Analyzing Risks in Business Process Models using a Deviational Technique

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Abstract: In a business environment, many processes are performing ineffectively due to different risks. Several methods and techniques for the identification and management of risks in business processes have been proposed. Some of them originate from other domains and have been adapted to the business environment such as deviational approaches. Nevertheless, there are few examples for potential applications of those methods in business process redesign. This paper addresses this gap through proposing an approach that adapts HAZOP (HA-Zard OP-erability), a systematic deviational technique, to business process environment. We discuss how this method can contribute to the improvement of business process models.

1 INTRODUCTION

In the last few years, organizations have become more aware of the importance of managing risks. They are increasingly implementing procedures that aim to control and manage business risks. This leads to an extra effort and costs that may sometimes distract people from doing what they should focus on: the business.

Therefore, creating and preserving value in business cannot be assured without bringing the risk management practices closer to business process management (BPM) domain. This need had given birth to the Risk aware business process. In fact, the Risk-aware business process system is a system that allows the reasoning about management of risks in BPM from the design to the post execution of business process. This integration has many advantages including the ability to:

- analyze risks and incorporate risk mitigation strategies in a business process model during design time (Goluch et al., 2008),
- monitor the emergence of risks and apply risk mitigation actions during run time (Conforti et al., 2011),
- Identify risks from logs and other post-execution artifacts (Jans et al., 2011).

This paper addresses the topic of risk-aware business process management. It describes an approach for analyzing risks in business process during the design time by studying the deviational behavior of the process. Since risk-aware business process environment has many similarities with the safety domain. The method described in this paper is inspired from this domain. Concretely, it uses HAZOP a deviational technique from the safety domain. That would potentially improve the risk analysis process. Thus, the results of risk analysis (HAZOP output) can be used to propose a redesign for the studied process. This is done by incorporating risk controls into the design since the analysis is considered earlier in process lifecycle.

This paper is structured as follows: Section 2 covers related work while Section 3 summarizes some preliminaries needed for the understanding of the concepts introduced in the paper. Section 4 describes EPC-Based HAZOP Analysis which is an adaptation of HAZOP a traditional method for deviational analysis. Section 5 discusses how our method can be used to motivate business process improvement. Finally, Section 6 concludes the paper.

2 RELATED WORK

The use of risk management techniques in design is a concept that had been initially adapted in safety critical systems. Many of those tools and methods, for example FMEA (Failure Mode and Effects

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Analysis), FTA (Fault Tree Analysis) and HAZOP (Hazardous Operability Analysis), have been used in various domains such as the military, power plant, aircraft and space industry. The objective is to design reliable and safe systems.

In software engineering for example, HAZOP studies have also been successfully performed on several kinds of models such as object-oriented models (Lano et al., 2002), data flow models and CORE models (McDermid, 1995). HAZOP has proved that it is useful for software hazard analysis, and safety-certification authorities recommend its use during software development. Subsequently, many adaptations have been proposed such as UML-BASED HAZOP analysis (Martin-Guillerez et al., 2010).

The application of risk management techniques in business environment is a concept that has been introduced in the past ten years. Most approaches that have been proposed in the area of risk-aware business process management tried to address the issue of risk in business processes at design time (Suriadi et al., 2012) including design time risk-analysis.

Suriadi et al. enumerated, in (Suriadi et al., 2012) risk-Aware BPM approaches that integrate risk analysis partially or comprehensively. However, the research efforts in this area are distributed across various types of risk analysis, including risk probability analysis, risk impact analysis, risk identification/discovery analysis, and risk mitigation analysis (Fenz and Neubauer, 2009), (Mock and Corvo,). They lack the technical precision to afford a convincing design-time risk analysis approach (Suriadi et al., 2012). In addition, even if the risk analysis is carried in the design-time, its output is not exploited to improve the reliability of the process. In fact, these approaches do not propose mechanisms that attach risk analysis to the design quality.

In this paper, we propose an approach of analyzing risks that can facilitate a design change in an earlier phase process lifecycle. This objective has been proposed formerly in (lhannaoui et al., 2013). Nevertheless, the present paper introduces more comprehensive version of the risk analysis method. It also details the concepts related to the risk analysis output.

3 PRELIMINARIES

In this section, we describe basic concepts that are used in this paper.

3.1 Event-Driven Process Chain

EPCs (Event-driven Process Chain) are a graphical business process description language introduced by Keller, Nuttgens and Scheer in 1992 (Govermatori, 2006). It was developed at the Institute for Information Systems of the University of Saarland, Germany, in collaboration with SAP AG. The EPC is a core part of the ARIS-framework and combines different views towards the description of enterprises and information systems in the control view on the conceptual level (ISO/DIS 31000, 2006).

EPCs describe processes on the level of their business logic. The name represents the control flow structure of the process as a chain of events and functions. Actually, the EPC describes processes by the use of alternating functions and events as time-referring state changes. Events and functions are linked by the control flow as directional edges (Govermatori, 2006).

An event-driven process chain consists of the following elements:

- Functions: The basic building blocks. Functions are active elements used to describe the tasks or activities of a business process that needs to be executed.
- Events: Passive elements used to describe under which circumstances a process (or a function) works or which state a process (or a function) results in (like pre- / post-conditions).
- Logical connectors: They can be used to connect activities and events. This is the way how the flow of control is specified. There are three types of connectors: AND, XOR (exclusive or) and OR.

The extended EPC includes the elements described below:

- The Organization Unit or Role is responsible for performing an activity or function.
- The Information Objects portray input data serving as the basis for a function, or output data produced by a function.
- The deliverables represent results (services or products) functions produce or input functions require.

In this paper, we will use EPC as a modeling language for describing business process.

3.2 HAZOP

The HAZard and Operability (HAZOP) study was initially developed by the company ICI in 1974 for chemical developing facilities but has later been extended to other types of systems and also to complex operations and to software systems (Ministry of Defense, 2000). It is typically conducted by a team consisting of four to eight persons with a detailed knowledge of the analyzed system. HAZOP is performed using a set of guidewords and attributes. It is based on a theory that assumes risk events are caused by deviations from design or operating intentions.

Table 1: HAZOP Guidewords.

Guidewords	Interpretation
No	This is a complete negation of the design intention. No part of the intention is achieved and nothing else happens.
More	This is a quantitative increase.
Less	This is a quantitative increase.
As well as	All the design intention is achieved together with additions.
Part of	Only some of the design intention is achieved.
Reverse	The logical opposite of the intention is achieved.
Other than	Complete substitution, where no part of the original intention is achieved but something quite different happens.
Early	Something happens earlier than expected relative to clock time.
Late	Something happens later than expected relative to clock time.
Before	Something happens before it is expected, relating to order or sequence.
After	Something happens after it is expected, relating to order or sequence.

The purpose of a HAZOP study is to identify what potentially hazardous variations from the design intent could occur in components and in the interactions between components of a system (Ministry of Defense, 2000). Consequently, this will permit us to avoid continuing development of designs with potential hazards (Ministry of Defense, 2000). The technique uses “guidewords” to promote creative thinking about the ways in which hazardous situations might occur. A guideword is used to express a particular kind of deviation (Table 1).

In this paper, we use HAZOP technique for risk analysis since it is:

- A qualitative method. In fact, our approach is based on the study of risk behavior rather than its appreciation;
- An inductive risk assessment tool, meaning that it is a “bottom-up” risk identification approach where we start from a particular fault to the general effect of the fault;
- Risk-focused. Actually, it concentrates on how the design will cope with abnormal conditions rather on how it will perform under normal conditions;
- Design-oriented because apart from being used for identifying hazards, it proposes recommendations with low-level details on the design.

4 EPC-BASED HAZOP

In this section, we present our method to analyze risks based on an EPC model representing a business process description. The risk analysis is then performed on this description using an adaptation of the HAZOP method. For this, we consider that we have an EPC business process model. The design should be done as early as possible in the development process to allow early identification of major risks and to program consequent adaptation of the design to incorporate risk controls.

4.1 Hazop Method Adaptation

This section aims to propose an adaptation of HAZOP for EPC-extended models. Actually, a business process model fragment can be considered as a HAZOP entity and its EPC elements as HAZOP attributes. Therefore, once the EPC model is completed, the EPC-based HAZOP method is applied by selecting model’s elements and applying the corresponding guidewords to them.

Since “Function”, is the only active element in the EPC models, we will only consider guidewords interpretation for this element.

For this, we simulate the function in an EPC model to a system in the safety domain. Its parameters are simulated to the other EPC elements: passive elements (events) and annotations. Therefore, we divide those parameters to three groups: the Role, the input parameters and the output parameters (Table 2).

Taking this into account, we then propose new definitions of hazard related to guidewords deviations which will suit for applying in the business environment. We call, consequently, EPC-based HAZOP the re-interpretation of HAZOP guidewords previously presented in Table 1 in the context of EPC modeling. Table 4 represents then the proposed definitions of the possible deviations that can be detected for the described guidewords and the related parameters.

Table 2: Groups of parameters.

Group	Parameters	Description
Role	The Organization Unit or Role	The Organization Unit or Role is responsible for performing an activity or function.
Input	Event (precondition)	Circumstances under which a function or a process works.
	The Information Objects	Input data serving as the basis for a function.
	The deliverables	Input services or products that functions require.
Output	Event (postcondition)	The state that a process or a function results in.
	The Information Objects	Output data produced by a function.
	The deliverables	The deliverables represent results (services or products) functions produce.

Table 3: Correlation of guidewords and parameters.

GW	Event		Role	Deliverables		Information objects	
	Precondition	Postcondition		Input	Output	Input	Output
No	+	+	+	+	+	+	+
Less				+	+	+	+
More				+	+	+	+
Part of	+	+		+	+	+	+
As well as		+	+		+		+
Reverse							
Other than		+		+	+	+	+

Once deviations have been identified, possible consequences and causes are analyzed. We note that some deviations can be caused by the deviation of other categories of elements, such as events, the organization role or unit, the deliverables and the information objects. In those cases, the overall deviation is associated to the function itself.

Consequently, Table 3 represents the mapping between guidewords and the other process elements.

The final outcome of EPC-Based HAZOP analysis consists of a list of recommendations and a list of hazards, together with the possible deviations leading to them. This list of hazards can be converted to a list of risks. HAZOP inherently assumes that risk events are caused by deviations from design or operating intentions. In the next section, we propose a new version of the HAZOP output in order to take into account all the variables that are related to business process risks.

4.2 EPC-based HAZOP Analysis Table

In this section, we will introduce EPC-based HAZOP table, an adapted version of HAZOP table (the output of HAZOP) that meets the purpose of our work. In the literature, Kletz defines, in (Suriadi et al., 2012), 5 principal columns in HAZOP table: guideword, deviation, possible causes, consequences action and severity, which represents a preliminary risk estimation of the impact of the deviation's consequences. and action required. Other columns can be added to the HAZOP table such as safeguards, comments, responsible for

In this paper, we use the term "recommendation" that relates to the new security requirement or the actions required to deal with the related deviation. The recommendation represents changes that should be applied to control risks.

We also introduce the severity and frequency which represent respectively, the deviation impact and the occurrence probability of the harm due to it. Those two columns represent the risk valuation.

For the consequences column, generally two levels are represented in the HAZOP table: The use case effect which represents the consequences of the deviation on the HAZOP element (the attribute) and the system effect which associates the deviation to the whole process and gives its effect in the real world.

To sum up, we propose a deviation analysis table with the following columns (c.f. Table 5):

- Attribute: the EPC element on which the deviation is applied.
- GW: the applied guideword.
- Description: the deviation resulting from the combination of the attribute and the guideword.
- Composite: if the deviation is resulted for an external reason or from the deviation of other parameters.
- Possible Causes: possible causes of the deviation that can be resulted from the deviation of any of the parameters predefined.
- Use Case Effect: effect at the use case level.
- System Effect: possible effect in the real world.
- Severity: rating of effect of the worst case scenario.

Table 4: List of deviations.

Element	Guideword	Interpretation	Related parameters
Function	Not	The function is not executed and the output is not generated	Event (Postcondition) , Output (deliverable, Information objects)
	More	The function has been executed several times or produced more than intended output	Event (Postcondition) , Output (deliverable, Information objects)
	Less	The function has produced less than the intended output	Event (Postcondition) , Output (deliverable, Information objects)
	As well As	The function has generated the intended output but with additional result	Event (Postcondition) , Output (deliverable, Information objects
	Part of	Only part of the intended activity occurs or a part of the output has been generated	Event (Postcondition) , Output (deliverable, Information objects
	Other than	A complete substitution of the activity has been performed	Event(Precondition), Input (Deliverable, Information objects)
	Early	The function happened earlier than what is intended	Event (Precondition)
	Late	The function happened later than what is intended	Event(Precondition)
	After	The action succeeds something that it should precede	Event(Precondition)
	Before	The action precedes something that it should succeeds	Event(Precondition)

Table 5: EPC-based HAZOP Output.

Deviation			Composite (O/N)	Possible Causes							Consequences		Severity	Frequency	Recommendation
Attribute	GW	Description		Event		Role	Deliverables		Information objects		Use case effect	System effect			
				Precondition	Post-condition		Input	Output	Input	Output					
Function 1			N												
Function 2	No	The function is not executed and the output is not generated	O						Input data is not available						

- Frequency: represents the occurrence probability of the deviation's consequences.
- Recommendation: the actions required to deal with the related deviation.

5 DEVIATIONAL ANALYSIS FOR BUSINESS PROCESS IMPROVEMENT

The purpose of this paper is to present an approach that allows identifying which potentially hazardous variations from the design intent could occur in the different elements of the business process model. This will help business process designers to optimize their work in order to incorporate risk controls in an early phase of the business process lifecycle: the design phase. In fact, taking risks into account in an early phase may reduce future costs of process changes and needs for process adaptations will decrease as those costs normally increase since reliability is improved. Furthermore, reducing risks in an early phase of business process lifecycle will decrease the number of failures during execution. Consequently, business losses are minimized. Therefore, it is becoming inconceivable in a competitive context, as the current one, to rely only on detective and curative treatment approaches while dealing with risks during process execution when we can reduce risks from the design phase.

In fact, (lhannaoui et al., 2013) showed through a motivation example how risk analysis can be used to change a business process model for the purpose of reducing process risks. EPC-based HAZOP is the only approach that links the risk analysis to the process model itself. Actually, it proposes a systematic approach for identifying and analyzing risks but also suggests hints regarding possible risk reduction means to prevent the occurrence of deviations or to provide protection against their unwanted effect. Once the analysis is conducted, there will be a way of preventing the occurrence of deviations. This is done by guaranteeing that recommendations are incorporated in the initial design in order to get an improved model.

Accordingly, we believe that EPC-based HAZOP presented in this paper, sketching out how new guidewords, attributes can be an input to business process improvement by providing to the organization's management the required tools to deal with risks in an early phase of the business process lifecycle. Such as, changes produced from the EPC-based HAZOP output will be used as input to re-design the process model(s) for future executions.

6 CONCLUSION

In order to improve business process, appropriate analysis methods are needed. For this, we propose new aspects that should be taken into account while changing a process design. Effectively, carrying out an appropriate risk analysis in an early phase of the process lifecycle can lead to a review of the business process model.

This paper presents an adaptation of HAZOP method that is applied in the business process environment. In fact EPC-based HAZOP simulates an EPC model to HAZOP entities for whose elements guide words may be applied. Later, we proposed a unified output for EPC-based HAZOP that aims to facilitate the translation of recommendations to design.

Finally, we plan to extend our approach by proposing mechanisms that permit to incorporate the recommendation in EPC-based HAZOP table in business process models in order to improve their reliability.

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