly added meta-elements and the original meta-elements of the second meta-model should be assured to maintain synchronization (this can be done by using common naming system or other means);
3. Leave the original meta-models as they are and develop supplementary mapping data structure, which would realize the link between those two meta-models. Any enrichment of the original model (e.g. BPMN BP diagram) with additional information (e.g. visualized business rules) would be realized via existing graphical and attributive elements by adding additional interpretation logic of those elements into the implementation of the solution itself.

One could say these approaches differ in strength of integration each having their own weaknesses and strengths, which will not be discussed here. In our case, the third approach was chosen to realize the BP↔BV/BR integration because of the decision to keep the existing SBVR and BPMN meta-models untouched. Even slight modifications of widely-accepted meta-models, such as SBVR and BPMN, will significantly narrow the area of practical application of such solution. Earlier mentioned *VeTIS* project as well as other practical experimentations

with the CASE tool *MagicDraw UML* proved the success of such integration approach.

In our suggested BP↔BV/BR integration approach, BPMN meta-model is linked with SBVR meta-model by mapping certain elements of one meta-model with the corresponding elements of another meta-model via supplementary mapping data structure. Basic principle of such integration is presented in Fig. 2.

Theoretical research as well as practical experimentation with certain BPMN and SBVR models allowed us to identify the mapping sets of elements on meta-models' level (Table 1). In the presented matrix, "x" symbol means that a certain element type from BPMN meta-model has its correspondence (or can be additionally specified) with some element type from SBVR meta-model. In other words, if the intersection of a certain BPMN element type *A* (e.g. *Activity*) with some SBVR element type *B* (e.g. *Fact Type*) is marked with "x", then a mapping pair "*A*↔*B*" is embedded on a meta-models mapping level. For example, from the mapping matrix, one can state that some activity from a BP model (i.e. BPMN element type *Activity*) may have certain SBVR noun concepts, fact types and rules associated with that activity. In Table 1, entries marked with "-" indicate that there is no mapping between the certain element types from SBVR and BPMN meta-models.

A set of "*A*↔*B*" mapping pairs can be viewed as a set of BP↔BV/BR mapping rules. These mapping rules are passed down to the modeling level where the instances of the *Mapping class* (Fig. 2) are being created during the process of BP modeling. In the instance *O(i)* of *Mapping class*, certain BPMN element type *A* is stored in *BPMN_Elem_Type* and SBVR element type *B* – in *SBVR_Elem_Type*, respectively. Then, instance of *A* (e.g. "Register Order", which is of BPMN element type *Task*) and *B* (e.g. "Order", which is of SBVR element type *Noun concept*) are stored in *BPMN_Elem_Name* and *SBVR_Elem_Name* of *O(i)*, respectively.

There can be no such instance of *Mapping class* where the pair values of *BPMN_Elem_Type* and *SBVR_Elem_Type* of the class instance would not correspond to some pair from the predefined set of "*A*↔*B*" mapping pairs.

Let us assume that a "Supplier" performs some *task* named "Register Order" (Fig. 5). Following our approach, two SBVR Business vocabulary concepts will be associated with the *task* "Register Order": a *noun concept* "order" and a *fact type* "supplier *registers* order"; in its turn, an *actor* (which is embedded into *lane* in BP diagram) "Supplier" will be associated with a *noun concept* "supplier" and also with a *fact type* "supplier *registers* order" from SBVR Business vocabulary.

In case SBVR model already exists before the development of BPMN Business process diagram, business user may be interactively prompted by the system to reuse fragments of business knowledge from the existing SBVR specification, e.g.:

- Select a *noun concept* "customer" as a name for a certain *l*ane in process diagram (thus reusing the already existing business concept);
- If the user specified *data object* "Order" on his own, prompt for an automatic mapping of this *data object* with SBVR *noun concept* "order", which was already specified in business vocabulary;
- When naming the *task* "Register Order", interactively prompt to use certain keywords (in this case, "Order");
- *Synonyms* and *synonymous forms* of *noun concepts* and *fact types* would also be put into use; e.g. BPMN *data object* "Order", which was mapped with SBVR *noun concept* "order", could be mapped with "product_order" and other synonyms of "order" specified in business vocabulary.

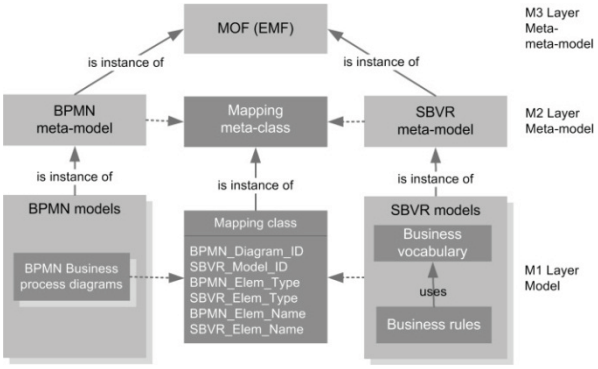

Figure 2. The principle of BPMN-SBVR integration in OMG's Model Driven Architecture

Table 1. Mapping pairs of elements of SBVR and BPMN meta-models

BPMN Category	BPMN Element	SBVR Noun Concept	SBVR Fact Type	SBVR Rule
Flow Objects	Event	x	x	x
	Activity	x	x	x
	Gateway	x	x	x
Connecting Objects	Sequence Flow	x	x	x
	Message Flow	-	-	-
	Association	-	-	-
	Data Association	-	-	-
Swim-lanes	Lane	x	x	-
	Pool	x	x	-
Data	Data Object	x	x	x
	Data Input	x	x	x
	Data Output	x	x	x
	Data Store	x	x	-
Artifacts	Group	x	-	-
	Text Annotation	-	-	-

More explanatory examples as well as the basic principles of BP↔BV/BR integration algorithm itself are presented further in this section.

3.2. Implementation aspects of the BP↔BV/BR approach

On technology level, the implementation of the proposed BP↔BV/BR approach may be viewed as an extension to our latest development – *VeTIS* tool [32], which can be used as a stand-alone tool or as a plug-in of the CASE tool *MagicDraw UML*. The main features of *VeTIS* tool are:

1. Input and editing of SBVR Business vocabularies & Rules with syntax validation;
2. Automatic transformation of SBVR models to UML class diagrams enriched with OCL constraints.

At this point, our main objective was to extend the functionality of the *VeTIS* tool by adding extensive BP↔BV/BR integration feature and thus allowing a user to work with SBVR Business vocabularies & Rules in parallel with BP modeling and at the same time keeping SBVR and BPMN models properly synchronized (Fig. 3). *MagicDraw UML* fully supports BPMN-based BP modeling; therefore, SBVR and BPMN modeling activities are fluently integrated under the same working environment.

The approach uses standard MOF/EMF-based SBVR and BPMN meta-models supported by *VeTIS* and *MagicDraw UML* CASE tools accordingly. Mapping rules and interpretation logic is embedded into BPMN-SBVR synchronization plug-in (Fig. 3).

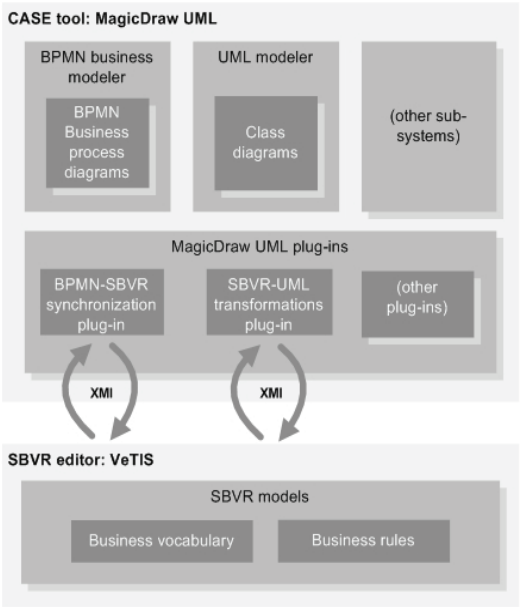

Figure 3. BPMN-SBVR integration using *MagicDraw UML* and *VeTIS* tools

Linking of BPMN elements with SBVR specification is realized via common element *Text Annotation* attaching specific stereotype <<*SBVR*>> to it; <<*SBVR*>> is a custom stereotype created for this approach (Fig. 4). There may be more than one SBVR entry attached to one stereotyped <<*SBVR*>> text annotation. Double-clicking on such stereotyped text annotation opens a list of SBVR entries associated with the particular BPMN element in *VeTIS* GUI window (Fig. 5), from which those entries may be viewed and edited. Data exchange (import/export) between *MagicDraw UML* and *VeTIS* is realized via XMI format documents.

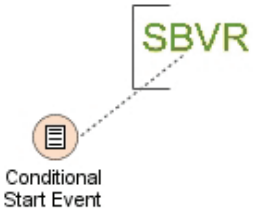

Figure 4. Stereotyped *Text Annotation* type element denoting the existence of SBVR expression(s) associated with some element in BPMN diagram

3.3. Basic algorithm of BP↔BV/BR approach

On the highest level of abstraction, the algorithm of BP↔BV/BR approach is composed of three basic stages (Fig. 6):

- *Stage 1*: Development and integration of Business process diagram and Business vocabulary.
- *Stage 2*: Augmentation of Business process diagram with business rules.
- *Stage 3*: Validation of the developed overall Business model with business domain expert.

In Fig. 6, the three stages are shown as consecutive steps and such is a standard process of BP↔BV/BR integration. However, these stages are quite autonomous ones and can be processed (or overpassed) in any order – that depends on the specific need of a modeler. For instance, one may need only certain business rules from SBVR model to be linked with some decision points in the BPMN Business process model; in such case, only the *Stage 2* will be executed. On another case, one may need to synchronize business terms used in business process model with the existing business vocabulary – then the *Stage 1* will be executed and, maybe, the *Stage 3* will also be undertaken to validate the result with the expert of business domain.

Further, *Stage 1* (Fig. 7) and *Stage 2* (Fig. 8) will be presented in more details; some aspects of the algorithm will be illustrated using a simplified BPMN Business process diagram (Fig. 5).

In this paper, *Stage 3* is assumed as a straightforward process of Business model validation with business domain expert, therefore, will not be elaborated and discussed any further.

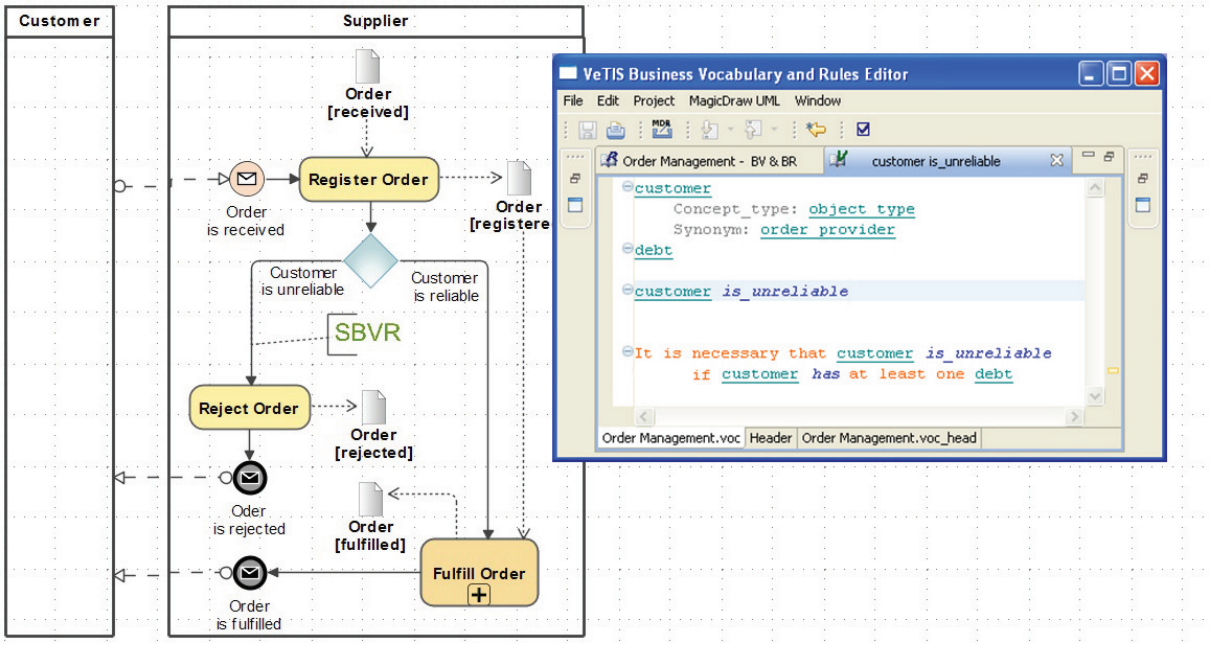

Figure 5. GUI window of *VeTIS* editor called out by clicking on the stereotyped <<SBVR>> text annotation in BPMN BP diagram (in the *MagicDraw UML* CASE tool environment)

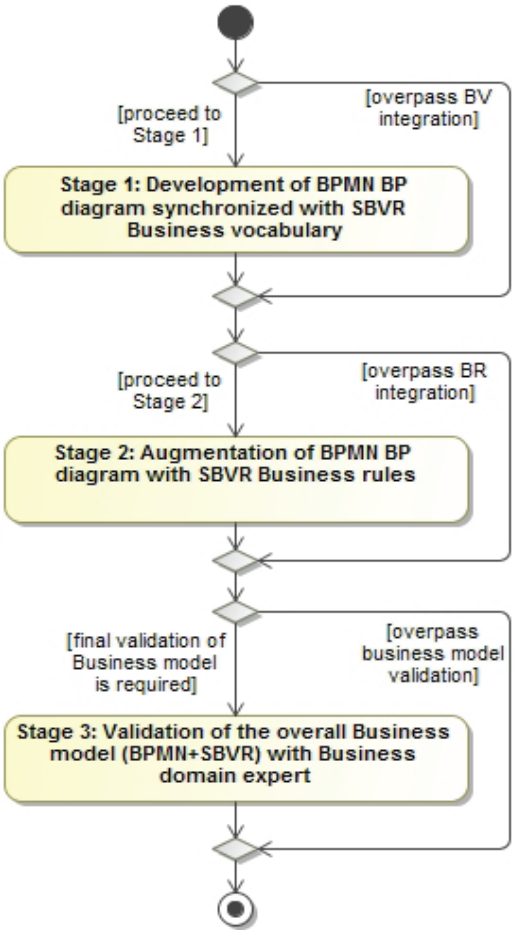

Figure 6. Basic stages of the algorithm

Stage 1 of the algorithm is about the development of BPMN Business process diagram synchronized with SBVR Business vocabulary (Fig. 7). A brief description of this stage is presented in Table 2.

Stage 2 of the algorithm is about the augmentation of BPMN Business process diagram with SBVR Business rules (Fig. 8). Unlike *Stage 1*, the augmentation of BP diagram with business rules is quite straight-forward process. Its basic principle is the attachment (linking) of the existing or newly specified SBVR business rules with certain elements of BP diagram. Business rules are linked to the elements of BP diagram via the stereotyped comments (text annotations). One element in BP diagram may be linked with many business vocabulary entries and business rules via one <<SBVR>> text annotation.

The final stage (i.e. Stage 3) in the algorithm of BP↔BV/BR approach is the validation of overall Business model with business domain expert.

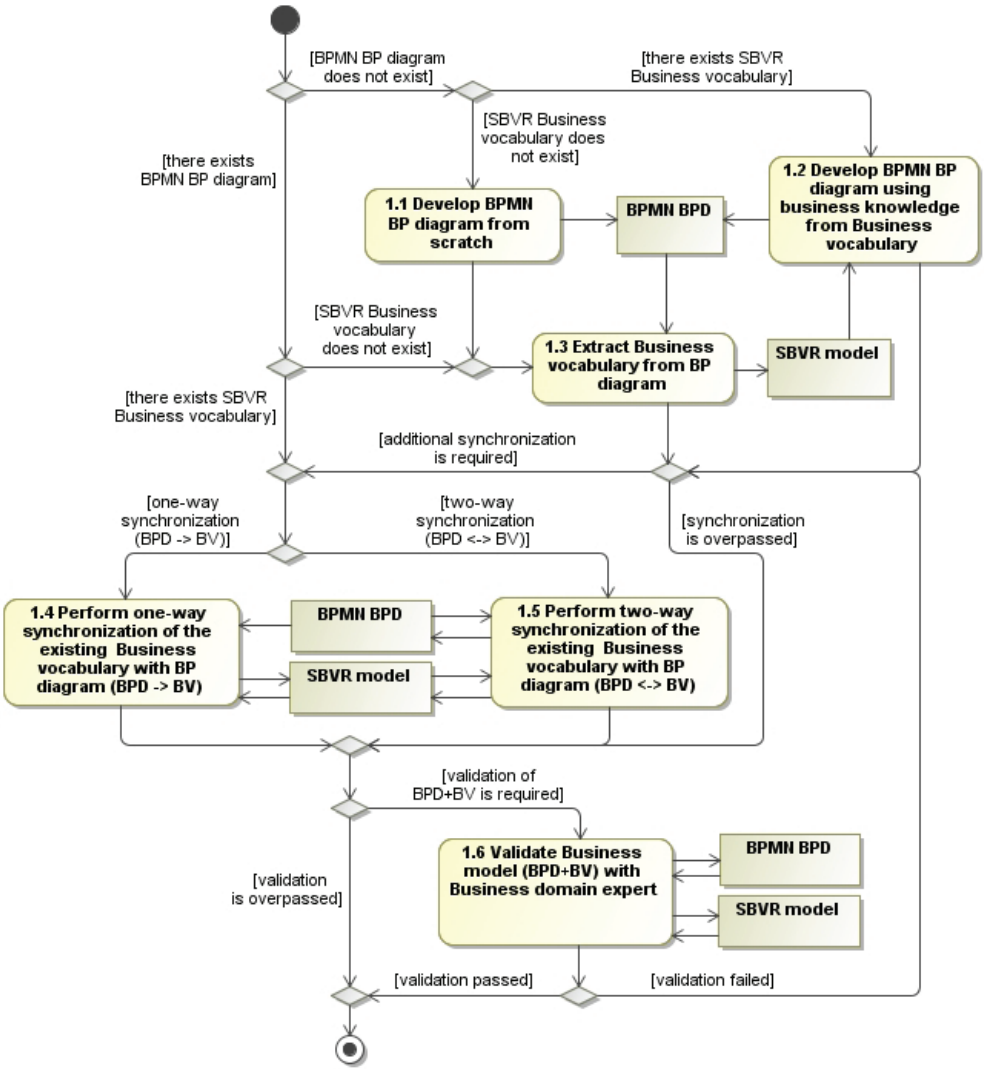

Figure 7. Stage 1: Development of BPMN Business process diagram synchronized with SBVR Business vocabulary

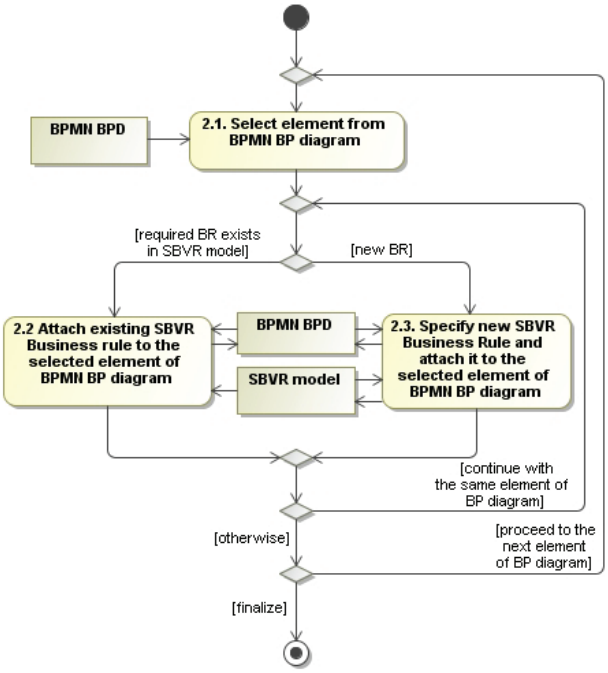

Figure 8. Stage 2: Augmentation of BPMN Business process diagram with SBVR Business rules

Table 2. Description of the Stage 1 (Fig. 7)

Steps of Stage 1	Description
-	There may be several starting positions for the Stage 1: both BP diagram and business vocabulary already exist before the initiation of Stage 1; neither of these exists; one of these exists. Depending on the situation, different branches of the algorithm will be undertaken.
1.1	If neither BP diagram nor business vocabulary exists, a business process diagram is developed from scratch.
1.2	If there is some business vocabulary of the problem domain already developed prior to the development of BP diagram, then the system assists the development of BP diagram by reusing business knowledge stored in business vocabulary and, at the same time, linking (mapping) particular elements of BP diagram with the concepts of business vocabulary. The basic features that might be activated at this step are as follows: • Enable auto-filling option when entering names for the diagram elements based on the existing entries of *noun concepts* and *fact types* in the business vocabulary (e.g. suggest the name "Order" for the *data object*, which is an input of the *task* "Register Order"). • Enable automatic linking (mapping) of elements of BP diagram with particular entries of business vocabulary if names of these elements coincide (e.g. link BPMN *data object* "Order" with SBVR *noun concept* "order" and other synonyms and synonymous forms, which are specified in the business vocabulary). • Suggest a list of candidate fact types to be associated with the task (or any other activity of a different type), which is being manually entered in the diagram (e.g. if a user assigns *task* "Register Order" to a "Supplier" *lane* then it will be prompted by the system to associate that task with "supplier *registers* order" fact type, which was already specified in business vocabulary). • Allow manual linking of BP diagram elements with the entries from business vocabulary simply by allowing a user to make additional associations as he sees them appropriate.
1.3	If BP diagram is already developed and there is still no business vocabulary in the project, then the system performs semi-automatic extraction (mining) of business terms and facts from the diagram. The entries of newly formed business vocabulary then might be additionally specified by user. From the diagram depicted in Fig. 5: Automatically extracted entries for business vocabulary are as follows: "customer", "supplier", "order". • *Data object* "Order" has its conditions: "received", "registered", "rejected" and "fulfilled". From such conditioned *data objects*, a user will be prompted to generate *categorization fact types* (e.g. "registered order *is_category_of* order", "rejected order *is_category_of* order" etc.) or more complex structures called *categorization schemas* (the latter involve categorization types as well). • For every *task* or any other *activity* from BP diagram, the system will prompt a user to specify certain entry for a *fact type* involving certain *noun concepts*, which were already identified (all fact types are based on certain noun concepts and verbs). E.g. with the assistance of the system, a *fact type* "supplier *registers* order" will be specified and automatically associated with the *task* "Register Order". • Conditioned control flows "customer is reliable" and "customer is unreliable" would imply the necessity to specify two unary fact types "customer *is_reliable*" and "customer *is_unreliable*". Of course, some of these business vocabulary mining features cannot be fully automated and some degree of user interaction is required. The degree of automation can be raised if some formal rules (syntax) for the naming of BP diagram elements are embedded (e.g name of activity should have a predefined formal structure "<action><business object>" etc.).
1.4	If both BP diagram and business vocabulary already exist before the *Stage 1* is initiated, business vocabulary can be modified/augmented based on the BP diagram (one way synchronization BPD →BV). In this case, BP diagram is interpreted as a primary source of business knowledge. On the implementation level, this step (as well as the next step 1.5) is quite a complex one; and the level of complexity increases with the level of automation. Such a feature is currently viewed as a theoretical possibility and requires further research and experimentation.
1.5	Two-way synchronization involves a controllable bi-directional checking for completeness and compatibility of both BP diagram and business vocabulary. Both models are interpreted as equal, complementary sources of business knowledge. In many cases a business vocabulary will store business concepts and facts of a larger business domain than required by the BP diagram; therefore, BV → BPD synchronization should be bounded to the business domain specified by the BP diagram. Yet again, automation of such feature is not a one-step task.
1.6	The step involves some manually performed verification activities performed in collaboration with business domain experts. This step assures that both BP model and business vocabulary are correct and synchronized.

4. Conclusions

Over the last decade, the subject of business process modeling hasn't lost its appeal as some were expecting. On the contrary, one can observe the increasing interest in BP modeling-related research and development activities resulting in various R&D initiatives. Some of the latest developments of OMG, - Business Process Modeling Language (BPMN) and Semantics of Business Vocabulary and Business Rules (SBVR), - are just few good examples of that.

Being a widely accepted business process modeling language BPMN however still lacks some vital features that need to be implemented in order to reach the full potential of this standard. We emphasize the necessity to integrate BPMN-based business process modeling with business vocabularies and business rules thus making a consistent BP model usable in various areas of applications, such as Business process management (e.g. simulation) and Information systems development (especially, MDA-based ISD).

We advocate the usage of SBVR standard to augment BPMN models with formally specified business vocabularies and business rules. Basic principles of such BP↔BV/BR integration approach are presented and briefly described in this paper. On the implementation level, the presented approach can be interpreted as an extension to some already developed *VeTIS* solution, which is composed of a full-featured SBVR editor and SBVR-to-UML transformation plug-in for the *MagicDraw UML* CASE tool. The implementation of the proposed BP↔BV/BR approach allows a user to develop BPMN models synchronized with SBVR specifications, also enabling some level of the process automation, e.g. semi-automated development of SBVR Business vocabularies from the existing BPMN business process models as well as some features of intelligent prompting to use parts of SBVR specification while developing BPMN model.

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