Chapter 4: Realization

1.Introduction to IoT Dataset Integration:

Integrating IOT datasets with Process Mining, especially using tools like ProM, enhances the accuracy and depth of process analysis. IoT data offers real-time, detailed insights into operational workflows, enriching event logs and enabling more precise process models. ProM leverages this data to uncover inefficiencies, predict deviations, and drive smarter decisionmaking, significantly advancing data-driven process optimization.

2.Benefits of IoT Dataset Integration:

Integrating Internet of Things (IoT) data into Process Mining significantly enhances the capabilities of traditional process analysis, offering numerous strategic advantages:

1. Real-Time Process Monitoring: IoT devices provide continuous, real-time data streams from operational systems. This enables Process Mining tools to generate insights as processes unfold, helping organizations respond instantly to operational changes, detect deviations, and take corrective actions before issues escalate.

2. Detailed Operational Insights: IoT sensors capture highly granular data at every operational touchpoint. This fine-grained visibility uncovers process bottlenecks, inefficiencies, and compliance issues that might remain hidden with conventional data sources. Organizations can optimize their workflows at a more precise level by understanding how individual elements contribute to overall performance.

3. Predictive Process Analysis: By combining IoT data with Process Mining, organizations can shift from reactive to proactive management. The predictive analytics capabilities offered by this integration help anticipate process deviations and inefficiencies before they occur, allowing businesses to take preemptive measures to maintain optimal performance and mitigate risks.

4. Enhanced Data Completeness: IoT sensors continuously track data across various stages of operations, filling gaps that often exist in traditional event logs. This enriched data improves the completeness and reliability of process models, leading to more accurate and insightful analyses that better reflect real-world operations.

5. Data-Driven Decision Making: Real-time insights derived from IoT-powered Process Mining empower decision-makers to make informed, data-backed decisions faster. Whether optimizing resource allocation, streamlining workflows, or improving

customer service, organizations can capitalize on actionable intelligence provided by IoT data to drive efficiency and competitiveness.

By integrating IoT data into Process Mining, businesses can achieve a more dynamic detailed and predictive understanding of their processes leading to enhanced operational efficiency and agility.

3.Integration Steps:

Integrating IoT datasets into Process Mining using ProM involves several key steps:

3.1 Data Collection and Preparation:

- Identify relevant IoT sensors and devices that capture data related to the target process.
- Collect and preprocess IoT data to ensure it is compatible with Process Mining analysis, including data cleaning, alignment, and enrichment.
- By using a dataset sourced from https://icpmconference.org/2020/bpi-challenge/ to conduct my analytical work.

3.2 ProM:

ProM is an extensible framework that supports a wide variety of process mining techniques in the form of plug-ins. It is platform independent as it is implemented in Java, and can be downloaded for free for charge.

Figure 2: ProM

3.3 Data Integration:

Combine IoT data and traditional event logs into a unified dataset, ensuring that the data aligns chronologically and semantically.

3.4 Process Discovery and Analysis:

Apply Process Mining techniques to the integrated dataset to discover process models, analyze conformance, and identify areas for improvement.

4.Use Cases and Examples:

Process mining is closely tied to continuous improvement, which originated in automobile manufacturing and has since gained popularity in industries across the board. Common use cases for process mining include:

1. Finance and procurement processes, such as procure-to-pay (P2P), order-to-cash (O2C), and accounts payable/receivable (AP/AR).
2. Banking, financial services, and insurance processes, such as customer onboarding, risk monitoring, and fraud detection.
3. Public sector processes, such as quality management, procurement, and tax administration.
4. Healthcare and pharmaceutical processes, such as patient onboarding, clinical trials, and physician referrals.
5. Manufacturing processes, such as production planning, inventory management, and plant maintenance.
6. IT service management processes, such as incident management, system migration, and change requests.

5.Challenges and Considerations:

The common challenges faced:

1. Data Quality (Incomplete or Inaccurate Data): Process mining heavily relies on event logs. If the data in these logs is incomplete, inaccurate, or inconsistent, it can lead to incorrect process models and flawed insights.

2. Handling Complexity: Some business processes are inherently complex with numerous decision points, loops, and variations. Process mining tools may struggle to accurately represent and analyse highly intricate processes.
3. Sensitive Information: Event logs may contain sensitive information about individuals, departments, or the organisation as a whole. Ensuring data privacy and complying with regulations like GDPR can be a challenge, especially when dealing with detailed process data.
4. Compatibility with Systems: Integrating process mining tools with existing IT systems can be challenging. Ensuring that the tools can extract and analyse data from various sources and formats requires careful consideration and planning.
5. Tool Selection and Expertise: (Choosing the Right Tool) There are various process mining tools available, each with its own strengths and limitations. Selecting the right tool for an organisation's specific needs can be challenging. Additionally, organisations may need to invest in training to build expertise in using these tools effectively.
6. Dynamic Processes: Some processes are highly dynamic, with frequent changes. Traditional process mining approaches may struggle to keep up with such dynamic environments, making it challenging to maintain accurate and up-to-date process models.
7. Scalability: As organisations grow, the volume of data generated by processes can increase significantly. Ensuring that process mining solutions are scalable to handle large datasets without compromising performance is crucial.

6. Practical demonstration:

In this section, we will showcase a practical example of applying an IoT dataset to Process Mining using the ProM framework and query language. This demonstration highlights how real-time data and detailed process insights can be utilized to enhance operational efficiency in manufacturing environments, a typical scenario where such integration proves beneficial.

6.1 Importation of event log:

The first step in process mining with tools like ProM is to import the event log. Since the log file is in the .xes format (a standard format for event logs in process mining)

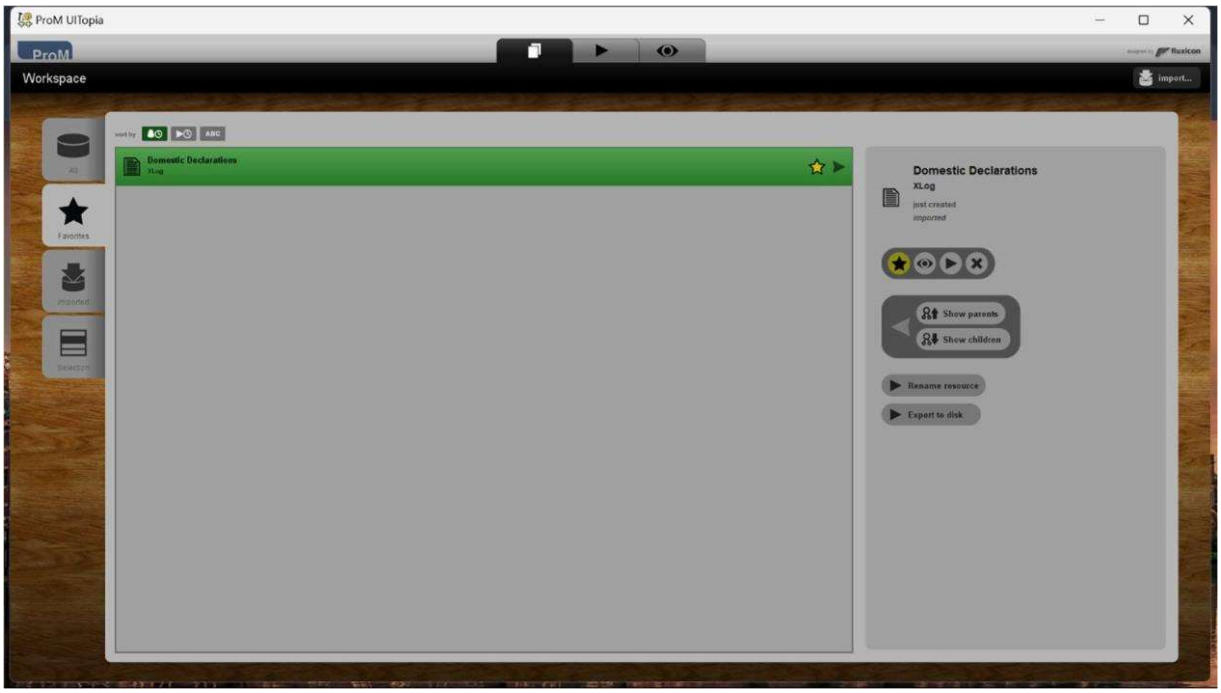

Figure 3: Import an event logs

6.2 Filter the event log:

Once the event logs are imported, the next step is to filter them. Filtering is an iterative process. Filtering in process mining refers to the process of narrowing down or refining an event log to focus on specific data that is relevant to a particular analysis or investigation. Since event logs can be large and contain a lot of variation, filtering allows you to work with a more

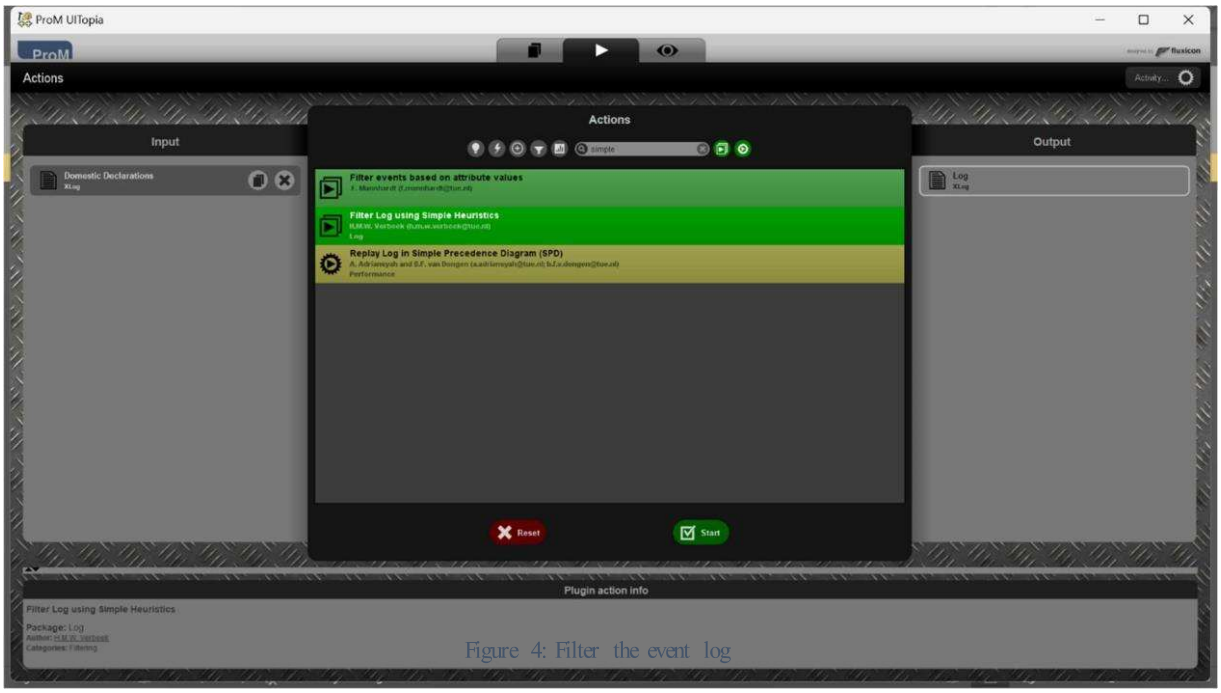

Figure 4: Filter the event log

manageable subset of the data. It helps in extracting meaningful insights and getting rid of unnecessary noise. For example, for process discovery, one can decide to focus on the 10 most

frequent activities to keep the model manageable, or eliminate some activities. We can use the plugin marked “filter log using simple heuristics”.

6.3 Explore the event log:

Exploring the Event Log "DottedChart": The "DottedChart" event log is a valuable resource that captures a chronological sequence of events. To effectively explore and analyze this event log, follow these steps:

Before delving into the event log, it's important to have a clear understanding of the context and purpose of the system or process being logged. This will help you interpret the events accurately and extract meaningful insights.

- Visualize the events in chronological order using a timeline or sequence chart. This will give you a high-level overview of how events are interconnected and how they unfold over time.

- We can change the X, Y and another attributes, choosing from the columns of the event log.

Looking for any anomalies, or recommendations based on the analysis.

Figure 5: Do edChart Plugin

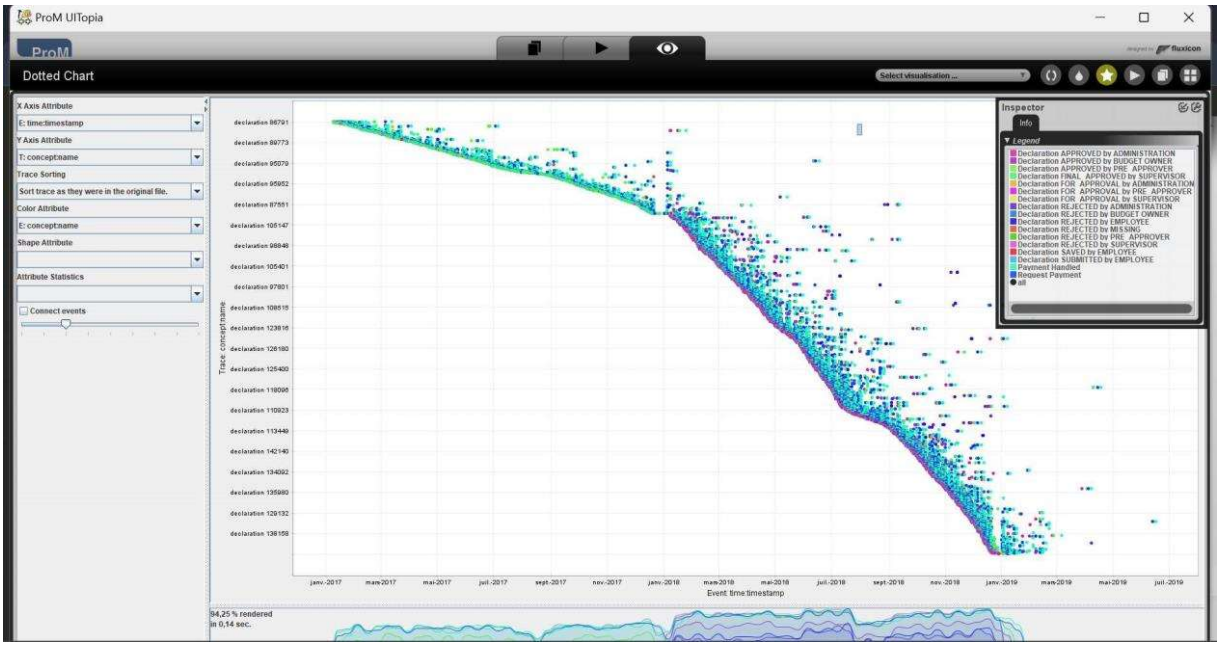

Figure 6: Do edChart interface

Change the X attribute to the duration of the process, and we visualize that most cases seem to be handled within 3-4 months, but there's significant variation in processing times.

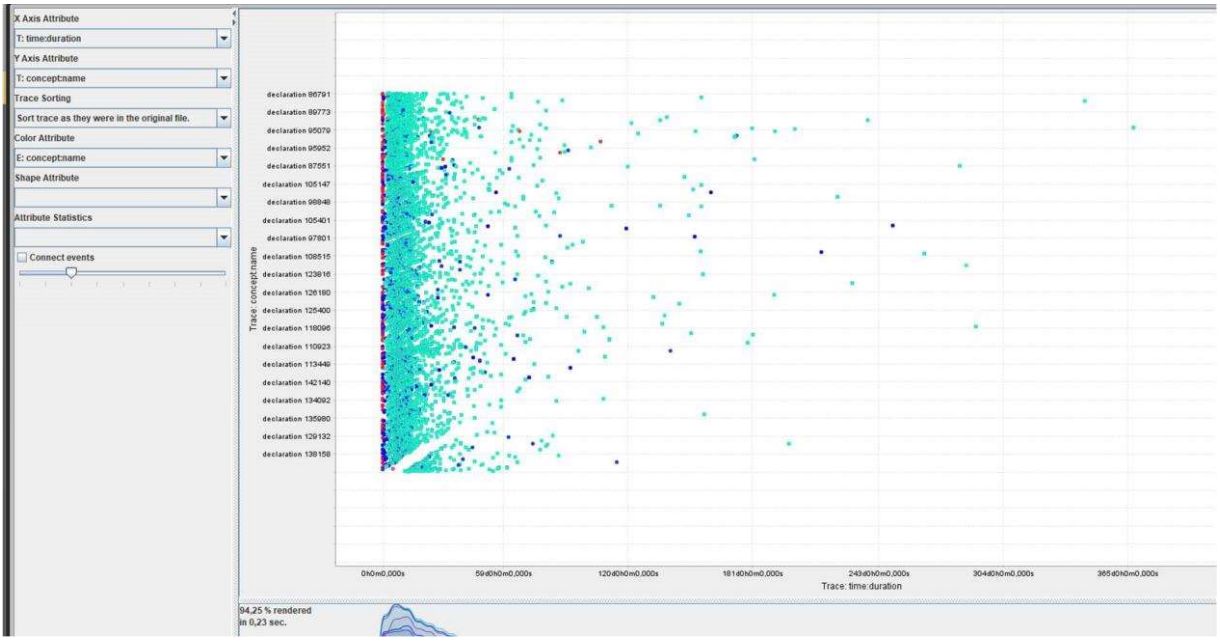

Figure 7: Duration of the process

6.4 Algorithms:

Next step is to apply the algorithms:

Inductive Miner:

The Inductive Miner is a process discovery algorithm used in process mining to generate structured, sound, and interpretable models. It is particularly effective in handling complex and noisy event logs, ensuring that the resulting process models are free from execution issues like deadlocks. The algorithm works by recursively splitting event logs into smaller parts, creating hierarchical process trees that accurately reflect the process structure. This approach makes the Inductive Miner well-suited for analyzing intricate processes, allowing for better optimization and understanding of workflows.

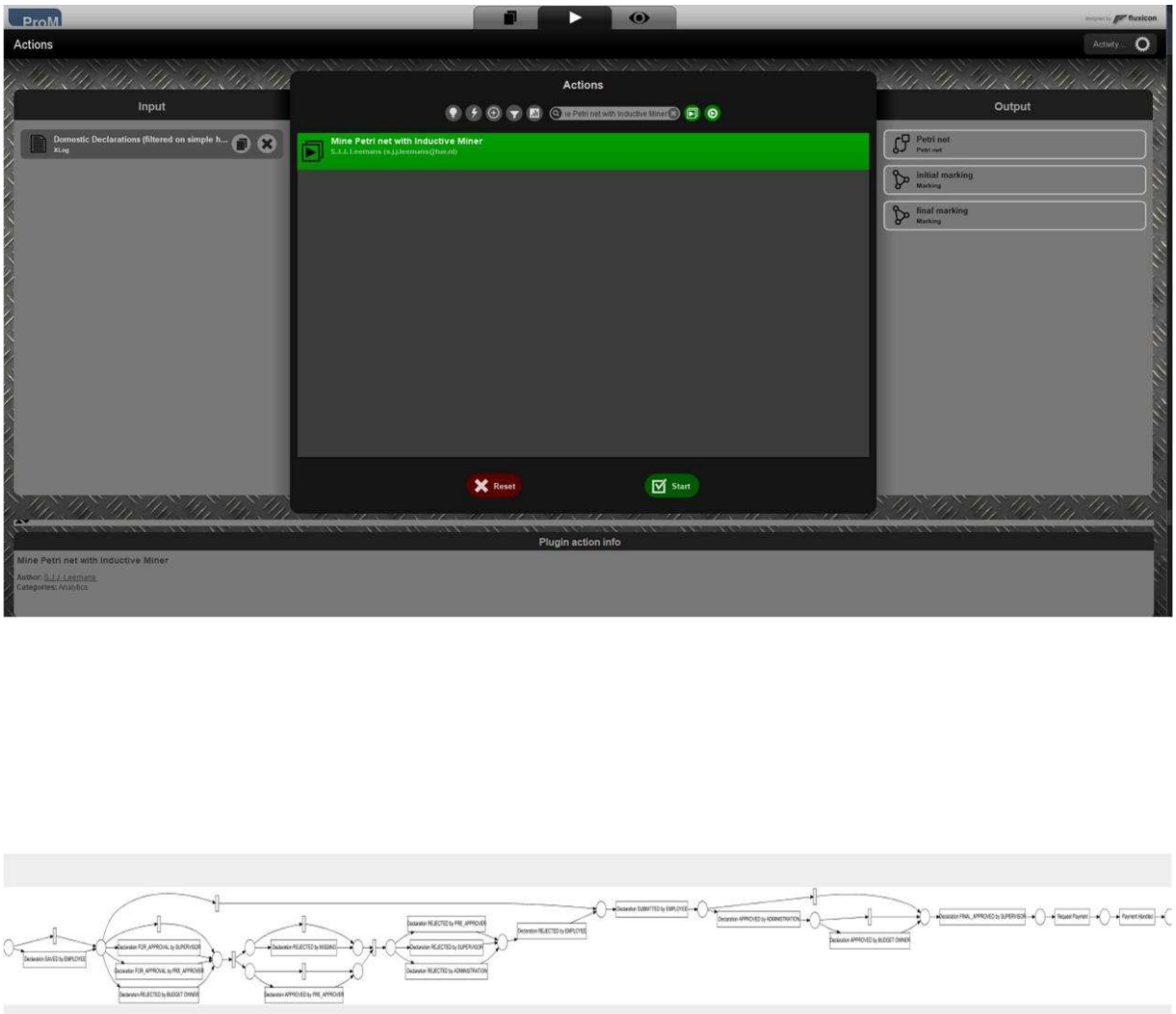

Figure 8 : Inductive miner

Heuristic Miner:

The Heuristic Miner algorithm balances simplicity and accuracy by using frequency-based measures to identify the most likely sequences of activities in a process. It effectively filters out noise, producing robust models that highlight the main process flow. The Heuristic Miner is well-suited for processes with some structure but also variability, offering a clear and accurate representation of the process.

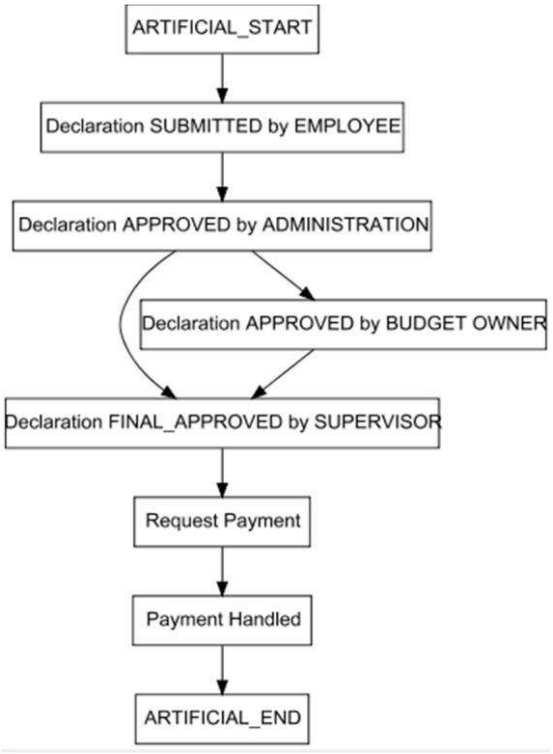

Figure 9: Heuris c Miner

Fuzzy Miner:

The Fuzzy Miner is a process discovery algorithm designed to handle complex, noisy, and unstructured event logs. Unlike other algorithms that aim to create precise models of the entire process, the Fuzzy Miner simplifies the model by emphasizing the most important and frequent activities, while downplaying less significant or rare behaviors.

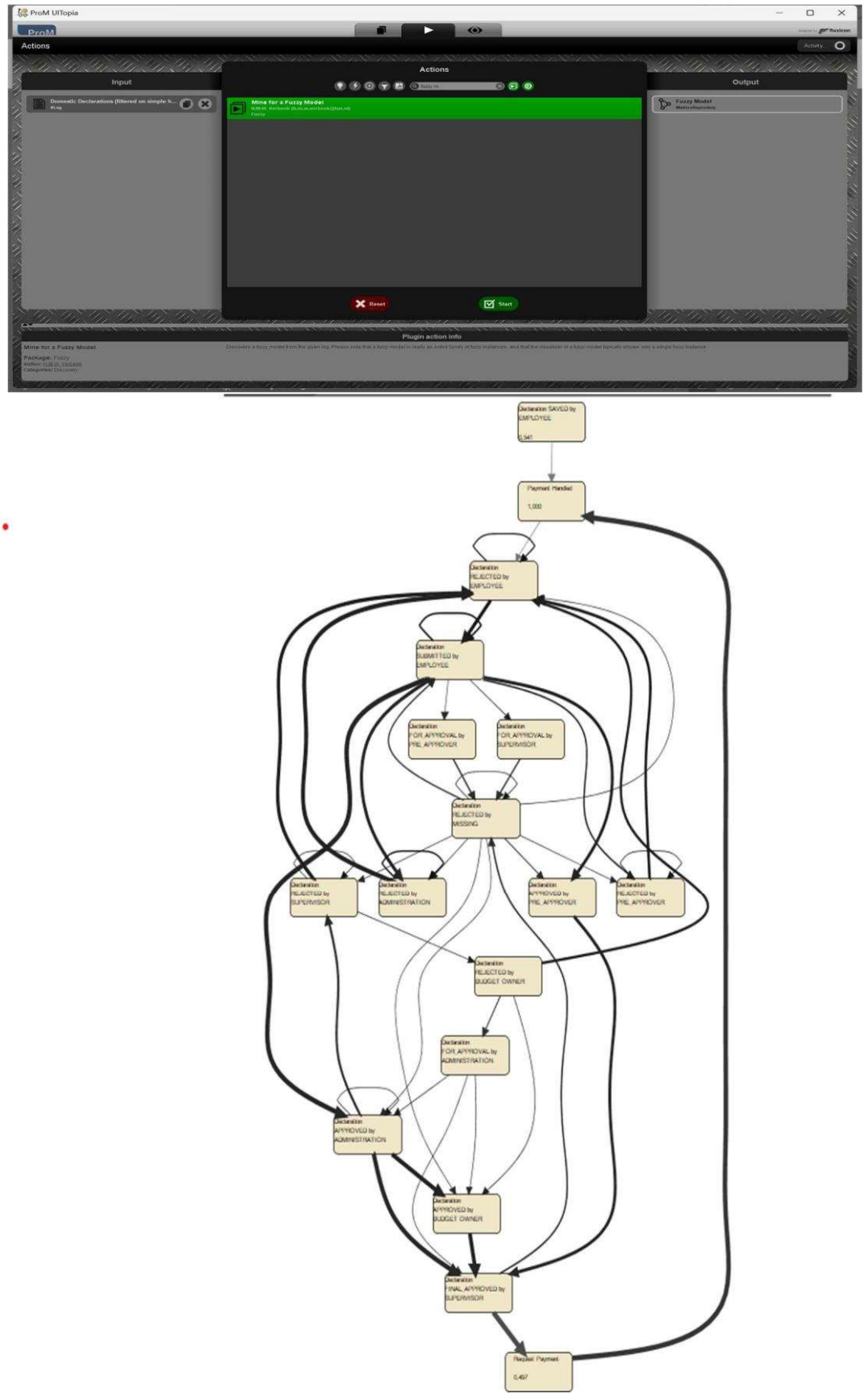

Figure 10: Fuzzy Miner

6.5 Conformance checking:

Conformance checking is a pivotal process mining technique that involves comparing a designed or expected process model with real-world event data. This analysis helps organizations identify deviations, or non-compliance within their processes. By systematically assessing how closely the actual

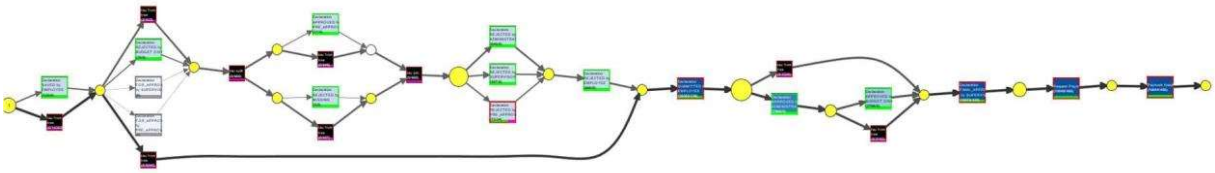

Figure 11: Conformance checking

For more clarification we going to use the inductive visual miner to visualize the deviations in the process:

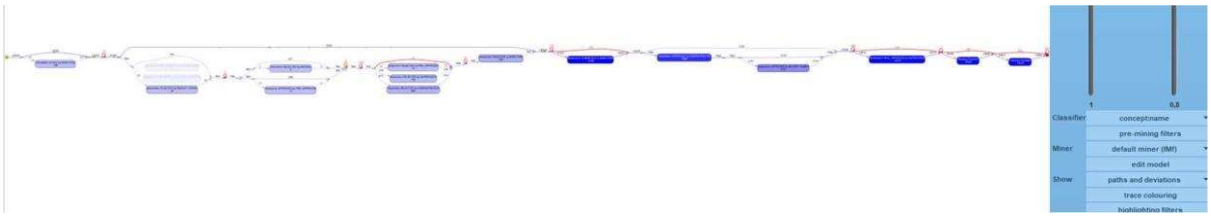

Figure 12: Inductive visual miner

7. Conclusion:

The application of IoT datasets in Process Mining using ProM represents a powerful synergy that enhances process visibility, efficiency, and decision making. By integrating IoT data with process mining, organizations can gain deeper insights into their operational processes, identifying inefficiencies and optimizing workflows. My analysis identified several bottlenecks, particularly in the "Permit FINAL APPROVED by SUPERVISOR" activity, which is likely due to approvals being handled by a single individual. This dependency on one supervisor slows down the process, taking an average of 2.7 days, but up to 361 days in some cases. Similarly,

payment processing takes an average of 8 days and can extend to 363 days, while administrative approval can take up to 203 days. These delays impact employee satisfaction and compliance. To mitigate these issues, increasing the number of supervisors or delegating approval authority to other roles could distribute the workload and reduce delays. Additional strategies include automation, real-time tracking, and process reengineering to streamline workflows and enhance process efficiency. By addressing these bottlenecks, organizations can fully leverage IoT data for continuous process improvement and innovation.

Conclusion:

The intersection of IoT and Process Mining is set to revolutionize industries and change how organizations make data-driven decisions and optimize processes. In this report we has examined the synergies and possibilities that arise when these two powerful technologies come together providing insight into a future where data becomes a critical strategic asset.

The benefits of integrating IoT with Process Mining are evident: real-time visibility process optimization predictive analytics improved quality control, stronger compliance and governance, cost savings, and driving innovation and automation. These advantages enable organizations to operate more efficiently, proactively address challenges, and continuously improve across sectors.

However unlocking the full potential of this intersection comes with challenges. Issues such as data privacy, the complexity of integrating diverse data sources, and the demand for advanced analytics are significant obstacles organizations must overcome. Addressing these requires a well-thought-out strategy, strong data governance, and investments in both technology and skilled personnel.

As IoT continues to grow and Process Mining evolves, the potential for synergy will expand. Organizations that embrace this integration will be better equipped to adapt to fast-changing markets, boost their competitiveness, and deliver more value to customers.

In summary, the merging of IoT and Process Mining is a transformative force that promises to drive operational excellence, innovation and competitiveness across industries. Organizations that approach this with a clear understanding of the opportunities and challenges will be well prepared to thrive in a data-driven future. By leveraging the strengths of both IoT and Process Mining, they can build a more efficient resilient and data-driven future.