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Continuous Quality Improvement of IT Processes based on Reference Models and Process Mining

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ABSTRACT

The inherent quality of business processes increasingly plays a significant role in the economic success of an organization. More and more business processes are supported through IT processes. In this contribution, we present a new approach which allows the continuous quality improvement of IT processes by the interconnection of IT Infrastructure Library (ITIL) reference model and process mining. On the basis of the reference model, to-be processes are set and key indicators are determined. As-is processes and their key indicators derived by process mining are subsequently compared to the to-be processes. This new approach enables the design and control of ITIL based customer support processes which will be trialed in a practice case of a customer relationship management (CRM) system. The procedural models, as well as its results, are introduced in this publication.

Keywords

Process management, process mining, ITIL, reference model, quality management, IT Service, compliance.

INTRODUCTION

Today, organizations consider themselves to be exposed to an ever increasing competitive pressure. Globalization and a rapid scientific transformation are often named as drivers of such development. To survive in such setting, organizations require optimally designed business processes: Here, not one-time optimized business processes play the essential role, but rather the ability to quickly react to new developments and to flexibly adapt respective business processes are decisive [15]. It is imperative that these processes are effectively supported through information technologies (IT) which consequently have been catalyzing increased interest in reference modeling for IT process management. Reference models such as ITIL and COBIT (Control Objectives for Information and related Technology) represent proven best practices and provide key indicators for the design and control of IT services [6]. On the one hand, utilization of reference models promises to enhance quality and facilitates better compliance according to statutes and contractual agreements [4]. On the other hand, IT processes have to correspond to corporate strategy and its respective goals. Therefore, the question arises how best practices can be implemented in a particular corporate environment. Another challenge lurks in the checking of reference process execution as well as in assuring compliance to IT procedure in respect to new or altered business processes.

To answer this question, organizations require transparence of their IT processes. However, in many organizations, a description of the processes is not or only insufficiently available, the reason often being a time-consuming and generally expensive process modeling stage. Very commonly, the process model is not maintained after implementation, so that it no longer corresponds with reality. Such discrepancies can be solved through the use of process mining, whereas the latter extracts the inherently derived process knowledge from an information system (IS) and visualizes it in the form of process models. Process mining opens a potential of automatization, whose utilization can vastly improve cost and time factors.

Additionally, organizations require transparency of the performance of the IT processes. Organizations have the ability to measure the efficiency and effectiveness of their IT processes with key indicators. Target value compliance allows detection of whether the reaching of a process goal might be jeopardized. In addition to previous control instruments, process mining provides process models for a continual improvement of IT processes. A comparison of the to-be model with the as-is model depicts whether IT processes comply with the business requirements. Information as to where deviations occur can contribute to determine associated reasons. Models showing the degree of maturity aide in the identification of potential improvements which help the as-is situation and contribute to delineate action alternatives.

In front of this background, this publication analyzes how a process can be improved on the basis of process mining through the aid of quality key indicators. Chapter 2 initially describes the fundamentals of ITIL and process mining. Afterwards, the

possibilities of quality management based on ITIL and process mining are explained in Chapter 3 through an example of incident management, a central ITIL service operation process. Chapter 4 introduces the detailed design and control of an ITIL based customer support process in the customer relationship management of a German airline. In Chapter 5, we discuss related work. Finally, Chapter 6 describes the central conclusions which were reached in the implementation in practice.

FUNDAMENTALS

IT Infrastructure Library (ITIL)

The British Office of Government Commerce (OGC) has been developing a process-oriented collection of best practices for design, control, and improvement of IT services since 1989, the focus of which being the consequent orientation based on customer demands. ITIL has developed into a de-facto international standard. In its third version, its contents are described in an anthology of five books which illustrates the entire life cycle of IT services. The book *Service Strategy* [10] comprises the strategic elements of IT service management and outlines the connection of IT services to business processes. Development methods of services are introduced in the book termed *Service Design* [7]. The volume *Service Transition* [11] describes the actions to develop necessary abilities to implement new or altered services. Duties in the management of service operations are summarized in the *Service Operation* [9] publication. Lastly, the book *Service Improvement* [8] provides instruments for the adaptation of IT services to the constantly changing requirements from business processes.

Process Mining

Process mining can be considered as specific data mining, the goal of which consists in the extraction of process knowledge from large data pools. Initial origins are the recordings of goal-oriented process execution culminating in process knowledge which consists of the information as to what, how, when and where something had to be done. This knowledge is derived in the form of process models [1, 5]. Additionally, process mining can be used to actualize the process models of an IS, to display changes and to analyze process knowledge from various perspectives [3]. The control flow describes the sequence in which single activities are executed. A point of view, tailored to the organization, reconstructs a behavior of the entities who or which are executing respective activities. The instance perspective examines the specific process execution. Within our study, we selected the process mining platform ProM [3], developed by the Technical University of Eindhoven.

QUALITY MANAGEMENT THROUGH ITIL AND PROCESS MINING

Using the example of an incident management process we will describe how a process which conforms to ITIL criteria is managed based on process mining and its quality key indicators.

Procedural Model of Service Operations according to ITIL

Today, numerous organizations with intensive customer contact already use ITIL for the optimization of their IT processes. Since the focus of this publication is the operation and improvement of IT services, the life cycles *Service Operation* and *Service Improvement* are described. The interface to the customer is represented by the service desk within the service operations. Its duties include the receiving, processing, and monitoring of support matters. The goal of problem management is to identify complications from which malfunctions arise and to solve them. In such instances, change management has to provide standardized processes [9]. The volume *Service Improvement* demands a continual improvement of IT services. In order to control IT processes, it is of utmost importance to understand what and why something needs to be measured: First, verification of key goal indicators (KGIs) and to-be values needs to be performed in order to determine whether process goals and associated effectiveness will be reached [4]. Key performance indicators (KPIs) define measurement ranges which, in conjunction with trend data and benchmarks, display whether process performances endanger the reaching of a process goal and its associated efficiency. Key indicators include, for example, the number of incidents and the reaction time. The permanent confrontation between to-be and as-is condition is delineated in seven steps [8]:

1. Define what is to be measured: Define criteria and goals through the design of processes, while simultaneously verifying the process in respect to quality, performance and compliance.
2. Define what can be measured: In the framework of given goal obligations, relevant boundary numbers are identified from the requirements of business processes, IT resources and available budget.
3. Collect data: Data aiding in the identification and proving of deviation causes is collected.
4. Modify data: In order to compare findings from dissimilar sources, data has to be transformed into a consistent format.

5. Analyze data: Key indicators are integrated as measurement points in the process management and analyzed periodically while always displaying them as a trend and in contrast to the to-be values. In the framework of such benchmarking, a common basis for comparison needs to be assured.
6. Present and use information: Necessary corrective actions need to be communicated to the organization and subsequently analyzed according to cost-benefit factors and resulting effects.
7. Implement corrective actions: A thorough implementation plan is devised and implemented according to the recommendations of the ITIL volume *Service Transition*. Subsequently, the improvement process starts anew.

Procedural Model of Service Operations based on Process Mining

Figure 1 shows the procedural model based on process mining. Many organizations use IS for the execution of their customer support processes which are configured based on to-be process models (M_2) (2). Process models formally describe business processes. Reference process models (M_1) provide initial hints for the implementations of these processes (1). ITIL, SCOR (Supply Chain Operations Reference Model), or COBIT are, amongst others, examples of reference models. At the beginning of a process execution, an instance is decided which may consist of various activities (3), e.g. the receiving of a customer's complaint. Generally, the execution is recorded through the IS and saved in log files (4). In Figure 1, all instances are recorded with the exception of process P_b. Log file L_a solely contains activities A and B since activity C is manually executed. For formalization of the log files, Mining Extensible Markup Language (MXML) [2], required by ProM, is used. On the basis of log file L_u, the process mining engine derives the implicitly present knowledge (5) in an as-is process model (M_3) while considering key indicators and goals. The evaluation engine (6) compares the as-is processes (M_3) with the reference and process models (M_1, M_2), aiming to continuously determine the degree of compliance of the latter. Therefore, as-is processes may be analyzed with respect to weaknesses and potential sites of improvement. Furthermore, being integrated into the procedural model, maturity models determine the level of quality of the customer support process and provide action recommendations to improve process quality. According to each level of abstraction, an adaptation on either a model level (M_1, M_2) or an instance level may be necessary.

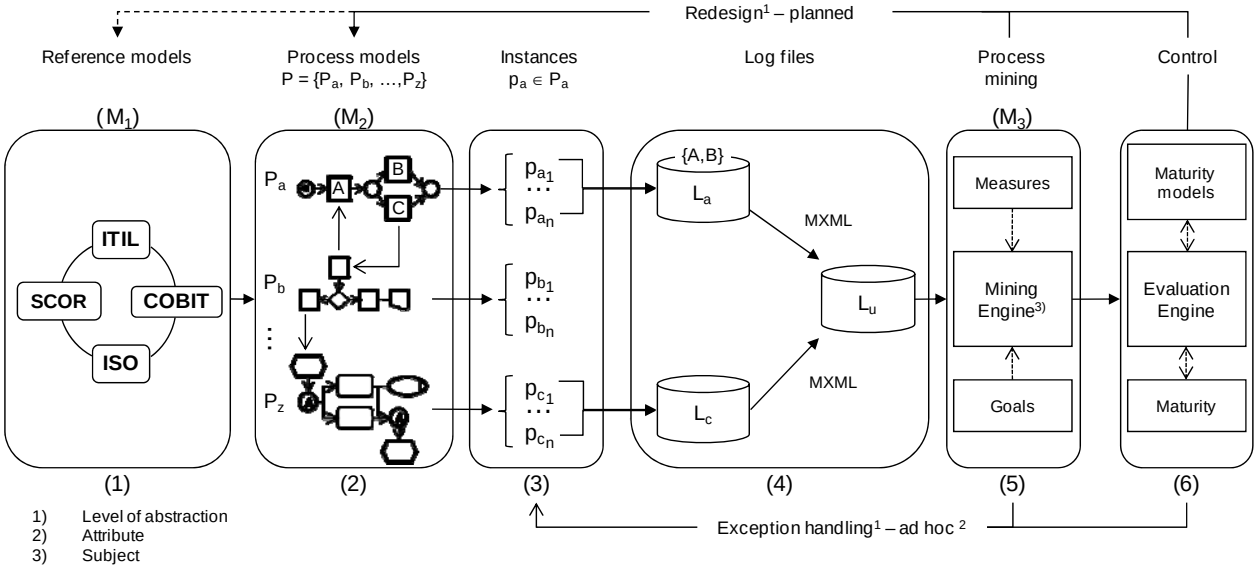

Figure 1. Procedural Model of Service Operations on the basis of Process Mining [14]

QUALITY IMPROVEMENT IN PRACTICE

Complaint Management of a Passenger Airline

The complaint management of a German airline using the Interaction Center (IAC) of the SAP CRM system for its complaint processing was analyzed. The application facilitates the processing of interactions between business partners. Each interaction is registered as an activity, such as the initiation of a payment order. Besides complaint description, further

information, such as associated priority may be detected. Every complaint is assigned with a process status, beginning with the receiving of a customer complaint. Should it be possible to provide a solution to the complaint based on a predefined regulation procedure, the activity "Communication Operation" is established, a response letter to the business partner is initiated and the sequence is ended. Should a more detailed processing be necessary, an activity of the categories of "Customer Relations", "Lost & Found" or "Customer Payment" is established, based on the content of the complaint issue. For example, complaints about lost and found items are processed by the "Lost & Found" department. If an inter-departmental processing becomes necessary, the complaint is forwarded to the responsible department through creation of a sequential activity in the system.

Continual Service Improvement (CSI)

Figure 2 describes the CSI of IT processes. Individual processes of an organization or a department will be monitored with the help of KPIs and KGIs. By using process mining, the output data can be analyzed and compared with to-be process characteristics. With this new approach, a continuous inter-departmental and inter-organizational process quality improvement can be realized.

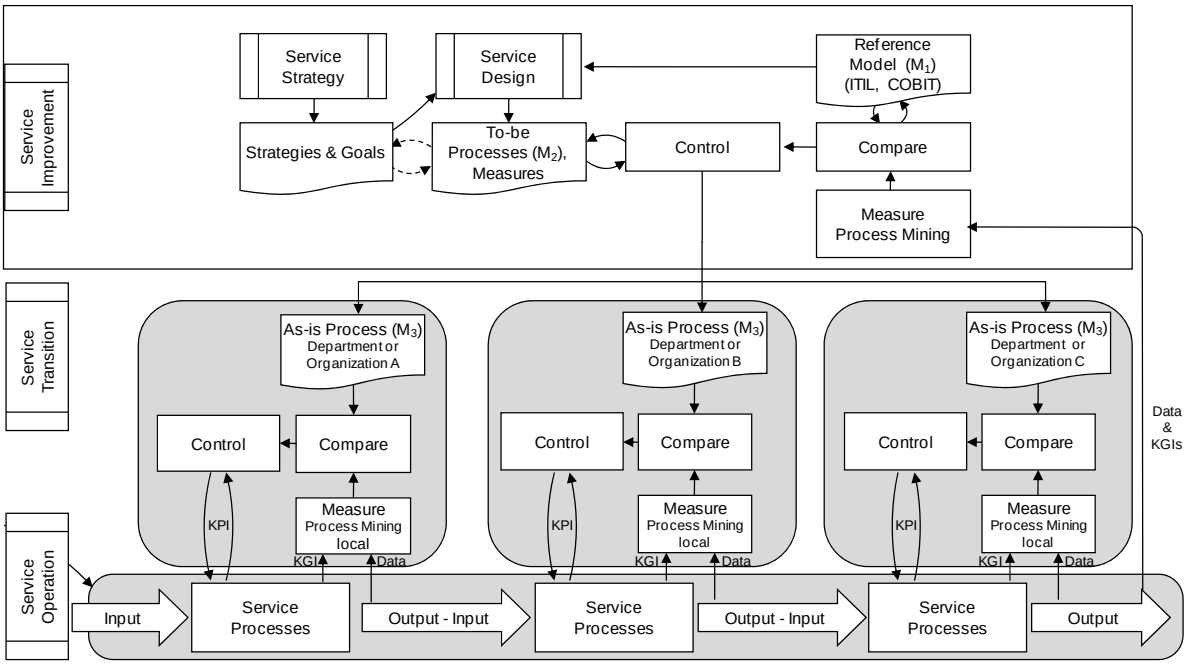

Figure 2. Continuous Quality Improvement of IT processes

CSI is strived for through the ITIL recommended seven-step procedure [8] and underscored with utilization of process mining.

1. Successful management of customer relations counts to the strategic challenges of the passenger airline. Especially the hints contained in customer complaints which are pointing towards quality deficiencies represent potential to increase customer satisfaction. This aim is closely tied to the goal to optimize complaint processing in order to simplify and standardize complaints. Therefore, the following should be measured:
   a. The extent of ITIL compliance of the IT service "complaint management".
   b. The degree of maturity of the IT processes.
2. Three processes are available at hand: An ITIL based reference model (M_1), a to-be model corresponding to the goals of the airline (M_2) and an as-is model mirroring the genuine complaint processing in the CRM system (M_3).
   a. Statements about compliance are derived from the comparison between two models: The comparison between M_1 and M_2 provides insight pertaining to the degree of ITIL compliance, while the comparison between M_1 and M_3 allows an additional analysis of the technical maturity of the IT processes. An evaluation of the service desk is made possible through a comparison between M_2 and M_3.

b. The degree of maturity is evaluated through the aide of the respective model based on the "Manage Service Desk and Incidents" COBIT process [4]. The model consists of six phases (0-5) which are shown in Figure 5. From the results of the compliance analysis, the as-is condition can be derived and subsequently be contrasted to the to-be condition. Action alternatives for the improvement of IT processes can be deduced from the determined discrepancies.

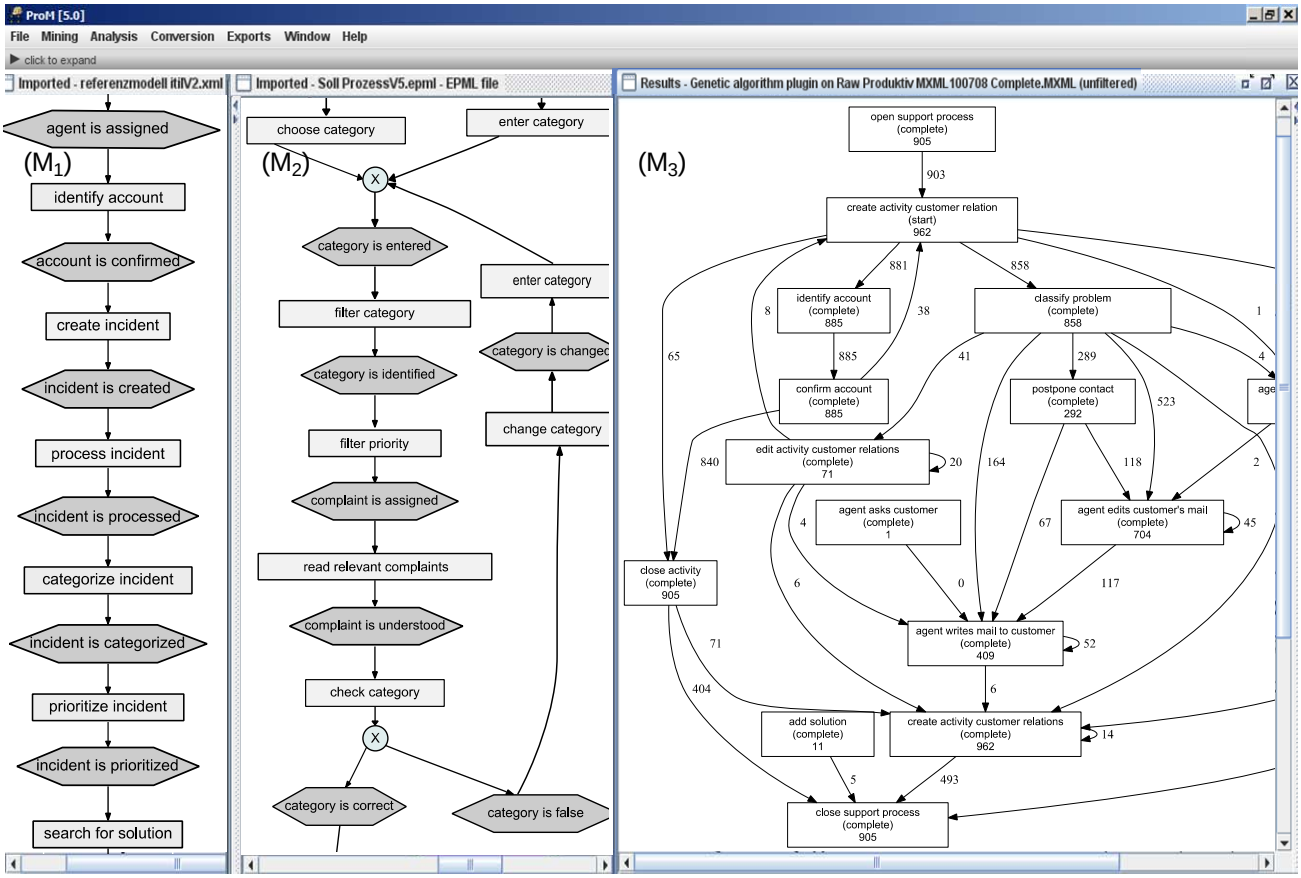

Figure 3. Model Hierarchy for Complaint Management

3. The reference model (see Figure 3, model M_1) was derived manually in the form of an event-driven process chain (EPC) according to the conceptual guidelines of ITIL. Amongst others, various activities include "create incident", "categorize incident", and "prioritize incident". The to-be model was similarly conceived in coordination with the airline (see Figure 3, model M_2) and mirrors the future processes, such as a planned online complaint collating system. The as-is model is to derived using process mining. Since the IAC does not support logging functions, all activities and their dependencies pertaining to a complaint case needed to be identified in the CRM system.

4. From the selected complaints, single events were generated according to the process mining requirements described in [13] and translated into MXML format. The extraction of the process model occurs using the "Genetic Algorithm Plug-in" [5]. Each of the nodes in Figure 3, model M_3, corresponds to an event expressed with current status and associated frequency of occurrence. Nodes are connected to directed arcs which display respective dependencies. In preparation for the compliance analysis, the process models were converted into Petri nets through ProM. Then, mapping between the events was manually performed, since events were present in different granularities.

5. To quantify compliance through the aide of fitness, the ProM plug-in "Conformance Checker" [12] was used. Fitness [18] analyzes how the behavior of a log file can be reproduced in the model. The result varies between 0 and 1: the closer this value reaches 1, the more behaviors can be reproduced. Figure 4 depicts the comparison between M_2 and M_3. The positive values in the circles display as to how often activities were not performed, although they should have been executed (heavily-shaded). Negative values provide the number of activities which were performed, although their execution was not planned (lightly-shaded). Activities displayed in white are not present in the log file. The number of edges denotes the complete number of executions. For example, the activity "classify problem" is executed 858 times,

whereas in 687 processes a classification was not performed. In 843 cases, a classification was performed although this activity was not planned (-843). If one would subtract executed activities from skipped activities and adds those which were performed in deviation to the model, one arrives at the sum of executed predecessor activity: 858-843+687 = 702.

The fitness of (M_2, M_3) amounts to 0.005, that of (M_1, M_3) to 0.390, and that of (M_1, M_2) to 0.250. However, these absolute numbers only provide the conclusion that the models do in fact deviate. Unfortunately, no reference values are available from the literature for a benchmark due to a lack of examples from practice. An experiment shows that the key indicator changes significantly from 0.39 to 0.60 if the sequence of two activities is inverted in the reference model. Nevertheless, fitness values will serve as reference values for further comparisons. We expect that the compliance analysis will yield higher fitness values if the technical maturity of the IS increases. Still, the comparison provides valuable information: due to the fact that the to-be model incorporates activities planned in the future, a notably high incurrence of white activities is discernable. Therefore, a lot of activities which are performed through planned online processing of the customer by the system are currently performed manually. The analysis furthermore shows that complaints are neither prioritized nor forwarded. It is not detected whether and how a solution is being provided. These results will be incorporated into the maturity model as initial estimates of the as-is situation.

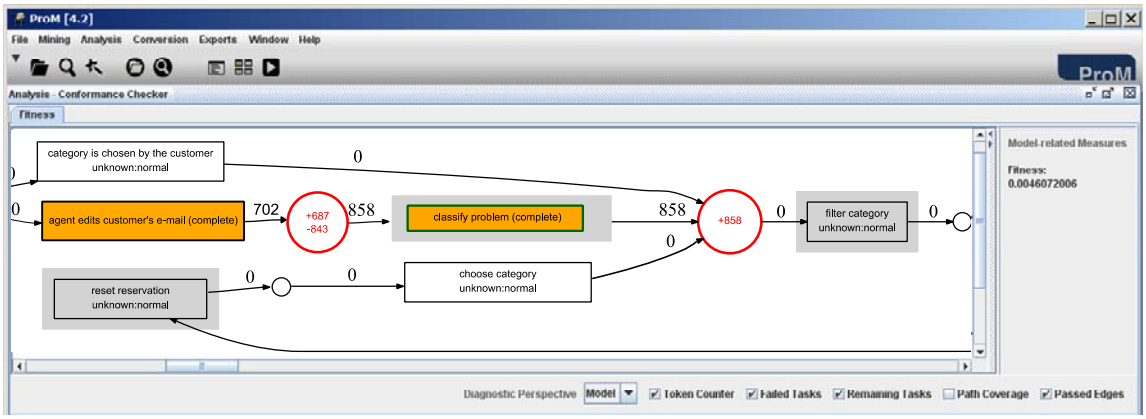

Figure 4. "Conformance Checker" Plug-in

6. The necessary measures to increase the quality level are determined in a workshop within the organization. Through the aid of the derived transparency the standardization in the field of complaint processing, the integration of process mining, the controllability of IT services as well as the assurance of compliance of business processes is sought after.

7. An adaptation of the application IAC is aspired in order to record exact timestamps for all activities associated with a complaint. The agents of the IAC have to fill out more details to timely protocol the interactions with the customer.

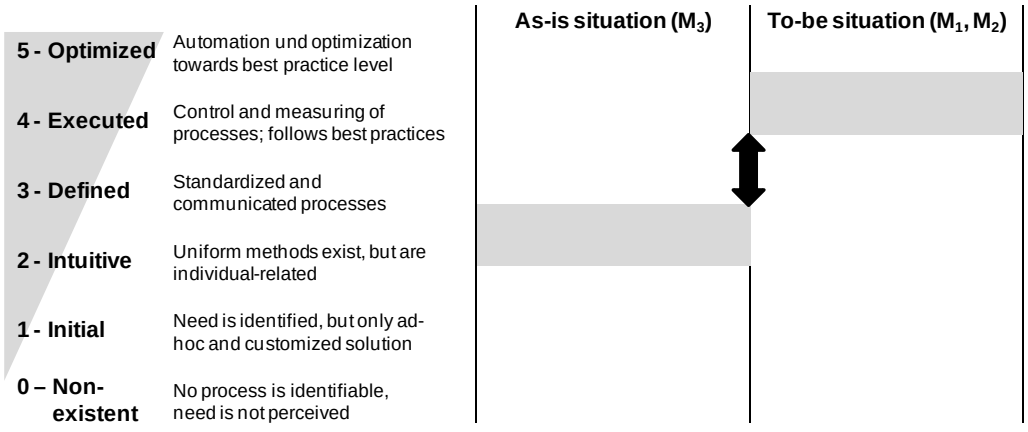

Figure 5. Maturity Model "Manage Service Desk and Incidents"

RELATED WORK

Our work can be related to different streams of research in the discovery and verification of process models. Conformance checking assumes the presence of a given process model. Therefore, process mining, which aims at the discovery of such a process model is closely related to the work presented in this paper. Various algorithms [1,5] have been developed to discover different types of models based on a log file. For more information on process mining we refer to a special issue of Computers in Industry on process mining [23] and a survey paper [1]. In the context of process model verification there are several notions for equivalence of process specifications such as behavioral equivalence [16, 18], trace equivalence [17], and bisimulation [17] that have been developed. The classical equivalence notions like bisimulation or trace equivalence are defined as a verification property which yields a yes-or-no boolean, but no degree of equivalence. When comparing a reference model with a process model, it is not realistic to assume that their granularities are the same. Therefore, the equivalence analysis with classical equivalence notions will most likely not be equal. Notions searching for behavioral similarity, e.g. causal footprint [16] and fitness function [18], are applicable in the context of process mining. In [16], the authors introduce an approach for determining the similarity between process models by comparing the footprint of models. The footprint identifies two relationships between activities that are called look-back and look-ahead links and returns the degree of the process similarity expressed in [0, 1]. This value is little expressive and hard to explain. It is not possible to trace the missing or dissent activities. Since traceability is an important requirement of the organization, the approach is not suitable. In [18], the authors introduce the behavioral and the structural precision and recall. The behavioral equivalence of the process models compares a process model with respect to some typical behavior recorded in log files. The structural precision and recall equate the term ``structure'' with all firing sequences of a Petri net that may occur in a process model. We introduced the corresponding fitness function in the CSI section. For a detailed overview of existing equivalence notions we refer to [18]. Our contribution can also be related to pattern matching or semantic matching. Existing approaches, for instance [16, 19, 20], assume that the correspondence of activities can be established automatically. Since they suppose that the same label implies same function, they try to identify the content of an activity by using an automated semantic matching algorithm based on the label of activities. Our use case shows that it is not realistic to only assume that equivalent activities can be identified, if one only considers similarities of labels when checking compliance with reference models. The work presented in this paper can furthermore be related to process improvement and process compliance. A promising approach for quality improvement in compliance is IT supported compliance evaluation [21]. The notion of compliance has also been discussed in the context of business alignment [22].

CONCLUSIONS

A procedural model to improve IT process quality through the aid of process mining and ITIL was trialed based on a practice example. Process modeling with process mining allows an objective and automated determination of the as-is condition, whose utilization may improve cost and time factors significantly. Here, the passenger airline obtains transparency of its current customer support processes, the latter being continuously evaluated based on quality indicators and sorted by degree of maturity. Quality-reducing and -improving factors are determined within the IT processes. The organization uses compliance as an indicator pertaining to relevance, applicability and implementability of ITIL reference processes. Measures for process improvement contribute to an optimization of IT process quality. In summary, the following benefit potentials can be described:

- Transparent customer support processes
- Control of process quality through quantifiable information
- Measureable degree of applied reference processes
- Improvement of quality level on the basis of a maturity model

The following measures proved themselves to be critical for the implementation in the respective organization:

- There is data which lies beyond the scope of process mining. Therefore, unrecorded activities are not recognized in the procedural model and limit the expressiveness of current processes and of the compliance analysis.
- Because of missing examples from practice, no benchmarks exist for the interpretation of fitness.
- Generally, reference and process models are available in different granularities. As mapping is not sufficiently supported, a comparison is currently only possible with high manual effort.
- An overemphasis of sequential adherence within executed activity is prevalent. In order to derive generic recommendations, best practices are created by expert monitoring and abstraction of procedures. Such methodology does not have to be mandatory for a specific organization.

Utilization of process mining requires processes which are derived from so-called “cases”. A case consists of a sequence of activities between which relations of dependence exist. A procedural model can therefore only be transposed to “case”-oriented processes. Because of the derived conclusions, the procedural model shall be applied to further processes in order to corroborate their uniform validity.

In the future, we will extend our studies and work on a measure to account for the specifics of compliance between business processes and reference models.

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