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Survey Paper

Transition between process models (BPMN) and service models (WS-BPEL and other standards): A systematic review

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Abstract

BPMN and BPEL have become de facto standards for modeling of business processes and implementation of business processes via Web services. There is a quintessential problem of discrepancy between these two approaches as they are applied in different phases of lifecycle and their fundamental concepts are different — BPMN is a graph based language while BPEL is basically a block-based programming language. This paper shows basic concepts and gives an overview of research and ideas which emerged during last two years, presents state of the art and possible future research directions. Systematic literature review was performed and critical review was given regarding the potential of the given solutions.

Keywords: BPMN, WS-BPEL, transition, translation, mapping

1. Introduction

During the last several years BPMN (Business Process Model and Notation) has become a de facto standard for modeling of business processes. It was developed by OMG (Object Management Group) with aim of developing a notation which would be readily understandable to users from business world and people involved in developing of information systems and it can be used for simple communication between different groups of users and modeling of business systems [25].

BPEL (Business Process Execution Language) is a business process implementation language based on Web services and is executed within a BPEL engine [1]. Numerous platforms support the execution of BPEL code and some provide the ability to graphically define BPEL processes, however, there is a problem that the tools are mostly focused on the syntax of BPEL and do not provide a sufficient level of abstraction that would allow the use of BPEL in earlier stages of development [28], [27].

Another approach is to model the system with BPMN diagrams and translate BPMN diagrams to BPEL. BPMN specification provides an example of mapping BPMN diagrams to BPEL, in the first version only in a form of textual guidelines, while version 2.0 gives actual examples of BPEL code for some BPMN elements. Tools that support the conversion from BPMN to BPEL usually guide the user through the process of detailed modeling by specifying additional properties for each element of BPMN diagram which results with generated BPEL code at the end of the process. Defining additional properties of BPMN elements is not supported by BPMN notation because diagrams would become too complex and cluttered; the tools usually provide that feature by storing metadata about diagram elements [38]. Basic requirements that must be met for the method of conversion to be valid are: completeness — applicability to any BPMN model, automation — capability of performing transformations without requiring human intervention and readability — producing readable code that can be further revised and edited as needed [28].

The problem with current methods of conversion between BPMN diagrams and BPEL code is that one or more aforementioned requests can not be met, current methods are either applicable

to some subset of BPMN, produce unreadable code or require a number of intermediary steps translating BPMN to some other form which is easier to translate to BPEL [12]. There is also the roundtrip problem — changes in generated BPEL code should automatically transfer to original BPMN diagram which is currently not the case, another important problem is the lack of possibility of formal verification because of vaguely defined specifications or some specific language constructs. BPEL specification does not define element notation which results in every tool defining its own symbols which impedes comparison with original BPMN diagram [33]. Recker and Mendling [31] indicate that there is a conceptual mismatch between languages which complicates translation and sometimes makes it impossible to convert BPMN to BPEL while the transition from BPEL code to BPMN diagram is a simpler problem [31] although it is not nearly trivial [36].

Research question: *In which direction is research on converting BPMN diagrams to BPEL advancing during the last two years.*

Research method: *systematic literature review.* Method described by Kitchenham [21] was used, consisting of three basic phases: planning the review, performing the review and reporting the results.

Section 2 contains systematic literature review, Section 3 gives the results and Section 4 concludes the paper.

2. Systematic literature review

2.1 Planning

Scientific databases and Google Scholar were used for the conducting of the systematic literature review. The following scientific databases were used:

- ScienceDirect
- IEEE Xplore
- IEEE Computer Society Digital Library
- SpringerLink
- ACM Digital Library

Keywords are *BPMN, BPEL, translating and mapping* and based on them were defined the following queries with time constraint between year 2008 and today (May 2011).

Q1: 'BPMN to BPEL' AND 'mapping'

Q2: 'BPMN to BPEL' AND 'translating'

Q3: 'BPMN and BPEL' AND 'mapping'

Q4: 'BPMN and BPEL' AND 'translating'

Article assessment process consisted of three phases:

1. Filtering based on title and keywords
2. Filtering based on paper abstract
3. Filtering based on paper full text

Database	Q1	Q2	Q3	Q4
ScienceDirect	13	11	9	4
IEEE Xplore	27	27	24	17
IEEE CSDL	20	25	20	25
SpringerLink	6	3	7	2
ACM	29	23	24	12

Table 1: Number of query results per database

2.2 Conduction

Queries returned the results visible in Table 1.

The results were filtered according to the research question and articles which were too general or which focused on other subjects were discarded. Some papers appeared in different combinations of queries and databases and after the first two phases of searching 38 papers entered the third phase.

After reading the papers the following results were obtained: 6 papers were discarded because their main focus is in other areas, 25 papers partially satisfy the criteria because they pursue either BPMN or BPEL aspects or some intermediary steps in the translating process and 7 papers completely focus on methods of translating BPMN to BPEL of which some even provide applications which can perform the translation. In the next two subsections these two categories are shown in detail.

2.3 Results Analysis

2.3.1 Papers focusing on BPMN or BPEL aspect

Among the papers partially covering the subject of translating BPMN to BPEL prominent are the following ideas: developing a tool for direct execution of BPMN (via translation to CPM) [20]; some papers recognize the impossibility of formal verification of BPMN diagrams: Wong and Gibbons translate BPMN to CSP formal language which allows formal verification and comparison of BPMN diagrams [39],[13], based on which was developed a tool [11], Prandi et al. convert BPMN to mathematical model COWS (Calculus of Orchestration of Web Services) [30], Asztalos et al. [2] apply first order logic for verification of transformations between BPMN and BPEL, Huai et al. define direct mapping of BPMN diagrams to Petri nets [18] for which formal mechanisms of verification are already available. Dubani et al. [9] define necessary steps during process modeling, from identification of business processes to their implementation but do not deal with details of translation from BPMN to BPEL, similar as in [4] where BPMN based model is given which facilitates translation to BPEL but also requires several intermediary steps which define additional process properties.

Holmes et al. create a new metamodel based on BPEL4People which introduces views and enables presentation of different views depending on desired level of abstraction [17]. Model driven approach (MDA) [7], [43] is based on manual refinement of BPMN diagrams until it reaches a level that can be automatically translated to BPEL. Weidlich et al. [37] deal with realization of dead path elimination in BPMN — one of the basic problems listed in their previous work [36]. Gruhn [16] deals with the problems of automatic simplification of diagrams through identification of patterns that recur and their simplification.

Several papers suggest using of YAWL for process modeling because it allows the use at the conceptual and the execution level [32], [40], [41], [8], although it is seldom used in practice — BPEL is supported by a standards body and has many implementations while YAWL currently has only one implementation.

Some papers approach the problem from the standpoint of graph theory: Vanhatalo et al. present RPST (The Refined Structure Tree) algorithm [35] used in IBM WebSphere environment and deals with parsing and decomposition of graphs and can be applied to Petri nets, YAWL, BPMN and similar directed graphs. Van der Aalst et al. [34] present an approach of generating readable BPEL code based on Workflow nets which are also based on colored Petri nets and indicate the possibility of applying the algorithm on BPMN but without details or examples. Pfitzner et al. [29] extend BPEL with the concept of choreography and introduce extension called BPEL4Chor which allows specification of communication between services while plain BPEL defines communication between the service and other systems as a black box; the same extension is transferred to BPMN. Yuan et al. [42] present an algorithm and application, which enables translating between XPDL (XML Process Definition Language — XML notation often used for storing of BPMN diagrams) to BPEL and vice versa but also cover only a subset of BPMN standard, unable to translate some elements like pool and lane.

2.4 Papers focusing on translating BPMN to BPEL

Papers focusing solely on methods for translating BPMN to BPEL are listed in Table 2; Google Scholar was used for determining an approximate number of citations for comparison.

Title	Year	Number of citations*
A Flexible Transformation Scheme between the 'OR' of BPMN and 'Link' of BPEL [3]	2008	2
Constructing a bidirectional transformation between BPMN and BPEL with a functional logic programming language [22]	2010	1
From business process models to process-oriented software systems [26]	2009	44
Interaction Mismatch Discovery Based Transformation from BPMN to BPEL [14]	2009	3
Token Analysis of Graph-Oriented Process Models [15]	2009	4
Translating Semantic Web Service based business process models [5]	2009	0
Transforming BPMN to BPEL Using Parsing and Attribute Evaluation with respect to a Hypergraph Grammar [23]	2009	1

Table 2: Papers that deal with translating BPMN into BPEL
*source: Google Scholar

There is still no complete solution that would fully cover the translation of any BPMN diagram to BPEL, current techniques focus either on some subset of BPMN, most often the basic subset [22], or some specific and focused elements such as translating between the 'OR' in BPMN to 'LINK' in BPEL [3].

Current techniques also impose constraints on the structure of BPMN diagrams — every loop must have single entry point and single exit point, every branching point must have a corresponding merging point [26].

Ouyang et al. [26] describe translation between BPMN and BPEL by pattern recognition and Petri nets logic and translating defined elements to BPEL but their approach is limited as it can not be applied to any BPMN diagram — it can not translate diagrams that define exception handling or that contain OR joins.

Gong and Xiong [14] deal with the problem of translating unsynchronized BPMN processes to BPEL and classify possible problems (deadlock, synchronization and problems in communication).

Götz et al. [15] approach the problem through token analysis in order to automatically identify the components with disadvantage that there is no formal verification of method validity.

Mazanek and Hanus translate BPMN to BPEL by translating BPMN to hypergraph and parsing the resulting hypergraph using functional logic language Curry [23], [22], however their solution can be applied only on well-structured diagrams.

FP6 project SUPER [19] deals with translating from BPMN to BPEL by defining ontologies and there is a number of papers resulting from the project and which show that it is possibly to use ontologies for translation but this approach also has its limitations, e.g. some BPEL concepts such as synchronization or event-based handling can not be mapped to OWL [5].

3. Results and discussion

One of the main problems stated by the authors is that BPMN itself is not completely semantically defined [26] and that some BPMN concepts can not be completely translated to BPEL. BPEL also supports some concepts that can not be appropriately displayed within the BPMN diagram e.g. message-based interactions, handling of events and exceptions, compensations etc. [36], [31].

Innovative is the use of semantic approach defined within the SUPER FP6 project [10],[24], [6], [5] where BPMO (Business Process Management Ontology or Business Process Modelling Ontology) is defined which makes it possible to create ontologies that represent business analysts' view on a business process with possibility to define annotations that describe data semantics, organizational and other business aspects. SUPER project introduces a set of ontologies that represent different views and levels of models of business processes. BPMO process description describes business context of process being modeled, contains process execution flow and can be translated to semantic BPEL (SBPEL), an extension of standard BPEL by an application developed within the project [5]. Semantic approach, if further developed and supported within standard tools, can facilitate translation and solve some of the problems currently partially solved with some other present methods although it has its own limitations.

Every aforementioned possibility of translation between BPMN and BPEL has its advantages and disadvantages, whether there are constraints in structure of diagrams or some additional intermediary conversions but in conclusion we can say that there is no universal solution which would be applicable to any diagram and that would satisfy the conditions enumerated at the beginning.

So to answer the research question — there are several promising areas of research, although to my best knowledge there is no conclusive solution which would be applicable to any diagram and give satisfactory results. Maybe the introduction of semantics brings a breakthrough if it becomes widely accepted and supported in major tools.

4. Conclusion

Transition between process model and service model is at the present not completely solved because there is a fundamental discrepancy between BPMN, which is based on the graph theory and BPEL, which is essentially a programming language based on blocks. This essential difference together with incomplete standard definitions impedes translation and sometimes makes it impossible to translate from BPMN to BPEL and it can be said that the basic idea stated in the standard that "BPMN creates standardized bridge for the gap between the business process design and process implementation" [25] remains limited on diagrams using the basic subset of BPMN and which are structured in a specific way consequence of which is that full standard's potential can not be utilized neither in the phase of process modeling nor in the implementation phase.

There is a lot of research in different directions, starting with recognizing patterns in BPMN and defining standardized mapping rules, formal verification of diagrams, conversion to Petri nets or similar more familiar graphs with already present methods of verification and their eventual conversion to BPEL, formal logic approach and using functional logic programming languages, but the most common solution is extending both BPMN and BPEL in a way that critical flaws are fixed, one promising approach is extending both standards by adding the semantics of elements although this also has some limitations.

Standardization bodies also consider translation problems and every new version of BPMN and BPEL standard tends to easier mapping and covers the concepts missing in the previous version but there are many open issues which may be solved by some new standard version and until then some of aforementioned mapping and translation strategies must be used and recommendations and restrictions in all modeling and implementation phases must be respected.

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