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BPMN VS. UML ACTIVITY DIAGRAM FOR BUSINESS PROCESS MODELING

Cristina Venera GEAMBAŞU[1]
The Bucharest University of Economic Studies, Romania

ABSTRACT

During the last years, it has been noticed a growing interest of organizations in improving their business processes in order to be more competitive in a globalized economy that passes nowadays through a severe financial crisis with restrictive market conditions and limited profit margins. The first step in achieving this goal is to use an adequate business process modeling language to represent their business processes. For this purpose, an evaluation of the existing business process modeling languages would be very useful in making the right decision. Our research work comes to supplement the previous researches that have evaluated business process modeling languages. The evaluation performed in this paper is focused on the two most widely used graphical notations for business processes: Business Process Modeling and Notation (BPMN) and UML Activity Diagram (UML AD). The evaluation criteria are: capacity of being readily understandable, adequacy of the graphical elements of BPMN and UML AD to represent the real business processes of an organization and mapping to Business Process Execution Languages. The results of evaluating BPMN and UML AD against each of these three criteria are presented in the paper.

Business Process Modeling, BPMN, UML Activity Diagram, Workflow Patterns, Business Process Execution Language

[1] *Correspondence address*: Cristina Venera Geambaşu, 6 Romana Square, The Bucharest Academy of Economic Studies, Romania; tel. (+40)319.19.00; email address: cristinageambasu@cig.ase.ro

INTRODUCTION

A business process is a collection of activities or related tasks that have a starting and an ending point, as well as clearly defined inputs and outputs. The focus is on the way the activity is carried out within an organization. A business process can be decomposed into several sub-processes, with specific features that together contribute to the aims of the basic process. Business processes "represent a strategic and critical intellectual asset that needs to be understood and proactively managed" (Schedlbauer, 2010).

The representation of business processes is a concern dating from the last century. Initially, the processes taking place within organizations were represented using Workflow Diagrams, which were centered on the activities of each department. Subsequently Business Process Models were developed, representing processes covering several departments, capturing the whole organization. Workflow Diagrams are centered on the processes carried out by people, based on documents, while Business Process Models are focused both on people and on system processes.

The main scope for existence of an economic organization is to generate financial advantages for its stakeholders, for that Jianu *et al*. (2011) mention that "for a long time, and even today, net income continues to be considered the main indicator for measuring economic performance of an entity". In the management process of a business "there are several categories of decisions to be taken for the development in terms of efficiency of economic activity of the company" (Ţarţavulea *et al.*, 2011). The business process models are created "to understand the key mechanisms of an existing business; to orient the creation of suitable information systems that support the business; to implement improvements in the current business; to show the structure of an innovated business; to experiment new business concepts; and to identify business elements not considered part of the core, which could be delegated to an outside supplier" (Eriksson & Penker, 2000). So, business process models help the economic organization management in taking adequate decisions in important problems of the organization life, with impact in generating the net income in order to be in accordance with stakeholder's expectations.

Over the years, different organizations (like OMG, BPMI, OASIS, IMB, W3C etc.) have elaborated a series of standards for the design, execution, administration, and monitoring of business processes. These standards can be used separately or combined depending on the compatibilities between them. As regards the notation languages, two standards are most popular (Kalnins & Vitolins, 2006) and widely used in the present: Business Process Languages Notation (BPMN) and UML Activity Diagrams (further referred as UML AD).

Considering that "various architectural models, dedicated to information systems, have been developed over time, on a logical as well as a physical level" (Cozgarea *et al.*, 2007), business process modelling, using BPMN or UML AD, has a very important role in the development of information systems, regardless of the used architecture. Business process modelling, using BPMN or UML AD, can also be used in describing the algorithms used in information systems, including applications of artificial intelligence because "artificial intelligence could become a base alternative for solving financial problems which require complex mathematic calculations or complex optimization" (Cozgarea *et al.*, 2008).

The question that arises is: which one of these two business process modeling languages, BPMN or AD, should be chosen by organizations for modeling their business processes? The main objective of our paper is to analyze BPMN and UML AD from three perspectives: how easy can they be understood by the users, how well do the graphical elements of these two notation languages represent the real business processes of an organization and how easy can these two business process modeling languages be mapped to Business Process Execution Languages.

1. LITERATURE REVIEW

The evaluation and comparison of business process modeling languages has been addressed in a various researches. BPMN and UML AD, being the two most used graphical notations for the representation of business processes, are subject of most of these researches.

The suitability of UML AD to represent business processes is examined by a series of authors (Dumas & ter Hofstede, 2001; Russell *et al.*, 2006c; Sarshar & Loos, 2007). Dumas and ter Hofstede (2001) examine the expressiveness and the adequacy of UML AD for workflow specification and evaluate its ability to capture a collection of workflow patterns. Russell *et al.* (2006c) argue the suitability of UML 2.0 Activity Diagrams for business process modeling, using the workflow patterns as an evaluation framework. Sarshar and Loos (2007) investigate UML 2.0 Activity Diagrams capabilities to model the resource perspective of business processes and compare the activity diagram with Petri net formalism.

Some important researches make an evaluation of BPMN and UML AD based on workflow patterns by analyzing the expressive power of these process modeling languages (van der Aalst *et al.*, 2003; Russell *et al.*, 2004a; Russell *et al.*, 2004b; White, 2004; Wohed *et al.*, 2004; Wohed *et al.*, 2006; Russell *et al.*, 2006a; Russell *et al.*, 2006b). The results of these evaluations showed that there is a notable similarity between BMPN and UML AD constructs.

BPMN and UML AD have also been studied by researchers who have conducted experiments in order to verify the hypotheses they have defined related to these two business process modeling languages. Peixoto *et al.* (2008) have conducted a controlled experiment to analyze UML AD and BPMN related to the legibility of the business process model. The participants to the experiment were computer science freshmen not familiar with the languages and with the modeled domain, representing internal customers of one organization. The conclusion was that, for the analyzed workflow patterns, the level of difficult for understanding the business process, in both languages, is the same. Birkmeier *et al*. (2010) made an empirical comparison of BPMN and UML AD. The results of this study indicate that UML AD is at least as usable as BPMN, since BPMN did neither differ significantly in effectiveness, efficiency, nor user satisfaction.

The capacity of BPMN and UML AD to map to business execution languages has been analyzed by several authors (Zhang and Duan, 2008; Mazanek & Hanus, 2011; Hlaoui & Benayed, 2011). Mazanek and Hanus (2011) show how functional logic programming techniques can be used to construct a bidirectional transformation between BPMN and BPEL. Zhang and Duan (2008) propose an approach to transform UML AD to BPEL. Though, this approach is limited because the UML AD models only capture the basic control patterns defined by Russell *et al.* (2006a) and the BPEL specification contains only those elements needed to describe the execution logic extracted from the process model. Hlaoui and Benayed (2011) propose a graph homomorphic mapping between UML AD and BPEL4WS language elements.

The researches mentioned above analyze business process modeling languages from a single perspective: their expressive power, their readability or their capability to map to business process execution languages. Also, the analyses are based on the versions of BPMN and UML AD that were in use at the time the researches were made, which are not the versions currently in use. Our research aims to provide an overall view over the latest versions of BPMN and UML AD, using all three perspectives mentioned above.

2. RESEARCH METHODOLOGY

Our research has begun with an analysis of the available standards in the field of business process modeling. From these standards we have selected the ones that are most frequently used in practice, namely BPMN and UML AD. Further, based on literature review, we have identified a series of criteria that are relevant for the evaluation of business process modeling languages. Then we have evaluated the currently used versions of BPMN and UML AD using these criteria. The evaluation has as starting point the previous researches that had as objective the evaluation of business process modeling languages and is based mostly on the study of the current normative documents of BPMN (OMG, 2011a) and UML AD

(OMG, 2011b). For the evaluation of BPMN and UML AD according to the criteria related to the adequacy of their graphical elements to represent the real business processes of an organization, we have used a case study. The purpose of the case study was to analyze the graphical symbols used by BPMN and UML AD for representing the business processes and to identify the similarities between them.

3. OVERVIEW OF BPMN AND UML AD

3.1. BPMN overview

A graphical notation language, widely accepted for modeling business processes is Business Process Modeling Notation (BPMN), developed by Business Process Management Initiative (BPMI). Since 2005, BPMN is maintained by the Object Management Group (OMG), after the merger between this organization and BPMI. In January 2011, OMG released BPMN version 2.0 which extends the scope and capabilities of the previous version, BPMN 1.2, in several areas (OMG, 2011a): formalizes the execution semantics for all BPMN elements, defines an extensibility mechanism for both Process model extensions and graphical extensions, refines Event composition and correlation, extends the definition of human interactions and defines a Choreography model.

The primary goal of BPMN is “to provide a notation that is readily understandable by all business users, from the business analysts that create the initial drafts of the processes, to the technical developers responsible for implementing the technology that will perform those processes, and finally, to the business people who will manage and monitor those processes.”

BPMN allows the creation of "end-to-end" business processes, being designed to cover many types of modeling, so that they can communicate a wide variety of information to a wide variety of audiences. An "end-to-end" BPMN model contains three basic types of sub-models: process, choreography and collaboration. By combining the three basic types of sub-models, a detailed representation of business processes can be obtained, but it is recommended that the designer to focus on a certain aspect of processes analysis to avoid creating too complex diagrams, which are difficult to understand.

3.2. UML and UML AD overview

UML was developed and is being maintained by OMG. The first version of UML was released in 1995. The current version - UML 2.4.1 was released in 2011. The main objective of UML is “to provide system architects, software engineers, and software developers with tools for analysis, design, and implementation of

software-based systems as well as for modeling business and similar processes" (OMG, 2011b).

The modeling artifact used in UML for business process modeling is the Activity Diagram, which is part of the behavioral models. "The focus of activity modeling is the sequence and conditions for coordinating lower-level behaviors […]. The behaviors coordinated by these models can be initiated because other behaviors finish executing, because objects and data become available, or because events occur external to the flow" (OMG, 2011b). Activity Diagrams are significantly redesigned in 2.0 version of UML, both in terms of syntax modifications as well as regarding the semantics, by switching from State Machine based semantics to token flow semantics. These changes have improved the UML AD capability to represent business processes.

4. BPMN VS. UML AD FOR BUSINESS PROCESS MODELING

BPMN and UML AD are being analyzed in this paper using three criteria: C1: Capacity of being readily understandable; C2: Adequacy of the graphical elements of BPMN and UML AD to represent the real business processes of an organization; C3: Mapping to Business Process Execution Languages. For the evaluation will be used the current versions of standards referring to the two business notation languages subject of our research: Business Process Model and Notation (BPMN) – version 2.0 (OMG, 2011a) and OMG Unified Modeling Language (OMG UML) – version 2.4.1 (OMG, 2011b) which includes UML AD.

C1: Capacity of being readily understandable

The results of business process modeling are of interest for different stakeholders: the business analysts that describe the processes using specific notations and tools, the technical developers who implement the technology used to perform those processes and the business users that will manage and monitor the processes. Business users "do not need to be experts in BPMLs (Business Process Modeling Languages), they only need to understand the results of the modeling, more specifically, and they should know how to read business process diagrams" (Peixoto *et al.*, 2008). Therefore, BPMLs should be easily used and understood by all parties that are, directly or indirectly, involved in the process.

The developers of BPMN standard consider that "the primary goal of BPMN is to provide a notation that is readily understandable by all business users […] Thus, BPMN creates a standardized bridge for the gap between the business process design and process implementation." (OMG, 2011a). UML, and implicitly UML AD, is also considered to be easily understood - "UML represents a natural choice for modeling business processes since it has been conceived for the communication

among people and then can be easily understood and used by customers, managers, and developers" (Nitto *et al.*, 2002).

The fact that both BPMN and UML AD are equally readily understandable is also demonstrated by an experiment conducted by Peixoto *et al.* (2008) with computer science students, not familiar with the languages and with the modeled domain, representing business users that need to read and understand business process diagrams. The experiment's results showed that the level of difficulty for understanding the business process, in both languages, is the same.

C2: Adequacy of the graphical elements of BPMN and UML AD to represent the real business processes of an organization

The representation power of Business Process Modeling Languages can be evaluated using a general accepted evaluation framework – the Workflow Patterns framework (van der Aalst *et al.*, 2003; Russell *et al.*, 2004a; Russell *et al.*, 2004b; Russell *et al.*, 2006a; Russell *et al.*, 2006b). The Workflow Patterns framework provides a general set of business process patterns that can be used to evaluate to which extent the analyzed workflow language or business process modeling language is able to represent a given workflow pattern.

The Workflow Patterns are divided into four categories: control-flow patterns, workflow data patterns, workflow resource patterns and exception handling patterns. The control-flow patterns can be used to analyze the aspects related to control-flow dependencies between various tasks. Workflow data patterns refer to the ways in which data is represented and used in workflows. Workflow resource patterns provide a comprehensive treatment of the resource perspective, capturing aspects related to the distribution of work to the resources associated with a business process, and the way this work is managed by those resources. The exception handling patterns aim to capture the causes of exceptions and the actions that need to be taken when exceptions occur.

Previous version of BPMN (BPMN 1.0 and BPMN 1.1.) and UML AD (UML AD 2.0) have been analyzed against workflow patterns by different researchers (van der Aalst *et al.*, 2003; Russell *et al.*, 2004a; Russell *et al.*, 2004b; White, 2004; Wohed *et al.*, 2004; Wohed *et al.*, 2006; Russell *et al.*, 2006a; Russell *et al.*, 2006b). The results of these researches was that both notations provide similar solutions for most of the patterns and that they offer comprehensive support for the control-flow and data perspectives, but they offer a limited number of solutions for workflow resource patterns and exception handling patterns.

BPMN 2.0 brings a series of enhancements to process modeling, compared to previous versions of the standard, especially as regards the graphical elements used to represent the control-flow patterns and the workflow data patterns. The main enhancements refer to: exclusive/parallel event-based gateway (instantiate),

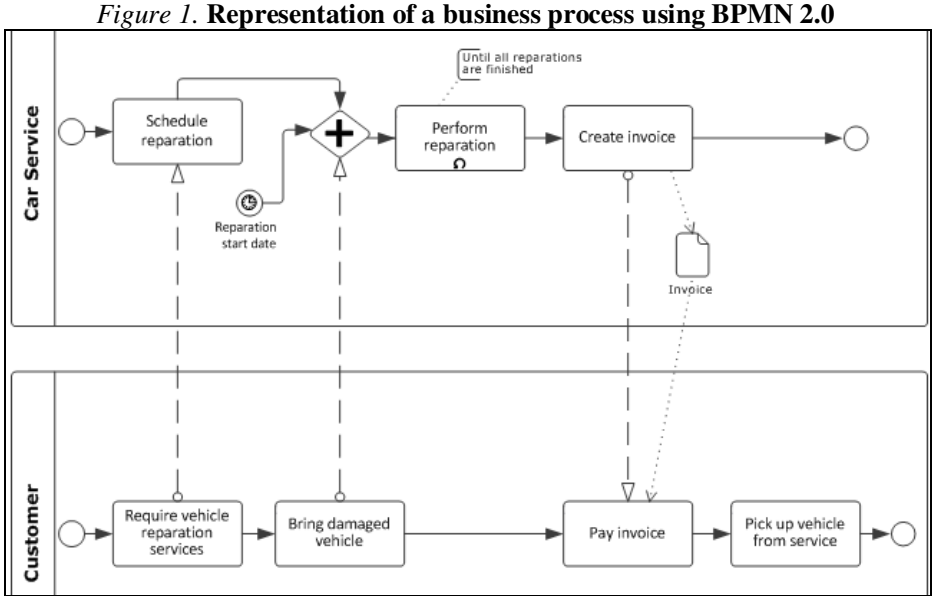
business rule tasks, sequential multi-instance activity, data objects, non-interrupting events for a process, event sub-processes for a process. Also, two new diagrams were added: the Choreography diagram and the Conversation diagram.

As regards UML AD, its representation power was significantly improved with the emergence of UML AD 2.0, but the latest version - UML AD 2.1.4 (subject of our research) brings only minor changes, changes that do not affect the extent to which UML AD is able to represent the workflow patterns.

Another aspect that should be considered when analyzing the representation power of BPMN and UML AD is to the complexity of the graphical symbols used to represent the real business processes of an organization. In many cases, BPMN and UML AD use similar symbols to describe business processes. However, there are aspects of business processes that can be modeled in BPMN using only one symbol, but for which the representation in UML AD requires the use of a group of symbols. This last situation comes as a result of the fact that BPMN does not always use a single symbol for the representation of each component of a business process; it also uses complex symbols to describe a series of information as a whole. On the other side, UML AD uses one symbol for each component of business processes.

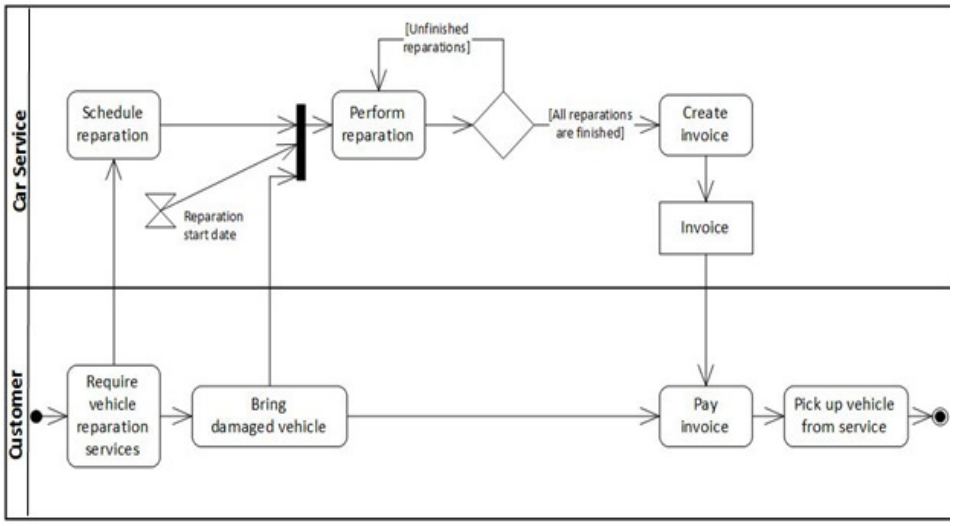
To analyze the graphical symbols used for business process modeling we have elaborated a case study that consists in modeling a business process using both BPMN (Figure 1) and UML AD (Figure 2).

Figure 1. **Representation of a business process using BPMN 2.0**



We have chosen to describe the processes involved by the reparations performed by a Car Service for the damaged vehicles brought by their customers. The process begins with the request made by the customer to the car service for vehicle reparation. The car service schedules the reparation. When the reparation start day comes, the customer brings its vehicle and the car service performs the required reparations. When all the reparations are finished the car service creates an invoice that must be paid by the customer in order to pick up his repaired vehicle.

Figure 2. **Representation of a business process using UML AD 2.1.4**

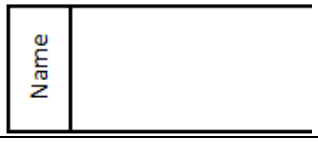
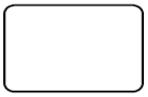
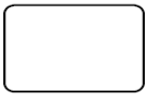


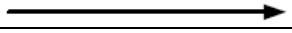
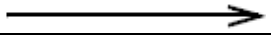
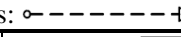
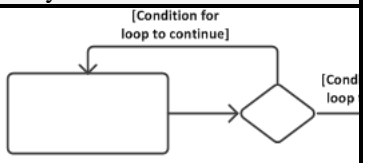
By analyzing the graphical symbols used for the representation of the business process described in Figure 1 and Figure 2 we can draw the following conclusions:

- The graphical symbols used for the representation of most parts of the process are similar in BPMN and UML AD.
- For the representation of the reparations performed by the car service, BPMN uses only one symbol (a task object with a standard loop marker), while UML AD uses a group of symbols (an action node, a decision node and two activity edges).

The conclusions mentioned above are synthetized in Table 1.

Table 1. **Comparative analysis of the graphical symbols used by BPMN 2.0 and UML AD 2.1.4 for representing the business process described in Figure 1 and Figure 2**

<table>
<tr><th>Element of the business process</th><th colspan="2">BPMN 2.0</th><th colspan="2">UML AD 2.1.4</th></tr>
<tr><td colspan="5">Elements of the business process that are represented in BPMN and UML AD using similar graphical symbols</td></tr>
<tr><td rowspan="2">Participants to the business process: Car Service, Customer</td><td colspan="2"> 
</td><td colspan="2"> 
</td></tr>
<tr><td colspan="2">Pool</td><td colspan="2">Swimlane</td></tr>
<tr><td rowspan="3">The start point and the end point of a process</td><td>  </td><td>  </td><td>  </td><td>  </td></tr>
<tr><td>Start event</td><td>End event</td><td>Initial node</td><td>Final node</td></tr>
<tr><td colspan="4">Note: In a process with more participants, BPMN uses a start event and an end event for the parts of the process corresponding to each participant, while UML AD uses only one initial node and one final node for the entire process.</td></tr>
<tr><td rowspan="2">Activities (without loop) performed by the participants: Require vehicle reparation services, Schedule reparation, Bring damaged vehicle, Create invoice, Pay invoice, Pick up vehicle from service</td><td colspan="2">  </td><td colspan="2">  </td></tr>
<tr><td colspan="2">Task object</td><td colspan="2">Action node</td></tr>
<tr><td>Occurring of a date that</td><td colspan="2">  </td><td colspan="2">  </td></tr>
</table>

Element of the business process	BPMN 2.0	UML AD 2.1.4
generates the performing of an activity: *Registration start date*	Timer event	Time event
Synchronize (combine) parallel flows		
	Parallel gateway	Join node
Flow elements		
	Sequence Flow	Activity Edge
	Note: The Sequence Flows cannot cross the boundaries of a Pool. The interaction between Pools is shown through Message Flows: 	
Representation of objects and data: *Invoice*		
	Data Object	Object node
Elements of the business process that are represented in BPMN using one symbol and in UML AD using a group of symbols		
Activity that repeat sequentially: *Perform reparation*		
	Task object with a standard loop marker (eventually with the loop condition shown as a text annotation)	Action node & decision node & activity edges

C3: Mapping to Business Process Execution Languages

The next step, after creating a visual representation of business processes (using business process modeling languages, such as BPMN and UML AD), is to execute them. In order to achieve this objective, it is necessary to map the visual representations of business process (BPMN and UML models) to a business process execution language (BPEL).

The latest version of BPEL is WS-BPEL 2.0 (OASIS, 2007) which is a language for specifying business process behavior based on Web Services. WS-BPEL 2.0

and brought significant enhancements to its previous version - BPEL4WS 1.1. "WS-BPEL defines an interoperable integration model that should facilitate the expansion of automated process integration in both the intra-corporate and the business-to-business spaces" (OASIS, 2007). The process information in WS-BPEL is exported and imported only by using web service interfaces.

BPMN 2.0 normative document (OMG, 2011a) includes a mapping of a subset of BPMN to a business process execution language, respectively WSBPEL. "Mappings to other emerging standards are considered to be separate efforts" (OMG, 2011a). Between BPMN and BPEL there are some important differences. For example, in BPMN tasks can be linked in any form, while the flows in BPEL support only forward links and no loops .Therefore, the mapping is not straightforward. In the "Mapping BPMN Models to WS-BPEL" section of BPMN 2.0 normative document (OMG, 2011a), the specification describe "basic mapping" and also "extended mapping" which refers to the blocks of BPMN for that can be mapped using multiple WS-BPEL patterns.

As regards UML AD, neither the latest normative document (OMG, 2011b), nor the previous version of the standard, do not include any specification of mapping UML AD to any business process execution language. However, in the past few years, defining a mapping between UML AD and BPEL was in the area of concern of a many researches. Zhang and Duan (2008) propose a model transformation of UML AD 2.0 to BPEL by decomposing an AD model into regions and identifying structural patterns separately. Hlaoui and Benayed (2011) propose a meta-model based transformation from UML activity diagrams to BPEL4WS language. Although the results of these researches are applicable in practice, they do not offer solutions for a complete automatic mapping of UML AD to business process execution languages.

DISCUSSION AND CONCLUSIONS

BPMN and UML AD were evaluated in this paper based on three evaluation criteria: capacity of being readily understandable, adequacy of the graphical elements of BPMN and UML AD to represent the real business processes of an organization and mapping to Business Process Execution Languages.

Concerning the capacity of being readily understandable, we can say that both BPMN and UML AD are equally easy to understand by the stakeholders interested on business process modeling (business analysts, technical developers and business users).

Adequacy of the graphical elements of BPMN and UML AD to represent the real business processes of an organization was analyzed in this paper from two

perspectives: the capacity of these business process modeling languages to capture the workflow patterns (as defined by van der Aalst *et al.*, 2003; Russell *et al.*, 2004a; Russell *et al.*, 2004b; Russell *et al.*, 2006a; Russell *et al.*, 2006b) and the complexity of the graphical symbols used to represent the real business processes of an organization.

The evaluation of BPMN and UML AD using the Workflow Patterns framework revealed the fact that both business process modeling languages provide similar solutions for most of the patterns. The results of the researches conducted by a series of authors on the capacity of the previous versions of BPMN and UML AD to capture the workflow patterns showed that both notations offer comprehensive support for the control-flow and data perspectives, but they offer a limited number of solutions for workflow resource patterns and exception handling patterns. These results are also confirmed by the analysis that we have performed on the current specifications of BPMN and UML AD.

The complexity of the graphical symbols used to represent the real business processes of an organization is evaluated in this research primarily through an analysis of the normative documents of BPMN and UML AD and secondly through a case study. The analysis results indicate that, in most of the cases, BPMN and UML AD use similar symbols to describe business processes, but that there are cases when components of the business processes are modeled using only one symbol in BPMN and using a group of symbols in UML AD.

As regards the mapping of the business process modeling languages to business process execution languages, BPMN current normative document includes a mapping of a subset of BPMN to WSBPEL, while UML AD normative document does not define mapping to any BPEL. Solutions for the mapping between UML AD and BPEL were described in a series of researches, but these solutions do not offer a completely automated mapping.

This paper presents a synthetic analysis of BPMN and UML AD in the light of the three criteria mentioned above. Future researches can provide solutions for the aspects of business processes that are not covered by BPMN and UML AD, as shown in this paper.

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