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A Monitoring Framework for Guidance and Risk Control Assistance of Environmental Compliance Officers

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Abstract: It is the ultimate goal of environmental compliance management to assure corporate compliance with given regulations. The work processes that are required to fulfill and maintain compliance are usually complex and long running processes that are composed of many interdependent human lead activities. Errors of human work activities and also material and equipment defects can lead to non-compliance. A monitoring framework is proposed that based on data entries of compliance officers can track compliance work processes and provide compliance officers with activity guidance. Main activity failures can be detected through failure detection functions that analyze the activity log, failure indicators, and also external data. Based on the proposed framework environmental information systems can be extended towards actively responding systems that guide compliance officers and provide them with assistance for risk control tasks.

Keywords: Environmental Information Systems, Environmental Compliance Management, Failure Estimation, Risk Assessment, Activity Monitoring, Reactive Information Systems.

1 Introduction

The work area of corporate environmental compliance management is directed at the fulfillment of environmental protection regulations by the company [Gu11] [Im12]. To this end specialists from disciplines such as occupational safety, hazardous material management, fire protection, and transportation safety work together with colleagues from other corporate areas. In general, environmental regulations can be directed at almost all corporate areas [HMB11]. Because of their potential to harm the environment often the areas of product engineering, manufacturing, logistics, plant maintenance and quality management are targeted by environmental regulations. Companies need to be prepared to carry out compliance enforcement activities at different levels of all business aspects. This includes for example activities focused on product properties, production and logistic processes, corporate infrastructure components, and also activities that concern the knowledge and skill level of the workforce. The company faces sanctions ranging from fines, withdrawal of licenses and even permits to mandatory closures and shutdowns when full compliance is not maintained at all times.

The successful completion of compliance management obligations that will lead to environmental compliance largely depends on carefully chosen and managed human-

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lead enforcement activities [Im95]. However, for human work in general one needs to assume that errors can occur and that work results may not meet given outcome constraints. This rule that human work bears the risk of errors, of course, also applies to compliance enforcement activities. Activity errors such as wrong decisions, wrong judgements, and wrong activity plans can result into non-compliance. In the light of the already enormous amount of legal regulations that is still increasingly growing in the future [BM09] errors of compliance management teams are however most likely to occur. In addition to humans also other aspects such as material errors and equipment defects can cause compliance management activities to fail.

In order to prevent that this can happen compliance officers can be provided with system generated guidance for activity completion and assistance for risk control measures. What is needed as foundation for an approach of a corresponding system with realtime responsive functionality is a component that monitors the human activities and performs checks in order to detect activity errors. A corresponding monitoring framework is proposed in this article. Based on data entries from the human actors of compliance activities the ongoing compliance work processes are tracked and also guided with respect to temporal constraints. Through corresponding failure detection functions that analyze the tracking data, failure indicators, and also company external data activity problems can be detected. In a next step the monitoring framework will be implemented within the environmental compliance management information system CCPro [Th15a] in order to obtain first evaluation results.

The use of information system approaches to enforce environmental compliance regulations has been studied so far by only a few research groups. Freundlieb and Teuteberg [FT09] proposed an approach that targets corporate environmental compliances through data warehousing based advanced reporting and analysis capabilities. A public web-based system which based on user input and an XML regulation framework generates a compliance decision has been developed by researchers of the Stanford University [Ke03]. Researchers from IBM and the University of Stuttgart proposed a system where similar to our approach compliance management activities are logged in database tables in order to detect anomalies that may indicate compliance violations [Ag06].

The remainder of this article is organized as follows. The following Section 2 gives an overview of corporate environmental compliance management obligations and especially describes two core work processes and their activities in more detail. The section also describes through a conceptual data model the main concepts of compliance management processes. Section 3 describes the motivation for system-based provisioning of activity guidance and risk control assistance. Furthermore, the three main activity failures of the compliance management processes that are focused in our work are identified. The proposed monitoring framework is described in Section 4 and concluding remarks are given in Section 5.

2 Environmental Compliance Management Processes

In general a company's environmental compliance management efforts are targeted on three goals [Gu11][HMB11]. First, the organization needs to ensure that at all times it knows all the relevant legal regulations for environmental protection. Second, for all relevant regulations the organization has to determine and implement measures that are required in order to fulfill given requirements. Third, the organization needs to document all considerations, measures, special permits obtained from regulation enforcement agencies, and measures targeted on environmental protection. This documentation task has to be completed in a way that enables the organization at any time to proof the fulfillment of the two previously described obligations. Especially, when auditors from accredited independent agencies conduct an environmental audit they expect the company to perform sufficient proofs of fulfillment. This usually involves the demonstrating of the environmental compliance management work practice, consistency checks of the required documents, and data validation steps with available information systems and tools.

In order to meet these goals companies are advised to define for the compliance management officers corresponding operational level business processes that they need to follow [Im95]. Similar to other corporate work areas which are also governed by a relatively large body of legal and other regulations (e.g., human resource management, financial accounting) one can describe a set of core compliance management processes that are applicable to many companies [BM09] [Im12]. For example, from an earlier empirical investigation [Th15a] of the compliance management work practice we obtained two core data-driven processes that serve as reference processes for the research described in this article. These two processes and their main component activities that need to meet temporal and outcome constraints are:

- The process of recognizing new regulations and of treating new regulations in order to enforce environmental compliance referred to in the following by *New Regulation Management process* or in short *NRM process*. This process can be roughly decomposed into the following sequence of activities (called NRM activities) that are to be documented in terms of their progress, actors, and other aspects:
    1. recognize new regulation and capture regulation in the corporate compliance management register
    2. evaluate relevance of new regulation at the company level, the level of organization units, and the level of company locations
    3. determine for relevant regulations those individuals and organizational units which need to decide about measures to respond to the new regulation so that non-compliance will be avoided
    4. implement the measures
    5. check effectiveness of measures

- The process of recognizing revisions on existing regulations and of treating the revisions in order to enforce environmental compliance referred to in the following by *Regulation Change Management process* or in short *RCM process*. The decomposition of this process yields a similar sequence of activities (RCM activities) as described above.

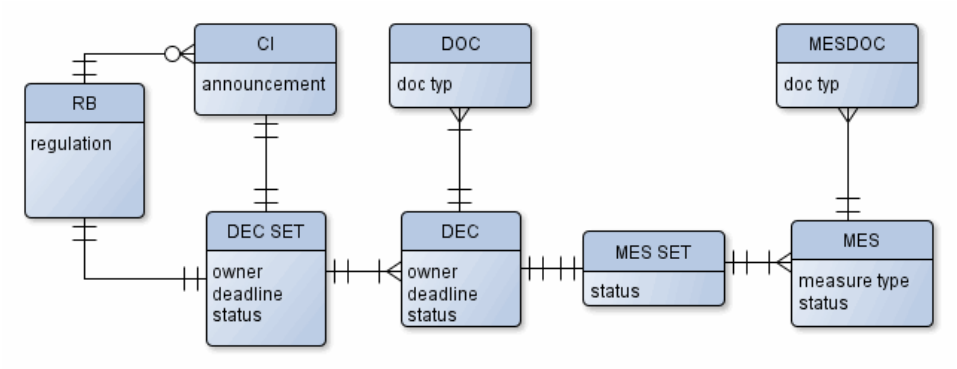

Fig. 1: Conceptual data model for environmental compliance management tasks.

The data objects that are addressed in these two core processes can be described as a corresponding conceptual data model such as given in Figure 1 which uses the popular Martin Notation for cardinalities [Ma90] that is a refined version of the Information Engineering Notation. The definitions of the concepts that capture the meaning of the real world entities addressed in the processes (i.e. object types) are as follows:

- Regulatory Basis (RB): These data objects refer to any kind of regulation that is part of the current general body of environmental laws and that is relevant to the company and thus captured in the regulation register. Every RB object is associated with decisions about compliance enforcement measures.
- Change Incidents (CI): An object of this type represents an announcement of a revision of a relevant regulation or a repeal of a regulation. Thus, every CI object is linked to a particular RB object. Furthermore, CI objects are linked to decisions about compliance enforcement measures.
- Decision sets (DEC SET) and (composite) decisions (DEC): In most cases when compliance enforcement measures are required several alternative actions are existing. This situation leads to a selection decision and this is addressed by a data object type DEC SET. This type represents a set of decisions that are all targeted either at the same CI object or the same RB object. The (composite) decisions that are part of a decision set are represented by the type DEC. It is the goal of each composite decision to obtain a set of proper compliance enforcement measures (MES SET).

- Documents involved in the decision making processes (DOC): For reasons including traceability and transparency the decision making processes are to be documented through a set of documents. The DOC objects are linked to the respective (composite) decision objects.
- Sets of measures (MES SET) and (composite) measures (MES): The data object type MES SET refers to sets of compliance enforcement measures that are to be completed at a certain deadline in order to maintain a given positive environmental compliance status. The (composite) measures that belong to a set of measures are represented by the object type MES. Each measure is of a certain measure type.
- Documents that describe measures (MESDOC): The measures are to be documented with respect to many aspects such as the completion state and the measure effectives through a set of documents. The MESDOC objects are linked to the referring MES object.

3 Motivation for Guidance and Assistance for Risk Control

As of today, environmental law overall is comprised of more than 9000 acts and subordinated regulations [BM09] [HMB11]. The assumption is that the density of environmental law provisions will continue to grow in the future. For years, new laws, directives or amendments to existing laws or previous amendments are being announced. Notices of the repeal of laws (i.e. repeal notices) are no longer the exception. The density of provisions and the amendment dynamic presents organizations with a challenge in keeping up with current, more specifically relevant legislation. But this is exactly what companies are obligated to do in order to achieve and maintain a positive environmental compliance status. Companies are obligated to know and comply with the relevant laws and regulations (obligation to stay informed). Should a company not comply with this obligation (knowingly or unknowingly), the company faces sanctions ranging from fines, withdrawal of licenses and permits to mandatory closures and shutdowns [Gu11]. Naturally, the principle *ignorantialegis non excusat* (ignorance of the law excuses no one) applies. Accordingly, companies hire internal and external environmental law specialists to assure that companies comply with all relevant statutory regulations. The growing complexity however is increasing the probability that compliance experts are over-challenged and thus fail to fulfill required compliance enforcement tasks which will cause corporate non-compliance. In addition to that there always exist the human factors such as compliance officers with mental problems as a further source of corporate non-compliance.

Apart from compliance officers that as individuals can be over-challenged by the sheer complexity of the regulation situation there exist also further sources of the risk of non-compliance. There are first of all the known phenomena of group work such as a destructive group atmosphere and the Group Think effects [Ja72] that can contribute to an increasing risk of non-compliance. In addition to that, measures that are targeted on

maintaining compliance can suffer from material errors and equipment defects. These aspects need to be treated as a further potential cause of the risk of non-compliance.

The potential for the risk of non-compliance motivates in the light of the severe consequences of compliance violations the specific research reported in this article. It is the goal to develop and study information system approaches that, firstly, offer to compliance experts helpful activity guidance [Bo09]. This guidance is directed at the pro-active enforcement of fulfilling both temporal constraints and outcome constraints of activities required by NRM processes and RCM processes. To this end the guidance is especially oriented at proposing appropriate activity time schedules to compliance management experts. Secondly, it is intended to offer to the compliance management experts assistance for risk control tasks directed at the risk of non-compliance. At the current state the focus of the latter is to detect potential risk sources and to present to compliance management experts the risk of non-compliance in the form of a risk diagram [Th15b].

The detection of risk sources is focused on evaluating NRM activities and RCM activities in terms of possible violations of the activities' temporal constraints and outcome constraints. These violations are generally referred to as *activity failures*. In the remainder of this chapter three specific activity failures are described which are referred to by *missed activities, overdue activities,* and *imperfect activities*. Also described are examples for approaches to detect such failures through the evaluation of easy to compute "hard indicators" and also more sophisticated "soft indicators" that can involve company external data and complex failure estimation methods.

By *missed activities* it is referred to activities that at a given point in time need to be executed in order to maintain compliance but however are missing in the set of ongoing activities. A missed activity, for example, can refer to a situation where the compliance team over-looked the announcement of a new community regulation for noise immission that will become effective at a certain future date. Consequently, the new regulation will not be addressed and cause a future non-compliance state. Checking "hard indicators" in order to detect missed activities means to compare the usual pattern of monitoring activities with the most recent pattern. Deviations between the patterns are to be treated as potential activity failures. Checking "soft indicators" can be performed by evaluating external information sources that store regulation announcements such as online information services and regulation portals. For example, assume that one identified a time period in which many new regulation announcements were published. When during this time period only a small number of monitoring activities is found in the corporate compliance management data it can be assumed that the company missed some monitoring activities.

By *overdue activities* it is referred to activities that are either overdue at the present time point or that will miss their activity deadline during a near future time interval. To give an example assume that the above described noise regulation was recognized and in a next step evaluated to be relevant for the company. As further activity it will be required

to decide about measures to fulfill the noise immission regulation. That is, one needs to schedule a corresponding decision activity and set an activity deadline. When the decision activity is not completed in time then it can happen that the measure implementation activity will not be completed in time, too. This activity failure can ultimately cause the company to fail the new noise immission regulation and result into a non-compliance state. In order to detect overdue activities one can simply check for activities that violated their deadlines. In order to complement this approach by an analysis that is directed at "soft indicators" one can check for activities that did not violate a deadline (yet) but that are likely to fail a required deadline. The identification of activities that are likely to fail deadlines can involve many aspects such as the activity complexity and the resources required. For example, consider a complex measure implementation activity that is behind its schedule. When the remaining time span to the deadline is relatively short a relatively high likelihood for a corresponding deadline violation can be assumed.

By *imperfect activities* it is referred to either already terminated activities that violated outcome constraints or still ongoing activities that will terminate during the near future time interval with outcome constraint violations, too. As an example, consider again the scenario of the noise immission constraint. Assume that in a further step it was decided to implement a noise immission fence. An imperfect activity refers to the situation that the fence (i.e. measure being implemented through a corresponding implementation activity) will not well enough shield the noise immission. As a result of the failed outcome constraint the noise limit will be violated which leads to a non-compliance status. The detection of terminated activities that violated outcome constraints is a relatively simple checking task. The detection of constraint violations for still ongoing activities is a more complex task that can be performed, for example, by the use of appropriate prediction methods (e.g. [SLM10]) and by expert judgements.

4 Monitoring Framework

A number of information systems have been developed by research teams and software companies that are in general oriented at corporate environmental management tasks – referred to by *Corporate Environmental Management Information Systems (EM-IS)* [TS09] [Me10] - or that are focused on the corporate environmental compliance management tasks – referred to by *Corporate Environmental Compliance Management Information Systems (ECM-IS)* [BM09]. It appears that in these approaches it is the predominant role of the information system to record activities, document activities, and to analyze and provide information for environmental management activities such as environmental reports. That is, similar to many other corporate information systems the role of EM-IS and ECM-IS has so far been viewed mostly as a passive role. The monitoring framework proposed in this article targets an extension of these systems towards active and self-responsive systems. It is the intension to enable these systems to automatically check conditions and to self-reactively provide online-response that is

helpful for corporate environmental compliance managers. Especially, active guidance and risk control assistance should be provided to the corporate compliance management team [Bo09].

The central pillars of the proposed monitoring framework are two data structures referred to by *Announcement Checking Schedule (ACS)* and *Execution Control Record (ECR)*. These data structures are specialized to the purpose of tracking and monitoring of environmental compliance management activities and the detection of activity failures in realtime as described in Section 3. Figure 2 gives an overview of the main principles of the framework by showing a corresponding concept diagram. The diagram focusses on the activities of the New Regulation Management (NRM) process that are depicted as boxes with activity names as labels. The principles explained in the following are also applicable to the activities of the Regulation Change Management (RCM) process. The functions to detect activity failures based on ACS data and ICR data are depicted as boxes with a gear wheel. The rounded boxes of Figure 2 correspond to data structures.

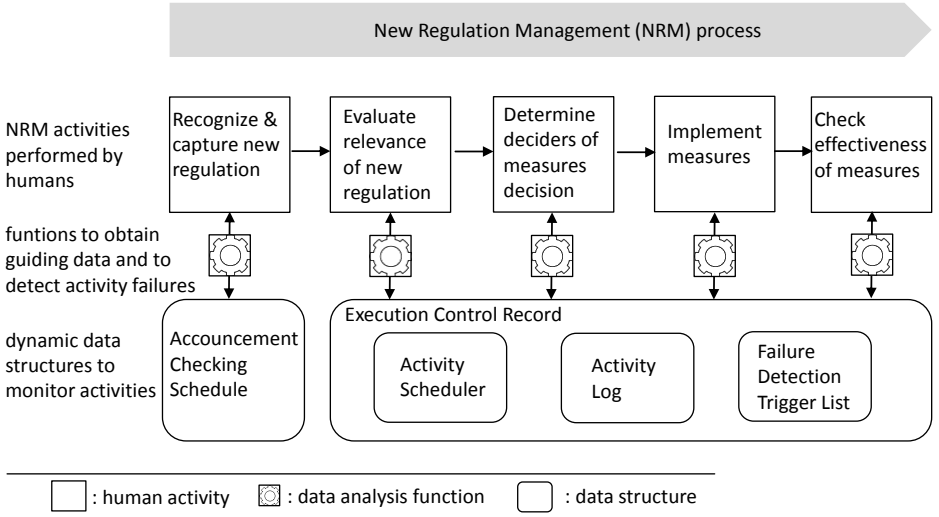

Fig. 2: Main principles of proposed monitoring framework.

The ACS contains both the schedule of required (i.e. planned) activities to monitor and to record new regulations and the set of confirmed (i.e. completed) activities. Based on the activity information it is possible to detect missed monitoring activities.

The ECR data structure consists of a set of three data objects that are created for every new regulation that is inserted in the regulation register. In order to perform an automated monitoring and evaluation of activities in realtime the data objects are dynamically revised and extended. The revision and extension operations are completed during the execution of the activities with the goal to accumulate data for detecting activity failures.

The *Activity Scheduler* specifies deadlines and time buffers for the activities that belong to NRM processes and RCM processes. The *Activity Log* records details about the activity execution. The *Failure Detection Trigger List* maintains a list of predefined triggers that enact failure detection functions. As described earlier on the basis of the data available in the ECR data structure it is possible to detect activity failures through the use of suitable failure detection functions.

In the ideal situation for an implementation of the proposed framework one can use an existing ECM-IS such as CCPro [Th15a] that is oriented at the compliance management processes described in Section 2. In addition to extending the system by the data structures described above obviously also the system needs to be extended by a corresponding active system service that is able to guide compliance officers and also to assist them for risk control purposes. At the present state the development of such an active system service is an ongoing task of a research project that targets a corresponding extension of the CCPro system.

5 Conclusions

The large amount of regulations and the threatening sanctions when a company does not comply with relevant laws imposes increasing pressure to companies to make sure that the compliance management obligations are carefully addressed. Especially the obligations are to be performed with awareness for activity failures that may cause non-compliance. A lot of the activity failures are related to the fact that environmental compliance management activities are performed by individuals and also groups of individuals. It is an unrealistic assumption to expect that through whatever measures a work practice can be achieved where human errors do not occur. However, for good reasons it can be assumed that through suitable computer-based guidance and assistance it is possible to minimize the number of failures in corporate work areas.

The monitoring framework described in this article is a first step towards an approach to extend environmental information systems by a new service that will guide compliance officers and also assist them in risk control tasks. A part from providing a complete view of the current compliance risk situation it is intended that the service is able to propose risk mitigation activities. It is expected that in many cases through these mitigation activities a future state of non-compliance can pro-actively be prevented.

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