Report PODS: Volvo IT BPI Challenge 2013

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1. Domain and Data Description

This project aims to delve deeper into the challenge proposed in BPI 2013, centered around gaining insights from Volvo IT's incident and problem management processes. The data focuses on how Volvo IT and help desk employees handle issues related to their IT infrastructure and service offerings. The domain spans **customer service** and **IT management**, emphasizing how incidents (unplanned interruptions) and problems (root causes of incidents) are tracked, managed, and resolved within the company's operational framework.

The data is sourced from Volvo IT's **VINST system**, an incident, and problem management tool likely comparable to industry-standard solutions like Jira or Trello. VINST records events across different organizational units and functions, capturing interactions, workflows, and resolutions for IT-related tasks. The domain is a hybrid of **customer support** and **IT operations**.

Datasets

Volvo provides three comprehensive datasets, each consisting of event logs tied to different management processes, however a special attention will be given to the incidents data:

1. **Incidents**:
    - 7554 cases
    - 65,533 events
    - Covers the incident management process, where the primary focus is resolving unplanned interruptions to IT services.
2. **Closed Problems**:
    - 1487 cases
    - 6660 events
    - Represents completed cases in the problem management process, where the root cause of incidents has been identified and resolved.
3. **Open Problems**:
    - 819 cases
    - 2351 events
    - Represents ongoing cases in the problem management process, where the resolution is yet to be achieved.

Common Columns in the Event Logs

Each event log includes the following columns, providing a detailed view of the processes:

Column	Description
Case_ID	A unique identifier for each case, representing an incident or problem.
Activity	The specific task or step performed during the process (e.g., "Assigned”, "Resolved").
Resource	The individual or system responsible for performing the activity.
Variant	A unique sequence of activities for a case, representing a specific workflow or path.
Variant_Index	An identifier for the variant sequence within the dataset.
concept_name	The name of the event or concept associated with the activity (similar to a label).
impact	The severity level of the incident/problem (e.g., "Low," "High," "Major").
lifecycle_transition	The state transition of the activity (e.g., "Start," "Complete").
org_group	The broader group or division within the organization performing the activity.
org_role	The specific role (e.g., "Support Team," "Manager") responsible for the activity.
organization_country	The country where the organization handling the case is located.

organization_involved	The specific organizational unit involved in the case (e.g., "Org Line A2," "Org Line C").
product	The product or service associated with the incident or problem.
resource_country	The country of the individual or system performing the activity.
End_time	The timestamp marking the completion of the activity.

Table 1: Column descriptions

2. Problem Description

The primary goal of the incident management process is restoring a customer's normal service operation as quickly as possible when incidents arise, ensuring that the best possible levels of service quality and availability are maintained. The incident management system includes the activities required to diagnose the root cause(s) of incidents and to secure the resolution of those problems to enhance the quality of IT services delivered and/or operated by Volvo IT Belgium.

The process owner was particularly concerned about 4 already known problems in the process that were recurrent throughout the IT department:

1. **Push to Front (incidents only):** Is there evidence that cases are pushed to the 2nd and 3rd line too often or too soon?
2. **Ping-Pong Behavior:** How frequently do cases ping pong between teams, and which teams are more or less involved in ping-ponging?
3. **Wait User abuse**: Is the "wait user" substates abused to hide problems with the total resolution time?
4. **Process Conformity per Organization**: Where do the two IT organizations differ and why?

After performing a deep analysis of the data and exploring solutions of the winners of BPI 2013, it was found that the analysis lacked a depth of variant analysis and what-if scenarios. This is in order to address and improve the actual existing process. Rather than just mere recommendations. To address this, several what-if scenarios were analyzed to explore potential improvements to the existing IT processes and quantify the extent of these improvements under ideal conditions.

It is essential to preprocess the data to ensure simulations are of acceptable quality. This preprocessing primarily involves estimating missing start timestamps [4]. However, the accuracy and reliability of these estimations depend on the data meeting two critical constraints:

1. **Absence of Sporadic Resources**: Resources that appear only once or twice in the dataset can distort calculations.
2. **Absence of Multitasking Resources**: Resources heavily engaged in overlapping activities or several of them in short time lapses can skew the approximations.

By addressing these constraints, the preprocessing step can significantly improve the quality and validity of the simulations, ensuring that the results provide actionable insights. Thus, a proxy for these measures is provided below, where an instance of multitasking is represented by the creation of an event in less than the minimum threshold (5 minutes). Finally, 2 figures for addressing the distribution of resources per case and number of events per user per case are presented.

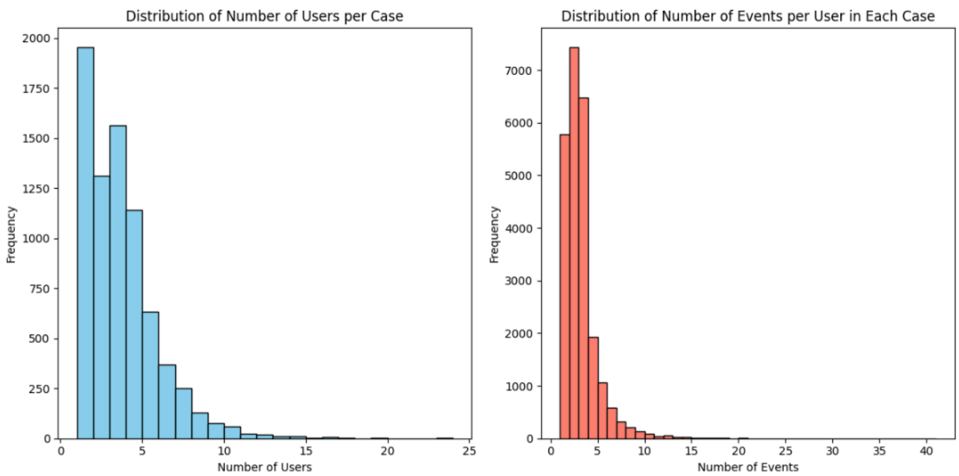

Figure 1: Distribution of resources per case (Blue) and Events per resource per case (Red)

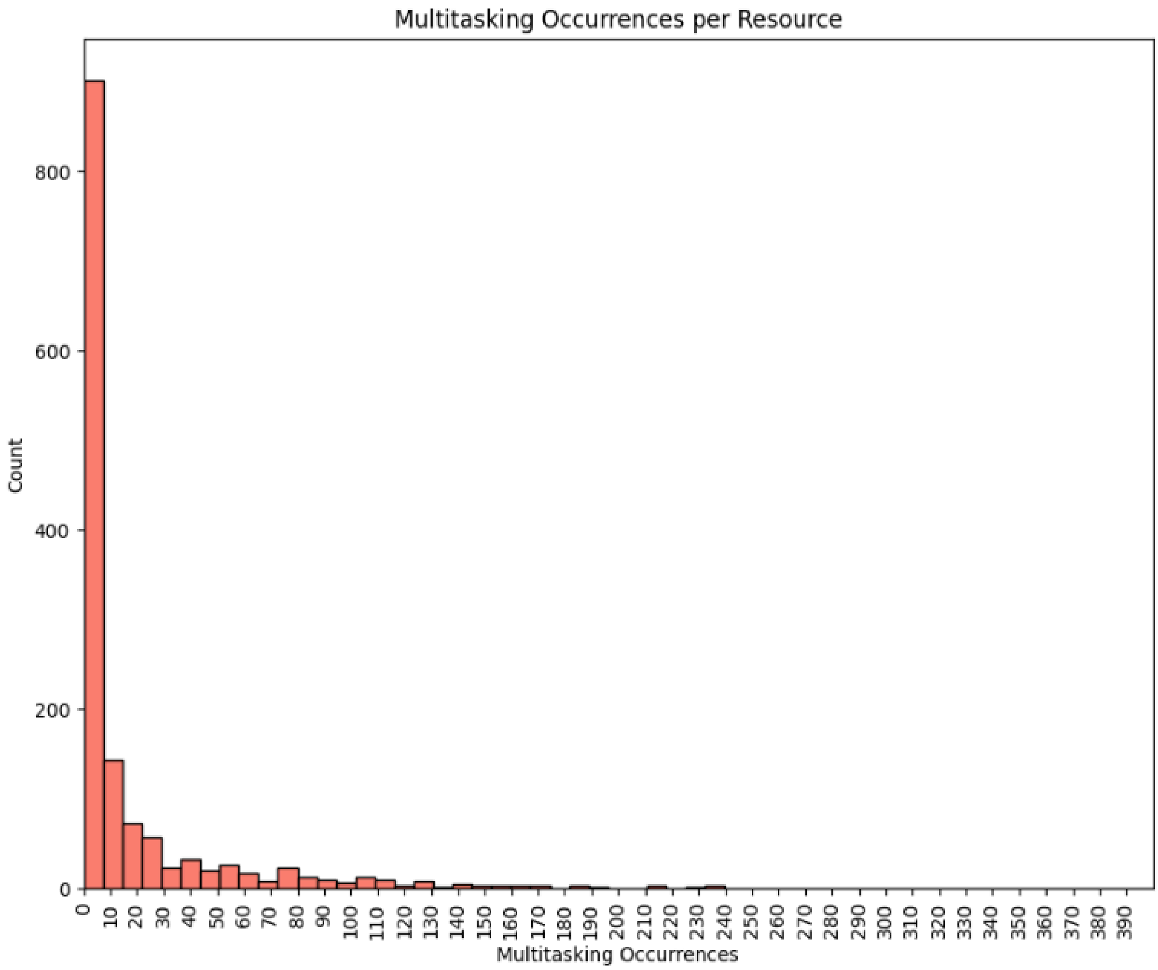

Figure 2: Distribution of instances of multitasking per case

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Given that the vast majority of resources perform less than 5 instances of multitasking and that the overwhelming majority of cases has less than 5 resources, start time estimation can be safely used. However, one needs to bear in mind that the distribution of events per user per case is highly skewed to the right.

Queue Ticket automatization

Comparing the automation of ticket selection versus the current process based on resource time, this automatization has the potential to significantly improve the efficiency of business process. Since it reduces the time and effort required for manual ticket selection and minimizes human errors.

In the current process flow, we observed that the task **Queued/Awaiting Assignment** accumulates a total duration of **56.49 years** across all cases. To focus on this inefficiency, we propose a simulation scenario to automate this tasks by assigning it only to the **JIRA_System**, where the execution time would be instantaneous.

To implement this in the BPMN model, the steps are:

1. Create new role **JIRA_System** and set the timetable to **24/7**.
2. Assign the task **Queued/Awaiting Assignment** to the role of **JIRA_System**.
3. Set both the waiting time and task execution time to instant.

This change aims to remove unnecessary awaiting time and might improve the overall performance of the business process.

Redistribution of resources in different roles

Currently, **73.44%** of cases are concentrated in role **V3_2**, creating potential inefficiencies as this role may require additional resources to handle tasks without delays. To avoid this imbalance and improve the overall efficiency of the business process, we suggest redistributing resource across roles using two simulation scenarios to avoid bottlenecks and ensure process consistency.

- Simulation 1:

We assume that the total number of resources (**3,790**) is distributed constantly across all roles, ensuring each role has approximately the same number of resources. With this approach, each role would have approximately **158** resources (calculated as $3790/total\ number\ of\ roles$).

To implement this in the BPMN model, the steps are:

1. Reassign the number of resources for each task, so that all roles receive the same number of resource

- Simulation 2:

In the original data, we observed that the role **V3_2** was assigned to most of the activities, contributing to a bottleneck in the process. To avoid this issue, we propose a simulation where the roles **V3_2**, **V3_3**, and **E_9** are collectively assigned to perform all the tasks. This redistribution aims to remove the bottleneck behavior.

To implement this in the BPMN model, the steps are:

1. Assign 1000 resources to each of the roles **V3_2**, **V3_3**, and **E_9**.
2. Assign all the tasks in the process flow to the roles **V3_2**, **V3_3**, and **E_9**.

3. Redistribute the rest of resources to the rest of tasks.

Redistribution of resources in high time-consuming tasks

Pinpoint tasks in the process that take up disproportionate amounts of time compared, creating bottlenecks and inefficiency.

Prioritization by Impact

In the BPI Challenge, the recommendation to standardize the process suggests creating uniform workflows or procedures to handle incidents consistently across the organization. This is suggested to reduce variability and inefficiency. In order to address business priorities, the simulation of process standardization will prioritize incidents based on their impact, following a ranking order of Major > High > Medium > Low. This prioritization will be implemented by ordering case priorities according to the impact attribute within the BPMN model.

Thus, in order to set an appropriate range of parameters for the simulation, the following assumptions have been made:

- We will assume that resources work on a 9h - 18h, instead of assuming a 24 hours workload
- Waiting times: for estimating the waiting times, we used the exponential distribution assigning the mean from the original BPMN model. It is a proper approximation in processes where events occur continuously and independently at a constant average rate.
- We haven't considered the groups granularization (because there was a bug in Apromore that couldn't relate roles to groups). We used all roles used in the original dataset but, by eliminating groups, we cannot consider the organisation distribution. It was the best selection to lose the least possible information.

3. Methods and tools

For this project, several tools were utilized to facilitate the analysis and interpretation of the Volvo IT management data. The selection of tools was driven by the need for rigorous and multifaceted process mining capabilities, as well as simulation and comparison functionalities.

1. Apromore

Apromore served as the primary tool for data ingestion, model discovery, and in-depth process mining analysis. Its advanced features allowed for:

- **Data Analysis**: Examination of event logs to uncover insights and trends.
- **Variant Analysis**: Identification and comparison of different workflow paths (variants) within the processes.
- **BPMN Model Generation**: Conversion of discovered processes into standard BPMN (Business Process Model and Notation) diagrams for visualization and standardization.
- **Simulation of What-If Scenarios**: Modeling and testing different scenarios by adjusting parameters to explore potential improvements and outcomes.
- **Start times inference:** This software is able to automatically apply the start time approximation algorithm [4] all over the data set without needing to manually preprocess the logs.

The rationale behind using Apromore is that it is the only free tool that allows for easy simulations and start time estimation [4], otherwise we would need to perform heavy preprocessing and potentially use proprietary software.

2. LibreOffice Sheets / Python+Pandas

Used for preliminary analysis of raw logs and offered quick, exploration, and validation of some hypothesis needed to confirm. Mainly, that the start timestamp inference algorithm requirements hold or not.

Comparison to 2013 Tools

When the BPI 2013 challenge was held, the field of process mining was in its early stages, with limited tool availability. The top performers in 2013 relied on **ProM** and **Disco**, which were among the most advanced process mining tools at the time. These tools provided robust functionality, however, they lacked some modern features now available in Apromore, as the aforementioned.

Ensuring Analytical Rigor

To maintain a high standard of rigor, the following methodology was adopted for simulation analysis:

- For each what-if scenario, **five independent simulations** were conducted.
- The **average performance metrics** from the simulations were computed.
- The simulation result closest to the mean was selected for detailed analysis and comparison against the original process model and baseline process metrics
- The data has been preprocessed to enable the computation of waiting times.
- The comparison of the simulation results are compared against a **baseline null mode**, a simulation without further changes in the original logs other than preprocessing.

This method ensures consistency, and avoiding outlier or extreme generated values, ensuring robust, actionable insights for process improvement.

4. Results

It is easy to draw conclusions from the following analysis that were performed during the analysis of the aforementioned what-if scenarios:

	Average Case Duration	Average Activity Duration	Average Resource Frequency
Original Dataset	1.33 mths	2.73 days	16.86
What-if: Prioritization by Impact	1.34 mths	2.69 days	16.93
What-if: Queue Ticket automatization	1.14 mths	2.45 days	16.89
What-if: Redistribution of resources Simulation 1 (uniform distribution)	1.32 mths	2.7 days	16.78
What-if: Redistribution of resources Simulation 2 (BottleNeck)	1.33 mths	2.73	17.02
Case 1, 2 and 4 together	1.1375 mths	2.46 days	17.11

Table 2: Simulation Results

Prioritization by Impact:

While the average process KPIs for all incidents remain unchanged, there is a significant improvement in the case duration for incidents with Major and High impact, indicating that the most critical cases are resolved faster. This improvement can lead to reduced downtime, higher customer satisfaction, and minimized business disruption.

For example, in the following graph which is filtered by impact = High, it is shown how, even though the average case duration is higher for most of the tasks, in the simulated

‘Prioritization’ model there are no more unmatched cases, compared with the base model, this means that cases that usually wouldn’t get matched and simply closed, will be prioritize.

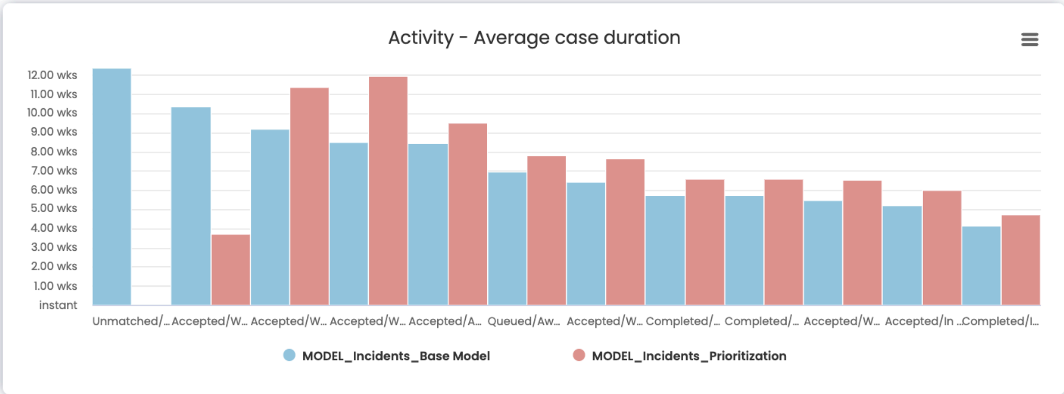

Figure 3: Prioritization by impact (Average case duration)

Queue Ticket Automatization:

From the table above, we can observe that the average duration of all cases has improved significantly due to the automation of the **Queued/Awaiting Assignment**. Obviously, the average time per activity has reduced as a direct result of the simulation.

However, the average resource frequency has shown a slight increase, given that the task is now handled by the **JIRA_System**, which affects the overall frequency distribution of resources within the process.

For instance, as shown in the **Case Duration** figure below, we can clearly observe that the average case duration has improved compared to the original flow process. Specifically, the number of cases with duration exceeding **4 months** has decreased, while cases with an **instant** or **1 month** duration have shown a significant increase.

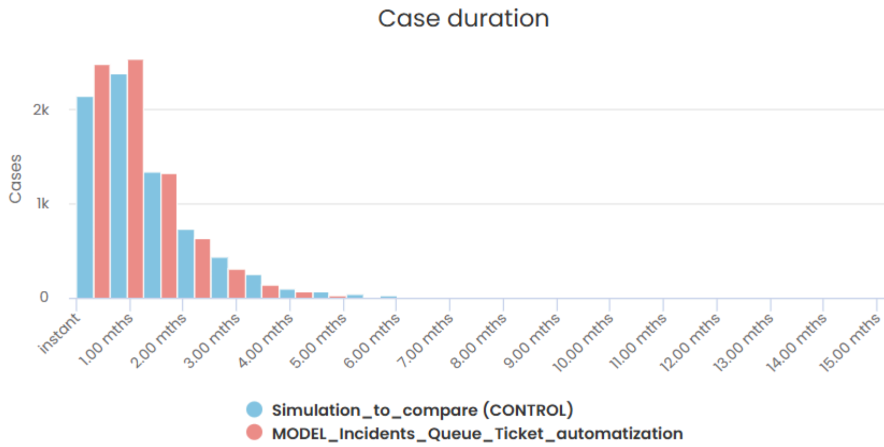

Figure 4: Queue Ticket Automatization (Case Duration)

Another figure to approve the successful implementation of queue ticket automation. Here, we can see that the task duration for **Queued/Awaiting Assignment** is effectively **0 seconds**, with the same start and end timestamps. Additionally, the waiting time has been reduced to **0**, as the next task (**Accepted/In Progress**) starts immediately, sharing the same start timestamp.

Activity	Start timestamp	End timestamp	Duration	Resource	AssignedTime
Accepted/In Progress	31.03.2010 15:59:42	02.04.2010 16:15:10	2.01 days	E_7-000001	31.03.2010 15:59:42
Accepted/Wait	05.04.2010 10:01:41	09.04.2010 10:09:13	4.01 days	E_7-000018	03.04.2010 08:46:27
Accepted/In Progress	26.04.2010 10:04:01	27.04.2010 10:47:19	1.03 days	V3_2-000111	25.04.2010 16:40:47
Queued/Awaiting Assignment	27.04.2010 14:11:58	27.04.2010 14:11:58	0 secs	JIRA System-000001	27.04.2010 14:11:58
Accepted/In Progress	27.04.2010 14:11:58	17.05.2010 10:24:07	2.83 wks	A2_5-000028	27.04.2010 14:11:58
Accepted/Assigned	17.05.2010 10:53:23	17.05.2010 11:39:09	45.76 mins	NULL-000407	17.05.2010 10:53:23
Accepted/In Progress	18.05.2010 15:43:10	02.06.2010 12:54:06	2.13 wks	A2_2-000119	18.05.2010 15:43:10
Queued/Awaiting Assignment	02.06.2010 13:25:04	02.06.2010 13:25:04	0 secs	JIRA System-000001	02.06.2010 13:25:04
Accepted/In Progress	02.06.2010 13:25:04	10.06.2010 18:16:05	1.17 wks	A2_2-000163	02.06.2010 13:25:04
Accepted/Wait - User	11.06.2010 10:23:49	14.06.2010 11:09:10	3.03 days	D_1-000086	10.06.2010 19:10:08

Figure 5: Queue Ticket Automatization (Timetable)

Redistribution of resources:

- Simulation 1 : The number of resources is distributed uniformly.

By observing the distribution and comparing the simulation results with the original data, we can conclude that both the minimum and maximum case durations have improved. In particular, the maximum case duration has decreased significantly, with most cases being reduced from 1.32 years to 9.88 months, showing an improvement of approximately 4 months. However, the minimum case duration improved by only 10 minutes. This improvement is due to the uniform distribution of resources, which allowed roles with fewer resources to handle more tasks efficiently. Consequently, tasks performed by these roles improved. On the other hand, the additional resources for these groups were taken from roles that exceeded the uniformly calculated average, causing some tasks in these roles to take longer than before the redistribution.

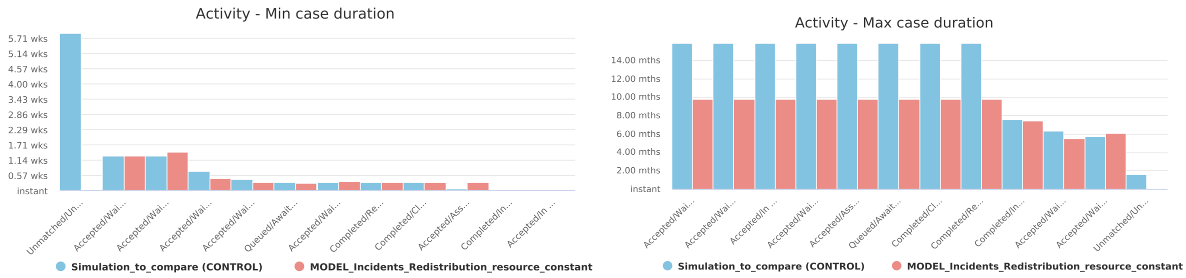

Figure 6: Redistribution Resources - Simulation 1 (Case Duration)

- Simulation 2: Assign **E_9**, **V3_2**, **V3_3** to do all the tasks with 1000 number of resources.

This simulation shows similar improvements to the observed in previous simulation, where only the maximum and minimum case durations improved. However, in this case, the improvement is more significant compared to the previous simulations because the improvement of the maximum case duration reached to **9 months**. That said, the average case duration remains unchanged across the original data, this simulation, and the previous simulations. The purpose of this simulation was to redistribute the tasks predominantly assigned to the role **V3_2** so that roles **E_9** and **V3_3** could share these tasks and thereby enhance the overall business process.

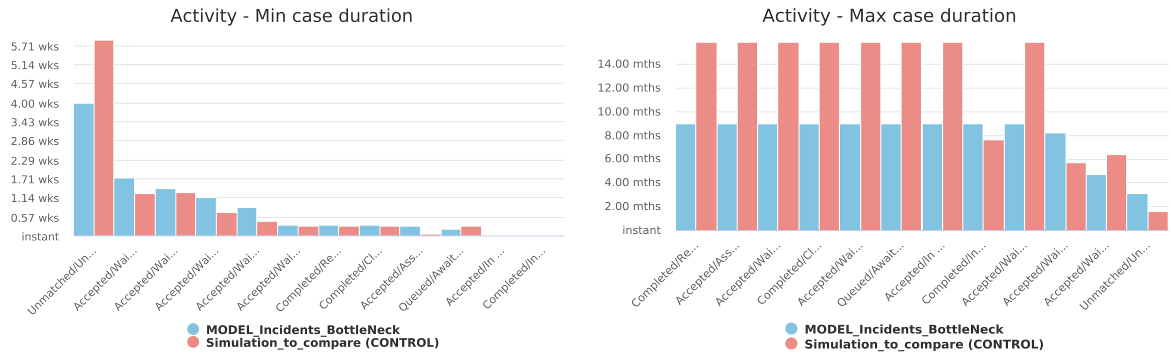

Figure 7: Redistribution Resources - Simulation 2 (Case Duration)

Case 1, 2 and 4 together

We selected the implementations from cases 1, 2, and 4, as all of them demonstrated improvements in the original process, and applied them simultaneously. Between both cases of redistribution of resources, we chose the 'bottleneck solution' one, since we believe that in real life is the one that has more potential to improve the process. This resulted in significant enhancements to the process. In the next figure, we observe the number of cases handled over time: the control simulation is shown in red, while the simulation after the modifications to the

BPMN model is shown in blue. It is evident that the same number of cases are processed more efficiently, as fewer cases are handled simultaneously while achieving the same overall output by the end.

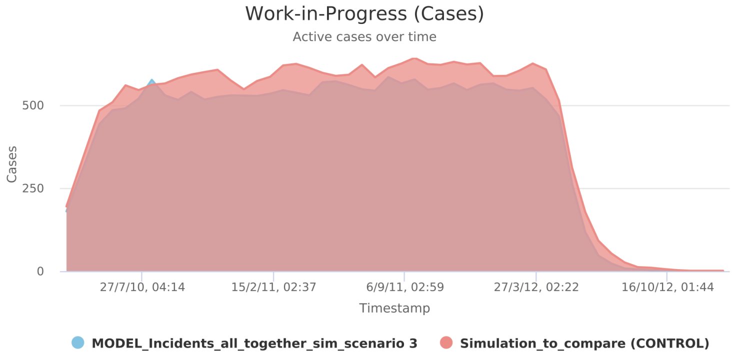

Figure 8: Active cases over time - All Together

5. Reflections and Conclusions

After analyzing various what-if scenarios, it was evident that the process can be significantly improved by implementing targeted changes. While some scenarios may face challenges in real-world implementation due to organizational complexity or resource constraints, their potential benefits, such as reduced resolution times and improved SLA compliance, make them worth exploring.

Different approaches were tried for achieving the aim of this project. Firstly, it was observed that one task could be completely automated, so users didn't lose time assigning tasks on the ticket system. This, along with the prioritization of high impact tasks, enhanced the performance of the process and the business conformity. Finally, we thought of re-distributing the resources available since it could be that they were concentrated on roles where they were not that much needed and as a collateral effect it was generating what we commonly know as a "bottleneck". By focusing the resources where they are more needed, this inefficiency is greatly diminished. After applying all of these modifications , it can clearly be seen that our simulations significantly improved the performance of the process. Almost 20% of speed-up is achieved following the aforementioned prescriptions.

Moving forward, piloting the most impactful scenarios and engaging stakeholders will be crucial for achieving lasting improvements in Volvo IT's processes. Thus, for refining the process and analysis to a greater degree, the feedback loop with the process owner and stakeholders is crucial.

The analysis depth was limited by the current immaturity of the Apromore software. Key issues include an unpolished user interface and missing or buggy simulation features. For example, in the **Redistribution of Resources** simulation (Simulation 2), assigning 3,000 resources to role *V3_2*—ideal for our scenario—was impossible due to a hard cap of 1,000 resources. Additionally, automating the assignment of processing and waiting times would improve usability, as these distributions and parameters can be derived from start and end times. However, due to the lack of these automatic features, waiting times distributions, tasks durations, roles, timetables, and other simulation parameters were manually inputted, increasing the complexity of the analysis.

We also faced bugs while assigning roles and groups, as these had to be added manually, and the assignments often failed to persist, preventing the possibility of group-level analyzes. Similarly, manually defined timetables sometimes disappeared unexpectedly. Fixing these bugs and automating the conversion of event logs into BPMN models with inferred simulation parameters could streamline the process significantly.

6. Further Work

Despite the valuable findings uncovered in this project, there remains significant room for improvement. Due to challenges and bugs encountered in Apromore, the depth of analysis was limited, leaving potential opportunities for additional performance gains on the table. Future analyses could address these limitations, focusing on resolving existing issues and expanding the study to other levels of organizational granularity within Volvo's hierarchy, such as groups, functions, and organizational units.

Further progress should begin with a new process mining iteration, incorporating refined business requirements and enhanced event logs to provide deeper insights and actionable recommendations.

Lastly, the identified bugs and suboptimal UI/UX features should be reported to the Apromore community through platforms like the GitHub issues tracker, as Apromore is an open-source project hosted on GitHub. With sufficient time and resources, contributors could also actively address these issues by fixing bugs and proposing pull requests to enhance Apromore's core codebase, driving improvements for the broader process mining community.

7. Bibliography

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8. Contribution of each member

For us, meeting during class was very productive, as it allowed us to discuss the project guidelines in detail each session. In every class, we agreed to individually delve deeper into specific topics, such as the problems we identified in the project. We encountered challenges when conducting the simulations and explored various solutions, which we discussed in our WhatsApp group. Later, we met in person at the library and successfully resolved the issue together. Once that was done, we performed multiple simulations and tested new ideas to enhance the process's performance. After obtaining the results, some team members focused on writing the report while others prepared the presentation, and from time to time we switched tasks.

From the report:

1. Domain and data description → Nayara and Bruna
2. Problem Description → Haonan and Hang
3. Methods and tools → Walter
4. Results → All
5. Reflections and Conclusions → All
6. Further Work → Walter
7. Bibliography → Bruna