



Comprehensive rule-based compliance checking and risk management with process mining

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ARTICLE INFO

Article history:

Received 11 October 2011

Received in revised form 16 August 2012

Accepted 4 December 2012

Available online 21 December 2012

Keywords:

Business rules

Compliance checking

Risk management

Process mining

Process-aware information systems

ABSTRACT

Process mining researchers have primarily focused on developing and improving process discovery techniques, while attention for the applicability of process mining has been below par. As a result, there only exists a partial fit with the traditional requirements for compliance checking and risk management.

This paper proposes a comprehensive rule-based process mining approach for a timely investigation of a complete set of enriched process event data. Additionally, the contribution elaborates a two-dimensional business rule taxonomy that serves as a source of business rules for the comprehensive rule-based compliance checking approach. Finally, the study provides a formal grounding for and an evaluation of the comprehensive rule-based compliance checking approach.

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1. Introduction

While the value creation abilities of an organization are increasingly determined by the flexibility of their information systems and business processes, this flexibility may also pose significant risks that could have an enormous negative impact on achieving the corporate objectives (such as regulatory compliance and profitability) [37]. Consequently, the organization's management performs a risk assessment and implements appropriate risk responses, such as (internal) control procedures for authorization rules and approval activities. Shareholders and other stakeholders of the organizations are likely to demand an independent assessment of the effectiveness of these risk responses, which is typically performed by auditors. Both risk and control effectiveness assessments make use of (similar) compliance checking techniques.

Process mining is a promising new research area that focuses on the development of innovative techniques for analyzing event logs of process-aware information systems [43,44] that execute and manage business processes. The resulting event logs contain an untapped reservoir of detailed and structured information on the business operations, for example time indicators and originator identifiers for the performed activities.

While (audit) compliance checking has been suggested as a potential application for multiple process mining techniques [23,34,40],

there does not exist a precise fit with the specific needs of contemporary risk and compliance activities. This paper contributes to the applied process mining research by:

- Proposing comprehensive rule-based compliance checking as a process mining technique for a timely assessment of the complete set of enriched process data.
- Introducing a two-dimensional business rule taxonomy, which serves as a source of configurable rule patterns used for specifying (internal) controls and other risk management activities.
- Providing both a formal grounding for and concrete applications of the comprehensive rule-based compliance checking approach.

The outline of the paper is as follows: Section 2 provides an overview of compliance checking with process mining and describes the partial fit. Section 3 discusses the details of the comprehensive rule-based compliance checking approach as well as its formal grounding, followed by the introduction of the running example (Section 4) and the elaboration of the business rule taxonomy (Section 5). Section 6 discusses the potential applications, opportunities, assumptions and challenges of the proposed compliance checking approach. The final section concludes the paper and presents an outlook for future research in this area.

2. Process mining

Process mining addresses the problem that most organizations, and their stakeholders, have very limited information about what is actually happening in the business processes [17,44,52]. Insights into

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the real behavior are acquired through analysis of the structured information contained in information systems' event logs. Process mining has received a vast amount of research attention resulting in a plethora of techniques, including process discovery techniques [4,9,16,20,45,53], techniques for the analysis of event log data [3,41,42,46], techniques for trace classifications [13,38], process metrics [11,34] and applied research [31,47]. Fig. 1 represents the process mining architecture.

2.1. Traditional compliance checking with process mining

Three broad sets of techniques are of main interest for compliance checking: process discovery and visualization, conformance checking and delta analysis, and logic-based property verification. Table 1 provides per technique a brief description and an overview the most influential contributions for the techniques.

While the first two approaches promote the analysis of the process as a whole, the last one can be used to focus on specific questions.

2.2. Partial fit between compliance checking and existing process mining techniques

Existing process mining techniques are often not fully adapted to the contemporary compliance checking requirements. Process mining researchers have primarily focused on improving techniques for control-flow and to a far lesser extent for social/organizational analysis. Besides the obvious requirement to be able to analyze and perform controls on the additional data in the event logs, this research focus results in other important restrictions. Firstly, conformance metrics might provide only a first impression of the overall conformance with the designed model. An in-depth evaluation of the problematic process parts, where the deviation from the designed model is significant, will be required. Additionally, we can question the correctness of the designed business processes. Procedural business process models often contain control-flow dependencies that are not dictated by internal or external directives, known as the overspecification of the process models [29]. Consequently, process deviations affecting the conformance measures, do not necessarily violate any internal or external directive. Moreover, defining all possible execution paths to deal with natural variations in a business environment can be challenging.

Due to the assumption that an event log will not contain all possible behavior, process discovery and visualization techniques have to balance model precision and generality. However, in a risk management and compliance checking setting generality is not important.

Table 1
Overview of traditional process mining based compliance checking techniques.

Technique type	Technique description	References
Process discovery and visualization	Summarize a specific aspect of the real business process dynamics in one visual. These aspects can be for example the control flow or a social network.	[9,36,45,48,49,53]
Conformance checking and delta analysis	Detect inconsistencies between a prescriptive model and its corresponding real-life process. Conformance checking uses the event log as a comparison base, while delta analysis uses a derived process model.	[2,5,19,34,35]
Logic-based property verification	Analyze specific process properties of the individual process instances. Examples of such process properties are the activity preconditions and the segregation of duties.	[8,10,26,46]

It might actually result in a cover up of (infrequent) harmful process deviations.

Similarly, the logic-based property verification research has predominantly focussed on activity ordering questions. However, business users require the ability to perform controls from a broader spectrum of common types [1].

3. Comprehensive rule-based compliance checking with process mining

In this section, we propose the comprehensive rule-based compliance checking approach. Subsection 3.1 presents the architecture of the proposed approach, followed by the presentation of a business rule taxonomy in Section 3.2 and the formal specifications in Section 3.3 subsection 3.

3.1. Comprehensive rule-based compliance checking architecture

The architecture supporting the proposed comprehensive rule-based compliance checking approach consists of three main components: 'business provenance', 'regulation, policies and other directives' and 'techniques' (Fig. 2).

Business provenance deals with the systematic and reliant recording of business events and (evolutions of) other business artifacts. Consequently, it keeps track of both the current status and the history. As business processes are becoming heavily supported by process-aware

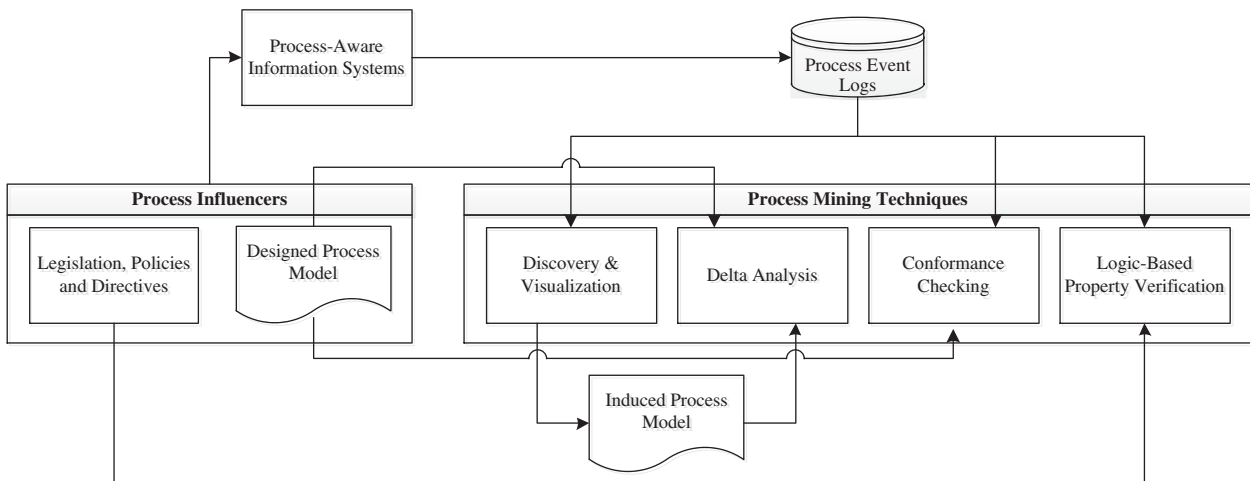


Fig. 1. Process mining architecture with traditional compliance checking approaches.

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