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Comparative Analysis of Business Process Modelling Tools for Compliance Management Support

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***Abstract* – The paper presents results of the comparative analysis of business process modelling tools for supporting automated compliance management in organisations. By compliance in the paper we mean compliance to legislation, regulations of municipalities, external regulatory requirements and also internal organisational policies. The goal of the research is (1) to identify main attributes of business process modelling tools relevant in compliance management, and (2) to use the identified attributes for analysis of the tools to better understand the scope of their capability to support compliance management. The attributes of the tools have been derived from the related research. The analysis of the tools has been performed by installing each tool and evaluating it against a set of the identified attributes. The obtained results are useful in choosing the tools for compliance management in general and for open source solutions to develop new compliance management tools in particular.**

***Keywords* – Business process compliance, compliance management, compliance management tools, open source business process modelling tools.**

I. Introduction

Modern organisations are under constant pressure not only to improve daily operations to stay competitive, but also to adhere to various types of regulations, e.g., legislation, regulations of municipalities, internal policies, and industry best practices. Non-adherence to legislation and regulations can result in potential legal problems, and non-adherence to best practices and internal policies can lead to unsatisfied customers and profit-loss for shareholders. To improve business processes, organisations shift to business process management and model business processes. There is a plethora of business process modelling tools to help an organisation analyse existing business processes – starting from drawing *as-is* business process diagrams to executing *to-be* business process models. However, not always business process modelling tools support compliance management or rely on external tools for compliance management.

The understanding what does it mean to support compliance management differs among researchers as well as among practitioners. Therefore, when choosing tools for business process modelling or building new compliance solutions, there is a problem to decide which existing tool to choose as a basis for compliance solution implementation because descriptions of the tools are not enough. This uncovers the need to enrich the knowledge about available business process modelling tools with respect to their feasibility for compliance management. As a response to this need, the goal of the paper is to evaluate existing business process modelling tools against a set of compliance management support criteria and draw conclusions with respect to feasibility of the tools for compliance solution implementation.

The paper is structured as follows. In Section 2, the research method is presented. In Section 3, we discuss related work and derive evaluation criteria from it. In Section 4, the selected business process modelling tools are presented. In Section 5, the experimental results are analysed. Brief conclusions and directions of future research are presented in Section 6.

II. Research Method

Compliance management is widely discussed, and the comparison of approaches is presented in different frameworks [1], [2], [3]. However, looking at these comparisons, it is not possible to fully understand the exact capabilities of business process modelling tools that support or may support these approaches. We pose two questions to be answered regarding this issue. First, what features are expected and relevant in compliance management tools, and, second, which business process modelling tools support these features and to what extent. To obtain the answers, the following tasks were set:

1. To conduct a literature review of publications available at IEEE Xplore digital library, ACM Digital Library, CEUR Press and proceedings of Springer computer science conferences (e.g., Business Process Management Conference). This activity was aimed at identifying research papers focused on compliance management (and business processes). The following search terms were used:
   compliance management, business process compliance management, regulations compliance, compliance requirements, business process compliance checking, automated compliance rule checking.
   Only a set of research literature sources on compliance management that concerned also business processes was selected.
2. To conduct a web search aimed at identifying business process modelling tools widely used in industry and academia. The tools mentioned in the research papers discovered in Step 1 were first considered and then a set of tools was extended by tools, which claimed that they had at least some compliance management capabilities. The following search terms were used:

business process modelling tools, compliance management tools, open source business process modelling tools, open source compliance management tools, business process compliance tools, regulations compliance tools, compliance requirements tools, business process compliance checking tools, automated compliance management tools, compliance rule checking tools.

3. To define a set of evaluation criteria for business process modelling tools relevant to compliance management based on identified attributes and compliance management features from selected research papers on compliance and business process modelling.
4. To perform evaluation of the selected tools based on a set of evaluation criteria. A subset of tools was assigned to each member of our research team. The research progress was discussed weekly to ensure that all evaluators had a common understanding of the features to make the results comparable.
5. To analyse the results and to draw conclusions about the capabilities of the analysed tools.

III. Evaluation Criteria Based on Related Works

Compliance of business processes has a significant research track and still attracts interest from academia and practitioners. For instance, the author of [1] contributes a comprehensive survey of existing solutions to Regulatory Compliance Management (RCM) and attempts to give a definition of RCM in the context of BPM. As a result, 8 solutions were retained as representative for the comprehensive RCM solution.

To illustrate the spectrum of approaches, we can look at the thesis [2] where the author provides a formal approach to support process design-time compliance checking. The thesis addresses the problem of consistency checking among various compliance requirements. The thesis also discusses checking compliance requirements against process models automatically.

In [3], the authors propose logic based formalism for describing semantics of business contracts and semantics of compliance checking procedures and close the gap between business processes and business contracts.

In [4], the author focuses on compliance by design and extends an artefact-centric approach to model compliance rules using Petri nets and shows how compliant business processes can be synthesised automatically from the point of view of the involved business objects.

In [5], the authors present an end-to-end pattern based approach for the specification of compliance requirements where compliance patterns are visually represented as BPMN-Q queries.

In [6], the authors present principles for creating flexibility and agility when implementing new or revised policies into business processes. These principles include: 1) defining and using business services, 2) integrating and orchestrating business services through the use of events, 3) separating process, knowledge and resources and 4) implementing policy in an integrated manner.

In [7], the authors analyse conceptualisation of modelling methods and conclude how the components of a specific implementation platform support the design of modelling methods.

Based on the above-mentioned and also other studies, evaluation criteria were distinguished (see Table I). These criteria were used in the experimental analysis of the tools. The list of tools used in the analysis is presented in Section 4.

TABLE I

A Set of Evaluation Criteria for Business Process Modelling Tools

Evaluation criteria	Reason for criteria
Ability to Create a Process Model from Fragments	The authors in [8] claim that process fragments enable an easier and faster development of process-based applications, and also that process fragment counterparts ease and speed up application integration.
Graphical User Interface	To empower business users, a tool should provide a set of graphical interface components designed to enable business users to build and update business process models without creating a code. According to [9], existence of graphical user interface and usage of graphical objects right up to implementation of process contribute to transparent and comprehensive implementation of the process.
Supported Notations	Supported notations by tool, e.g., industry standard BPMN [10]. According to [11], BPMN is widely used in industry for process modelling.
Ability to Configure Objects in Model	According to [12], complexity in developing business application is continually growing and to cope with this complexity, business process modelling solutions need to provide a flexible meta-modelling capabilities, i.e., the meta-model can be freely defined and adapted.
Dedicated Compliance Management Feature	Features that enable compliance management in the business process modelling tool, e.g., ability to reference a decision table to a specific gateway, built-in business rules engine, built-in process templates from industry best-practice standards.
Publishing Formats	Support of publishing a business process model to enable multiple users to view and collaborate on a shared model, e.g., as a wiki page, on Microsoft SharePoint server, as a webpage, as image.
Export	Supported export and import formats, e.g., XPDL or BPEL. To enable business process model export and import to different tools that business users and IT engineers are working with.
Import	
Ability to Accommodate User-Defined Reusable Functionality	Is it possible to define reusable user-defined functionalities, e.g., model comparison, and import/export mechanisms, specific queries on business process models? According to [7], specification of tailored and reusable mechanisms and algorithms ensures an adequate user experience and performs the machine-processing of the models.
Ability to Link Objects with External or Internal Objects	Ability to reference other objects in the same or different model and other models, or external objects, e.g., specific paragraphs in regulatory documents, files.

Search Functionality	Search functionality that enables a business user to search for a specific node in the business process model based on keywords, e.g., to find an activity that performs credit check.
Hierarchy of Business Process Models	According to [11], hierarchical representations of business process models are effective representation of the end-to-end business processes to business users.
In-tool Verification of Notation	Verification of notation *on-the-fly* supports a user in creating correct and conformant to the modelling standard business process models.
Change Management of Models	According to [13], if change management is not performed, then business process models become obsolete and alignment of business and IT is lost.
Implementation Language	Based on what programming language tool was implemented, e.g., Java, C#, etc.
Open Source	Determines availability of the core code for the required modifications.
Semantic Mapping	Semantic mapping is the task of identifying concept and attribute correspondences between two systems through a matching process [14]. Semantic mapping is one of the advanced solutions that can be used to solve an interoperability issue between compliance rules and business process models.
Soundness of Business Process Models	Soundness defines a minimum correctness criterion that a process model should fulfil [15]. Business process modelling tool should reason about the soundness of the business process model in order to execute formal execution on the model, e.g., semantic mapping or automated compliance checking.
Automated Compliance Checking Approaches	Manual compliance checking is time-consuming and error-prone, especially for large and complex processes [16]. Automated compliance checking approaches against a set of compliance rules are helpful to organisations in defining compliant business processes.
Verification of Generated Code	Feature to verify an automatically generated executable code from business process models, e.g., whether generated BPEL is correct according to BPEL rules. This feature is needed to check automated compliance and soundness properties of business process models.

IV. The Selected Business Process Modelling Tools

Within the framework of the research, 19 business process modelling tools were evaluated against the criteria depicted in Table I. Evaluated business process modelling tools are listed in alphabetical order in Table II. The tools mentioned in the research papers on compliance management were considered first and then a set of tools was extended by tools, which claimed that they had at least some compliance management capabilities.

Tools were installed on computers with MS Windows operating system and evaluated against a set of criteria described in Table I by performing (1) standard business process modelling activities: defining business process start and end events, defining sequence of activities and sub-processes, defining process flow logic using different types of gateways, defining a set of different business process participants, and (2) executing tool evaluation scenarios to test a particular tool against a set of criteria defined in Table I.

All tools were installed with full capabilities using freeware, educational or non-commercial licensing or using the allowed trial period for the commercial tools. According to available information on tool homepages, the installed trial versions had no other limitations other than a limited time period for exploring functionality with only exception for ITP Commerce [27], where functionality was limited for the trial version.

During the analysis, all criteria were considered in experiments with the tools presented in Table II.

TABLE II

The List of Business Process Modelling Tools

Tool	**Version**	**Abbreviation Used**
ADONIS:Community Edition [17]	3.0	ADONIS
ARIS Architect & Designer [18]	9.7 (trial)	ARIS A&D
AristaFlow [19]	1.0.92 (trial)	
BizAgi [20]	2.8	
BonitaSoft [21]	6	
Cameo Business Modeler [22]	18 (trial)	Cameo Bus. Mod.
CPN Tool [23]	4.0.0	CPN Tool
Enterprise Architect [24]	11.1 (trial)	Enterprise Arch.
Greta (Eclipse based) [25]	2.0.0	Greta
Intalio BPMS [26]	7.0	Intalio BPMS
ITP Commerce. Business process modeller for MS Visio [27]	6 (trial)	ITP Commerce
jBPM [28]	6.1.0	jBPM
Oracle Business Process Analysis Suite [29]	12.1.3.0.0 (trial)	Oracle BPA suite
Oryx [30]		Oryx
ProcessMaker Open Source [31]	2.5.2	ProcessMaker
ProM Tools [32]	6.4	ProM Tools
TIBCO Business Studio [33]	3.5 (trial)	TIBCO Bus. Stud.
MS Visio [34]	2013	MS Visio
Visual Paradigm [35]	11.1 (trial)	Visual Paradigm

Results of experiments are represented in Table III in the next section.

V. The Results of Analysis

The section presents the results of evaluation experiment of comparative business process modelling tools. The results are demonstrated in Table III. Titles of the columns correspond to the evaluated tools; criteria are depicted in the first column.

Rows depict how a particular tool supports the corresponding criteria, e.g., + means that a tool supports the criterion, – means that a tool does not support the criterion, other abbreviations are clarified below the table.

TABLE III

Results of Evaluation of Comparative Business Process Modelling Tools

	Adonis	ARIS A&D	AristaFlow	BizAgi	BonitaSoft	Cameo Bus. Mod	CPN Tool	Enterprise Arch.	Greta	Intalio BPMS	ITP Commerce	jBPM	Oracle BPA suite	Oryx	ProcessMaker	ProM Tools	TIBCO Bus. Stud.	MS Visio	Visual Paradigm
Ability to reate a process model from fragments	+	+	–	+	+	+	+	+	+	–	+	–	+	+	–	+	+	–	+
Graphical user interface	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Supported notations:																			
BPMN	+	+	+	+	+	+	+	+	–	+	+	+	+	+	–	+	+	+	+
BPEL	–	+	–	–	–	–	–	+	–	–	–	–	+	–	–	–	–	–	–
UML	–	+	–	–	–	+	+	+	–	–	–	–	+	–	–	–	–	+	+
Other	–	+	+	–	–	–	+	+	+	–	–	–	+	–	–	–	–	+	+
Ability to configure objects in model*	P	P	P	P	P	P	P	A	P	P	A	P	P	P	P	P	P	A	A
Dedicated compliance management feature	+	+	–	–	–	–	–	–	–	–	+	–	–	–	–	+	–	–	–
Publishing formats																			
Image	+	–	+	+	+	–	–	+	–	+	–	+	+	+	–	+	+	+	+
Ms Word	+	–	–	+	–	+	–	+	–	–	+	–	–	–	–	–	–	–	–
PDF	+	+	–	+	+	–	+	+	–	+	–	–	–	–	–	+	–	+	–
Web	+	–	+	+	+	–	–	+	–	–	+	–	+	–	–	–	+	–	+
Export	+	+	+	–	+	+	+	+	+	+	+	–	+	–	+	+	+	+	+
BPEL	+	–	–	–	–	–	–	–	–	–	+	–	+	–	–	–	–	+	–
BPMN	+	+	–	–	+	–	–	–	–	–	+	–	+	–	–	–	–	+	+
XPDL	+	+	–	–	+	–	–	–	–	+	+	–	+	–	–	–	–	+	–
XML	+	+	–	–	–	+	+	+	–	–	+	–	+	–	–	–	+	+	+
Other	+	+	–	+	–	+	+	+	–	–	+	–	+	–	+	+	+	+	+
Import	+	+	+	–	+	+	+	+	–	+	+	+	+	+	+	+	+	+	+
BPEL	–	–	–	–	–	–	–	–	–	–	+	–	+	–	–	–	–	+	–
BPMN	+	+	–	–	+	–	–	–	–	+	+	+	+	+	–	+	–	+	+
XPDL	+	–	–	–	–	+	+	–	–	–	+	–	+	–	–	+	–	+	–
XML	+	+	–	–	–	–	–	+	–	–	+	–	+	–	–	–	+	+	+
Other	+		–	+	+	–	+	+	+	–	+	+	+	+	+	+	+	+	+
Ability to implement user-defined reusable functionality	+	+	–	+	+	–	+	+	–	+	+	+	+	+	+	+	+	+	+
Ability to link objects with external or internal objects**	I	B	B	B	B	I	I	B	–	B	B	B	B	B	I	–	B	B	B
Search functionality	+	+	–	+	+	+	+	+	–	+	–	–	+	–	–	+	–	+	+
Hierarchy of process models	+	+	–	+	+	+	+	+	–	+	+	+	+	–	+	+	+	+	+
In-tool verification of notation	+	+	+	+	+	+	+	+	+	+	+	+	+	+	–	+	+	+	+
Change management of models	+	+	–	+	+	–	+	+	–	+	+	–	+	–	+	+	–	+	+
Implementation language***	C	J	J	J N	J	J	S	C	J	J	C	J	J	J	P	J	J	C	J
Open-Source	+	–	–	–	–	–	+	–	+	+	–	+	–	+	+	+	–	–	–
Semantic mapping				–	–					–									
Soundness of business process models				–	–					–									
Automated compliance checking approaches				–	–					–									
Verification of generated code				+	+					+									

** A = All objects; P = Predefined objects*

***I = only internal; E = external B = both internal and external*

**** J = JAVA; N = .NET; C = C++; S = Standard ML*

The results can be analysed by comparing the results of experiments. The results of the analysis can be summarised as follows:

1. The criterion that is supported by all evaluated tools is a graphical user interface (GUI). GUI contributes to transparent and comprehensive implementation of the process.
2. Common trends can be viewed in support of BPMN (except tool Greta [25]); however, the supported BPMN elements differ. There are different reasons for this, e.g.,

the BPMN specification [10] is not unambiguous regarding a set of BPMN elements that each BPMN compatible tool must support, and each tool vendor is free to choose what elements to include – tools focused on business users might exclude BPMN elements meant for execution, and tools designed for BPMN model implementation must include a complete set of BPMN elements.

3. Other common characteristic is in-tool build verification of the notations (except ProcessMaker [31] and ProM tools [32]).
4. Most criteria are supported by Enterprise Architect [24], Adonis [17] and Visual Paradigm [35]. However, Enterprise Architect [24] is lacking functionality regarding business process compliance management, but addresses enterprise architecture compliance problem [36], and its source code is not available for modification.
5. Adonis [17] is lacking only support of range of the notations and linking external objects.
6. Visual Paradigm [35] lacks compliance management support, supports fewer notations (most notably there is no BPEL support), has fewer publishing options, and its source code is not available.
7. For solutions where it is important to use other notations than BPMN, e.g., executable modelling notation BPEL, for example, in [37], tools Enterprise Architect [24], Oracle BPA suite [29] and ARIS Architect & Designer [18] are recommended.
8. The evaluated open source products satisfy fewer criteria than the evaluated commercial products, despite the additional criteria dedicated to the open source products. For the solutions where built-in functionality is not sufficient and requires additional development according to the criteria, best tools according to our analysis are CPN Tool [23] and Intalio BPMS [26]. Both tools are open source and modifications of the code are possible; however, licensing fees apply for the whole source code for Intalio BPMS [26]. The main weak points of the Intalio BPMS [26] are (1) not having possibility to create a process model from fragments, and (2) support of only BPMN.
9. CPN Tools [23] is an open source tool under GNU General Public License. Yet to develop additional functionality it requires knowledge of specific programming language – Standard ML '97 [38]. It can also be concluded that (1) out-of-the box functionality is not supported, (2) linkage between internal and external objects is not supported.
10. According to the results presented in Table III, the analysed business process modelling tools do not have an in-built semantic mapping feature, feature of checking soundness of business process models, and automated compliance checking approaches. This highlights the lack of automated compliance management functionality in modern business process modelling tools, raises new research possibilities in this field, and justifies a need for developing a tool for business process modelling tools with automated compliance management features.

The obtained results are useful for choosing the tools for compliance management in general and for choosing the open source solution as a basis for developing a new tool in particular.

VI. Conclusion

The paper presents the results of the comparative analysis of business process modelling tools regarding their capabilities to support compliance management in business process modelling. The main contributions of the paper are the following: 1) a set of criteria for tool evaluation, and 2) the experimental results of tool evaluation regarding compliance management. The results of experiments and their analysis may be helpful in choosing business process modelling solutions that already contain compliance management features as well as in developing business process modelling tools capable of compliance management for business processes. The evaluation has clearly shown the gap between existing tools and techniques used for automated or semi-automated compliance checking, and highlighted the need for a tool combining business process modelling and compliance management.

The results of experiments are valid only for the evaluated versions of the tools. However, the criteria used in experiments are made on the basis of comprehensive literature study and may be used for the analysis of further versions of the tools as well.

A set of tools used in the evaluation is rather small; it still includes the most tools mentioned in compliance management and business process management literature, and gives an insight into the current strengths and limitations of available solutions.

The results of the research will be used in our further research regarding the design of the environment for effective semi-automated compliance management in enterprises.

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