

Bot Log Mining: Using Logs from Robotic Process Automation for Process Mining

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Background and Motivation (1/3)

- Robotic Process Automation (RPA) is an emerging technology that refers to tools that mimic human actions on computer systems by interacting with the user interface or by connecting to APIs. Applied for repetitive tasks, RPA can replace or even outperform humans regarding time, costs and quality
- Process mining is based on process logs and allows for discovering as-is models, enhancing existing process models with new insights as well as checking conformance of process enactments. Process logs describe occurrences of historic events and can be extracted from organizations' information systems

Background and Motivation (2/3)

- In the relatively new research field around RPA, some approaches combine techniques from process mining with RPA
- However, there is a lack of papers investigating the post implementation phase, i.e. when bots are already deployed in an organization. This phase plays a crucial role in increasing bot efficiencies. After bots are implemented and run live, their actions and performance have to be continuously observed to detect exceptions and opportunities for further development or bot redesign
- Therefore, an integrated view of steps performed by bots in the context of existing business processes is needed to analyze effects and the role of bots in business processes

Background and Motivation (3/3)

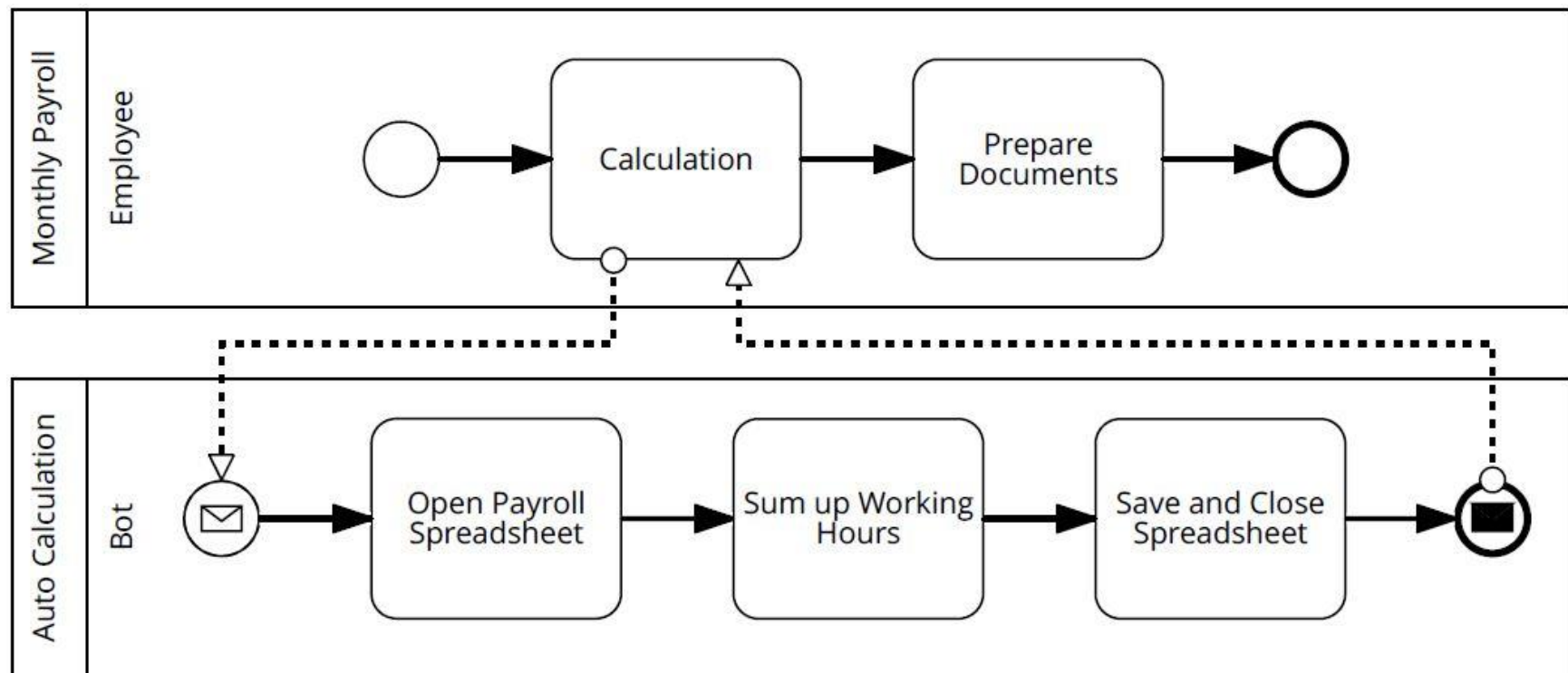
- On the one hand, leading RPA software can be configured to record logs of the executed steps of bots (bot logs). On the other hand, process mining offers a wide range of tools and techniques to discover process inefficiencies from process logs.
- Therefore, an integrated analysis using bot and process logs could provide new insights in bot-human interaction, show effects of bots on business processes, show how exceptions of bots are handled and benefit the redesign of bots used in business processes.
- We investigate the following research question: *How can bot logs and process logs be used for process mining to get a better understanding of the behaviors of bots in RPA-enabled business processes?*

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Running Example (1/3)

- This exemplary process serves as running example for better understanding



Running Example (2/3)

- Consider an organization with a simplified business process 'Monthly Payroll' which consists of the two activities 'Calculation' and 'Prepare Documents'.
- Imagine that a bot process 'Auto Calculation', which consists of the three activities 'Open Payroll Spreadsheet', 'Sum up Working Hours' and 'Save and Close Spreadsheet', now automates the so far manual activity 'Calculation'.
- Let's assume that process activity 'Calculation' fails in 80% of the cases because bot activity 'Open Payroll Spreadsheet' encounters exceptions when opening the spreadsheet.
- The failure of 'Calculation' has negative effects on the whole process 'Monthly Payroll'.

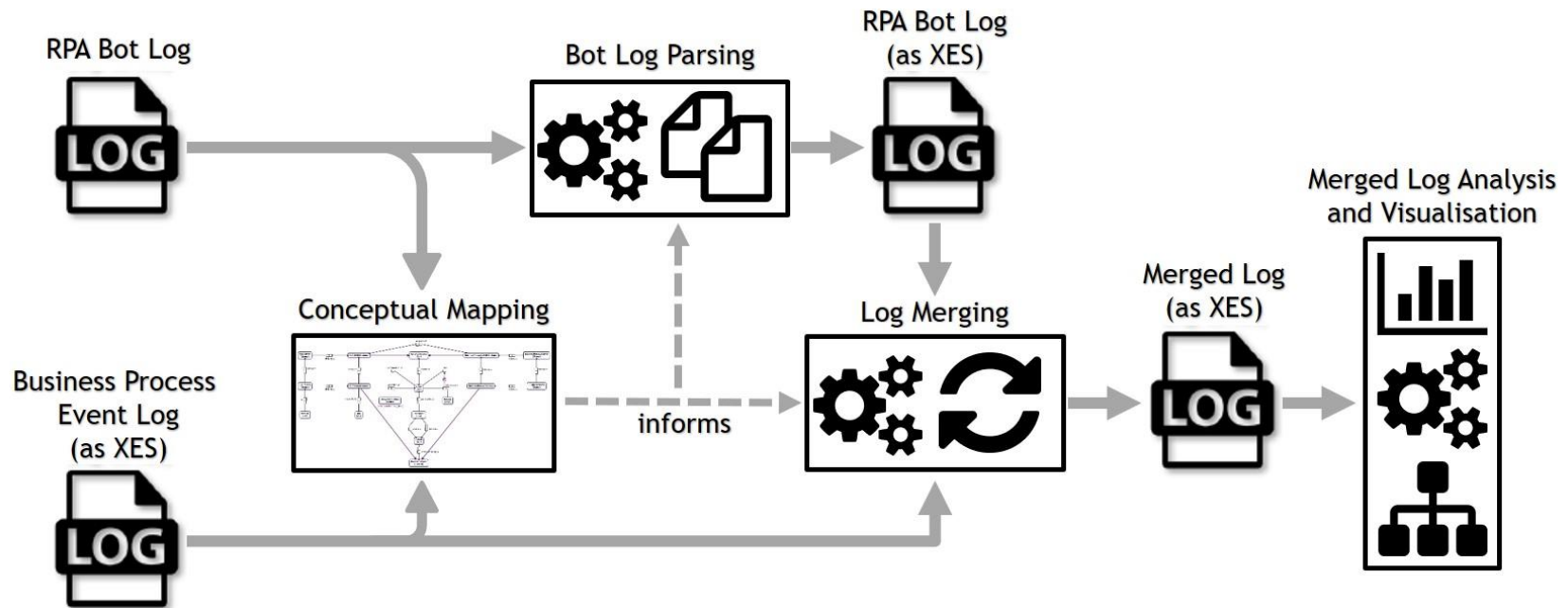
Running Example (3/3)

- If we solely analyze the process log, the failures of 'Calculation' and the resulting effects on the rest of the process can be detected. However, the exact reasons of these failures remain unclear.
- On the other hand, by solely looking at the bot log, the exact reason for the fails, namely the bot activity 'Open Payroll Spreadsheet', can be observed with all relevant variables, however the resulting effects on the business process 'Monthly Payroll' can not.
- By combining the bot log with the process log, however, the exact causes and the effects of exceptions are observable in an integrated analysis.

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Conceptual Overview of our Approach (1/2)



Conceptual Overview of our Approach (2/2)

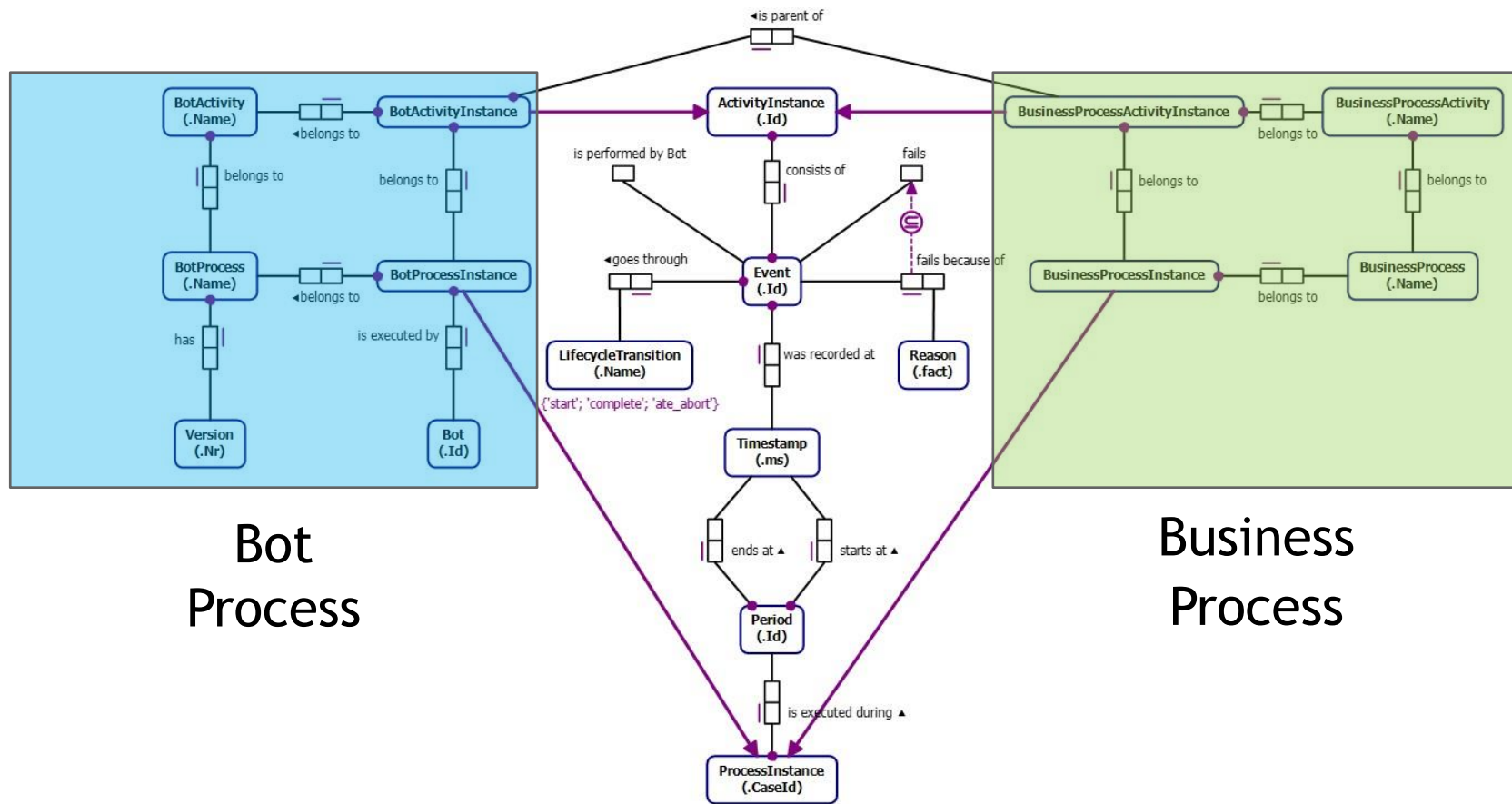
- As a first step we developed a data model that describes the structure and relation of bot processes and business processes along with the required attributes for using bot logs for process mining.
- Second, we introduce the bot log parser, bringing bot logs of the three leading RPA vendors into XES format.
- Third, we specify the log merger that combines XES-parsed bot logs with process logs to one aggregated merged log.
- Fourth, the resulting merged log can be used to gain new insights regarding the role of bots in business processes. For this purpose we suggest exemplary measures as well as develop a concept for visualizing results. We implemented the bot log parser and the log merger in Java as well as the suggested measures as an extension for the Directly Follows visual Miner in the open-source ProM framework (<https://svn.win.tue.nl/repos/prom/Packages/BotLogMining/Trunk/src/>)

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Conceptual Mapping of Bot Logs and Process Logs (1/3)

- The structure of bot and business processes along with attributes that are needed to effectively merge bot logs and process logs



Conceptual Mapping of Bot Logs and Process Logs (2/3)

- A bot process is identified by a name and has a version, identified by a number. A bot process (e.g. 'Auto Calculation' in the running example) is an algorithm created with RPA software, including the actions a bot performs.
- A bot process consists of bot activities, identified by a name. One bot activity for the bot process 'Auto Calculation' is 'Open Payroll Spreadsheet'.
- An instance of a bot process is a bot process instance, executed by a bot, with an identifying Id. A bot is a resource and can be allocated to bot processes. A bot process instance is a subtype of a process instance and is identified by a case Id which in turn is executed during a period that consists of a start and an end timestamp.

Conceptual Mapping of Bot Logs and Process Logs (3/3)

- A bot process instance consists of bot activity instances which are the instances of corresponding bot activities and subtypes of activity instances.
- An activity instance consists of events with an identifying Id, recorded at a specific timestamp, going through a lifecycle like `start` or `complete`, being performed by a bot or not and either failing (because of a reason) or not.

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Bot Log Parsing (1/2)

- To bring bot logs into XES format, relevant attributes have to be extracted from the bot log and standardized according to the specification in the table below to conform to established attribute definitions of the XES standard.
- The notion 'customized' indicates, that the logging can be customized in different ways, depending on the underlying process and therefore the extraction of the standardized attribute can be done in different ways.

XES Attribute	UiPath	Blue Prism	Automation Anywhere	Attribute in ORM diagram
concept:name	DisplayName	StageName	<i>customized</i>	BotActivityName
time:timestamp	timeStamp	Resource Start+End	first attribute	Timestamp
lifecycle:transition	State	Resource Start+End	<i>customized</i>	LifecycleTransition
eventId	fingerprint	StageID	<i>customized</i>	EventId
caseId	jobId	<i>customized</i>	<i>customized</i>	CaseId
org:resource	robotName	<i>customized</i>	<i>customized</i>	BotId
botProcessName	processName	Process	<i>customized</i>	BotProcessName
botProcessVersionNumber	processVersion	<i>customized</i>	<i>customized</i>	VersionNr
success	State	Result	<i>customized</i>	fails
connectingAttribute	<i>customized</i>	<i>customized</i>	<i>customized</i>	<i>customized</i>

Bot Log Parsing (2/2)

- Parsing of an exemplary UiPath Bot Log of the Running Example

```

13:15:38.2143 Trace {"message": "Open Payroll Spreadsheet",
                    "level": "Trace", "logType": "Default",
                    "timeStamp": "1970-01-01T13:15:38.2143395+10:00",
                    "fingerprint": "57ce7e4c-667b-49a3-83c8-a5cd4510f15b",
                    "windowsIdentity": "Laptop\\User1", "machineName": "LAPTOP",
                    "processName": "Auto Calculation",
                    "processVersion": "1.0.0",
                    "jobId": "94c633de-1263-4f85-8762-699ded67e9b3",
                    "robotName": "Bot1", "machineId": 0, "fileName": "Main",
                    "activityInfo": {"Activity": "Excel.Application.Scope",
                    "DisplayName": "Open Payroll Spreadsheet", "State": "Executing",
                    "Variables": {"WorkbookPath": "C:\\Users\\User1\\Desktop\\Payroll.xlsx",
                    "documentId": "PE830617"}, "Arguments": {}}}
13:15:39.8324 Trace {"message": "Sum up Working Hours",
                    "level": "Trace", "logType": "Default",
                    "timeStamp": "1970-01-01T13:15:39.8324476+10:00",
                    "fingerprint": "5c0684e4-43ac-46ba-9a46-f9371aedf561",
                    "windowsIdentity": "Laptop\\User1", "machineName": "LAPTOP",
                    "processName": "Auto Calculation",
                    "processVersion": "1.0.0",
                    "jobId": "94c633de-1263-4f85-8762-699ded67e9b3",
                    "robotName": "Bot1", "machineId": 0, "fileName": "Main",
                    "activityInfo": {"Activity": "Excel.Application.Scope",
                    "DisplayName": "Sum up Working Hours", "State": "Faulted",
                    "Variables": {"SheetName": "Sheet1", "documentId": "PE830617"},
                    "Arguments": {}}}
13:16:04.3771 Trace {"message": "Save and Close Spreadsheet",
                    "level": "Trace", "logType": "Default",
                    "timeStamp": "1970-01-01T13:16:04.3771715+10:00",
                    "fingerprint": "3faced6f-c71d-425f-9ae5-3b4196471203",
                    "windowsIdentity": "Laptop\\User1", "machineName": "LAPTOP",
                    "processName": "Auto Calculation",
                    "processVersion": "1.0.0",
                    "jobId": "94c633de-1263-4f85-8762-699ded67e9b3",
                    "robotName": "Bot1", "machineId": 0, "fileName": "Main",
                    "activityInfo": {"Activity": "Excel.Application.Scope",
                    "DisplayName": "Save and Close Spreadsheet", "State": "Executing",
                    "Variables": {"WorkbookPath": "C:\\Users\\User1\\Desktop\\Payroll.xlsx",
                    "documentId": "PE830617"}, "Arguments": {}}}

```



```

<trace>
  <string key="concept:name" value="94c633de-1263-4f85-8762-699ded67e9b3"/>
  <event>
    <string key="concept:name" value="Open Payroll Spreadsheet"/>
    <date key="time:timestamp" value="1970-01-01T13:15:38.214+10:00"/>
    <string key="lifecycle:transition" value="start"/>
    <string key="eventid" value="57ce7e4c-667b-49a3-83c8-a5cd4510f15b"/>
    <string key="caseid" value="94c633de-1263-4f85-8762-699ded67e9b3"/>
    <string key="org:resource" value="Bot1"/>
    <string key="botProcessName" value="Auto Calculation"/>
    <string key="botProcessVersionNumber" value="1.0.0"/>
    <boolean key="success" value="true"/>
    <string key="documentId" value="PE830617"/>
  </event>
  <event>
    <string key="concept:name" value="Sum up Working Hours"/>
    <date key="time:timestamp" value="1970-01-01T13:15:39.832+10:00"/>
    <string key="lifecycle:transition" value="ate:abort"/>
    <string key="eventid" value="5c0684e4-43ac-46ba-9a46-f9371aedf561"/>
    <string key="caseid" value="94c633de-1263-4f85-8762-699ded67e9b3"/>
    <string key="org:resource" value="Bot1"/>
    <string key="botProcessName" value="Auto Calculation"/>
    <string key="botProcessVersionNumber" value="1.0.0"/>
    <boolean key="success" value="false"/>
    <string key="documentId" value="PE830617"/>
  </event>
  <event>
    <string key="concept:name" value="Save and Close Spreadsheet"/>
    <date key="time:timestamp" value="1970-01-01T13:16:04.377+10:00"/>
    <string key="lifecycle:transition" value="start"/>
    <string key="eventid" value="3faced6f-c71d-425f-9ae5-3b4196471203"/>
    <string key="caseid" value="94c633de-1263-4f85-8762-699ded67e9b3"/>
    <string key="org:resource" value="Bot1"/>
    <string key="botProcessName" value="Auto Calculation"/>
    <string key="botProcessVersionNumber" value="1.0.0"/>
    <boolean key="success" value="true"/>
    <string key="documentId" value="PE830617"/>
  </event>
</trace>

```

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Log Merging (1/2)

- The goal of the log merger is to create a merged log in XES format by combining a bot log with a process log.
- As input, the merger takes the process log, the bot log, and the name of the connecting attribute in the process log and in the bot log, respectively.
- The log merger iterates over the events in the process log and checks the value of the connecting attribute. It then compares this value with the values of the connecting attribute of all events in the bot log.
- If the values match, the bot event is put at the correct position in the process log, depending on the lifecycle attribute of the process event: If it is in the `start` lifecycle, the bot event is put after the process event, if it is in the `complete` lifecycle, the bot event is put before the process event.

Log Merging (2/2)

- Exemplary Merging of the UiPath Bot Log with the Business Process Log of the Running Example

```

<trace>
  <string key="concept:name" value="94c633de-1263-4f85-8762-699ded67e9b3"/>
  <event>
    <string key="concept:name" value="Open Payroll Spreadsheet"/>
    <date key="time:timestamp" value="1970-01-01T13:15:38.214+10:00"/>
    <string key="lifecycle:transition" value="start"/>
    <string key="eventid" value="57ce7e4c-667b-49a3-83c8-a5cd4510f15b"/>
    <string key="caseid" value="94c633de-1263-4f85-8762-699ded67e9b3"/>
    <string key="org:resource" value="Bot1"/>
    <string key="botProcessName" value="Auto Calculation"/>
    <string key="botProcessVersionNumber" value="1.0.0"/>
    <boolean key="success" value="true"/>
    <boolean key="bot" value="true"/>
    <string key="documentId" value="PE830617"/>
  </event>
  <event>
    <string key="concept:name" value="Sum up Working Hours"/>
    <date key="time:timestamp" value="1970-01-01T13:15:39.832+10:00"/>
    <string key="lifecycle:transition" value="ate:abort"/>
    <string key="eventid" value="5c0684e4-43ac-46ba-9a46-f9371aedf561"/>
    <string key="caseid" value="94c633de-1263-4f85-8762-699ded67e9b3"/>
    <string key="org:resource" value="Bot1"/>
    <string key="botProcessName" value="Auto Calculation"/>
    <string key="botProcessVersionNumber" value="1.0.0"/>
    <boolean key="success" value="false"/>
    <boolean key="bot" value="true"/>
    <string key="documentId" value="PE830617"/>
  </event>
  <event>
    <string key="concept:name" value="Save and Close Spreadsheet"/>
    <date key="time:timestamp" value="1970-01-01T13:16:04.377+10:00"/>
    <string key="lifecycle:transition" value="start"/>
    <string key="eventid" value="3faced6f-c71d-425f-9ae5-3b4196471203"/>
    <string key="caseid" value="94c633de-1263-4f85-8762-699ded67e9b3"/>
    <string key="org:resource" value="Bot1"/>
    <string key="botProcessName" value="Auto Calculation"/>
    <string key="botProcessVersionNumber" value="1.0.0"/>
    <boolean key="success" value="true"/>
    <boolean key="bot" value="true"/>
    <string key="documentId" value="PE830617"/>
  </event>
</trace>

```

```

<trace>
  <string key="concept:name" value="bc2cd219-5727-409e-8b39-44b5a9cc4665"/>
  <event>
    <string key="concept:name" value="Calculation"/>
    <date key="time:timestamp" value="1970-01-01T13:15:37.179+10:00"/>
    <string key="lifecycle:transition" value="start"/>
    <string key="eventid" value="7e7633d7-1041-4370-9667-50af17aaf35d"/>
    <string key="caseid" value="bc2cd219-5727-409e-8b39-44b5a9cc4665"/>
    <string key="org:resource" value="Bot1"/>
    <string key="BusinessProcessName" value="Monthly Payroll"/>
    <boolean key="success" value="false"/>
    <string key="documentId" value="PE830617"/>
  </event>
  <event>
    <string key="concept:name" value="Prepare Documents"/>
    <date key="time:timestamp" value="1970-01-01T13:16:06.299+10:00"/>
    <string key="lifecycle:transition" value="start"/>
    <string key="eventid" value="dbd2b572-ffcd-4192-ad8d-0a873a247df9"/>
    <string key="caseid" value="bc2cd219-5727-409e-8b39-44b5a9cc4665"/>
    <string key="org:resource" value="Employee1"/>
    <string key="BusinessProcessName" value="Monthly Payroll"/>
    <boolean key="success" value="true"/>
    <string key="documentId" value="PE830617"/>
  </event>
</trace>

```

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Merged Log Analysis and Visualization (1/3)

- A merged log provides opportunities for a more detailed analysis of the underlying processes. The idea is to create new measures and visualizations for process mining that use a merged log as input and provide useful information on the underlying partly automated processes as output.
- There are many possibilities for new measures, we developed two exemplary measures here, 'Exception Time Impact' (ETI) and 'Relative Fails' (RF), to illustrate the concept of our approach.

Merged Log Analysis and Visualization (2/3)

- The ETI measure, calculates the average impact (in terms of time) which an activity (A) has on the process, if A fails. It compares the average remaining duration of the whole process in cases where A failed to the average remaining duration of the whole process in cases where A did not fail.
- An interpretation of the measure for the running example could be for example: When the bot activity `Open Payroll Spreadsheet` fails, the business process `Monthly Payroll` on average takes 5 hours longer to end. In the visualization of the measure, activities are then colored based on the average time impact in case of failure and based on if they were performed manually or by a bot. This view enables the discovery of critical parts in the process as well as possible effects between bot and human activities.

$$ETI_A = \frac{\sum \text{Trace rem. Dur. (A failed)}}{\#\text{traces(A failed)}} - \frac{\sum \text{Trace rem. Dur. (A success)}}{\#\text{traces(A success)}}$$

Merged Log Analysis and Visualization (3/3)

- The RF measure, calculates the relative exception rate of A by dividing the number of events of A that have the success attribute value 'false' by the total number of occurrences of A in the merged log. In the visualization A is then colored based on the result of that division and based on by whom it was performed. This coloring enables the discovery of often failing activities by bots and humans and possible connections of fail rates of different activities. Further, the fail rates at points of bot-human interaction can be observed and checked for possible patterns.

$$RF_A = \frac{\#events(A\ failed)}{\#events(A)}$$

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Conclusion and Future Work (1/3)

- In this paper we presented an approach that uses bot logs for process mining, in order to get a better understanding of the behavior of bots in business processes.
- We already conducted a first evaluation by parsing a real-life and three artificial bot logs, merging the resulting log with a real-life process log and analyzing the resulting merged log with the two created measures.
- We extend existing knowledge by describing the structure and relation of bot and business processes and by enabling the use of bot logs for process mining.

Conclusion and Future Work (2/3)

- Our work has some limitations that raise opportunities for future work.
- First, the basic inputs for the approach are bot logs, which assumes that RPA users have set their logging level accordingly. A more detailed logging can result in more data, which may not always be favored in practice.
- Second, our approach requires a connecting attribute that allows linking bot actions and business process actions. If there is no such attribute, event correlation techniques have to be applied.
- Third, more measures are needed to analyze merged logs. We provided two measures to illustrate how new information can be gained from analyzing merged logs. However, there are more opportunities to extract useful information from merged logs, and thus more complex measures are needed.

Conclusion and Future Work (3/3)

- A possible avenue for future work is to develop an event correlation approach specific for the RPA context. This can help merging bot logs and process logs when connecting attributes are missing, and thus provides further opportunities for generating merged logs.
- Additional to the two sample measures, more complex measures can be implemented. One idea is to analyze failing bot activities and search for patterns in the corresponding bot log attributes. This measure could be used for mapping exact causes of bot exceptions and exact effects on business processes and thus could benefit bot and process redesign.
- We plan to extend the evaluation with more real-world and artificial data.
- More sophisticated techniques like machine learning could be used on merged logs. Bot behavior in new business processes could be predicted and thus possible effects can be derived prior to bot implementation.