**CHAPTER - 1**

**INTRODUCTION**

Process mining techniques are often used when no formal description of the process an be obtained by other approaches, or when the quality of existing documentation is questionable. For example, application of process mining methodology to the audit trails of a [workflow management system](https://en.m.wikipedia.org/wiki/Workflow_management_system), the transaction logs of an [enterprise resource planning](https://en.m.wikipedia.org/wiki/Enterprise_resource_planning) system, or the [electronic patient records](https://en.m.wikipedia.org/wiki/Electronic_health_record) in a hospital can result in models describing processes of organizations. Event log analysis can also be used to compare event logs with [prior](https://en.m.wikipedia.org/wiki/Prior_probability) model(s) to understand whether the observations conform to a prescriptive or descriptive model. It is required that the event logs data be linked to a case ID, activities, and timestamps.

Contemporary management trends such as BAM ([Business Activity Monitoring](https://en.m.wikipedia.org/wiki/Business_Activity_Monitoring)), BOM ([Business Operations Management](https://en.m.wikipedia.org/wiki/Business_Operations_Management)), and BPI ([business process intelligence](https://en.m.wikipedia.org/wiki/Business_process_intelligence)) illustrate the interest in supporting diagnosis functionality in the context of [Business Process Management](https://en.m.wikipedia.org/wiki/Business_Process_Management) technology (e.g., [Workflow Management Systems](https://en.m.wikipedia.org/wiki/Workflow_Management_System) and other process-aware information systems). Process mining is different from mainstream [machine learning](https://en.m.wikipedia.org/wiki/Machine_learning), [data mining](https://en.m.wikipedia.org/wiki/Data_mining), and [artificial intelligence](https://en.m.wikipedia.org/wiki/Artificial_intelligence) techniques. For example, process discovery techniques in the field of process mining try to discover end-to-end process models that are able to describe sequential, choice relation, concurrent and loop behavior. Conformance checking techniques are closer to [optimization](https://en.m.wikipedia.org/wiki/Optimization) than to traditional learning approaches. However, process mining can be used to generate [machine learning](https://en.m.wikipedia.org/wiki/Machine_learning), [data mining](https://en.m.wikipedia.org/wiki/Data_mining), and [artificial intelligence](https://en.m.wikipedia.org/wiki/Artificial_intelligence) problems. After discovering a process model and aligning the event log, it is possible to create basic supervised and unsupervised learning problems.For example, to predict the remaining processing time of a running case or to identify the root causes of compliance problems.

The IEEE [Task Force on Process Mining](https://en.m.wikipedia.org/wiki/Task_Force_on_Process_Mining) was established in October 2009 as part of the IEEE Computational Intelligence Society. This is a vendor-neutral organization aims to promote the research, development, education and understanding of process mining, make end-users, developers, consultants, and researchers aware of the state-of-the-art in process mining, promote the use of process mining techniques and tools and stimulate new applications, play a role in standardization efforts for logging event data (e.g., XES), organize tutorials, special sessions, workshops, competitions, panels, and develop material (papers, books, online courses, movies, etc.) to inform and guide people new to the field. The IEEE [Task Force on Process Mining](https://en.m.wikipedia.org/wiki/Task_Force_on_Process_Mining) established the International Process Mining Conference (ICPM) series, lead the development of the IEEE XES standard for storing and exchanging event data, and wrote the Process Mining Manifesto which was translated into 16 languages.

Process mining is a family of techniques relating the fields of [data science](https://en.m.wikipedia.org/wiki/Data_science) and [process management](https://en.m.wikipedia.org/wiki/Business_process_management) to support the analysis of operational processes based on event logs. The goal of process mining is to turn event data into insights and actions. Process mining is an integral part of data science, fueled by the availability of event data and the desire to improve processes. Process mining techniques use event data to show what people, machines, and organizations are really doing. Process mining provides novel insights that can be used to identify the execution paths taken by operational processes and address their performance and compliance problems.

Process mining starts from event data. Input for process mining is an event log. An event log views a process from a particular angle. Each event in the log should contain a unique identifier for a particular process instance (called case id), an activity (description of the event that is occurring), and a timestamp. There may be additional event attributes referring to resources, costs, etc., but these are optional. With some effort, such data can be extracted from any information system supporting operational processes. Process mining uses these event data to answer a variety of process-related questions.

Business ecosystem is changing everyday across the globe. The changes bring ad hoc shift In processes and systems that are complex and multi-dimensional. Hence process mining and data analytics become more important for business organizations to learn and attain insights on the hidden process details and their impact on the business.

Process mining is the practice of examining processes, cases, and events logged by enterprise applications by using specialized data mining algorithms. It provides you data-driven insights to manage, monitor, and control your business processes. The insights from process mining include process models and statistics, model comparisons and conformance check with a reference model, process deviations, cost and time estimation, process delays and inefficiencies, resource mapping, and task analysis. In addition, the process mining helps you to make intelligent decisions for process improvements by creating process simulations based on the data-driven insights and analytics.

Following are some of the scenarios where you can employ the process mining services:

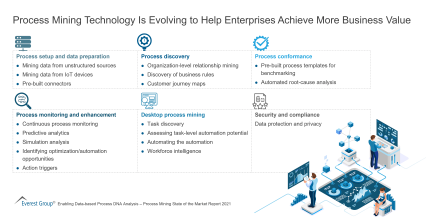
* Insurance claims tasks
* Data collection and reporting
* Regulations and compliance
* Vehicle checks and reporting
* Medical claims tasks
* Order management

**CHAPTER - 2**

**TECHNOLOGY**

Process mining technology encompasses various techniques and tools used to analyze event data and uncover insights about business processes. Here are some key aspects of process mining technology:

**Data Collection and Preprocessing:** The process begins with collecting event data from various systems, such as ERP, CRM, or workflow management tools. This data includes timestamps, user actions, and other relevant information. Before analysis, the data may need to be cleaned, transformed, and standardized to ensure accuracy.



**Fig. No. 2.1: Process Mining Technology**

**Fig. No. 2(**Chapter Number**).1(**Figure number in that chapter**)**

**Automated Process Discovery:** This technique involves creating process models from the event data without prior knowledge of the process. Algorithms automatically construct process maps, flowcharts, or Petri nets to visualize how activities are connected and sequences are executed. This provides a baseline understanding of the process.

**Conformance Checking:** Once a process model is generated, it's compared to the actual event data to identify deviations, non-compliant behaviors, and variations between the modeled process and the real process. This helps in identifying where and why actual processes differ from the intended ones.

**Performance Analysis:** Process mining evaluates the performance of processes by analyzing time-related aspects, such as cycle times, waiting times, and resource utilization. This enables the identification of bottlenecks, delays, and areas for improvement.

**Variant Analysis:** Businesses often have multiple paths or variants within a process due to exceptions or different decision points. Variant analysis helps uncover these variations and understand their frequency and impact on overall process efficiency.

**Root Cause Analysis:** Process mining can help identify the underlying causes of process inefficiencies or deviations. By tracing back to the origin of issues, organizations can take targeted corrective actions.

**Predictive Analytics:** Some advanced process mining tools incorporate predictive capabilities to forecast potential future process behavior based on historical data. This can assist in proactive decision-making and resource allocation.

**Continuous Monitoring:** Process mining isn't a one-time analysis; it's a continuous process. Monitoring tools keep track of ongoing processes and provide real-time insights, helping organizations respond promptly to changes and deviations.

**Visualization:** Visualizations play a crucial role in process mining, offering intuitive representations of complex data. These visualizations include process maps, flowcharts, histograms, and performance metrics.

**Integration with BPM Systems:** Many process mining tools integrate with Business Process Management (BPM) systems, allowing seamless transition from analysis to process optimization and automation.

**Machine Learning and AI:** Advanced process mining solutions may incorporate machine learning and AI techniques to enhance accuracy, prediction capabilities, and handling of large datasets.

**Privacy and Security**: As process mining involves sensitive data, ensuring privacy and security is essential. Anonymization techniques may be employed to protect user and business information.

Process mining technology continues to evolve, and new methods and tools are being developed to address various aspects of process analysis and improvement. Its application spans across industries, offering organizations the opportunity to gain deeper insights into their operations and drive meaningful enhancements

**What is process mining?**

Process mining applies data science to discover, validate and improve [workflows](https://www.ibm.com/topics/workflow). By combining data mining and process analytics, organizations can mine log data from their information systems to understand the performance of their processes, revealing bottlenecks and other areas of improvement. Process mining leverages a data-driven approach to process optimization, allowing managers to remain objective in their decision-making around resource allocation for existing processes.

Information systems, such as Enterprise Resource Planning (ERP) or Customer Relationship Management (CRM) tools, provide an audit trail of processes with their respective log data. Process mining utilizes this data from IT systems to create a process model, or process graph. From here, the end-to-end process is examined, and the details of it and any variations are outlined. Specialized algorithms can also provide insight into the root causes of deviations from the norm. These algorithms and visualizations enable management to see if their processes are functioning as intended, and if they aren’t, they arm them with the information to justify and allocate the necessary resources to optimize them. They can also uncover opportunities to incorporate [robotic process automation](https://www.ibm.com/topics/rpa) into processes, expediting any automation initiatives for a company.

Process mining сan also be described as a part of business process management (BPM) that applies data science (with its data mining and [machine learning](https://www.altexsoft.com/whitepapers/machine-learning-bridging-between-business-and-data-science/) techniques) to dig into the records of the company’s software, get the understanding of its processes performance, and support optimization activities.

There are different perspectives that process mining can be focused on.

1. **The control-flow perspective** is about the order of activities, and the goal here is to find the optimal path of performing a process.
2. **The organizational perspective** targets the resources involved in a process, i.e., roles, departments, etc. The general purpose is to come up with an optimal structure for the organizational units.
3. **The time perspective** is focused on the timing and frequency of events.
4. **The case perspective** considers the properties that are inherent in different cases or types of processes. Further analysis defines relations and hidden dependencies between these properties, giving a deeper understanding of the problem and its causes.

.**Types of process mining**

Wil van der Aalst, a Dutch computer scientist and professor, is credited with much of the academic research around process mining. Both his research and the above-mentioned manifesto describe three types of process mining, which are discovery, conformance, and enhancement.

**Discovery:**  Process discovery uses event log data to create a process model without outside influence. Under this classification, no previous process models would exist to inform the development of a new process model. This type of process mining is the most widely adopted.

**Conformance:** Conformance checking confirms if the intended process model is reflected in practice. This type of process mining compares a process description to an existing process model based on its event log data, identifying any deviations from the intended model.

**Enhancement**: This type of process mining has also been referred to as extension, organizational mining, or performance mining. In this class of process mining, additional information is used to improve an existing process model. For example, the output of conformance checking can assist in identifying bottlenecks within a process model, allowing managers to optimize an existing process.

**Process mining vs. data mining vs. business process management**

Process mining sits at the intersection of [business process management](https://www.ibm.com/topics/business-process-management) (BPM) and data mining. While process mining and data mining both work with data, the scope of each dataset differs. Process mining specifically uses event log data to generate process models which can be used to discover, compare, or enhance a given process. The scope of data mining is much broader, and it extends to a variety of data sets. It is used to observe and predict behaviors, having applications within customer churn, fraud detection, and market basket analysis to name a few.

Process mining takes a more data-driven approach to BPM, which has historically been managed more manually. BPM generally collects data more informally through workshops and interviews, and then uses software to document that workflow as a [process map](https://www.ibm.com/topics/process-mapping). Since the data that informs these process maps is more qualitative, process mining brings a more quantitative approach to a process problem, detailing the actual process through event data.

**Why is process mining important?**

Increasing sales isn’t the only way to generate revenue. Six sigma and lean methodologies also demonstrate how the reduction of operational costs can also increase your return-on-investment (ROI). Process mining helps businesses reduce these costs by quantifying the inefficiencies in their operational models, allowing leaders to make objective decisions about resource allocation. The discovery of these bottlenecks can not only reduce costs and expedite process improvement, but it can also drive more innovation, quality, and better customer retention. However, since process mining is still a relatively new discipline, it still has some hurdles to overcome. Some of those challenges include:

* **Data Quality:** Finding, merging and cleaning data is usually required to enable process mining. Data might be distributed over various data sources. It can also be incomplete or contain different labels or levels of granularity. Accounting for these differences will be important to the information that a process model yields.
* **Concept drift:** Sometimes processes change as they are being analyzed, resulting in concept drift.

**Process mining use cases**

Process mining techniques have been used to improve process flows across a wide variety of industries. Since process maps highlight the key performance indicators (KPIs) which impact performance, they have spurred businesses to reexamine their operational inefficiencies. Some use cases include:

* **Education:** Process mining can help identify effective course curriculums by monitoring and evaluating student performance and behaviors, such as how much time a student spends viewing class materials.
* **Finance:** Financial institutions have used process mining software to improve inter-organizational processes, audit accounts, increase income, and broaden its customer base.
* **Public works:** Process mining has been used to streamline the invoice process for public works projects, which involve various stakeholders, such as construction companies, cleaning businesses, and environmental bureaus.
* **Software Development:** Since engineering processes are typically disorganized, process mining can help to identify a clearly documented process. It can also help IT administrators monitor the process, allowing them to verify that the system is running as expected.
* **Healthcare:** Process mining provides recommendations for reducing the treatment processing time of patients.
* **E-commerce:** It can provide insight into buyer behaviors and provide accurate recommendations to increase sales.
* **Manufacturing:** Process mining can help to assign the appropriate resources depending on case—i.e. product—attributes, allowing managers to transform their business operations. They can gain insight into production times and reallocate resources, such as storage space, machines, or workers, accordingly.

**CHAPTER - 3**

**APPLICATIONS**

Here are some specific applications of process mining:

**1. Process Discovery:** Process mining helps uncover the actual flow of processes by analyzing event logs. This can be particularly useful when there's a lack of documentation or when processes are complex. It provides a visual representation of how activities are connected, allowing organizations to understand their processes better.

**2. Conformance Checking:** Process mining compares the actual execution of processes with their intended design. This helps identify deviations, inefficiencies, or non-compliance. By comparing the expected sequence of activities with what actually happens, organizations can spot discrepancies and take corrective actions.

**3. Performance Analysis:** Process mining allows the identification of bottlenecks and inefficiencies in processes. It can help answer questions like where delays occur, which steps take the most time, and where resources are being underutilized. This information is crucial for optimizing processes.

**4. Root Cause Analysis:** When problems or deviations are detected in a process, process mining can help trace back to the root causes. This can lead to targeted improvements that address the underlying issues, rather than just the symptoms.

**5. Predictive Analytics:** By analyzing historical data, process mining can also provide insights into future trends or potential issues. This can help organizations take proactive measures to avoid problems or capitalize on opportunities.

**6. Auditing and Compliance:** Process mining can be used to ensure that processes comply with regulations and standards. It provides an objective way to demonstrate adherence to regulations by analyzing actual process execution.

**7. Workflow Optimization:** Process mining can suggest improvements to workflows based on real-world data. These optimizations might involve rearranging tasks, reallocating resources, or redesigning certain steps to streamline the process.

**8. Customer Journey Analysis:** In customer-centric industries, process mining can track and analyze the paths customers take when interacting with a company. This helps in understanding customer behavior, preferences, and pain points.

**9. Supply Chain Management:** Process mining can be applied to analyze and optimize supply chain processes. It helps in identifying delays, optimizing inventory management, and enhancing coordination among different stakeholders.

**10. Healthcare Management:** In healthcare, process mining can be used to analyze patient journeys, optimize treatment protocols, and identify areas for improved efficiency and patient care.

These are just a few examples of how process mining can be applied across various industries to enhance efficiency, effectiveness, and compliance within processes.

## ****General Processes****

**1- Process discovery for automation:** Automation provides faster and lower-cost solutions. However, companies need to examine their business processes to use automation tools, such as robotic process automation (RPA) efficiently. Process mining vendors claim that their technology can reduce automation implementation time by [50%](https://research.aimultiple.com/process-mining-stats/#benefits).

**2- Process optimization except automation:** Companies can use process mining for faster and more accurate analysis of their processes. The event logs can infer performance metrics and process models, which can be used to identify bottlenecks and costly steps to optimize speed. Instead of wasting time on understanding business processes, companies can use their time to take potential actions for business process management and improvement. Among 51 process mining case studies we collected, process mining benefits included identify process bottlenecks by [43%](https://research.aimultiple.com/process-mining-benefits/) and eliminating unnecessary steps by [4%](https://research.aimultiple.com/process-mining-benefits/).

**3- Conformance validation:**Companies can check if their as is process conform to the given specifications with [conformance checks.](https://research.aimultiple.com/conformance-analysis/) For example, purchasing decisions need different approvals based on the ticket size and nature of the item purchased.

Nonconforming cases, reasons for deviations and, conformance trends can be analyzed, too. Companies can take action to reduce these deviations and ensure standardized processes.

**4- Harmonization:** Companies can use process mining to harmonize distinct processes efficiently. The insights from process mining tools enable the fast realization of the planned synergies. For example, a[process mining case study](https://research.aimultiple.com/process-mining-case-studies/) from Nokia adapts its purchase-to-pay and order-to-cash processes to achieve a smooth customer experience. By mining its processes, Nokia obtained the necessary knowledge of how to conjugate these processes.

**5- Process Simulation:** Process mining capabilities can include [process simulation](https://research.aimultiple.com/process-simulation/)and [predictive analytics](https://research.aimultiple.com/predictive-process-mining/). Firms can make future predictions by mining and simulating their processes with the data gained from event logs. Their predictive analysis can be used to inform stakeholders and customers. For example, the customer can receive an accurate estimate of when her loan application will be processed.

**6- Organizational Mining:** Process logs can identify organizational relationships, performance gaps, and best practices. However, almost all processes have a human component. Process data can be used to understand and improve the human aspects of business processes.

**CHAPTER - 4**

**MODULES EXPLANATION**

**Fig. No. 1.1: Life cycle**

**Fig. No. 1(**Chapter Number**).1(**Figure number in that chapter**)**