Model-Based Compliance in Information Systems – Foundations, Case Description and Data Set of the MobIS-Challenge for Students and Doctoral Candidates

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Abstract. Information systems (IS) can significantly support the organization of business processes. However, the proceeding digitalization of processes can also lead to an increasing organizational complexity and the need to more intensely investigate the adherence to external or internal compliance rules. Process-related data from IS and underlying process models can, however, also contribute to an effective compliance checking. This paper first presents conceptual foundations of model-based compliance checking that motivated the MobIS-Challenge workshop for students and doctoral candidates at WI 2019. Second, we introduce the challenge itself and its corresponding data set. The data describes an exemplary travel management process in a medium-sized consulting company and served for the development and validation of adequate solutions addressing the compliance checking requirements. Solutions accepted for presentation at the workshop are briefly outlined in this paper.

Keywords: GRC, Governance, Risk and Compliance, BPM, Business Process Management, Process Mining, Data Set

1 Introduction

Nowadays, business processes are increasingly carried out digitally with the help of information systems (IS), which can significantly support an effective, efficient and flexible management of business processes. However, the proceeding digitalization of business processes can also lead to an increasing complexity of organizations and the need to more intensely analyze and ensure the adherence to externally or internally specified compliance rules. In this context, process data from IS and underlying business processes as well as business process models can, however, also considerably contribute to an effective compliance checking. The usage of data from IS allows for an easier reconstruction of business processes, e.g. based on built-in logging mechanisms, and furthermore facilitates the identification of violations of internal or external compliance rules. In this context, there are some research streams,

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such as process discovery and conformance checking, that develop new methods and techniques to analyze the process data logged by information systems and to use the gained insights for the benefit of the company.

This contribution presents the WI 2019-Workshop "MobIS-Challenge for Students and Doctoral Candidates: *Model-Based Compliance in Information Systems*", the topic's conceptual foundations, the use case which was investigated by the challenge participants as well as the corresponding data set. Participants of the MobIS-Challenge were supposed to identify opportunities to use IT tools (e.g. existing process mining tools, BPM solutions, self-developed programs etc.) for analyzing and improving the business process compliance in the addressed business travel management scenario, specifically by examining the compliance of this process and pointing out its weaknesses.

The remainder of this paper is organized as follows: in section 2, we introduce some conceptual foundations of model-based compliance management with a particular focus on business process data from information systems. In section 3, we describe the travel management use case to be analyzed in more detail providing a verbal description as well as an according business process model which served as a basis for the simulation and development of the data set. Section 4 provides a detailed description of the data set focusing on the most severe compliance violations included in the approximately 6,500 business travel management cases contained in the data. Section 5 presents the tasks which had to be addressed in the challenge as well as a brief description of potential solutions by the authors of this paper, while section 6 introduces accepted solutions which participants submitted to the MobIS-Challenge.[1] Section 7 concludes the paper.

2 Business Process Compliance

Business process models can serve as an instrument to express and clarify the course of activities in the context of value creation in organizations [1]. While business processes can be understood as sequences of executions for the purpose of creating goods and services [2], business process models are representations of business processes which provide the basis for several different tasks of Business Process Management (BPM) [3], such as process implementation, execution, controlling or systematic process improvement [4].

In order to support their daily operations, business organizations use information systems (IS), like enterprise systems (ES) for enterprise resource planning (ERP), supply chain management (SCM) or customer relationship management (CRM) etc. Such IS – no matter whether they are process-oriented and explicitly produce so-called process log data or not – generate data, which can serve to obtain a view of the underlying business processes. The data generated by IS can, thus, also serve for the identification of compliance violations.

[1] We currently plan to separately publish a detailed report on the accepted solutions submitted to the MobIS-Challenge.

In literature, *compliance* is one major aspect of the comprehensive topic addressed by the umbrella term *Governance, Risk and Compliance* (GRC). GRC and its related policies and rules as well as technical support approaches and methods are supposed to ensure a good, responsible and sustainable management of organizations, which follow the applicable law and commonly accepted standards [5, 6]. Compliance management is supposed to ensure the conformity of "business processes, operations and practice […] with a prescribed and/or agreed set of norms" [7]. In this context, external and internal compliance requirements can be differentiated. Typical external compliance requirements are legal initiatives like the *Sarbanes-Oxley Act* (SarbOx) in the US or *Basel III* in the financial sector as well as the so-called *Bribery Act 2010* as an anti-corruption legislation example passed in the UK. Furthermore, many organizations have defined internal compliance requirements, which have not been formulated by external authorities, but which are supposed to ensure a voluntary conformity of the organization's behavior with common standards.

The term *business process compliance* is ambiguous and used to address different concepts in literature. Some contributions aim at checking the compliance of business process instances (*as-is processes*) in terms of a defined process model, focusing on their identity without looking at operational business issues. Other contributions refer to business process compliance as a means of checking the operational compliance of an organization based on the underlying business processes, e.g. using process logs to identify and investigate potential violations of external or internal compliance rules [8-12]. In this contribution, we use the term *business process compliance* according to the latter understanding.

FELLMANN and ZASADA give a comprehensive overview of the current state-of-the-art in their review contribution investigating a total of 84 business process compliance approaches [13]. They identified different dimensions for compliance checking (p. 5) which are described in Table 1.

Table 1: Dimensions of Compliance Checking (Fellmann and Zasada, 2014)

Nr.	*Dimension*	*Sub-Dimensions*
1	*Scope*	Order and occurrence, Information, Resource, Time, Location
2	*Lifecycle phase*	Design, Execution, After Execution
3	*Formality*	Verification / Validation, Business-oriented
4	*Contribution type*	Technical artefact, Method, Other

Known approaches for a business process-oriented compliance checking, e.g. use process mining techniques [14] or so-called control patterns [15]. Furthermore, there are several commercial tools, which already implement compliance checking techniques in different contexts [16]. The following section describes the underlying business travel management case treated in the MobIS-Challenge.

3 Case: Business Travel Management Process

3.1 Case Description and Process Model

The case that we provide for the workshop describes a business travel management process in a medium-sized software consulting company. While the data itself was generated by simulation, the process and its governing compliance rules are inspired by one we have encountered in a recent research project.

The goal of the business travel management process is to keep track of all business trips the employees take and their related expenses, such that they can be invoiced to the respective customer, for whose project the respective trip is taken. As is usual in consulting companies, the employees travel quite often to meet with customers, but as software consulting includes some work that can be done remotely, they are not constantly traveling. In order to better control the bookings, to take advantage of economies of scale in the booking process, and to avoid lengthy reimbursements, the company has decided to install a separate travel department, where multiple travel agents are responsible for booking business trips, always in accordance with the respective employee.

To improve the internal process organization, the company has developed its own internal workflow management system which can be accessed by each employee. Travel management is fully covered and logged by this system, with the travel management process implemented as a workflow and the tasks and rights assigned according to the employee's role in the company.

Within the process, there are four acting roles:

(1) the Employee, who wants to go on a business trip,
(2) the Manager, who has to approve the trip and the expense report,
(3) the Travel Department, which is responsible for bookings and price information, and
(4) the Accounting, which is responsible for calculating and reimbursing costs.

In our case company, there are 300 employees, 15 managers (including 3 directors), 5 travel agents, and 10 accounting clerks.

The process starts, when an employee files a travel request. Such a request offers two options: The employee can either directly file a request or she can initiate a preliminary price inquiry, which is helpful if the travel expenses and potential booking options are unclear. In this case, the request is forwarded to the travel department, where a travel agent provides a booking proposal and discusses it with the employee. If the employee accepts this proposal, she can adapt her price inquiry accordingly and then transform it into an official travel request. If the proposal is not accepted, she first has to check whether the trip is still necessary and all data is up-to-date, before requesting an update of the booking proposal from the travel agent.

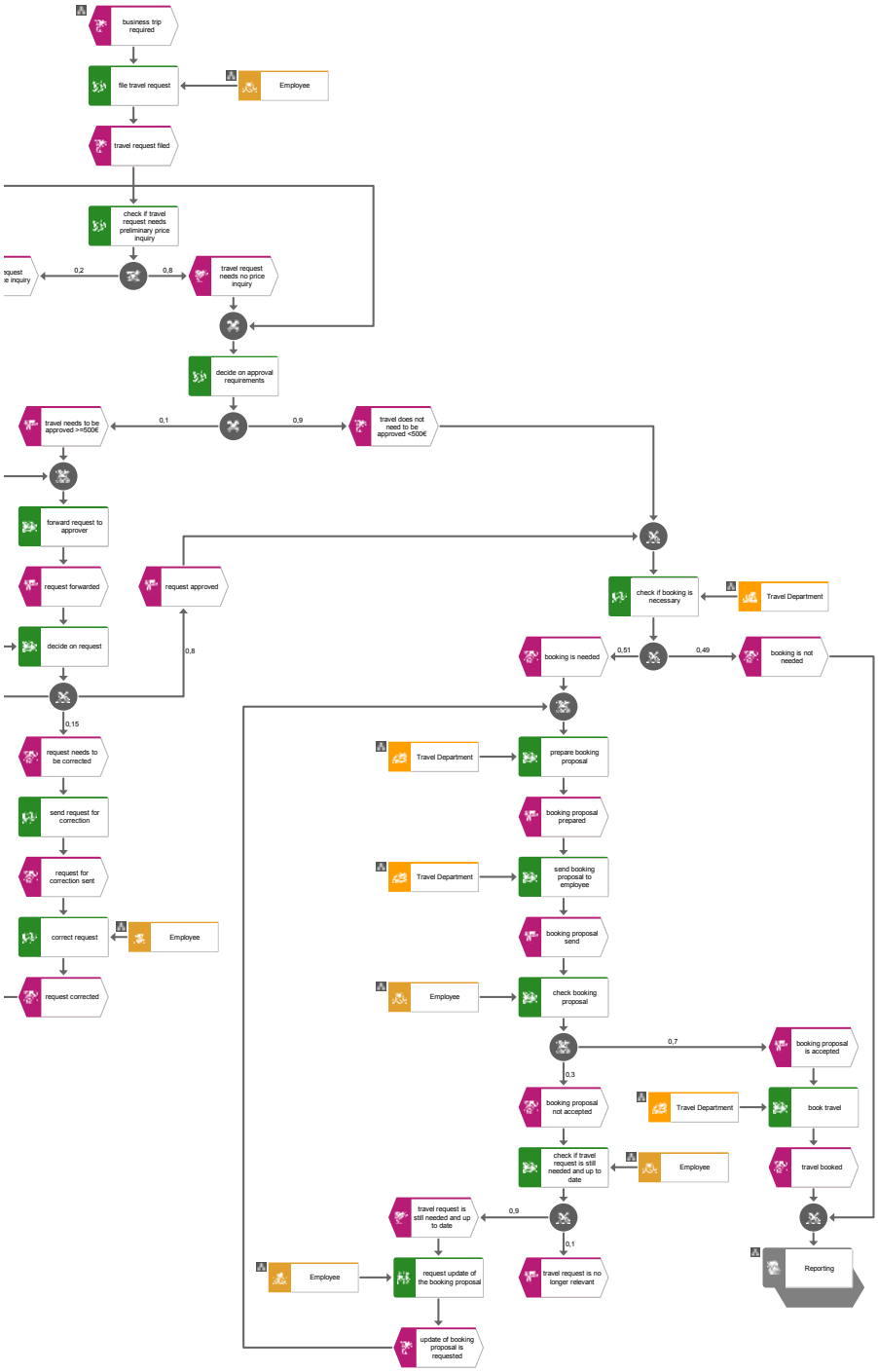

Figure 1: Excerpt of the *planning part* of the travel management process

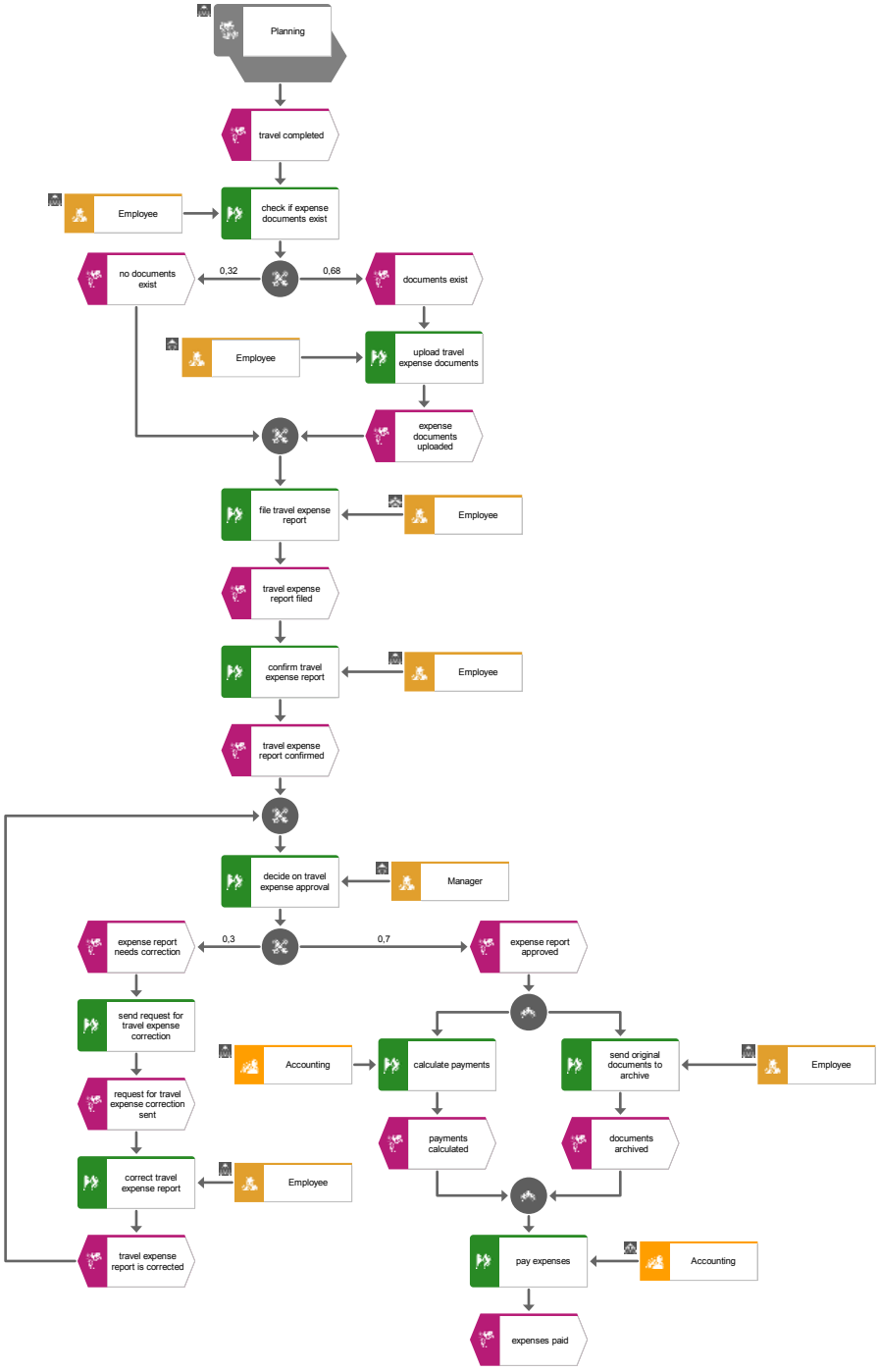

Figure 2: The *reporting part* of the travel management process

When the travel request is officially filed, it has to be checked for approval before it can be handled by the travel department. The workflow system automatically checks whether the request fulfills the approval requirements and forwards it to the responsible manager for approval. The manager checks the request and either approves it, rejects it, or asks for a correction. In the latter case, the system redirects the request to the employee, such that she can make adjustments according to the manager's requests. This correction process is repeated, until the manager finally approves or rejects the travel request.

Once a travel request is approved, or if approval is not required, it is forwarded to the travel department and assigned to a travel agent, who checks whether the request requires any bookings. If not, for example if the employee takes her own car or a company car for a business trip, there is nothing left to do for the travel department. If yes, the travel agent prepares a booking proposal according to the employee's specifications and sends it back for approval. If the employee approves the proposal, the travel agent confirms and pays for all bookings (e.g. hotel, flights, or rental cars). If the employee does not approve the proposal, she has to confirm the data and relevance of the travel request, before she can ask the travel department for an updated booking proposal.

After a business trip is concluded, the employee has to fill out a travel expense report in order to be reimbursed for any travel-related costs. To ensure correct accounting procedures, employees also have to fill out a report if no expenses have incurred. Therefore, the employee first needs to check whether she has any travel-related expense documents (e.g. invoices or receipts). If such documents exist, they have to be uploaded in a digital form, such as a scan. Afterwards, the employee fills out the travel expense report as provided by the workflow system. The confirmed report is automatically forwarded to the respective manager for approval. If the manager decides that the report cannot be approved, it is sent back to the employee for corrections. After the report is approved, the accounting department is in charge of calculating the total travel costs, archiving the travel-related documents, and paying the expenses of the employee.

3.2 Compliance Rules

Within the travel management process, there are a number of external and internal compliance rules, which must be followed. The internal rules are mainly important to keep the accounts correct and up-to-date, whereas the external rules are necessary for invoicing travel expenses to the customer. In detail, the travel management process conforms to the following compliance rules:

(1) For each business trip, an according travel request must be filed and, if necessary, approved before the beginning of the trip.
(2) Business trips must be necessary to ensure the success of a project. If this necessity cannot be documented, a manager might reject the request.
(3) A travel request must contain realistic cost estimations. The real costs in the travel expense report filed after the trip should not exceed this estimation.

(4) If the estimated travel cost does not exceed 500€, it does not need to be approved.
(5) If the estimated travel cost exceeds 500€, the trip must be approved by the employee's responsible manager.
(6) Managers' trips must be approved by a director. The three directors approve each other's trips.
(7) Managers should promptly approve, reject, or react to incoming requests.
(8) If possible, trips should be booked and paid for by the travel department.
(9) After a trip has ended, the travel expense report should be filed immediately.
(10) All travel-related expenses should be documented with a receipt.
(11) Travel expense reports must be approved by the employee's responsible manager. Again, managers' travel expense reports are approved by a director and the directors approve each other's reports.
(12) Managers should check requests and expense reports carefully and ask for corrections, if they find any rule violations.

4 Data Set[2]

4.1 Model Development

In order to generate a viable process log for the MobIS-Challenge case, we first developed a process model that we could use as the basis for data generation. We used the ARIS simulation component for data generation and modelled our process as an *Event-Driven Process Chain* (EPC). Then we enriched it with data that is required for simulation. According to the description above, we separated the process into two major parts. Large parts of the travel planning process are shown in Figure 1. While the price inquiry handling is described on the left side of the complete process (not displayed in the excerpt in figure 1), the right side of the process model deals with approving travel requests in the loop on the left and handling the bookings in the subprocess on the right. The second part of the process, expense reporting, is shown in Figure 2. First, the employee uploads all travel-related documents and produces an expense report, which is then approved by the manager in the loop on the bottom left. Expenses are reimbursed by the accounting department on the bottom right.

ARIS offers a multitude of attributes to be defined for each model element, some of which were necessary to ensure that our simulation would produce a viable data set. In our case, we needed to define an executing role for each function to assign resources in the process log, the number of employees that instantiate each role, probabilities for each XOR-connector to determine the path frequency, execution times for each function to allocate sufficient time for its execution, and schedules for employees to account for normal working hours. We also associated the start event

[2] Data set source: Scheid, M., Rehse, J.-R., Houy, C., & Fettke, P. (2018). *Data Set for MobIS Challenge 2019 [Data set]*. https://doi.org/10.13140/RG.2.2.11870.28487.

with an instantiation schedule and a fluctuating delay to introduce some randomness into the start times of each case.

As can be seen in the process model, each function is associated with a role that is responsible for its execution; roles without an explicitly associated role are automatically executed by the workflow system itself. Each role is associated with a schedule, which determines its typical working hours. Employees can work anytime between 6am and 11pm, which factors in that consultants sometimes do organizational tasks like travel management at odd hours. The administrative personnel, i.e. the travel agents and accounting clerks, work typical office hours from 9am until 5pm. We included one week of vacation time in July, where no travel agent was working. In the managers' schedule, we defined their working hours to be only between 1pm and 2pm to account for the fact that managers are typically very busy and only tend to administrative tasks like travel management at certain hours, e.g. after lunch.

We also defined a fluctuating execution time for each function. ARIS allows several options to set either strict or varying execution times and we decided to model them all as a capped normal distribution, specifying the expected value, standard deviation, minimum and maximum time for each function. Realistic values were set for each function, such that automated functions executed by the workflow system only take a few seconds, whereas time-intensive functions like preparing a booking proposal takes several hours.

The number of employees (300) and managers (15) in the company were predefined before simulation, but the necessary number of travel agents had to be determined empirically, such that some, but not too many cases were piling up at any given time. 5 travel agents turned out to be a sufficient number.

For most functions, we did not have to define static waiting times to account for employees being busy with other tasks that have nothing to do with travel management. All waiting times for the travel department are caused dynamically, because other cases are handled first. Only the accounting functions wait statically for a few days to account for other responsibilities of the accounting department.

4.2 Data Generation

After the model was developed, we used it as the basis for simulating the process data. This simulation consisted of multiple steps.

Process Simulation with ARIS. Based on the developed process model, we used the ARIS simulation component to generate execution data. To account for the travel time that occurred between the two process parts, we connected them with an artificial function (“travel”), with fluctuating static waiting times (to account for the time passing between a travel request and the trip itself) and execution times (to account for the duration of the trip). We wanted to simulate data for one year, so the simulation period was set from October 1st 2016 to December 31st 2017, with the first 91 days functioning as a warm-up phase to have plenty of cases in the system. ARIS used the specified process data to simulate its execution. Each simulation took about

15 to 20 minutes to complete. We exported the case data from ARIS and converted it into a CSV file to proceed further.

Generating Additional Data with Excel. The ARIS simulation was only able to generate the process steps itself, so we had to enrich the log with additional data on travel costs and the organizational structure. We defined the company's internal organizational structure, such that we could assign each case to an employee and the responsible manager. There were three cost values that had to be generated, the estimated travel costs, the real travel costs, and the reimbursed costs. The estimated costs were calculated randomly, depending on the length of the trip and whether or not the travel request has to be approved. The real travel cost was calculated to randomly fluctuate in both directions around the estimated cost. Finally, the reimbursed costs depend on whether the travel department booked the trip for the employee. If yes, they were lower than the travel costs, if no, the two numbers were equal.

Manual Data Cleaning. After all data was generated, we had to manually go over it to remove some mistakes and irregularities, such as business trips during Christmas time. After cleaning the data and introducing compliance violations (explained in the next section) our final data set contains 6,555 cases with 26 activities and a total of 83,256 events.

4.3 Violations of Compliance Rules

After the process log was simulated, enriched, and cleaned, we introduced compliance violations. From a data perspective, there are two types of compliance violations, those that were caused by simulation parameters and were already present in the log and those that had to be entered manually.

Violations caused by Simulation Parameters. We defined our simulation parameters (schedules, waiting times, cost calculations) such that we deliberately build some compliance violations directly into the log. They are listed in Table 2 and shortly explained in the following.

Table 2: Compliance violations caused by simulation parameters

ID	*Compliance violation*	*Simulation cause*
1	Long delays in manager's reaction	Managers are encouraged to answer promptly to incoming travel requests, to avoid not reacting in time for the trip. (*Rule 7*)
2	Long delays in expense reporting	Accounting should promptly reimburse the employees for their expenses, to avoid unnecessary payment legacy. (*Rule 9*)
3	Real travel expenses significantly exceed calculated expenses	Employees should give a realistic estimation of expected travel costs, to ensure necessary approvals and facilitate accounting. (*Rule 3*)

Violation (1) stems from a time restriction. According to their time plan, managers spend one hour each day for administrative tasks, causing requests to build up. This artificial restriction causes a bottleneck in the process, such that travel requests are delayed for several days before being approved or declined. Violation (2) can be accounted to fluctuating static waiting times, which we attributed to the functions to simulate other responsibilities of the accounting department. Finally, violation (3) is due to the fact that during cost simulation, we had real travel expenses fluctuate in relation to calculated expenses, such that they sometimes are much higher.

Manually entered Compliance Violations. However, most compliance violations (especially those that deviated from the normal process flow) could not be built directly into the log, but had to be manually entered. These violations, which include 9 of the 12 in total, are listed in Table 3. For each violation, we explain how it contradicts our compliance rules and give its frequency in the log, i.e. the number of existing cases which we altered to violate compliance in the described way.

Table 1: Manually entered compliance violations

ID	*Compliance violation*	*Compliance explanation*	*Freq.*
4	Travel request is submitted after the trip	Travel request must be filed and approved before the trip. (*Rule 1*)	8
5	Only price enquiry is submitted	Price enquiry must be converted into a travel request before the trip. (*Rule 1*)	12
6	Manager approves his own trip	Manager's trips must be approved by a director (four eyes principle). (*Rule 6*)	5
7	Manager approves his own expense calculation	Manager's expense calculations must be approved by a director (four eyes principle). (*Rule 6*)	10
8	Trip is approved by the wrong manager	Trips must be approved by the employee's own manager. (*Rule 5*)	11
9	Employee travels despite rejected travel request	Travel requests must be approved by a manager to ensure their necessity. (*Rule 1+2*)	2
10	Multiple travel requests (less than 500€) for one trip	Requests only have to be approved if the estimated costs exceed 500€. (*Rule 4+5*)	8
11	New travel request after rejection	The manager assessed the trip as unnecessary for the project success. (*Rule 2*)	3
12	Paid expenses exceed calculated expenses	The accounting department paid more to the employee than costs incurred for the trip. (*Rule 3*)	17

The following two sections give a brief description of the tasks and *potential* solutions to the problem to be treated in the MobIS-Challenge (section 5) and, furthermore, present the *submitted* solutions which were accepted for presentation at the MobIS-Challenge (section 6).

5 Tasks and Potential Approaches

The participants of the MobIS-Challenge were supposed to identify opportunities to use IT tools (e.g. existing process mining tools, BPM solutions, but also self-developed programs) for analyzing and improving process compliance and pointing out process weaknesses, even beyond conformance issues.

The tasks and leading questions for the MobIS-Challenge were as follows:

(1) Describe the process depicted in the log with graphical means. From this description, derive meaningful compliance rules that go beyond the [.] description [given in the call for papers].

(2) Which compliance violations can be found in the data? How can these be prevented?

(3) Beyond compliance issues, which weaknesses in the process or the organization can be found in the data? How could these be improved?

(4) Which additional insights can be drawn from the data? You can use any tool to develop interesting additional insights in a creative way.

To address and answer these questions, different approaches can be used. At first, the data should be carefully surveyed in order to get an overview of available data fields and their meanings in particular contexts. There is, e.g. a significant difference between the meanings of the different values in the field "cost" depending on the process step in which the costs play a role. In this context, we can differentiate between (a.) estimated costs, (b.) real costs and (c.) reimbursed costs.

Common *process discovery* approaches can be used to derive a graphical process model from the provided data set. In this context, different discovery algorithms (*heuristics miner*, *fuzzy miner*, *alpha miner* etc.) can be used and the different results can be compared. An adequate choice of the settings concerning activities and traces should be elaborated in order to develop a helpful process model which supports finding answers and solutions to the above problems.

Next, most process mining tools offer the opportunity to calculate distributions of cases, the identification of outliers and an overview of different process variants in the data set. Furthermore, time-related analyses can be conducted, e.g. to identify anomalous process durations.

Furthermore, there are several different possibilities to perform advanced analyses by identifying clusters in the data representing different classes of process variants as well as outliers which can then be analyzed in more detail to identify function deviations or anomalies. Moreover, the participants of the MobIS-Challenge could also "manually" develop a process model based on the data, e.g. a petri net, and then perform an automated conformance checking against the data set in order to identify outliers and anomalies. The same can be done in terms of rules. Obvious compliance rules which were followed in data set can be modelled and then be checked against the whole data set to identify outliers. The following section presents the solutions accepted for presentation at the workshop.

6 Solutions Accepted for Presentation at the Workshop

The following submitted solutions were accepted for presentation at the 2019 MobIS-Challenge workshop at WI 2019 in Siegen:

(1) In their extended abstract submission *Conformance Checking with Dynamic Condition Response (DCR) Graphs – An application to the MobIS Challenge 2019*, DUNZER, BAIER and STIERLE use a process conformance checking technique based on so-called *Dynamic Condition Response* (DCR) graphs [17]. Their approach follows the declarative process modeling paradigm and was instantiated as a software tool using Python. In order to answer the questions and fulfil the tasks of the MobIS-Challenge the CRISP-DM framework was used as a basis for structuring the project. The DCR graphs serve for the formulation of compliance rules which are then used for the identification of compliance violations in the data set.

(2) In their extended abstract submission named *Detection of Compliance Rule Violation in Business Processes using Sequence-to-Sequence Autoencoder*, WILLEMS and PFEIFFER describe the development of a framework for an automated detection of compliance violations based on neural networks. A sequence-to-sequence long short term memory (LSTM) autoencoder was trained using the entire event log from the MobIS-Challenge data set. By encoding and decoding traces from the event log, differences between input and output traces which are likely to indicate anomalous behavior can be calculated. The reconstruction error is used to find sequences of suspicious events. Furthermore, the extended abstract reports on the usage of state-of-the-art process mining tools like ProM, Disco, Celonis and bupaR for the further analysis of the event data set in order to provide detailed process mining-related analyses in the planned completed report.

7 Conclusions

This contribution presented the WI 2019-Workshop "MobIS-Challenge for Students and Doctoral Candidates: *Model-Based Compliance in Information Systems*". We provided a detailed description of the use case, which had to be investigated by the challenge participants as well as the corresponding data set. We have accepted two interesting initial descriptions of solution approaches. The challenge participants were invited to present detailed information concerning their solutions at the workshop.

Beyond the workshop in Siegen at WI 2019, we believe that the provided data set can also serve for and support further BPM research endeavors, e.g. in terms of the validation and evaluation of process mining or data analytics approaches for the investigation of data, which is relevant for business process compliance issues.

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