Improving Quality of Business Models Using a Business Vocabulary-based Synchronization Method

L. Tutkute[1], R. Butleris[2], V. Uzdanaviciute[1], E. Sinkevicius[1], T. Skersys[2], K. Kapocius[2]
[1]*Department of Information Systems, Kaunas University of Technology, Studentu St. 50–309a, LT-51368 Kaunas, Lithuania*
[2]*Centre of Information Systems Design Technologies, Kaunas University of Technology, Studentu St. 50–313a, LT-51368 Kaunas, Lithuania*
lina.tutkute@ktu.lt

***Abstract*—The synchronization of the business processes and business vocabulary allows to increase the effectiveness in the business process management, eliminate the inconsistencies in the models and enables users to represent real world processes adequately. The proposed method allows synchronizing Business Process Model and Notation process models and Semantic Business Vocabulary and Rules business vocabulary in an automatic manner. The extraction of the elements of the business vocabulary is based on the Stanford POS Tagger method which is adapted to the peculiarity of the business process models. The paper represents the main principles of the synchronization method and the results of its evaluation performing the practical experiment. The defined quality criteria (inner compatibility of business process model, automated extraction of business vocabulary, completeness of obtained business vocabulary, validity of obtained business vocabulary and adequacy to domain) reveal the main advantages of the proposed method.**

***Index Terms*—Business process model and notation, semantic business vocabulary and rules, business process, business vocabulary.**

I. INTRODUCTION

The main reasons influencing the demand of business process modelling are the optimization and reformation of the inner processes of the organizations, reorganization, unification or separation of enterprises and introduction of new product/item into the market. The graphical representation of the processes is the definitive approach of conveying the real world processes that defines the actual businesses, conditions, responsible persons, and constraints. The main reasons conditioning the relevant process conveyance in the model are: the customer's ability to understand the information adequately; proper amount of elements; and successive methodology of process development.

In order to have the complete business process representation, the synchronization of the process behaviour and related information flows are necessary. Current standards do not ensure such possibility. One of the fundamental elements linking the dynamic and static process aspects is the business vocabulary. It ensures the unanimous terminology of the business process, reduces the probability of duplicated information, and synchronizes the information flows in the various departments of the organization. As a business vocabulary involves all the enterprise's business processes, its maintenance and renewal adds extra costs. The automatic formation and synchronization of a business vocabulary would ensure the completeness of the vocabulary and the permanent possibility to renew re-used business vocabulary elements situated in the inventory of the process.

The method ensuring the partly automated formation of a business vocabulary from existing business process models and re-using it in the new process models is presented in this paper (the third and the fourth sections). The analysis of the current situation is given in the second section. The main attention is paid to the evaluation of the method using the practical experiment that is described in the fifth section. The last section is dedicated to the conclusions.

Manuscript received February 1, 2013; accepted March 2, 2013.
The work described in this paper has been carried out within the project VP1-3.1-ŠMM-10-V-02-008 „Integration of Business Processes and Business Rules on the Basis of Business Semantics".

II. CURRENT SITUATION

Business process is the set of related structured businesses or tasks involving both the business or IT specialists and technical means in order to achieve the concrete goal of organization or system unit [1]. Business process modelling (BPM) is the representation of organization processes and simulation by means of software [2]. The main purpose of it is to represent the real world processes completely and unambiguously. This is a structured method helping to analyse processes, determining the bottlenecks and defining the possible improvements for the business participants.

The newest standards (e.g. BPMN – Business Process Model and Notation [3]) allow defining the process, its implementation circumstances, constraints, responsible persons, and to monitor the process management performing their simulation. The choice of modelling language depends on various criteria: domain, alteration frequency, modelling responsibilities, integration aspects, etc. [4]. In order to evaluate the suitability of a modelling language, it is analysed using evaluation frameworks (semiotic quality framework, Bunge-Wand-Weber ontology, etc.).

Wahl and Sindre [5] evaluated BPMN according to the Semiotic Quality Framework (match of domain, the

language knowledge suitability of participants, the appropriateness of knowledge representation, the correctness of understanding, the interpretation of technical performers, organizational applicability) and determined that the suitability level of this language understanding is high as well as the domain adequacy is expressed appropriately. Nysetvold and Krogstie [6] also found that, compared to the UML (Unified Modeling Language) [7], BPMN has higher scores in almost all comparison aspects. The aspect of the understandability of a language is of none the less importance. Compared by this aspect, both modelling languages have similar estimation as they both use elements in a similar manner. Comparing by the suitability of customer's language knowledge and the interpretation of technical performers, the modelling languages are analogous; however BPMN advantage is the possibility to transform BPMN models into the executable models (BPEL) [8].

Evaluation criteria are not elaborated depending on certain domains. Therefore, performing the comparison of modelling languages the subjectivity of the expert - assessor occurs. Summarizing, the business process diagram of BPMN supports the multi-layered business processes. Also, the hierarchy of roles allows the synchronization of organizational structure in the business process models [9]. UML AD supports the modelling perspective of one level [10]. The targeted group of BPMN process model is business analysts and representatives of company whereas UML users are software developers. The main drawback of business process modelling is a non-integrated business vocabulary, which would be needed to ensure the compatibility of the business processes.

A business vocabulary is the knowledge structure in organization [11] identifying the main terms and defining their interconnections. So, a business vocabulary is composed of set of terms and facts. Facts are formed using terms, combining them with verbs and keywords. The main tasks in writing a business vocabulary are as follows: to unify business vocabularies of various organization departments; identify synonyms; synchronize the verbosity used in the business activities. The business vocabulary or the fact model is one of the initial models necessary to analyse the organization both dynamically (modelling processes) and statically (modelling entities and their qualities). Business vocabulary ensures the unanimous conception of used terms (concepts) in organization. The probability that the facts duplicate the information can also be eliminated using the business vocabulary.

OMG organization attributed business vocabulary as an internal part of business rules standard. SBVR (Semantics of Business Vocabulary and Business Rules) is an OMG standard for specifying business vocabulary and business rules by a limited natural language. However, business vocabulary can be autonomous and used in various models of organization. The standard of SBVR defines semantics of business vocabulary, business facts and business rules. However, present solutions that seek to integrate business process models together with business rules standards (and models of business vocabulary) do not incorporate the ability to create and maintain the business vocabulary automatically [12]–[17].

III. BUSINESS VOCABULARY SYNCHRONIZATION WITH BUSINESS PROCESS MODEL

Considering the accomplished researches, the business behaviour in a CIM level is specified by BPMN standard, which involves both organizational and informative aspects. SBVR standard belonging to CIM level allows defining business constraints related to the business behaviour and data (informative aspect). Business aspects specified by these standards are layered. According to this reason the possibility to re-use the information represented by one of the standard models in other standard models occurs. Thus the double information check is performed using the synchronization between standards and the customer can gather the duplicate information once or renew it if necessary keeping the required completeness of the models.

Modern standards-based business process model and business vocabulary synchronization solutions could be implemented in many more areas of practical application (Fig. 1.).

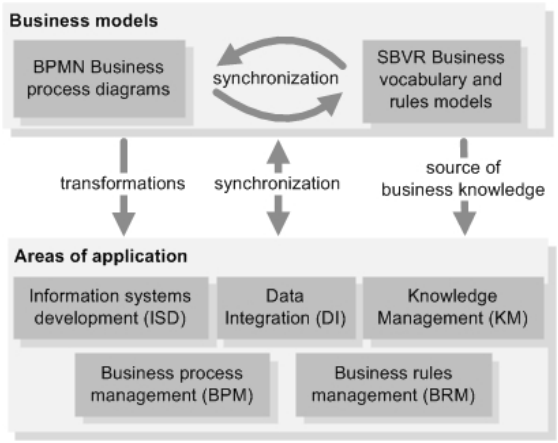

Fig. 1. Basic areas of application for the BPMN Business process models enriched with SBVR Business vocabulary and Rules.

One particular area (the integration of the data models based on the ontologies) is developed using the results of the offered method. Uzdanaviciute et al. [18] applied the idea of the business vocabulary-based data integration using ontologies. The proposed hybrid data integration process is based on the use of the ontology that explicitly captures knowledge about different types of the data sources. It relies on the following elements: a business vocabulary and a local ontology per each heterogeneous data source. The business vocabulary is formed using business process and business vocabulary synchronization method. It consists of the concepts of the domain, the attributes characterizing each concept, the different representation formats, and values for each attribute (feature values). In order to integrate the data from the heterogeneous data sources using the hybrid method, the relations between the business vocabulary and the local ontologies, and the relations between local ontology and the corresponding data sources are built up.

The extracted business vocabularies can also be used as a source of business knowledge to one of our ongoing developments – a tool for SBVR-based specification of business vocabularies and rules, i.e. VeTIS tool [19]. Such formally specified business vocabularies enhance the knowledge base of a problem domain and can be continuously used of the various community members,

translated in an automated manner into other languages, distributed and integrated with each other.

IV. MAIN PRINCIPLES OF THE SYNCHRONIZATION METHOD

The offered synchronization method for business processes and business vocabulary is described in detail in the paper of T. Skersys and etc. [20]. The main steps of the algorithm elaborating this method are presented in Fig. 2. It consists of six main steps described in Table I.

A business vocabulary consists of the following elements:

- term is used to render the types of objects and roles in a singular form (e.g. person, address, loan);
- proper name renders individual concepts (e.g. Vilnius, Oracle);
- *verb* is used rendering verbs, preposition or their combination (e.g. *has*, *sign in*, *is broken*);
- keyword identifies language elements required for formation of propositions and definitions (e.g. a, of).

A fact type is developed from terms, proper names, verbs and keywords. Fact type can be rendered by means of sentential form, (e.g. employer *pays* salary or salary *is paid* by employer) or noun form (e.g. employer's salary).

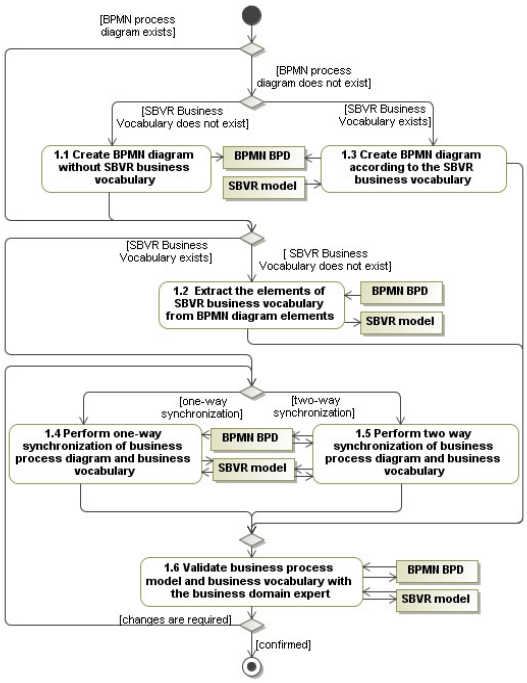

Fig. 2. The main steps of the algorithm "Synchronization of business process model and business vocabulary".

TABLE I. MAIN STEPS OF THE SYNCHRONIZATION METHOD

Steps	Description
1.1 Develop BPMN diagram without SBVR vocabulary	If a business process diagram and a business vocabulary do not exist, then the business process diagram is developed from the initial information of the process.
1.2 Extract the elements of SBVR business vocabulary from BPMN diagram elements	If a business vocabulary exists, it can be used developing the business process model by using its business knowledge. At the same time, business process elements are being related to the concrete elements of business process model. The names of business process elements are separated into single words. In accordance with the Stanford POS Tagger method the obtained word types by language parts are determined. The implementation of the method of the language parts recognition is adapted to the business process modelling evaluating peculiarity of it. The business vocabulary elements are formed according to the structured rules.
1.3 Create BPMN diagram according to the SBVR business vocabulary	If a business process diagram exists, but there is an absence of business vocabulary, then a business vocabulary is being formed in partly automatic way obtaining the terms and facts from the diagram. Customer also can form new elements of business vocabulary.
1.4 Perform one-way synchronization of business process diagram and business vocabulary	If a business process diagram and a business vocabulary exist, then the business vocabulary is being modified and expanded with new business process diagram elements. Business vocabulary is considered to be the initial knowledge source since it embraces several process diagrams.
1.5 Perform two way synchronization of business process diagram and business vocabulary	The two-way synchronization has to ensure the mutual compatibility between a business process diagram and business vocabulary elements. Both models in an aspect of knowledge are equivalent. This synchronization covers the steps 1.2 and 1.3 and unites their results.
1.6 Validate business process model and business vocabulary with the business domain expert	This step is performed manually by business domain expert. He has to validate the business vocabulary and business process model to ensure their proper synchronization.

The example of the BPMN element is: <<Activity>> "pay a salary to a new employer". The construction of the language parts after applying the method is "VBZ DT NN TO DT JJ NN". The identified elements of the business vocabulary are: *pay* [verb]; salary [term]; employer [term]; employer *is new* [fact type]. Another example of a BPMN element is: <<Event>> "employer is requesting for salary". The construction of the language parts is "NN VBZ VBG IN NN". The identified elements of the business vocabulary are: employer [term]; salary [term]; employer *is requesting* [fact type].

V. EXPERIMENT

The purpose of an experiment is to define whether the business vocabulary formed automatically from the business process coincides with domain, expressing the knowledge correctly and evaluating the reduction of time.

The main quality criteria for the method evaluation are:

- Inner compatibility of the certain business process model. This criterion evaluates the synonymy level of BPM in business vocabulary and the re-use of business vocabulary elements by creating new business process models;
- Automated extraction of business vocabulary. This criterion covers automatic elements extraction of business vocabulary evaluating whether the required elements are obtained. Time expenditure of business vocabulary formations is reduced by performing automatic business vocabulary extraction;
- Completeness of obtained business vocabulary. This criterion includes analysed types' quantity of business process diagram elements, quantity of obtained language parts and quantity of business vocabulary elements;
- Validity of the obtained business vocabulary and adequacy to domain. This criterion evaluates possible elements' mistakes of obtained language vocabulary.

These mistakes can be of various types: syntactical dependent on language parts which are extracted inadequately and semantic defining the inadequately extracted elements of business vocabulary according to the domain.

The experiment consists of three main parts:

1. The formation of business process diagrams according to the available description of the process (in accordance with the method evaluating the formation rules of BPMN diagram elements);
2. Business vocabulary extraction and formation in an automatic manner from the project of available business processes (terms extraction; synonyms formation; verbs extraction; fact types extraction);
3. Formation of the business vocabulary recommendations to model the new business process diagrams.

The processes chosen for an experiment are made of different experimental groups (2-3 consultants and 5-10 experts were participating in their development). The structured BPM was being confirmed by experts and process owners to approve that the models coincidence with the real world processes. The chosen processes define various certain areas. The quantity of formed diagrams and complexity differ as the amount of formed elements. The quantity of used elements is relevant pursuing to determine the availability and effectiveness of the suggested method.

Three processes are chosen for experiment realization:

- Customers service process in the company supplying the technical services (I process);
- Events organizational process in the company presenting training services (II process);
- University entrance process (III process). This process consists of three parts in order to evaluate the re-use possibilities of business vocabulary. The business vocabulary extracted from the first process (EBS – Entrance Bachelor Studies) is used to develop EMS2 (Entrance Master Studies) process. EMS1 process is developed without re-using the available business vocabulary. The extracted business vocabularies are integrated, their completeness and optimization level are evaluated.

Table 2 presents the resume of BPMN diagrams in accordance with initial description of processes. The complexity of process is evaluated by the quantity of diagrams in it, number of hierarchical levels (it defines process complexity into the deep) and quantity of re-use elements. The obtained results are presented in Table 3. The results cover the extraction of terms, verbs and fact types. In Table 4, the resume of obtained results while performing the re-use of business vocabulary and forming new processes is presented (III process). The amount of extracted terms, mistakes and automatic fixes in the three analysed processes are presented in Fig. 4. Fig. 5 and Fig. 6 represent the same information about verbs and fact types extracted from the business processes.

Fig. 7 shows the results of the reuse of the existing business vocabulary in the formation of a new business process. SBS is the existing business vocabulary. EMS1 is a new formed business vocabulary without the method. EMS2 is a new formed business vocabulary using the method. UES_1 (Unified Entrance Studies) and EUS_2 are, respectively, the integrated business vocabulary without using the method and using it. The smaller amount of the unique elements in the business vocabulary identifies the higher integration level of the analysed vocabularies.

TABLE II. THE STATISTIC INFORMATION OF THE EXPERIMENT.

Criteria		**I**	**II**	**III a**	**III b**	**III c**
Number of BPMN diagrams		11	6	12	9	9
Number of hierarchical levels in BPMN model		4	2	4	3	3
Number of different type elements in BPMN model		16	16	17	16	16
Number of BPMN element:		451	118	490	368	358
Flow Objects	Event	54	19	53	43	42
	Activity	62	18	101	73	71
	Gateway	61	21	36	28	26
Connecting objects		238	38	249	189	185
Swimlanes		34	20	51	35	34
Data		2	0	0	0	0

TABLE III. THE MAIN RESULTS OF THE EXPERIEMNT.

Criteria	***Count***	***Count***	***EBS Count***	***EMS1 Count***	***EMS2 Count***
Terms					
Unique terms extracted	80	56	125	118	93
Terms extracted	386	167	518	371	365
Number of identified synonyms (by expert)	9	4	22	25	7
Changes made to standardize terminology by synonyms	77	33	69	57	15
Error count, when not-noun is identified as a noun	20	6	14	17	12
Error count when noun is identified improperly	16	3	43	21	14
Verbs					
Extracted unique verbs	46	31	51	33	26
Extracted verbs	90	46	130	77	72
Error count when verb is identified improperly	52	26	26	51	48
Fact Types					
Unique types of extracted facts	153	105	283	217	185
Types of facts extracted from the combined BPMN diagram elements	52	36	104	65	61
Types of facts extracted from single BPMN diagram elements	184	88	248	197	185
Error count	8	5	11	11	8
Number of formed types of fact types	5	5	4	4	4
Unary fact type	124	45	75	63	58
Binary fact type	53	39	133	65	67
Binary fact type (of)	52	39	76	134	121
Binary fact type (has)	4	0	0	0	0
Binary fact type (')	3	1	1	0	1

Received results from the Table II - IV, Fig. 4–Fig. 7 are generalized according to the defined criteria of evaluation.

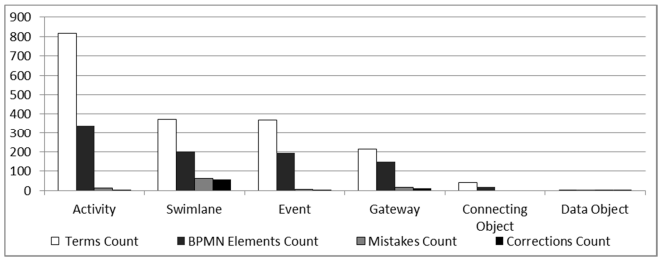

Fig. 4. The amount of extracted terms, mistakes and automatic fixes.

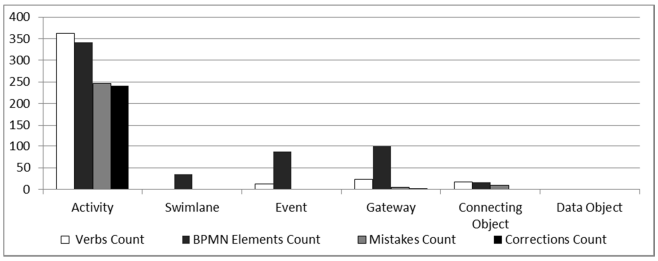

Fig. 5. The amount of extracted verbs, mistakes and automatic fixes.

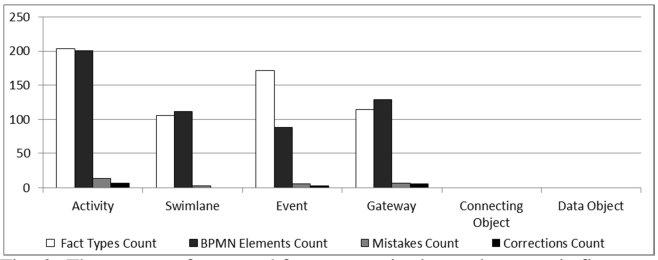

Fig. 6. The amount of extracted fact types, mistakes and automatic fixes.

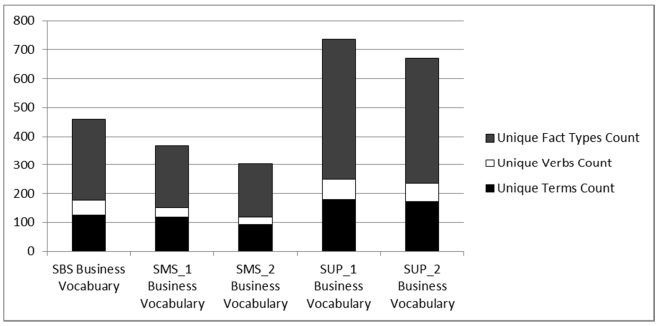

Fig. 7. The reuse of the business vocabulary in the new business process

TABLE IV. THE RESULTS OF THE RESUING ELEMENTS OF BUSINESS VOCABULARY.

Criteria	Unique	Total
Number of overlapping terms in EBS and EMS1	63	202
Number of overlapping terms in EBS and EMS2	46	252
Number of overlapping verbs in EBS and EMS1	14	44
Number of overlapping verbs in EBS and EMS2	14	59
Number of overlapping fact types in EBS and EMS1	15	25
Number of overlapping fact types in EBS and EMS2	32	57

A. *Inner compatibility of business process model*

The amount of synonyms makes an average of 14% of all unique terms. They are eliminated in order to increase the inner model compatibility.

When the method is applied an average of 37% unique terms from the main business vocabulary are re-used for the development of a new diagram and it makes 49% unique terms of a new process. Overall, re-used terms make 49% of the main business vocabulary and 69% of the business vocabulary of a new business process. Thus the model inner compatibility is expanded. The business vocabulary is augmented with 27% of new unique terms. The usage of new terms is 18%. The smaller amount of new elements enables greater inner compatibility. When the method is not applied, the overlap of unique terms is 50%; however it makes 53% of new process unique terms. The general amount of overlapping terms makes 39% of the overall vocabulary elements and 54% of the business vocabulary of the new process. The quantity of new unique terms is 31% and the general quantity of new terms is 25%.

Applying the method an average of 28% unique verbs are re-used in the development of new diagram which makes 67% unique verbs of new process. Overall, re-used verbs make 45% of the main business vocabulary and 82% of the business vocabulary of the new process. Thus the model inner compatibility is increased. Business vocabulary is expanded with 12% of new unique verbs. 9% of new verbs are used. The smaller amount of new elements secures the greater inner compatibility. Without applying the method the overlapping of unique verbs is 28%, however, it makes 42% of unique verbs of the new process. The general amount of overlapped verbs is 34% of the total number of vocabulary elements and 57% of business vocabulary of the new process. The quantity of new unique verbs is 27% and total quantity of new verbs makes 20%.

When the method is applied an average of 11% unique fact types are re-used in the development of a new diagram and it makes 17% unique fact types of a new process. Overall, re-used fact types make 16% of main business vocabulary and 32% of business vocabulary of new process. Thus the model inner compatibility is increased. Business vocabulary is expanded with 34% of new unique fact types, and 35% of new fact types are used. The smaller amount of new elements secures the greater inner compatibility. Without applying the method the overlapping of unique fact types is 5% however it makes 7% of unique fact types of a new process. The general amount of overlapped fact types is 9% of total vocabulary elements and 7% of business vocabulary of new process. The quantity of new unique fact types is 42% and total quantity of new fact types makes 40%.

B. *Automated extraction of business vocabulary*

A number of 472 of the unique terms are automatically extracted from 909 BPMN elements in business process model, which is 51% of all BPMN elements (some of the BPMN elements do not keep the information). Overall, 1807 terms are extracted. Moderately, 1.01 terms are extracted from one BPMN element.

Automatically 187 unique verbs from business process model of 578 BPMN elements are extracted from 32% of all BPMN elements. Overall, 415 verbs are extracted. Moderately, 1.23 verbs are extracted of one BPMN element.

Automatically 943 unique fact types from business process model of 897 BPMN elements are extracted from 50% of all BPMN elements. Overall 902 fact types are extracted from single BPMN elements and 318 fact types from multiple structures of BPMN elements.

C. Completeness of obtained business vocabulary

The complete set of types of BPMN elements that are used in the processes are analyzed in our method. Some types of elements of BPMN do not keep customer's information. The method secures the formation of business vocabulary being hierarchical decomposition of the process. During the experiment all the hierarchy levels in the processes' models are analyzed. All of the BPMN elements presented in diagrams are analyzed, and 63% of probable types of language parts are extracted. Also, all possible types of language parts are analyzed in this method. The relevant amount of extracted terms is 98.91%. The relevant amount of extracted verbs is 99.05%. The relevant amount of extracted fact types is 99.11%. The correctness of the extraction is not 100% because the extraction rules for automatic elimination of mistakes could not fully evaluate user's behaviour. Half of the possible types of fact types are presented in experiment, and 100% of the possible types of fact types are analyzed in the method itself.

D. Validity of obtained business vocabulary and adequacy to certain area

Fulfilling the recognition of language parts 5.37% of false terms are defined. Performing the automatic application of rules for errors' correction the quantity of false terms makes 1.1%. Fulfilling the recognition of language parts 62.89% of false verbs are defined. Performing the automatic application of rules for errors' correction the quantity of false verbs makes 4.34 %. Fulfilling the recognition of language parts 3.28% of false fact types are defined. Performing the automatic application of rules for errors' correction the quantity of false fact types is 2.3%.

VI. CONCLUSIONS

The developed method of business vocabulary synchronization with business process model ensures the following: the extraction of partly automated business vocabulary using the identification method of language parts reducing the time expenditures and mistakes' probability and developing the unanimous business vocabulary of organization; repeated use of business vocabulary elements and the binding of different business process models reducing the elements quantity of business vocabulary by eliminating synonyms and increasing inner compatibility of models.

Pursuing the experiment the following are defined: business vocabulary formed automatically coincides with the knowledge of particular domain by 99%; the quantity of possible mistakes is reduced by 2.58%; mutual synchronization between business vocabulary and process reduces the quantity of elements of business vocabulary by 8.17% and increases their repeated use by 21.67%.

The composed business process models can be developed in the further architecture stages based on models by solving tasks with diverse characteristics (data integration, process re-engineering, optimization, IS development and etc.).

REFERENCES

[1] A. Lindsay, D. Downs, K. Lunn "Business processes–attempts to find a definition", *Information and Software Technology Journal*, vol. 45, no 15, pp. 1015–1019, 2003. [Online]. Available: http://dx.doi.org/10.1016/S0950-5849(03)00129-0

[2] W. M. P. Van der Aalst, A. H. M. Hofstede, M. Weske, "Business process management: a survey", in *Proc. of the International Conference on Business Process Management,* 2003, pp. 1–12.

[3] *Business Process Model and Notation (BPMN), v.2.0,* OMG Document Number: formal/2011-01-03. OMG group, 2011. [Online]. Available: http://www.omg.org/spec/BPMN/2.0

[4] J. Krogstie. P. McBrien, R. Owens, A. H. Seltveit, "Information Systems Development Using a Combination of Process and Rule-Based Approaches" , in *Proc. of the Third International Conf. on Advanced Information Systems Engineering*, 1991, pp. 401–406. [Online]. Available: http://dx.doi.org/10.1007/3-540-54059-8_92

[5] T. Wahl, G. Sindre, "An Analytical Evaluation of BPMN Using a Semiotic Quality Framework", in *Proc. of the CAiSE'05 Workshops,* 2005, vol. 1, pp. 533–544.

[6] A. G. Nysetvold, J. Krogstie, "Assessing Business Processing Modeling Languages Using a Generic Quality Framework", in *Proc. of the CAiSE'05 Workshops,* 2005, vol. 1.

[7] *Unified Modeling Language (OMG UML)*, Superstructure, V2.4.1. OMG Available Specification formal/2011-08-05, 2011.

[8] J. Recker, J. Mendling, "On the translation between BPMN and BPEL: Conceptual mismatch between process modeling languages", in *Proc. of the Workshops and Doctoral Consortium for the 18th International Conf. on Advanced Information Systems Engineering,* 2006, pp. 521–532.

[9] J. C. Recker, M. Indulska, M. Rosemann, P. Green, "How Good is BPMN Really? Insights from Theory and Practice", in *Proc. 14th European Conference on Information Systems,* 2006, pp. 1582–1593.

[10] R. K. L. Ko, S. S. G. Lee, E. W. Lee, "Business process management standards: a survey", *Business Process Management Journal*, vol. 15, no. 5, pp. 744–791, 2009. [Online]. Available: http://dx.doi.org/10.1108/14637150910987937

[11] R. Ross, *Principles of The Business Rule Approach*. Addison Wesley.

[12] F. Corradini, G. Meschini, A. Polzonetti, O. Riganelli, "A Rule-Driven Business Process Design", in *Proc. of the International Conf. on Information Technology Interfaces*, 2007, pp. 401–406.

[13] T. Graml, R. Bracht, M. Spies, "Patterns of business rules to enable agile business processes", *Journal Enterprise Information Systems*, vol. 2, no. 4, pp. 385–402, 2008. [Online]. Available: http://dx.doi.org/10.1080/17517570802245441

[14] M. Lezoche, . Missikoff, L. Tininini "Business Process Evolution: a Rule-based Approach", in *Proc. of the 9th Workshop on Business Process Modeling, Development and Support*, *2008,* vol. 335.

[15] M. Milanovic, D. Gasevic, G. Wagner, "Combining Rules and Activities for Modeling Service-Based Business Processes", in *Proc. of the 12th Enterprise Distributed Object Computing Conference Workshops*, 2008, pp. 11–22. [Online]. Available: http://dx.doi.org/10.1109/EDOCW.2008.23

[16] Z. Wu, S. Yao, G. He, G. Zue, "Rules Oriented Business Process Modeling", in *Proc. of the International conference on Internet Technology and Applications (iTAP)*, 2011, pp. 1–4.

[17] K. Zhao, S. Ying, L. Zhang, L. Hu, "Achieving business process and business rules integration using SPL Future Information Technology and Management Engineering", in *Proc. of the International Conference,* 2010, vol. 2, pp. 329–332.

[18] V. Uzdanavičiūtė, R. Butleris, "Ontology-based Foundations for Data Integration", in *Proc. of the 1st International Conf. on Business Intelligence and Technology, 2011,* pp. 34–39.

[19] L. Nemuraite, T. Skersys, A. Sukys, E. Sinkevicius, L. Ablonskis, "VETIS tool for editing and transforming SBVR business vocabularies and business rules into UML&OCL models", in *Proc. of the 16th international conf. on Information and Software Technologies*, 2010, pp. 377–384.

[20] T. Skersys, L. Tutkutė, R. Butleris, R. Butkienė, "Extending BPMN business process model with SBVR business vocabulary and rules", *Information technology and control*, vol. 41, no. 4, pp. 356–367, 2012.