Definition and Validation of Process Mining Use Cases

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Abstract. Process mining is an emerging topic in the BPM marketplace. Recently, several (commercial) software solutions have become available. Due to the lack of an evaluation framework, it is very difficult for potential users to assess the strengths and weaknesses of these process mining tools. As the first step towards such an evaluation framework, we developed a set of process mining use cases and validated these use cases by means of expert interviews and a survey. We present the list of use cases and discuss the insights from our empirical validation. These use cases will then form the basis for a detailed evaluation of current process mining tools on the market.

Keywords: Business Process Intelligence, Process mining, Use cases, Evaluation framework.

1 Introduction

The area of Process Mining has attracted the attention of both researchers and practitioners. As a consequence, a significant number of algorithms and tools were developed. For instance, the academic process mining tool ProM Version 5.2 contains more than 280 pluggable algorithms, developed to provide a wide range of functionalities and techniques. Additionally, commercial process mining tools have emerged on the market and often use their own standards and naming. For a potential user, this situation is quite confusing and it is difficult to choose the most suitable process mining tool or algorithm for the task at hand.

Our goal is to develop an evaluation framework that can be used to assess the strengths and weaknesses of different process mining tools. We will then apply this evaluation framework to compare commercial process mining tools that are currently available on the market. Therefore, the main questions of this project are:

1. What are typical process mining *use cases*?
2. Which *process mining tools* are suitable for which use case?

As *process mining tool* we consider any software that is able to extract process models from raw event logs (without having to manually create a model beforehand). As process mining *use cases* we consider typical applications of process mining functionality in a practical situation.

Consider Figure 1, which illustrates that the use of any process mining tool will be carried out in a certain context. We can assume that the context of the person using

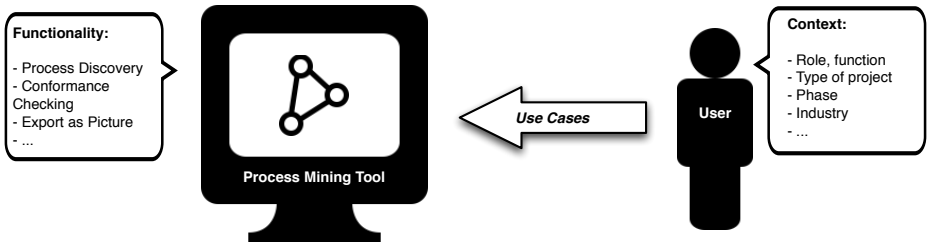

Fig. 1. Use cases for process mining may vary depending on the context

process mining has an influence on which type of functionality is considered most important. For example, the role or function a person fulfills in their organization might impact the type of analysis that the user is interested in (e.g., an auditor would be more interested in checking the compliance of processes whereas a process analyst will be mostly focused on process improvement). Another example is the type of project: In a process improvement project a user is likely to be more focused on diagnosing process bottlenecks and inefficiencies whereas in an IT re-implementation project the main goal might be to extract the current processes in an executable process modeling language such as BPMN. Even within one project, process mining could be used in different phases (e.g., as a quick-scan in the beginning of an improvement project or as a means to validate the actual improvements at the end of the project).

In this paper, we address the first question of the project by reporting on the development of an evaluation framework by defining and categorizing use cases for process mining. To ensure that the list of use cases is as complete and as relevant as possible, we validate these use cases by expert interviews with practitioners and a survey. During the validation, we also capture information about the context of the user to find out how their role affects the importance they give to the different use cases. These use cases will then form the basis for a detailed evaluation of current process mining tools in the market. The definition of the evaluation criteria and the results obtained are, however, outside the focus of this paper.

The remainder of the paper is organized as follows. Section 2 discusses related work. Section 3 describes the approach that we followed to define and validate the process mining use cases. Section 4 introduces our list of process mining use cases in detail. In Section 5, we then describe how we validated these use cases through expert interviews and a survey. Finally, in Section 6 we give an outlook on how we are currently detailing and applying our evaluation framework for the assessment of different commercial process mining tools.

2 Related Work

As process mining is an emerging topic, little work has been done on the systematic identification of use cases. Lion's share of process mining literature focuses on process discovery. Several authors describe how to evaluate discovered process models [10, 4–6, 8, 7]. For example, in [8] an evaluation framework is defined. The framework provides an extended set of tests to judge the quality of process mining results. One of

the problems is a lack of commonly agreed upon benchmark logs. This year's Business Processing Intelligence Challenge (BPIC) aims to address this problem by providing a reference log.

Unlike the approaches aiming to judge the quality of the discovered process model [4–6, 8, 7], we focus on the different functionalities related to process mining. Clearly, this extends beyond pure control-flow discovery.

Our approach to define and validate use cases is related to [9] (e.g., conducting interviews with BPM experts). However, in [9] the focus is on business process model abstraction rather than process mining. Also related are the evaluations done in the context of the workflow patterns [2].

3 Approach

One of the challenges of our study was to decide which approach we are going to follow in defining and validating the list of use cases to be used for the tools evaluation. Since there was no standard reference for process mining use cases, we followed an inductive approach, similar to the one described in [9], which aimed at defining a list of process mining functionalities needed in practice that is as complete and relevant as possible. Figure 2 illustrates the sequence of steps that constitute the approach we followed.

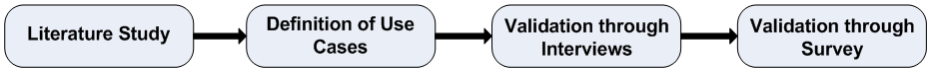

Fig. 2. The four phases of the approach

Literature study The purpose of the literature study was to get an overview about the existing functionality available in the context of process mining. In order to do this, we looked at the functionality provided by the process mining tool ProM [1] and focused our attention on academic articles about process mining techniques as well as on marketing brochures and descriptions of a couple of commercial process mining tools present on the web.

Definition of Use Cases The next step was the definition of an initial list of process mining use cases. We consider a use case to represent the use of a concrete process mining functionality with the goal to obtain an independent and final result. Therefore, actions performed before the actual analysis, like the import of the event log or filtering, are not included in our list. When defining the list of use cases, we used the classification of process mining techniques described in [10]. Figure 3 is a simpler representation of this classification and also shows our scope in relation with the entire classification. The definition of use cases is thus restricted to the offline analysis and does not include any techniques that deal with prediction, detection or recommendation. This limitation was introduced due to the inability of

evaluating the systems participating in the study in an online analysis environment. The description and examples of each use case are introduced in Section 4.

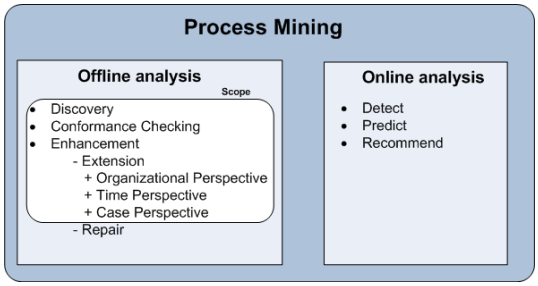

Fig. 3. The project's scope in the context of process mining

Validation through Interviews The great number of existing process mining techniques and the lack of a standard list of use cases led to the need of validating the defined list. We started our validation phase by conducting a series of ten semi-structured interviews with practitioners having process mining expertise. First, we wanted to verify the understandability of the descriptions of the use cases by asking them to provide examples with situations in which each use case would be useful. Second, the goal of the interviews was to validate the list of use cases by removing the use cases that the participants considered irrelevant, and by determining whether there are use cases missing from the initial set. Furthermore, we wanted to find out whether there are differences between the importance of each use case for different categories of end users. One lesson learnt from the interviews was that participants have the tendency of saying that all use cases are equally important. As a result of this observation, we deviated from the approach described in [9], where use cases were just classified as important or not important, and instead used the sorting method for *ranking* the use cases based on their importance. The findings of the interviews are presented in detail in Section 5.1.

Validation through Survey Distributing a survey among people familiar with the field of process mining was the most suitable method to collect a larger number of responses for the validation phase. In total, we obtained 47 responses. The main goals of the survey were to capture the context of the respondents by asking for their role and domain, get the use cases rankings, and find out what additional functionality not covered by the list of use cases is considered important and should be included in our tool evaluation. The results of the survey are discussed in Section 5.2.

The list of validated use cases will serve as a basis for a detailed evaluation of a couple of commercial process mining systems. For this purpose, an evaluation framework has been developed. This framework incorporates next to the description and the example for each use case, also related assumptions and a set of acceptance criteria used to decide whether the use case is supported or not by a tool.

4 Use Cases

This section introduces the list of process mining use cases by providing a short description of each use case. A more complete presentation, containing in addition a practical example for every use case, is given in [3]. The use cases are grouped into the categories described in [10]. Section 4.1 contains use cases belonging to the process discovery part, subsection 4.2 focuses on the conformance checking use cases, while sections 4.3, 4.4, 4.5 present the use cases related to the organizational, the time, and the case perspective.

4.1 Discovery

The use cases belonging to this category are focused on the control flow perspective of the process. The user gets a clear understanding of the analyzed process by looking at its structure, frequent behavior and at the percentages of cases following every discovered path.

Use case 1: Structure of the process. Determine the structure of an unknown process or discover how a process looks like in practice.

Use case 2: Routing probabilities. Get a deeper understanding of the process by looking at the probabilities of following one path or another after a choice point.

Use case 3: Most frequent path in the process. Discover what is the path in the process that is followed by the highest percentage of cases.

Use case 4: Distribution of cases over paths. Discover common and uncommon behavior in the process by looking at the distribution of cases over the possible paths in the process.

4.2 Conformance Checking

This category consists of use cases which have the purpose of checking whether the process has the intended behavior in practice. The use cases pertaining to this category have in common that in order to execute them one needs an additional input besides the event log of the process to be analyzed. This input may be a reference model of the process or a rule which the discovered process has to be checked against.

Use case 5: Exceptions from the normal path. Discover the outliers of the process by looking at the exceptional behavior observed in practice.

Use case 6: The degree in which the rules are obeyed. Check whether the rules and regulations related to the process are obeyed.

Use case 7: Compliance to the explicit model. Compare the documented process model with the real process as observed in the event log.

4.3 Enhancement - Extension - Organizational Perspective

The focus of the use cases included in this category is on the organizational analysis. The outcome of executing these use cases provides the user with an insight in the issues related to the resource perspective of the process.

Use case 8: Resources per task. Discover the relation between resources and tasks.

Use case 9: Resources involved in a case. Discover the group of resources involved in

solving a particular case.
Use case 10: Work handovers. Manage resource location or determine possible causes for quality and time issues by looking at how work is transferred between resources.
Use case 11: Central employees. Determine who the central resources for a process are by analyzing the social network based on handovers of work.

4.4 Enhancement - Extension - Time Perspective

As performance-related insights are most valuable, most of the use cases related to enhancement correspond to the time perspective.
Use case 12: Throughput time of cases. Determine the time that passed since the start of a case in process until its completion.
Use case 13: Slowest activities. Discover potential time problems by looking at the slowest activities in the process.
Use case 14: Longest waiting times. Determine delays between activities by analyzing the waiting times before each activity.
Use case 15: Cycles. Learn whether additional delays occur in the process due to cycles.

Use case 16: Arrival rate of cases. Determine the frequency with which new cases arrive in the process.
Use case 17: Resource utilization rate. Determine what are the utilization rates of the resource i.e, measure the fraction of time that a resource is busy.
Use case 18: Time sequence of events. Get a deeper understanding on the organization of a process by looking at the time sequence of activities for a specific case. (e.g. Gant-graph for activities).

4.5 Enhancement - Extension - Case Perspective

The case perspective of the process is represented by a single use case.
Use case 19: Business rules. Discover what are the process attributes that influence the choice points and what are the conditions for following one branch or another.

5 Validation of the use cases

The use cases were validated by conducting ten interviews (Section 5.1) and by distributing a survey (Section 5.2) among process mining users and experts.

5.1 Interviews

We conducted in total ten interviews with process mining users and domain experts. The interviews can be divided into two categories:(1) interviews aimed at gaining some qualitative feedback on the understandability of the use cases and (2) interviews which were focused on obtaining a ranking of the use cases based on their importance for the interviewees and on identifying missing use cases.

(1) Based on the feedback received from the first type of interviews (in total: four) two non-relevant use cases were removed from the list, the descriptions of a couple of

use case were refined and a short motivation was added for each remaining use case. The two irrelevant use cases referred to the possibility of identifying the paths in the process taking most time and to the possibility of visualizing the list of process attributes stored in the event log. The aim of refining the use case descriptions and of adding the motivation dimension was to increase the understandability and clarity of what each use case is about and what its practical purpose is.

(2) In the second type of interviews (in total: six) we asked the interviewees to sort the list of cases in the order of their importance in practice and on discovering any missing use cases. Moreover, we were interested in gaining additional insights on what are the functionalities that a process mining tool should provide to its users. These interviews were structured in three parts. The first part aimed at getting information about the experience of the interviewee in the context of process mining and about the added value that process mining brings to their work. Secondly, the interviewees were shown the list of use cases and were asked to assign to each use case a score from 1 to 19 based on its importance (1 being the most important). The last part of the interview was meant to summarize the discussion, to learn about possible use cases missing from the initial list and about additional functionality that interviewees consider useful in a process mining tool. The complete summary of the outcomes of these six interviews can be found in [3].

The six interviews we conducted were balanced from the point of view of the interviewee's role in the context of using process mining techniques. Three of the persons interviewed were process analysts and the other three were auditors. The second dimension we took into account when selecting the interviewees was the domain they belong to. In this context we aimed at having a broader range of domains and therefore we talked with people working in the banking industry, healthcare, public sector, and business process consulting.

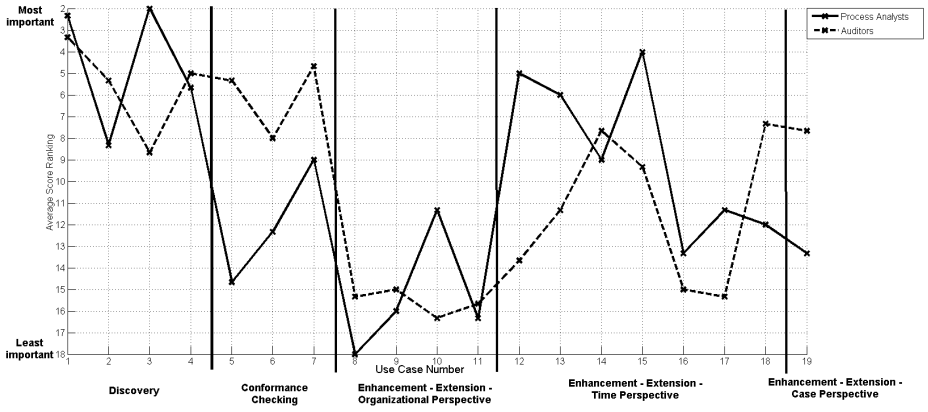

Fig. 4. Use cases ranking results from the interviews with process analysts and auditors

Figure 4 depicts the profiles of process analysts and auditors based on the use case rankings collected from our interviews. On the x-axis we refer to use case numbers, while the y-axis represents the averages of the scores the use cases were assigned during the interviews. The graphic shows there are some differences in ranking the use cases based on the profile of the respondents. For instance, use case 12 (Throughput time of cases) is one of the most important use cases according to the process analysts group, while the auditors consider this quite irrelevant in practice. The opposite holds for use case 5 (Exceptions from the normal path), which is ranked as highly important by the auditors and less important by the process analysts.

Furthermore, the top five and bottom five use cases were extracted for each category of respondents (cf. Table 1 and Table 2). Our expectations regarding the difference in needs of people having different roles are confirmed by comparing the top five use cases for each category. The contents of the top rankings are quite different, except for two use cases that are considered important by all: discovering the structure of a process and looking at the distribution of cases over the paths in the process.

When comparing the rankings of the least interesting use cases, one can also identify some similarities. Four use cases are common for both rankings. Respondents, independent of their role, consider that determining the group of resources performing a task and the group of resources involved in a case, as well as looking at the central employees of a process and at the arrival rate of cases in the process are less relevant use cases.

Table 1. Top 5 and Bottom 5 Use Cases for Process Analysts

Top 5 Use cases	**Bottom 5 Use Cases**
U3. Most frequent path in the process	U8. Resources per task
U1. Structure of the process	U11. Central employees
U15. Cycles	U9. Resources involved in a case
U12. Throughput time of cases	U5. Exceptions from the normal path
U4. Distribution of cases over paths	U16. Arrival rate of cases U19. Business rules

Table 2. Top 5 and Bottom 5 Use Cases for Auditors

Top 5 Use cases	**Bottom 5 Use Cases**
U1. Structure of the process	U10. Work handovers
U7. Compliance to the explicit model	U11. Central employees
U4. Distribution of cases over paths	U8. Resources per task
U2. Routing probabilities	U17. Resource utilization rate
U5. Exceptions from the normal path	U9. Resources involved in a case U16. Arrival rate of cases

5.2 Survey

As a next step, we designed and distributed a survey to collect a larger number of responses. The survey contained all the questions addressed during the interviews, but

also additional ones, which serve the purpose of capturing more detailed information about the end user's need in terms of process mining functionality. The contents of the survey and the complete results are given in [3].

This section presents the results obtained for a selection of the questions asked. We focus on the role and activity domain of the respondents, the ranking of the use cases, the identification of missing use cases and the possible functionality important for a process mining tool but not covered in the list of use cases.

From this survey, we received 47 responses. Although this number of responses is not enough to obtain statistically significant results, nor to generalize them, the survey results can provide useful qualitative feedback to validate our use cases. The highest percentages of responses we received are from people working in domains like academia (43%, 20 responses), information technology(21%, 10 responses), business process management consulting (19%, 9 responses), and banking (6%, 3 responses). The distribution over the roles shows a high percentage of researchers (51%, 24 responses), followed by process analysts (28%, 13 responses), process managers (9%, 4 responses), and consultants (6%, 3 responses).

The scores obtained by each use case based on the rankings were computed both over all responses and based on the role of the respondent. The score of a use case is the average of all scores registered from all rankings of the respondents belonging to the same role (the lower the score the more important is the use case). Based on these scores, we generated the graph depicted in Figure 5, which presents the profiles of the four most representative roles among the respondents.

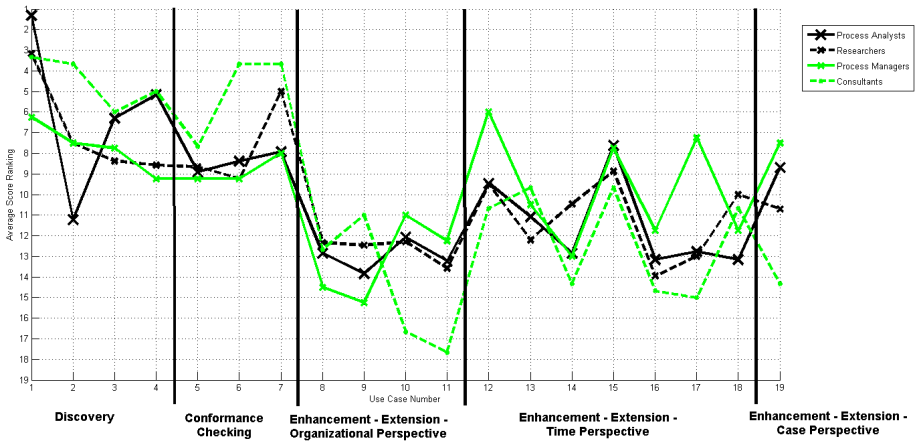

Fig. 5. Use cases ranking results based on respondents roles

Again, the results confirmed our expectation that the way users rank the use cases differs based on the role they have. It is interesting to see that use case 6 (The degree in which rules are obeyed) is considered medium important by researchers, process analysts and process managers while consultants view it as an essential use case. The same

observation holds for use case 17 (Resource utilization rates); process managers view it as a highly relevant use case, while the respondents belonging to the other categories have a different opinion.

However, similarities in the ranking are also quite frequent. For instance, use case 1 (Structure of the process) is graded as one of the most important use cases by all the roles. Similarly, use cases 3 (Most frequent path in the process) and 7 (Compliance to the explicit model) are present in the tops of all rankings. The lower parts of the four rankings also share common use cases. Examples are use case 11 (Central employees) and use case 16 (Arrival rate of cases).

The rankings obtained for the use cases were also grouped based on the domains of activity of the respondents. The results show few differences between the three domains considered (academia, information technology and business process management consulting). The profiles of the domains are shown in [3].

Table 3 presents the results of rankings of the use cases based on the survey responses. We make the distinction between use cases relevant for all the roles, use cases less relevant for all the roles and use cases relevant only for some specific roles. This distinction was made by considering relevant the top nine use cases from the aggregated rankings of each role and less relevant the remaining ten use cases.

Four use cases (U1, U3, U4, and U7) are considered important by all the groups of respondents, while six use cases (U8, U9, U10, U14, U16, and U18) are rated as less important by all the groups. It is interesting to note that there are two use cases (U13 and U17) that are relevant for only one of the categories of respondents. The opposite holds for use cases U5, U6, U12, and U15, which resulted to be important for three out of the four categories of respondents.

Table 3. Aggregated results survey

Uses case relevant for all roles
U1. Structure of the Process
U3. Most frequent path in the process
U4. Distribution of cases over paths
U7. Compliance to the explicit model

Use cases less relevant for all roles
U8. Resources per task
U9. Resources involved in a case
U10. Work handovers
U14. Longest waiting times
U16. Arrival rate of cases
U18. Time sequence of events

Use case	**Relevant for**
U2. Routing probabilities	researchers, pr managers, consultants
U5. Exceptions from the normal path	researchers, pr analysts, consultants
U6. The degree in which the rules are obeyed	researchers, pr analysts, consultants
U12. Throughput time of cases	researchers, pr analysts, pr managers
U13. Slowest activities	consultants
U15. Cycles	researchers, pr analysts, pr managers, consultants
U17. Resource utilization rate	pr managers
U19. Business rules	pr analysts, pr managers

For the question asking whether there are any missing use cases, 58% of the respondents answered no, while 42% suggest new use cases. Among these suggestions, the measurement of different KPIs (cost, quality, flexibility, etc), the creation of a simulation model, and the online analysis of an event log with the purpose of making predictions were mentioned. Since our scope is limited to the process mining techniques that perform an offline analysis of processes and the last two indications we received are related to the online type of analysis, they are not considered for new use cases. The suggestion related to the KPIs measurement does however fit in our scope, but at the moment is too vague and general to be transformed in a testable use case.

The answers regarding the additional functionalities that a process mining system should offer to its users can be grouped into the following categories: input and output capabilities, the ability to filter and cluster data, the integration with external systems like databases, BPM tools, ERP, CRM, etc, animation capabilities, and the support for large input event logs. This information will be used as basis for the extended evaluation of the process mining tools in the following phases of the project.

5.3 Conclusions of the validation phase

The use cases ranking results derived from the survey are in line with the ones resulted from the interviews, in the sense that respondents having different roles have different needs in terms of process mining functionality. This is reflected in the scores assigned to the use cases. Another similarity between the results of the two validation steps is the fact that use case 1 (Structure of the process) was considered overall the most important one, while use cases 11 (Central employees) and 16 (Arrival rate of cases) are the least significant ones.

Based on the feedback received during the validation phase of our approach, we removed two irrelevant use cases, we rephrased all the use cases descriptions that were unclear, and we obtained a classification of use cases based on their importance for different roles.

The outcome of the interviews and survey was the validated list of process mining use cases. By validated, we mean use cases properly formulated, understandable, and corresponding to the needs of process mining users. Additional developments of the use cases needed for the practical tool evaluation are described in section 6.

6 Future Work

In this paper we presented the method we used to define and validate a list of process mining use cases. We employed an exploratory approach to collect a comprehensive set of process mining functionalities needed in practice. We started by looking at the literature in the domain of process mining and the functionality available in ProM. The next step was the definition of a set of use cases grouped according to the classification of process mining techniques given in [10]. We then validated the use cases by means of ten semi-structured interviews with domain experts and process mining users and by a survey.

The outcome of this study, namely the validated list of process mining use cases, is a part of a broader project that aims at evaluating a set of commercial process mining systems. The evaluation is done by judging whether a system provides support for each of the use cases in the list.

To do this, the use cases are currently further refined by assumptions and detailed acceptance criteria to allow for an unambiguous and repeatable evaluation. For example, use case 1 (Structure of the process) will be tested based on detailed acceptance criteria that determine which kinds of behavioral patterns [2] can be discovered by the tool. Additional to the complete use cases framework, we developed a set of benchmark event logs as part of our experimental setup for the evaluation.

So far we used our framework to evaluate two process mining tools: Futura Reflect by Futura Process Inteligence and ProcessAnalyzer by QPR. Based on the use cases we created a comprehensive set of event logs to test the functionality. Our initial findings show that the approach indeed reveals relevant strengths and weaknesses of the different tools. Currently, we are working on the evaluation of two other systems: ARIS Performance Process Manager (PPM) by Software AG and Flow by Fourspark.

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