A Systematic Review of Compliance Measurement Based on Goals and Indicators

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Abstract. Business process compliance management is an important part of corporate governance as it helps meet objectives while avoiding consequences and penalties. Although there is much research in this area, we believe goal-oriented compliance management using Key Performance Indicators (KPIs) to measure the compliance level of organizations is an area that can be further developed. To investigate this hypothesis, we undertook a systematic literature review, querying four major search engines and performing manual searches in related workshops and citations. From a research body consisting of 198 articles and their references, we have systematically selected 32 papers. We grouped these papers into five categories and highlighted their main contributions. The results show that all selected papers were written in the last five years, and that few effectively represent compliance results using dashboards or similar tools. Although all individual pieces are available, no existing solution yet combines goals with KPIs for measuring the overall compliance level of an organization.

Keywords: Systematic Review, Business Process, Goal Modeling, Legal Compliance, Key Performance Indicator.

1 Introduction

Ensuring that business processes comply with legislation, regulations, and policies is a very important activity. Every year, organizations invest time and money to ensure business process compliance (BPC). According to a survey by the Illinois Banker Association [9] in 2010, among the 128 banks who responded, over 54% spend 5% of their annual operating expenses on compliance and internal audits, 40% spend between 5% and 20% on compliance, while 4% spend more than 20% on compliance.

Compliance management becomes complex due to an overwhelming number of regulations introduced each year. With so many rules to follow, large organizations face difficult challenges when measuring business process compliance levels in a quantitative way. They also have a hard time assessing the impact of making their business processes compliant to organization goals and finding suitable tradeoffs.

While there is ongoing research on BPC, the lack of comprehensive techniques for *measuring* the level of business process compliance against regulations while considering *processes* and *goals* motivates us to conduct a systematic literature review in this area. The objective of our review is the systematic selection and characterization of literature that focuses on BPC. The research questions we address in this paper are:

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- What are the methods based on Key Performance Indicators (KPIs) used for measuring the compliance of business processes against policies and laws?
- What goal-oriented modeling methods are used for compliance measurement?

Although some systematic literature reviews have been done in the field of compliance management [1, 5], these reviews are limited to the information systems domain or focus on the compliance assessment of business process instances to process definitions (without consideration for legal aspects or means to reason about tradeoffs with other organization goals). Hence, they do not answer our research questions.

In our research, we followed the approach proposed by Kitchenham [15] for systematic literature reviews. We divided our method into three main phases, shown in Fig. 1. The first phase is the selection of the related work, the second is the analysis of the selected material, and the third is the detailed review of relevant papers.

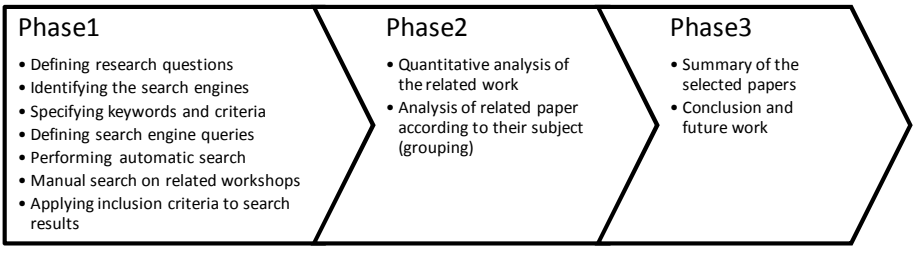

Fig. 1. Research Method

This paper is organized as follows. Section 2 details the first phase on paper selection. Section 3 categorizes and analyzes the selected papers. A summary of the most important papers is presented in section 4, followed by our conclusions in section 5.

2 Phase 1: Selection of Related Work

This phase identifies the search engines, selection criteria, and inclusion criteria.

2.1 Identification of Search Engines and Other Sources

We considered four popular IT search engines for this research, including SpringerLink, IEEE Xplorer, and the ACM Digital Library. Google Scholar was also included in order to cover a broader range of domains (e.g., management and auditing) and venues. In addition, a manual search was done for the following workshops: *i** Workshop (for goal modeling) and GRCIS (for regulatory compliance). We also extended the initial selection with relevant articles that have been cited in the papers found. We did not scope the review to a particular time period. The data set consisted of 142 papers from the search results and 56 papers from the manual inspection. Since not all papers found by the search engines were related to our research questions, we defined selection criteria, discussed in the next section, to filter out the first set of results.

2.2 Selection Criteria

We were looking for papers focusing on goal modeling approaches and/or KPIs for measuring compliance of processes with regards to regulations or policies. We chose five main sets of keywords for defining the search engine queries as well as the final filtering of the search results. The reviewed articles should at least focus on *Compliance*, *Business Process*, *Legal/Law/Policy*, *KPI*, and *Goal Modeling*.

Using these five selection criteria, we formally defined keywords and queries for the search engines. The main abstract query is (goal AND compliance AND (law OR legal OR policy) AND ("performance indicator" OR KPI OR "compliance indicator") AND "business process" AND model), used for all search engines except for Google Scholar. The latter returned thousands of unrelated papers with the aforementioned keywords; therefore we decided to narrow down the results by replacing "business process" keyword with "business process compliance". In addition we tried a simpler query ("Business process compliance" AND "Goal" AND ("KPI" OR "Indicator")) on all four search engines, but most articles found were the same as in the first set of queries, and only 8 new articles were found. A manual search of the two related workshops led to an additional 56 papers. The search results are illustrated in Table 1.

Table 1. Automatic and Manual Search Results

	Springer	IEEE	ACM	Google Scholar	GRCIS	iSTAR	Simpler Query	Cited	Total
Search Result	44	45	20	25	13	43	8	0	198
Finally Selected	2	7	4	8	4	2	0	5	32

2.3 Inclusion/Exclusion Criteria and Procedures

In this step, we reviewed each of the 198 papers by reading the abstracts and conclusions. A paper was included if any of the following were true:

- It was related to compliance of processes or legal/policy compliance.
- It used KPI for any kind of measurement not just BPC (e.g., for process performance or for assessing the security of a complex process).
- It was related to stakeholder or organization goals (goal-oriented).

The last two aforementioned criteria were defined to improve our understanding of the other applications of goal-oriented and KPI-based approaches. Furthermore, a paper was excluded if any of the following were true:

- It discussed compliance but not in relation to business processes or to the legal/policy domain (e.g., network compliance).
- The paper was not written in English.

Finally, after considering all the papers against the above criteria, we selected 32 papers for the next phase for further analysis and detailed review. Table 2 lists all 32 papers, the criteria (keywords) they satisfy, and the five categories introduced in section 3.

Table 2. Selected Papers and Criteria

Category	Paper	Goal	Business Process	Compliance Modeling	Process Modeling	Law/Legal /Policy/Rule	Compliance	Indicator /KPI
Compliance framework and standards	[33]	No	No	No	No	Yes	Yes	No
	[11]	No	Yes	No	Yes	Yes	Yes	No
	[12]	No	Yes	No	Yes	Yes	Yes	No
	[14]	No	Yes	No	Yes	Yes	Yes	No
	[13]	No	Yes	No	Yes	Yes	Yes	No
	[17]	No	Yes	No	Yes	Yes	Yes	No
	[16]	No	No	No	No	No	Yes	No
Measure of compliance levels	[26]	No	Yes	No	Yes	Yes	Yes	No
	[18]	No	Yes	No	Yes	Yes	Yes	No
	[37]	No	Yes	No	No	Yes	Yes	Yes
	[34]	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Discovery and controls of non-compliant business processes	[27]	No	Yes	No	No	Yes	Yes	No
	[36]	No	Yes	Yes	Yes	Yes	Yes	No
	[21]	Yes	Yes	Yes	Yes	Yes	Yes	No
	[7]	Yes	Yes	Yes	Yes	Yes	Yes	No
	[8]	Yes	Yes	Yes	Yes	Yes	Yes	No
	[35]	No	Yes	No	No	Yes	Yes	Yes
	[2]	No	Yes	No	Yes	Yes	Yes	No
	[38]	No	Yes	No	Yes	Yes	Yes	No
Goal-oriented techniques and KPI	[32]	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	[31]	Yes	Yes	No	Yes	No	No	Yes
	[28]	Yes	Yes	No	Yes	Yes	No	Yes
	[4]	No	No	No	No	No	No	Yes
	[23]	No	No	No	No	Yes	No	Yes
	[6]	No	Yes	No	No	Yes	No	Yes
	[25]	Yes	No	No	No	No	Yes	No
	[24]	Yes	Yes	No	Yes	No	No	No
	[3]	Yes	Yes	No	Yes	No	No	No
Others	[22]	No	Yes	No	Yes	No	No	Yes
	[29]	No	Yes	No	No	Yes	Yes	Yes
	[19]	No	No	No	No	No	Yes	Yes
	[20]	No	No	No	No	No	Yes	Yes

3 Phase 2: Analysis of Related Work

In this phase, we analyzed the selected papers in two ways. First, we performed a quantitative analysis to show the distribution of the articles over the years. We observed that the selected papers were all published after 2006. The second analysis is the main contribution of this literature review. After careful analysis of the papers' contents, we grouped the papers into five categories considering their subject and our research questions.

- *Compliance frameworks and standards*: This category includes papers that suggest a framework for regulatory compliance or compare standards (see 4.1).
- *Measurement of compliance levels*: Approaches that not only discover non-compliant business processes but also measure their compliance level qualitatively and/or quantitatively (see 4.2).
- *Discovery and control of non-compliant business processes*: Approaches for discovering and controlling non-compliant business processes that however do not suggest solutions for measuring compliance levels (see 4.3).
- *Goal-oriented techniques and KPI*: Papers using goal-oriented techniques and KPI measurements for applications not related to compliance (see 4.4).
- *Others*: Papers related to compliance not appropriate for any of the previous compliance related categories (see 4.5).

4 Phase 3: Summary of Selected Papers

4.3 Compliance Frameworks and Standards

There are a number of methodologies and standards for IT security and governance helping companies increase IT efficiency and meet regulatory requirements. Radovanovic *et al.* [33] compare several. According to a survey referred in their work, out of 1865 companies, 69% use COBIT for IT governance, 11% use ITIL for its best practices in IT services management, and 12% use ISO 27002 for IT security. These standards are used for internal audits and IT process improvement, as well as addressing legal requirements such as protection and non-disclosure of personal data and the Sarbanes-Oxley Act (SOX).

Karagiannis *et al.* [11] propose a six-step business process modelling approach for SOX regulatory compliance. This approach relies on detecting risks in processes (related to a particular section of the SOX regulations) and addressing them by defining controls. In addition, they design extensive test cycles to verify compliance. If the test results show a gap, then a redesign step is considered to address the detected issues. They also propose the use of a business process management (BPM) platform called ADONIS as the supporting tool for the methodology [12].

Kharbili and Stein [13, 14] define high-level requirements and an architecture for compliance management. They introduce a three-layer-architecture: 1) one to document and model policies, 2) one for design-time artifacts such as process models and business rules, and 3) one for the execution of both processes and rules. Furthermore, they propose transforming regulations into semantic policies, and then transforming semantic policies into semantic business rules, and then a final transformation into operational rules which can be used to automate processes. They also discuss eight dimensions used to assess a compliance management system.

Ly *et al.* [17] propose the fundamental requirements for process management systems' compliance with rules/policies. In addition, they assess the existing frameworks with respect to the proposed requirements.

Finally, Koliads and Ghose [16] describe a compliance program, a set of management processes, helping organizations with regulation compliance. In their context, a compliance program should be able to discover compliance obligations and to report on the overall compliance of the organization. In addition, it should have a mechanism for improving non-compliant processes and be able to identify, measure, and mitigate risks.

4.2 Measurement of Compliance Levels

Morrison *et al.* [26] define a method for measuring the degree of compliance of processes with respect to both crisp and imprecise compliance requirements. Their method relies on creating a compliance scale model that allows measurement of both qualitative and quantitative values for a particular process instance. Although this method can assess the level of compliance of a process, it requires a lot of preparatory work to determine the compliance scales.

Lu *et al.* [18] propose a method for measuring BPC against control rules defined using control objectives from different sources (e.g., regulations or partner contracts) and are modeled using FCL (Formal Contract Language). They define concepts of ideal semantics for control rules in order to categorize various degrees of compliance between processes and rules. They categorize them into four groups including ideal, sub-ideal, irrelevant, and non-compliant situations. They calculate both ideal and sub-ideal compliance degrees of businesses processes against control rules to evaluate how well the process model supports control rules.

Silveira *et al.* [37] suggest a compliance governance dashboard (CGD), with *key compliance indicators (KCI) used to measure the compliance level of processes*. Their CGD consists of different levels of abstraction. The top-level page shows the most critical regulatory and policy indicators, the compliance level of the main processes, as well as an overall compliance level for the organization. One can drill down to see more details and analyze the compliance of individual process atomic units in various business units. Furthermore, one can view compliance violation reports consisting of all the information reported to internal and external auditors.

Rifaut and Dubois [34] propose a method to combine and model the regulations and business requirements for processes. They combine tabular requirements with *i** goal models, where they model *purposes,* and decompose them all the way down to indicators used to assess and measure the success of processes. This framework can be used prior to the design and implementation of a process, as well as later on for monitoring and controlling the compliance of processes.

4.3 Discovery and Control of Non-compliant Business Processes

Namiri and Stojanovic [27] propose a formal logic-based framework for managing BPC. They identify significant accounts (e.g., Inventory) with major impact on financial reporting. Afterwards, they identify all relevant risks (e.g., customer order rejection) and processes (e.g., warehousing and purchasing process). Finally, they define a set of controls for these risks, and suggest properties focusing on relationships between the accounts, controls, processes, and risks.

Sadiq *et al.* [36] propose a structured approach bringing together compliance control objectives and process models. Control objectives are modeled through a modal logic based on FCL. They also propose four types of control tags (i.e., flow, data, resource, and time) used to visually annotate process models and illustrate the aspects of a process controlled by control objectives.

Marino *et al.* [21] check BPC at design time to detect sources of non-compliant. They define control objectives, derived from both regulations and business objectives/goals, at a high level and refine them into lower-level functions and procedures (activity controls) implemented in the form of control processes. In addition, they propose an algorithm used to perform bottom-up satisfaction analysis of control objectives. A second algorithm is suggested to detect the impact of process activities on the control objects in terms of satisfaction and compliance.

Ghanavati *et al.* [7, 8] propose a requirements management framework for BPC based on the User Requirements Notation (URN) [10]. In this framework, the legal requirements and organization goals are modeled using URN's Goal-oriented Requirement Language and business processes with URN's Use Case Maps. In addition, the models are linked to policies and legal documents using a commercial

requirement management system. Several types of links between organizational and legal models are defined to detect non-compliant and react to changes in the law.

Rodriguez *et al.* [35] build on the results obtained from CGD [37] using a decision tree algorithm and data mining to analyze, predict, and explain non-compliant process instances. They successfully apply their method to a drug dispensation process.

Awad *et al.* [2] propose a method for automatic detection and resolution of compliance violation in process models using patterns. This is a great step toward addressing maintenance issues in process compliance space. Weber *et al.* [38] propose an approach for validating a process against a set of predefined constraints. The objective of this work is to detect states of the process execution violating the defined rules.

4.4 Goal-Oriented Techniques and KPI

Pourshahid *et al.* [32] extend URN to validate processes from both performance and compliance points of view. In addition, [31] use the aspect-oriented extensions to URN to improve processes dynamically using KPIs and redesign patterns.

Nigam *et al.* [28] suggest an artifact-centric approach for BPM. They model the high-level business goals that drive operational goals as well as the KPIs used to manage and monitor operational artifacts. In addition, they formally introduce the concept of a management rule, defined to react to events occurring in the organizations. Boehmer [4] also uses efficiency and effectiveness KPIs to evaluate and measure the value of an investment to prevent risk in the implementation of an Information Security Management System based on ISO 27001. Martin and Refai [23] propose a framework for measuring and monitoring IT security performance using metrics.

Dang *et al.* [6] describe an ontological framework for designing healthcare processes, resources, and rules. Their framework contains five different views of a hospital as well as the relations between components of these views. KPIs' view is used to monitor and evaluate performance from different perspectives.

Morandini *et al.* [25] summarize three goal-oriented research areas ongoing at the University of Trento, i.e., system requirements for compliance with laws, the selection of the best design patterns during system design, and self-adaptive systems using software agents that select alternative paths at run-time to achieve system goals.

Martinez *et al.* [24] propose a goal-based approach (using TROPOS) to monitor and assess the impact of processes on enterprise and actor goals. Furthermore, Popova and Sharpanskykh [30] very recently proposed a framework for modeling organization goals based on KPIs. Behnam *et al.* [3] use a goal-driven development method, considering both organization and system goals, to design and develop patient surveillance software for monitoring adverse events.

4.5 Others

Compliance has a critical role in outsourcing environments where trust between clients and contractors can be an issue. Massacci and Yautsiukhin [22] use indicators to assess the security of a complex process in such situations. They use Key Assurance Indicators (KAI) to show how client goals are met, and Key Security Indicators (KSI) to measure the security techniques utilized by contractors. According to Pasic *et al.* [29], KAI can be used to evaluate process compliance and KSI can illustrate the quality of the control processes used to achieve compliance.

Mahnic *et al.* [19, 20] discuss the compliance of AGIT (AGIle software developmenT) against COBIT with regards to indicators. AGIT models consist of indicators for the performance of a Scrum development process. The authors compare AGIT indicators with COBIT indicators to check whether the latter are measurable using AGIT. Finally, they propose adding new indicators to AGIT to cover the gaps.

5 Conclusions and Opportunities

This paper reports on a systematic literature review that addresses two questions: *Have KPIs been used for compliance measurement?* and *Are there any goal-oriented methods for compliance measurement?* Although the answer is yes to both questions, no available solution yet combines goals with KPIs for measuring the overall compliance of organizations.

We have grouped the 32 selected papers into five categories. The first one focuses on compliance frameworks, reference models, and standards, and it can be used as general guidelines for assessing compliance management frameworks. The next category targets the measurement of compliance levels of processes. The two papers most related to our research topic here are [37], which suggests a dashboard/KPI approach to measure the overall compliance of an organization, and [34], which proposes a goal-oriented process assessment model capturing and measuring process requirements. Although the approach in [34] addresses both of our research questions, the paper does not identify how KPI values are measured and does not suggest a method for measuring the overall compliance level of the organization. In the category related to non-compliant business processes, some papers propose logic-based frameworks for modeling controls and rules whereas others use goal-oriented languages such as URN or *i**. The goal-oriented and KPI category cover papers with approaches in research areas not related to compliance. Finally, the last category discusses papers related to compliance that are not appropriate for any other category.

Research on BPC has increased significantly in the past 5 years. Much of the research uses control objectives as a means of expressing compliance goals for business processes, while internal controls are used as means to make processes compliant. Also, several goal-oriented and measurement (KPI)-based approaches to manage and control compliance in organizations have been proposed. These two types of approaches are similar in the sense that in both cases, regulation requirements are imposed on processes as process objectives. None of these approaches, however, provides a final qualitative indicator on the compliance level of organizations. This would be a key enabler for upper management to analyze the current state of the organization and plan for the future. As a result, an important item for the research agenda in this area is the qualitative measurement of the level of compliance in organizations. Future work should tackle the combination of KPIs with goal-oriented approaches, possibly using business intelligence applications for visualization and reporting to provide the infrastructure for measuring and monitoring the compliance level of organizations.

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