Handling Instance Spanning Constraints in Compliance Management

Ruhul Amin

Senior Data Entry Control Operator (IT), ED-Maintenance Office, Bangladesh Bank (Head Office), Dhaka, **BANGLADESH**

*Corresponding Contact:
Email: ruhulaminshuzon@gmail.com

ABSTRACT

Instance spanning constraints refers to instruments to establish controls during multiple instances in or several processes. Many business entities crave an established ISC support system. Take, for instance, the bundling and unbundling of cargo from various logistics processes or the dependence of various examinations in medical treatment systems. During such systems, non-compliance with the ISC would lead to immense consequences and penalties, which can be fatal if it occurs in the medical field. ISC can also occur from process execution logs. Business execution store execution information for the process instance and, consequently, the characteristics of the execution logs. Discovering ISC early enough helps in supporting ISC design and execution. The purpose of this study is to contribute towards the categorization of the ISC and hence contribute to the digitalized ISC and its compliance management.

Keywords: ISC, compliance management, spanning constraints

INTRODUCTION

When software systems interact with the real world, event data will be created. The event data happen at a particular time stamp, and the collection of events known as the "event log." Also, these event logs might contain event identification information, Name, date, etc. and collection or sequence of event logs named as traces. Process Mining has been done with this event data and the techniques that help to handle to operate real-time cases such as banking, public transport, hospital and other sectors. Therefore, process mining can be considered as a connection between event data and process model that used to configure software systems about fifteen years ago, Cook and Wolf were attempted first process mining practical applications (Awad, et al. 2010). After that, several works were conducted in this field and focused on the development of new algorithms for the automatic discovery of business processes

Process Mining is a contemporary knowledge of ML that can highlight among the seminal articles and it focuses on extracting knowledge from available information and stored in the databases of information systems. In recent times, many studies were conducted to analyze hospital processes, including Business Process Redesign, Evidence-Based Medicine, and among others. Business systems designed by complex models with the subject to significant variati on over time[6] and these variations will be caused by multiple factors such as performing resources at different patient conditions or activities

Despite that, current research area helped in business processes for discovering process models from event logs. Proposed techniques or algorithms will provide an expert system in business operations and the ability to respond to questions about performance issues, thereby generating improvement opportunities (Abrial, 2010). The ability to discover process model and performance analysis provides an excellent opportunity for data stored in event logs. Application of process-mining techniques in business not only ensures performance improvement but also benefited in service quality improvement and a positive impact on the management of medical centers

However, to achieve an advantage of information stored in business event data, there is a need to utilize process model discovery and performance analysis techniques. Mentioned research outcomes would be beneficial for all hospital staff to make accurate decisions and explains the workflow of the system including process models with visual analytics.

Problem Statement

Business Process Compliance often follows a life cycle which includes several phases, among this are constraint elicitation, constraint formalization, constraint verification and constraint validation and redesign. There exists a large body of research and works which features the formalization and the verification of compliance of business process models and the process instance with compliance constraints during a given design time and during runtime. However, despite this, there are other challenges which exists. First, there exists a challenge in handling constraints which spans multiple instanced of one or even several process types. Such constraints are often referred to as instance spanning constraints. Secondly, support for constraint elicitation from the data sources such as through text, more so in the context of regulatory documents and in the process execution logs. The purpose of this study is address both of this challenges.

Aims and Objectives

The aims of this study is to address both challenges identified in the statement problem. The first challenge envisages support of ISC present in various domains which often includes logistics, production and healthcare coverage. ISC in some cases might span various or multiple instances or several process. For instance, a patient can be involved in two different treatment, that of dermatology and diabetes. A list of drugs should not be taken during the dermatology treatment. In this case, the diabetes treatment should consider this. In a detailed view, two process does exists, that of dermatology and another one for the diabetes treatment. The second challenge identified refines ISC discovery and its analysis on the process execution in an ex post manner.

To achieve the objectives, the following research questions were defined in order to govern this study.

RQ1. How can instance spanning constraint be handled in the run time?

RQ2. What data has to be extracted and how has it to be mapped to enable and store the relationship knowledge?

RQ3. How can business process mining be extended with technical aspects in order to uncover 1. User and system throughput times for business activity executions and, 2. Correlations between business process performance and system behavior?

LITERATURE REVIEW

Instant spanning constraint is rooted in the area of data mining and business process compliance. During the BPC life cycle, the moment spanning constraint is located in the phases of constraint elicitation and validation. The ISC can be termed as a constraint mining technique which can be found at the intersection of data mining and in the process mining. Process mining has, over the years, been unfolded as a unique technique used in the discovery, analyzation, and the enhancement of the process-based execution of logs. Most algorithms, such as the Heuristics Miner and the Fuzzy Miner, are often used ex-post, which is after the process of instance, execution has been done away with or is complete. In the recent past, online data process mining has gained immense interest since the discovery of event streams. In this process, conformance checking is often used to determine how far a given process execution logs into and conforms to the system, either against the ex-post or during a given runtime (Knuplesch et al., 2015). The fitness of these systems is often measured through fitness, simplicity, generalization, and precision. As a result of the trade-off on the automatic provision on the results given the mining algorithms and the consequential involvement with human beings, the process manifesto states that balancing of the fitness, simplicity, precision, and generalization which can be quite challenging.

For this reason, some of the most potent discovery use discovery techniques are provided on various platforms and parameters. Most of the persuasive process discovery does provide different parameters. The improved algorithms that are needed can be further developed to help balance such competing dimension. Further, any existing parameters should only be used to understand the end-user.

Compliance constraints and the ISC constraint are the subjects of this paper, which is the output of the given algorithm. In the whole process of compliance, the limitations and the ISC functions as an important regulatory norm as they do top up on the processes. Leitner (2012) elucidates on a framework that can be used in the normative requirements such as the permissions and the prohibitions. The framework that is proposed by Kaes et al. (2014) argues for more controlled modeling functionality in the constraints. This refers to the control flow in the processes data, time, and resources. The goal of this being the achievement of compliance within the constraints. One way and option to deal with the compliance is through the introduction of the artifact-centric business process. The other existing option is to check for compliance during the design run time, i.e., using the process model or during the run time using the process execution logs. This process of checking the run time compliance can also be used when checking the compliance through the ex-post, for instance, on process execution logs instead of using the event streams in the process.

Instance spanning constraints form a major subset of the multiple spanning instances for one or even more process model. Further, they do also follow a given lifecycle. During the first stage, the ISC is modeled and then formalized through the use of, for example, Event

Calculus (EC) that is developed well with a defined structure and working semantics. The ISC can then be implemented, enacted, and can also be monitored. One of the commonly used ISC implementations is the top of the Rete rile engine. The instance spanning constraint can be used in several instances, such as during instance batching, during situation queuing, and in the security applications. CIE, in their study, aimed at predicting an inter-caste feature that can be used in the process monitoring and can be used as the first step in the prediction of the ISC compliance.

Discovering constraints from texts based mining methods and procedures has emerged recently as a vibrant research topic. Some of the data mining technique that is involved in the discovery of patterns does exist in forms of rules such as the association rule mining, the sequence mining, and even the episode mining. In their analysis, Ghose & Koliadis (2007) identifies that when rule mining is used for anomaly detection, it can lead to better results in the execution logs. Other key approaches that have been used to classify and find rules on the decision points have been cited and researched by (Joshi et al., 2003). Declarative process mining approaches do employ mining techniques when discovering process logs. However, as point out by Lenzi (2005), such techniques does not concern itself with the ISC modeling at the moment.

PROCESSING

For the Algorithm as identified in the figure above, the merged log is used in the input data structure. The output list is discovered in the merged logs. Each of the resulting ISC is then verified by the user at the algorithms which are delivered in the ISC suggestions. In a bid to reduce the false positive, which is caused by chance, such as the logging errors, with each of the algorithms being fine-tuned in the last parameter. The following evaluation seeks to elucidate the working of various parameters.

Algorithm 1: $\gamma1\in[0,1]$ and $\varepsilon1\in R0+$ in seconds

Algorithm 2: $\gamma2\in[0,1]$ and $\varepsilon2\in R0+$ in seconds

Algorithm 3: $\gamma3\in[0,1]$ and $\kappa\in[0,0.5)$

Algorithm 4: $\varepsilon4\in R0+$ in seconds.

The algorithm starts with the iterating the traces when it is merged in the logged platform. The checkLC is used to evaluate when true occurrence occurs and if there is only one type of the lifecycle is given in the process. The events are then traced and appended in the list, and the resulting absolute occurrence is then recorded (Lenzi, 2005). In this way, the events must be able to start simultaneously, although this can be finished at various times, which is thus reasonable when considering for instance the centrifugation time.

ISC at Run Time

During runtime, process modeling can be instantiated; this can be done per patent or per lab. The results of this process can then be executed. Such an execution takes the forms of markings as identified by Ghose & Koliadis (2007), or it can occur during the logged-in process execution models. More importantly, for each of the given activity execution, one or several of the events can then be grouped together within their timestamp and the additional data that is incurred during this process stored. The resulting events are then grouped by the resulting case id that which corresponds, and it identifies the associated process in the instances that follows this.

The Process Execution Log

The process execution log, for process P, does consist of immense cases such as the process instances. Each of these instances does constribut6e to the trace t, which has a unique order event. Such events can then be equipped with certain attributes that have information on the timestamp, the organizational resources, and even the costs in the process. The automatic discovery of the ISC does depend on the existing four algorithms and categories. The logs are prepared, and as identified in the figure below, the process model for each of the log is then mined through the use of process discovery algorithm. Given the category, each of these results is then contained in the one constraint or in the several process models that are enriched with the ISC categorization and candidates in each of the categories.

Pre-processing of logs in ISC Runtime

If one of the discoveries in the log is associated with the process type, then this is taken as it is. When one of the process type and consequently, one of the logs are analyzed at the moment, the different logs must be linked during this process. The main reason for this is that the discovery of the algorithm must know which types of instances belong to which groups or is linked together. Linking, in this case, happens when the instances refer to a given subject, i.e., when the instances refer to the same customer, same patient, or even the same product description. In a more detailed summation, the linking of logs happens when multiple processes are being done, often through the use of linking attribute that has a unique case identifier. Examples of these case identities include customer identification, patient id, or even the use of the arbitrary identification systems such as 1b5 and 4z7 in the run time. Based on the above attributes, the resulting associated traces can have the same attribute value, or they can be combined. Resulting merged files would then consist of merged traces of the different processes, for instance, the id of the patient can be used to retrieve traces on the medical whereabouts of the patients of hat he has been buying in the hospital. When two or more traces are merged into a single trace, then these events can be rearranged and fixed based on their resulting timestamp. Due to the fact that the ISC category 3 and 4 spans multiple process types, it then becomes obvious that the merging of the logs would be mandatory. Categ. 1 and 2 ISC, spanning of the only type of process is only possible and this can be through the original log.

RESEARCH METHODOLOGY

In collecting the data for this study, the author had to come up with a plan. For this study, there was a detailed plan that would facilitate the actual documentation process for the paper. The primary goal of this study is to test research questions that are connected to the issue of instant spanning constraints, as stated in the previous chapter of the article. To achieve this goal, specific instruments and approaches were used. The research methodology section describes the rationale for the application of the procedures used to gather information. It also identifies, analyzes, and selects the information that is used in finding a deeper understanding of the research question. It not only allows the reader to find appropriate answers to the research questions but also to evaluate the reliability and validity of the study in general.

Design

The research design, which will be integrated into this research paper, will be created based ona systematic review of the secondary data on the topic. The reason for selecting

this approach is that it will help in defining various aspects of the research paper. It has been recently found that the use of systematic reviews has increased, as it is applied in the international field for the purpose of examining the different levels of developmental impact. It further helps in measuring the impact of healthcare interventions. This review has been selected in this study because it will help in deriving the critical reflection of the study. The use of systematic reviews will further help the researcher to enhance the firmness and width of literature reviews. Hence this approach will help to find a number of solutions regarding the research topic.

This research would utilize a qualitative approach that would make use of the literature review. The purpose of this literature reviews would be to look at the findings and the results of other scholars that have been done on the field and concerning the topic. This paper would thus make use of six scholarly papers that are relevant to the topic. This literature review would be able to form a baseline for the study. Its results would be compared with other studies and similarities or any differences would be discussed. Further, themes in this studies would be highlighted. This literature review would be able to spotlight the regions that have been highlighted in the subject topic and the different forms that are present also. This would be crucial in the avoidance of repetition.

The secondary roots of this data would be able to provide counseling and advice on the subject and thus would be able to add more information. Further, it would be able to highlight the gaps that exist in the field currently. This would thus be able to offer a comparative approach and dimension and study on the subject. The type of care that is in place currently would be identified and cited throughout the study and this analyzed. This would be done in a co0mparative manner and thus would aid in the growth of a specialized kind of treatment and maintenance that should be given to the elderly. This way, a comprehensive set of data would be garnered. This kind of information would then be merged and be analyzed. Further from the shortcomings that the quantitative approach has, this method enables a researcher to provide enough data on the subject. Such would be able to get the research a comprehensive perspective concerning the problem that the researcher is handling.

Rationale of Methodology

This study would be able to use the qualitative method in its approach. The use of a qualitative method has been informed by the fact that the study into the literature review of other established studied on the same. This would ideally make use of past studies and their findings on the same. The questionnaires and the interviews would get quantitative data. Despite the fact that this to techniques has its fair share of challenges in data collection, it remains as the two most practical ways that can be used to collect data. Further from getting data from a large set of audience, these methods ensure that data collection is done in a speedy manner and in a way that would be easy to be used by all the individuals in the study.

Data Collection

The data collection process, which will be used in this research paper, will be a secondary data approach. This data collection method is most appropriate, as it will save both times, as well as money, and is not the same for primary data. Contextually, the primary data is collected for the first time and is a long process that requires a lot of time and money. In this context, the secondary data enables the researcher to use an already existing data set. One of the advantages of using secondary data is that the data set used by the public

consists of large samples, longitudinal designs, and even measures of many constructs that will help in developing several questions, which may not be derived while going for primary data. In this study, the researcher will be able to use purposive sampling for identifying the published articles in the journals. In this analysis, the keyword search would be able to identify the articles that the researcher deems to be having the pre-requisite characteristics in the study. Further, this study also aims at utilizing the use of the quantitative approach in the analysis. This study assumes a research design that will be able to assist in data acquisitions that are essential for addressing the research questions and objectives. The method used in this research is the quantitative method. A plenty number of literature and journal articles will be carefully examined to quantify many alternatives and establish data that can be converted into statistical data and existing information.

Data Analysis and Presentation

This study will be able to examine the articles with the given themes. A sample of this population of the articles would then be collected, and the themes are analyzed. This information included the articles in the news articles, those that appeared in the special feature reports, and such. In this sense, particular pages will be identified. The content of the same will also be examined according to the frequency in information publication, the nature of the same. Data analysis is key in the process of data interpretation helps in the summation of conclusions and findings on the study. In this study, the data will be analyzed for accuracy and consistency. The analysis will be carried out through textual formats with the help of contextual diagrams and tables if need be.

FINDINGS

Integration of Filter techniques

To investigate the misbehavior of some event logs, we incorporated the 'Performance filter' into the outcome model. Results are concluding that two percent of event logs are misbehaving (i.e., long-running) in the system, which limits the process execution at on time. The happening of significant mean delay (14months) for data exchange from final billing to CODE OK was mostly affecting the system performance. This delay might be caused by the overflow of event logs (i.e., bottleneck value) or data discrepancy. If the system is in "IDEAL STATE" or bottleneck, then staff who was are working with event data that not help in the growth of the system performance (Joshi et al., 2003). In conclusion, proposed methods can assist in raising the process performance and provide immediate suggestions to hospital authority by reporting about data deviation at particular activities.

Process mining utilizes optimization of unusual behavior of event logs based on the information of HIS Database. Moreover, process-mining can consider as three segments such as process discovery, conformance checking, and enhancement[3-4] and each one has different strategies, which aimed for an accurate model that will mention real behavior of a process. Process discovery allows for model extraction from an event log file; conformance check will monitor data deviations between the generated model and the actual model and finally, enhancement uses original recorded event data to extend or improve an existing process models. Currently, these techniques were in high demand for business systems because of significance for methods to figure out the clinical pathways and the business service redesign (Kae et al., 2014). The process mining manifesto also

highlights the necessity for the integration of process mining with other methodologies. Recent growth in these systems allows beginners to find a model for processing. By producing the model, this technique highlights the importance of the integration of process mining with other methodologies and types of analysis, such as simulation and visual analytics. It can also provide better insight into the relationships between resources to collaboration improvement and reducing the waiting and service times.

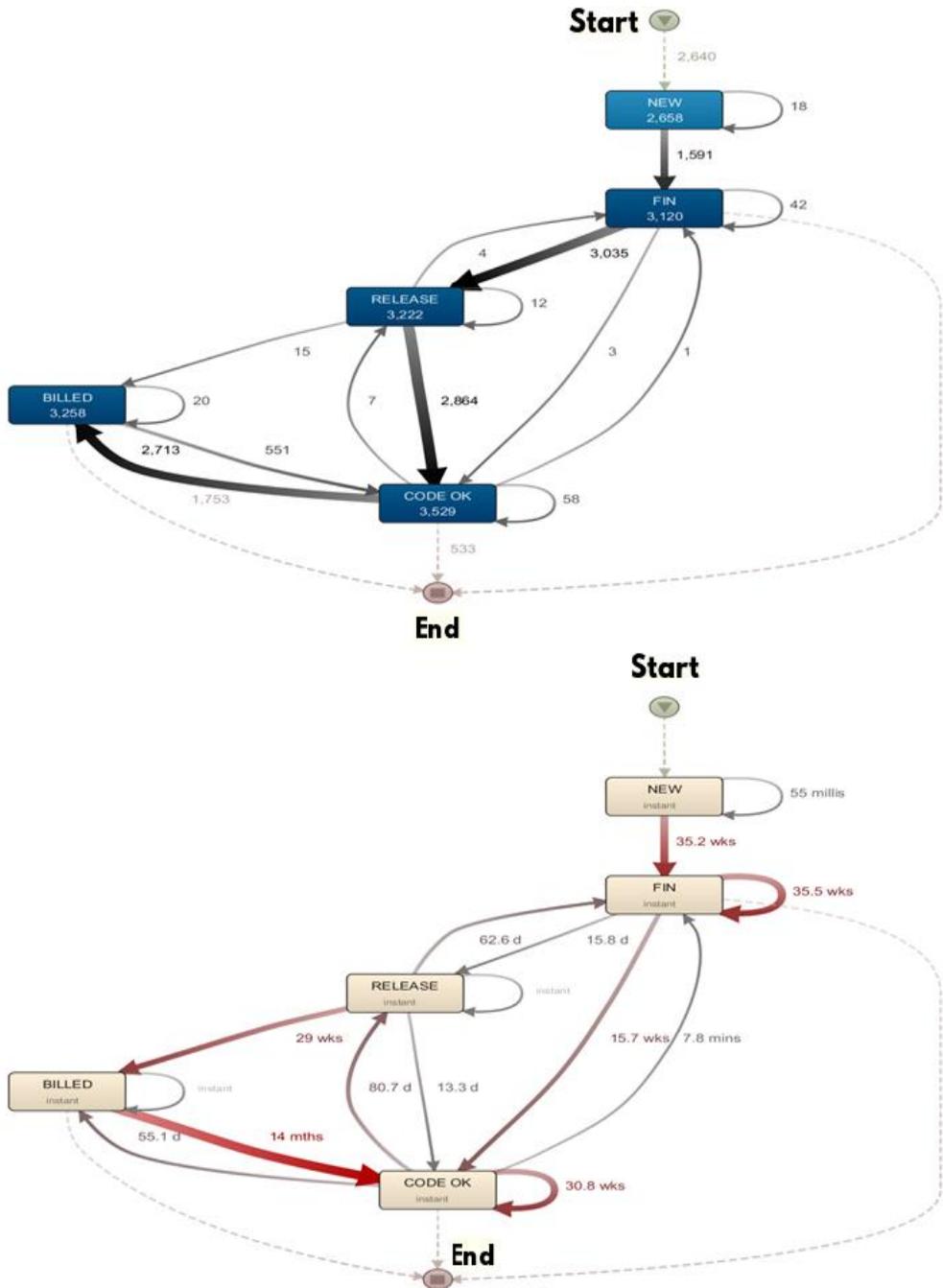Figure 2. Outcome Models with Frequency+ Mean Duration of Activities

Figure 3: Model with the involvement of Filtering Techniques

Furthermore, process mining was developed as a young research discipline to achieve the appropriate extraction that uses an event log data containing all the executed activities for support, control and further process (Ghose & Koliadis, 2007). However, any business process can be designed for storage of customer data as event logs by the help of real-time

communication and event logs processed for enhancing different goals of medical centers such as financial, staff monitoring, and mainly on customer services (Boubaker et al. 2015). By clustering algorithm, large event logs are split into subparts (i.e., events with same properties) which will emphasize the service quality in medical centers. Also, to address communication issues these methods enabling the frequent interactions between activities. Therefore, process mining regularly comes up with the right approach and these methods might be adjusted or even dispensed with an ultimate objective of change.

Eventually, process mining can visualize the real process flow steps in the system. Different types of resources (clinical and non-clinical) including physicians, nurses, technical specialists, dentists, clerks are involved and their patient activities are stored in information systems. Executed process analysis of health systems needs knowledge extraction from a stored data set. Because of differences in patient conditions and other factors business dataset consists of significant variation over time. Results are mentioning that the possibility of substantial delay between CODES OK and final billing. If hospital billing was left free to violate the order of operations on mandatory events, it might affect model performance. Typically, the patient will report this delay to the manager, and consequently, this might tend to lose patient count if it does not happen on time. To do this, a manager can assign efficient people to those activities to make things happen faster (Knuplesch et al., 2015). Similarly, by predicting bottleneck hospital staff will be more conscious about duplicate events and this will boost the system performance.

Additionally, research has given the answers about system delay by prediction of irregular activities. For bottleneck analysis, it will be necessary to go outside of the data to speak with the people who involved in it. Therefore increasing the number of staff or resources could be the right solution to system delay. Management of efficient health quality system is one of the complex issues because tasks like service cost reduction, better management of patient waiting for time and monitor of patient health are mostly related to on-time execution of the process. Moreover, the CODE OK activity step performed by the manager, and might this could be a low priority task and collect them all the requests are coming in jointly process all these at once. However, they do not realize how it affects the rest of the process. Therefore, these analyses can help business managers and explain the problem of what exactly happened inside the system. We tried to decrease the computational complexity and increase the accuracy by focusing on main events. The functionality of each unit in health systems was assessed by using different pathway connections that each one was the input for the following activity. During the processing, these techniques provide essential information, which is possible to find reliability issues, policies, and encourage hospital staff. Despite, this study also designed for event alignment with time stamps. Consequently, the outcomes can help in service quality, patient loyalty, advancement in the staff abilities, and expanded benefit bringing about the higher and faster degree of profitability.

BUSINESS PROCESS MINING

A technique that provides visibility for the business layer is process mining, which is a still very young but already well-established research discipline. Its development in recent years, amplified through the industries' huge interest yielded in multiple process mining techniques and tools. Process mining can be located between computational intelligence and data mining on the technical side and process modeling and analysis with the origin from business on the other side (Leitner, 2012). It can be described as the interface between

traditional business process management (BPM) and data mining. Therefore, process mining should not be seen as a type of data mining, but more like an extension to it. Business process mining is also often used as a term but it only restricts the areas of interest to processes out of a business context. In the remainder of the work, the term process mining will be used, although the business context is apparent through the whole work.

Use Cases of Business Process Mining

The applications of process mining are manifold (Maggi et al., 2011). Its main usage is to automatically discover processes of an organization without applying any prior modeling in order to capture the real occurring system behavior. Moreover, process mining is generally applied to find process weaknesses and their root causes. Process weaknesses can be classified into process inefficiencies as for instance bottlenecks, rework and changes and into deviations from a to-be process like for example compliance violations. Process mining is used to continuously measure outcomes of process improvement initiatives like fundamental re-engineering as well as incremental improvement. Mature PMTs recommend actions for strategic and operational decisions and can predict costs, risks and delays.

Types of Process Mining

Conformance-The second type of process mining is conformance checking where a normative or descriptive to-be model is checked against the as-is reality. The goal is to find deviations between the process model and the event log that might indicate inefficiencies or compliance violations. A distinction is made between global conformance measures and local diagnostics. The first ones interpret the overall conformance of a process (e.g. 38% of all cases are conforming to the given model) while the latter one gives detailed insights where a violation occurs (e.g. activity X is followed by activity Y although the model forbids this sequence) (Montali et al. 2014). Deviations from the to-be model cannot per se be seen as something undesired. If for instance additional activities are being performed to retain a customer, this single process instance might have violations that are desirable. Therefore, the viewpoint of interpreting violations is of importance. In the described scenario, the model could be possibly adapted to achieve a higher fit to reality.

Enhancement -As in conformance checking, enhancement also makes use of a priori model. The aim of the third type of process mining is to either extend or repair the existent model through data coming from the event log. In repair, the process model is altered so that it reflects the reality better than the a priori model, e.g. a sequential order is modeled in parallel since that is how the case is being processed in reality. Extension on the other hand extends the model by a new aspect or perspective. An example could be performance indicators such as throughput times that are being calculated and shown in the model.

Operational support-The fourth type, operational support seeks to not analyze process instances offline but online (or in near real-time). Through historical data from the event log, predictions on how a case will be processed in the future can be made. With these insights the future processing of a case can be influenced.

Process visualization

Process visualization applies a fuzzy mining algorithm for generating the process model. Fuzzy models are well suited for expressing complexity, which arises for example through a high number of distinct activities and edges. In the context of mining user click paths,

complexity appears through the high amount of edges, since a user can perform almost any activity at every step of the process. This leads to a potentially high number of edges (i.e. connections) in the process model. Early process mining algorithms were not able to control this complexity, since they assumed a more structured and controlled process. To handle this complexity, fuzzy mining techniques simplify complex process typologies by using aggregation and abstraction mechanisms, as applied for geographic maps. The complexity of the model can be influenced with two parameters that increase or decrease the amount of activities and edges shown in the model, which is called the process coverage. Starting with a low coverage, one would see a high level view of the process with the most common paths and activities. By increasing the process coverage, one could step-by-step analyze less frequently occurring patterns of a process.

Case Frequency

The Case Frequency KPI represents the total amount of cases that pass a certain activity or connection between two activities.

Activity Frequency

In contrast, the Activity Frequency KPI describes how often a certain activity was executed in total and not per case. The perspective is switched from a case to an activity perspective. If the user for instance searches for available cars more than once during one session, the case frequency would only count it once while the activity frequency would note two executions and sum it up to derive the total amount of called activities (Sadiq et al., 2007). Duration The Duration KPI enhances the process model with two types of durations. The first is tied to each activity and represents the average time the system needs to process an activity. The formula implemented for the activity calculates the average value for all equal activities and is defined in PQL as AVG ("activities". "duration"). The second duration is laid over the edges and represents the time between two activities. The duration between an activities that is directly followed by activity b is calculated as the date difference between the start timestamp of activity and the end timestamp of activity b, which is implemented as follows:

The durations on edges are only implemented between activities of the user type. In this case, they for example represent the time a user needs for navigating in an app or the time between a car reservation and a booking. Durations between technical activities are not implemented which is due to the fact that they are calling each other and an end timestamp of activity a, followed by activity b, is higher than the end start timestamp of activity b, which follows activity.

DISTRIBUTED TRACING AND PROCESS MINING

Depart from the event log have no timestamps are included in the data of L1. Only ordering relations, which lead to the different sets of sequence, are given. The indices indicate how often a unique trace is found. Moreover, a case id also does not exist explicitly but is implicitly given through having sets of activity traces. The algorithm scans the event log for four basic ordering relations that occur between two activities. Direct succession A >W B holds true iff there is at least one ordering relation where B is directly followed by A. But A and B do not necessarily have to have a dependency relation since A and B can also have a parallel relation. Causality A→W B holds true iff A >W B and B ≯W A. Parallelism AkW B holds true iff A >W B and B >W A. Choice A#W B holds true iff A

⇸W B and B ⇸W A. These described relations are used to learn patterns in the event log. So called footprints of a Log L1 can be created that map the relationship of two activities in a matrix. The activities tuples all have one of the four described relationship. The actual algorithm is performed in eight steps: 1. The event log L is checked on activities that appear in an event log. The activities will correspond to transitions in the workflow petri net and will be saved to a set T. 2. Starting activities, meaning those who appear first in a trace are saved in set T1. 3. Final activities, meaning those who appear as last in a trace are saved in set T0. 4. The algorithm determines the positions of activities and their connections in the graph. Pairs (A,B) of sets of activities are found, where a) every element $a \in$ A and every element $b \in$ B are causally related meaning (i.e. $a \rightarrow L$ b) and, b) two arbitrary activities from A (or B) never follow each other or one activity never follows itself i.e. a1 #L a2 and b1 #L b2. 5. From the sum of all possible places, the ones are removed that also appear in other relations. So only maximum pairs of (A,B) remain in the set. 6. The remaining places are now being stored in PL and a unique source and sink place is added. 7. Now the connections (arcs) between the activities are defined. A connection is made between each place of P(A,B) and the elements a $\in$ A of source transitions and each elements b $\in$ B of target transitions. Moreover, arcs are drawn from the source place to each start transition and from the sink to each end transition. Finally, the petri net is returned with places PL, transitions TL and arcs FL.

POLICY IMPLICATIONS

ISC does plays important role for various companies and domains all over the world. Violation of the ISC can result in severe consequences resulting in fines or even quality problems and issues for companies. Consequently, checking for and discovering ISC from the process execution logs does plays an important and essential role in the digitalized environment. This study stated its research questions as well as the aims and objectives of the study. From the research conducted, this study argues for designing an automatic algorithm set to discover ISC candidates during runtime.

CONCLUSION

ISC plays an important role for various companies. Violation of the ISC at any given point has severe consequence on the whole process of doing business. Consequently, checking for any issues and discovering ISC from the process execution is an important factor in a digitalized compliance system. Hence, we stated the following research questions in the introduction;

RQ1. How can instance spanning constraint be handled in the run time?

RQ2. What data has to be extracted and how has it to be mapped to enable and store the relationship knowledge?

RQ3. How can business process mining be extended with technical aspects in order to uncover 1. User and system throughput times for business activity executions and, 2. Correlations between business process performance and system behavior?

Concluding, we can state that this three research questions have been met. However, this study suggests that future work needs to address the discovery of ISC candidates tracing back to the exception handling.

REFERENCES

Abrial, J.R.: Modeling in Event-B: System and Software Engineering, 1st edn. Cambridge University Press, New York (2010)

Awad, A., Weidlich, M., Weske, M.: Consistency checking of compliance rules. In: Abramowicz, W., Tolksdorf, R. (eds.) BIS 2010. LNBIP, vol. 47, pp. 106–118. Springer, Heidelberg (2010)

Boubaker, S., Gaaloul, W., Graiet, M., Hadj-Alouane, N.B.: Event-b based approach for verifying cloud resource allocation in business process. In: International Conference on Services Computing, pp. 538–545 (2015)

Donepudi, P. K. (2015). Crossing Point of Artificial Intelligence in Cybersecurity. *American Journal of Trade and Policy*, 2(3), 121-128. https://doi.org/10.18034/ajtp.v2i3.49

Donepudi, P. K. (2016). Influence of Cloud Computing in Business: Are They Robust?. Asian Journal of Applied Science and Engineering, 5(3), 193–196. http://doi.org/10.5281/zenodo.4110309

Donepudi, P. K. (2017). Machine Learning and Artificial Intelligence in Banking. *Engineering International*, 5(2), 83-86. https://doi.org/10.18034/ei.v5i2.490

Donepudi, P. K. (2018). AI and Machine Learning in Retail Pharmacy: Systematic Review of Related Literature. *ABC Journal of Advanced Research*, 7(2), 109-112. https://doi.org/10.18034/abcjar.v7i2.514

Ghose, A., Koliadis, G.: Auditing business process compliance. In: International Conference on Service-Oriented Computing, pp. 169–180 (2007)

Joshi, R., Lamport, L., Matthews, J., Tasiran, S., Tuttle, M., Yu, Y.: Checking cache-coherence protocols with TLA++ . Form. Methods Syst. Des. **22**(2), 125–131 (2003)

Kaes, G., RinderleMa, S., Vigne, R., Mangler, J.: Flexibility requirements in real-world process scenarios and prototypical realization in the care domain. In: OTM Workshops, pp. 55–64 (2014)

Knuplesch, D., Reichert, M., Kumar, A.: Visually monitoring multiple perspectives of business process compliance. In: International Conference on Business Process Management, pp. 263–279 (2015)

Leitner, M., Mangler, J., Rinderle-Ma, S.: Definition and enactment of instance-spanning process constraints. In: International Conference on Web Information Systems Engineering, pp. 652–658 (2012)

Lenzi, G.: The modal $\mu\mu$ -calculus: a survey. Task Q. **9**(3), 293–316 (2005)

Maggi, F.M., Montali, M., Westergaard, M., van der Aalst, W.: Monitoring business constraints with linear temporal logic: an approach based on colored automata. In: Rinderle-Ma, S., Toumani, F., Wolf, K. (eds.) BPM 2011. LNCS, vol. 6896, pp. 132–147. Springer, Heidelberg (2011)

Montali, M., Maggi, F.M., Chesani, F., Mello, P., van der Aalst, W.M.P.: Monitoring business constraints with the event calculus. ACM Trans. Intell. Syst. Technol. **5**(1), 1–30 (2014)

Sadiq, W., Governatori, G., Namiri, K.: Modeling control objectives for business process compliance. In: Alonso, G., Dadam, P., Rosemann, M. (eds.) BPM 2007. LNCS, vol. 4714, pp. 149–164. Springer, Heidelberg (2007)

--0--