



Lars Reinkemeyer *Editor*

Process Mining in Action

Principles, Use Cases and Outlook

 Springer

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Dedicated to my Family

Foreword



The world is becoming increasingly complex—a mantra heard every day—so it is all the more important to bear it in mind. Because it doesn't just affect everyday life, but also the markets in which companies operate. New players constantly appear and change the game, both from a technical point of view and in terms of the competitive situation. An example of this is the platform economy. The digital transformation has long since arrived in the Business Services world: organizations that want to be successful here need to continuously strive for innovation in order to better handle the complexity of their processes, to improve operational efficiency and excellence and to stay ahead of the game.

Especially in organizations with a huge variety of processes, there is a great deal of complexity which forces to find new and innovative ways to handle these complications and gain more transparency. This is the reason why Siemens started as early as 2011 to exploit and thus become an early adopter of a technology that takes an innovative path in simplifying complexity: Process Mining. It essentially creates transparency on business processes and improvement measures can be derived from it.

Process Mining has evolved as a particularly exciting technical innovation, as it allows a holistic understanding of even the most complex processes and is a good example of how academic research can support established industries and drive

innovation in practice. By implementing Process Mining, the data that numerous processes produce during daily work is converted into insights, thus creating a seamless end-to-end experience and transparency.

In the last couple of years, Process Mining has been established in many parts of the Siemens organization and has become a commonly adopted technology which supports operational excellence in Purchase-to-Pay and Order-to-Cash processes. For example, Process Mining drives transparency in all Order-to-Cash processes from incoming orders to payment receipts and helps to quickly identify improvement and automation levers. In Purchase-to-Pay processes, from sending orders to goods receipt and paying invoices, it enables transparency and again helps to quickly identify automation levers, which in turn have directly led to a reduction in operational inefficiency. In this way, a high amount of process variants can be reduced and the remaining once be optimized, digitalization potential identified, and the most favorable payment terms taken.

Process Mining has therefore become a reliable and indispensable single source of truth and provides employees and management, as well as customers, with the same objective insights. This transparency is of utter importance as the future will see technology progress at an increasing pace, opening up the door for new symbioses as already seen by combining Robotic Process Automation and Artificial Intelligence, for example. Process Mining can be used as a fundamental enabler as its transparency provides guidance for automation potentials and Artificial Intelligence use cases. Thus, Process Mining, in addition to Robotics Process Automation and Artificial Intelligence, is a building block on the way to a new way of work that empowers employees with digital tools and ultimately shapes the digital organization of the future.

This book, written by practitioners for practitioners, provides an excellent overview on Process Mining principles and a broad variety of use cases. Each practitioner shares individual experiences, and the multitude of outlooks from practitioners and academics will foster future development and innovations and increase business value, thus, leaving Process Mining as an academic and innovative field that could well be one of the key technologies driving the Digital Transformation.

Enjoy reading!

Siemens AG
Munich, Germany

Hannes Apitzsch

Foreword



Process Mining in a Volatile World

Today's world is driven by volatility, speed, major steps in technology development, uncertainties in political relationships, and a significant change in environmental protection. These topics are propelling the transformation all over the world. The key reason to these changes is a radical implementation of mature IT technologies within the last 10–20 years. In the mobility industry, the effects are zero emission mobility, autonomous driving, shared business models, and connecting every car to the World Wide Web. These are key words of disruption in the automotive world. Technology drivers for this are: worldwide connection to the internet, big data, artificial intelligence, IoT, blockchain, cloud platforms, additive manufacturing/3d printing, standardization of technologies and APIs, cyber security, robots, and process automation. Digitalization is the combination of all these technologies. Digitalization could be described with two words: speed and flexibility.

In the mobility and automotive industry, this leads to three dimensions:

1. The customer of mobility becomes the focus point of the new business models (CRM).
2. The car gets a part of the internet combined with new powertrain solutions (ACES—autonomous, connected, electrified, shared).
3. The current business models will be disrupted (data-oriented, IoT, and cloud platforms).

Thus, business process models have to be transformed into the next generation. Between 2007 and 2010, Nokia has shown that a world leader in mobile technologies will not be part of the game, if not or too slowly reacting to these changes. The transformation of the business process models will be successful if full process transparency (KPI, real time, documentation) is given, the processes are analyzed end to end, and process organization, IT optimization, and reengineering are based on this process transparency.

The BMW Group IT Strategy 1.0 (2016) and IT-Strategy 2.0 (2019) is adopting disruptive changes within the automotive environment. Speed and flexibility are and will be the main characteristics for the next decade. On the one hand, this means the SW engineering process has to be transformed and the base has to be set up for implementing the new technologies and transforming legacy into the future.

The BMW Group IT Program is called “100% agile.” Changing from “waterfall SW engineering” to “100% agile SW engineering” with increasing internal competencies enables the implementation of all these new differentiating IT technologies.

Best practice models were taken from digital leaders such as Spotify, Netflix, Google, Salesforce, Airbnb, Amazon, Tencent, and Alibaba. Moreover, a target picture “agile working model” was developed and implemented to become a driver in the tech mobility industry.

In 2016, a small team of the BMW Group IT made an exploration of the Process Mining technology with two proofs of concept. The capability was evaluated in a 12-month project. In the end of 2017, first potentials were checked in the two areas “worldwide purchase to pay process” and “paint shop process of a BMW car manufacturing plant.” In the beginning of 2018, the decision to set up a “Center of Excellence for Process Mining” was made. This CoE (process excellence, tool experience, operational excellence) was the driver for building up a worldwide internal competence network (IT and Data). The Process Mining Network had to implement the technology into the BMW Group processes. Many external partners (Software Provider, implementation partner, research partner/universities) were integrated. BMW is an innovator in “process-oriented organizations” since the end of the 1990s. Six core processes were defined: Idea to Offer (development), Order to Deliver (production), Offer to Order and Deliver to Customer Care (sales), Financial Services, Business Management (e.g., strategy, governance), and Resource Management (e.g., finance, IT, human resource, procurement). In all areas, the Process Mining technology was evaluated and implemented. With a cross-functional team,

the areas with highest potential for BMW were prioritized. Process Mining helps BMW to improve services and products successfully (tremendous productivity increase), for instance:

- Purchasing and Finance (improves compliance and automation rates)
- Development (reduces development cycle and increases standards)
- Change Management (improve transparency and product quality)
- Production (reduce throughput times and rework rates)
- Leasing (faster processes)
- User Experience (usage of products)
- Aftersales (optimization of customer touch points)
- IT (optimization of the IT system landscape)

Process Mining could be used not only in classical administration processes but also in production, production control, development, financial services, and sales processes. Therefore, Process Mining fits into all areas, where IT is implemented “end to end” and cross-functional. In 2019, reengineering highlights were processes in car distribution, customs, the car navigation system, and in cost analysis of production. Furthermore, the implementation of Process Mining gets sustainable because of the objectification of process performance all over the company. All in all, the transformation of an organization into a digital organization will only be successful if Process Mining tools and methods are implemented in day-to-day operations.

Important in the Process Mining environment is the how and what of the implementation. This book, with many pragmatic and operative examples, gives a guideline and a framework for the utilization in different branches and organizations. It shows us that this new technology will not be a short-time hype. It will be a foundation technology for digitalization of organizations. Take this book as a basic description of Process Mining for the next years. Get advantages out of these examples.

Munich, Germany

Klaus Straub

Preface

Imagine full transparency regarding operational processes and activities as they actually happen in your organization. Imagine the power of such insight to reduce complexity and expedite digital transformation of internal processes.

Complexity is a key challenge for any organization. Large organizations have to deal with hundreds of thousands of suppliers as well as millions of purchase orders, customer orders, deliveries, and financial transactions. Smaller companies equally face the challenge to understand actual business processes and organizational complexity in order to continuously improve operational efficiency, reduce transactional cost, and compete with an increasing number of digital native contestants.

Process Mining, as a key lever to address the complexity challenge, represents perhaps the most exciting technological innovation since the advent of digital transformation. No other technology is capable to provide similar process transparency, allows a similar understanding of actual process performance and thus fuels digital transformation of internal processes based on objective insights and facts. While the underlying principles of Process Mining—collecting digital traces of actual business processes and visualizing complex process flows to allow a thorough understanding and sustainable improvement—are straightforward and have been extensively discussed in academic publications, the devil for operational implementation and impact lies in the detail.

In the last decade many companies started to use Process Mining in an operational environment and gained substantial experiences. Process Mining principles have been adopted to industrial requirements in order to create economic and ecologic value. An increasing number of use cases have been applied along the whole value chain, with a growing community sharing and promoting the potentials and benefits of Process Mining. This book reflects these developments, with best practice use cases from companies which have successfully deployed Process Mining. Contributors have been invited based on their proven success to establish Process Mining in their respective organization and represent a broad range of different industries, functions, and use cases. The book is written by practitioners for practitioners and independent of Process Mining software vendors or consultants in order to provide an unbiased overview of current usage, technological capabilities, and future potentials. It provides hands-on examples and experiences on how to use Process Mining in different organizational environments for strategic insights,

digital transformation, and sustainable operations in order to ultimately generate operational impact and value.

In addition to economic value, Process Mining can also contribute to ecologic benefits. As environmental challenges prevail, it is time for a sustainability revolution, and technological innovations such as Process Mining must play a significant role, e.g., to identify process inefficiencies, reduce energy consumption, and support the reduction of material waste. Respective best practices and potential positive impacts have been flagged out throughout the book wherever applicable.

The book complements the large number of academic publications. Process Mining as an academic field of research has been expanding since the beginning of this millennium. It was “invented” by Wil van der Aalst in the late 1990s; he provided groundbreaking research and established a global academic community. Based on a solid academic foundation, Process Mining has received increasing interest from operational business with many companies already harvesting benefits. The market has seen the rise of new software companies providing innovative solutions and an increasing awareness of the power of this innovative technology, which is becoming a foundation technology for the digitization of organizations.

Commercial usage of Process Mining started earlier this decade, initially with a strong focus on single projects, e.g., for audit with one-time effort, short duration, and limited scope. As the value of Process Mining became more transparent and relevant for digital transformation, it extended across different business functions, such as Procurement, Sales, Finance, and Logistics, and different industries, such as Manufacturing, Automotive, Telecommunication, Healthcare, Insurance, and Aeronautics. The technology is used in single departments for operational improvement and as part of strategic programs to drive digital transformation and increase organizational efficiency. In large organizations like BMW, Siemens, and Telekom, it is used enterprise-wide as a standard tool for digital transformation and identification of process inefficiencies and reduction of waste.

Complementary to corporate applications, which provide a centrally defined standard format used by a large numbers of users, there are communities of individual users applying the technology to unique local use cases. The book describes use cases and business impact along the value chain, from corporate to local applications, developed with functional experts and thus representing state-of-the-art domain know-how.

Besides success stories, the book discloses challenges, learnings, and failures in order to share experiences with the reader and provide guidance on how to avoid pitfalls and assure a successful operational deployment.

Outline of the Book

The book is structured in three parts: Part I provides an introduction to the topic, from fundamental principles to key success factors and an overview of operational use cases. As a wholistic description of Process Mining in a business environment, this part is probably more beneficial for readers not yet very familiar with the topic.

Part II presents 12 use cases written by contributors from multiple functions and industries. As use cases are presented in detail, this part is probably more beneficial for users who are already familiar with the topic. Part III provides an outlook on the future of Process Mining, both from an academic and an operational perspective.

Part I sets the stage by describing the principles and value of Process Mining. Principles such as event logs and process variants are discussed to explain how Process Mining can provide process transparency and create business value. As a practical guide, hands-on experiences on how to get started are shared, including recommendations for how to initiate first successful projects. Three aspects are crucial for the success of any project, defined as the “three Ps” of Process Mining and discussed in one chapter each:

- **Purpose:** the specific demand or Purpose should be defined by the Process Owner before starting any project to assure that technology will deliver value by providing insights which will be turned into operational actions.
- **People:** as valuable as a digital tool can be—engaging the right people to turn insights into action is crucial. The right digital mindset is a prerequisite to improve operational efficiency.
- **Process traces:** Process Mining is based on event logs and the identification, collection, and customization of digital process traces is a major effort driver.

Sharing challenges, pitfalls, and failures, Chap. 6 discloses numerous experiences which are discussed to help avoid similar experiences during the reader’s journey. Further technologies used for digital transformation, such as Robotic Process Automation (RPA) and Business Process Management (BPM), will be set into relation with Process Mining and the concept of a Digital Twin of an Organization (DTO) will be explained.

The part is concluded with a summary of ten key learnings, reflecting the key messages from the previous chapters.

Part II presents 12 use cases from companies which have successfully applied Process Mining for different purposes, from optimization of customer journeys to manufacturing processes, from improvement of supply chain management to service processes, from strategic reinvention to product management inventions, and from digitization of internal audit to automation of finance processes. All use cases have been written by Process Mining experts, who are independent from any particular software vendor.

Prerequisite for the selection of use cases has been, that the respective project was implemented with tangible benefits. To allow consistent reading, all use cases are presented in a standardized structure, including Abstract, Challenges, Use Cases, Impact, Technology, Lessons Learned, and Outlook. The use cases represent a variety of different industries, functions, operational roles (e.g., Management, Process Owner, Consulting), and software vendors. It allows to learn from practitioners as they describe which challenges they have faced, which use cases have created impact, and which lessons have been learned and provide an outlook on the future of Process Mining.

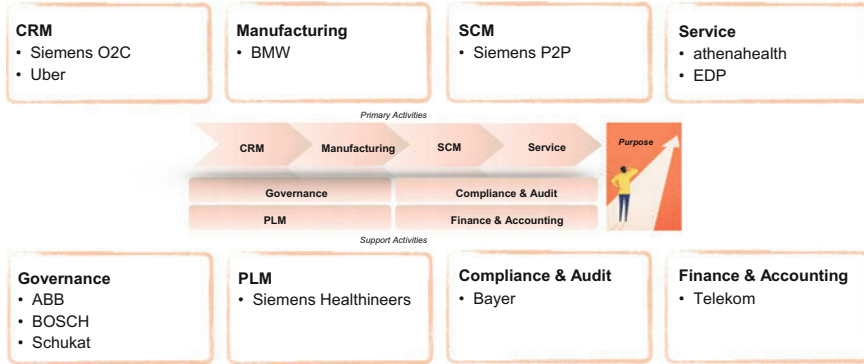


Fig. 1 Use Cases

To visualize the widespread of use cases across different functions, a value chain model has been applied with primary functions (CRM, Manufacturing, SCM, Service) and support activities (Governance, PLM, Compliance & Audit, Finance & Accounting). This model, which is shown in Fig. 1, is similarly used to discuss the purpose of Process Mining in Chap. 3.

Part III gives an outlook on the future of Process Mining, both from an academic and from a business perspective. The academic perspective is contributed by Professor Wil van der Aalst, who “invented” Process Mining. Wil describes the evolution of Process Mining, reveals the inconvenient truth regarding commercial software, discusses the most pressing novel challenges, and concludes with his vision of Business Process Hygiene, which implies that *not* using Process Mining should require a justification—and not the other way around.

The business perspective provides an operational outlook and takes a liberty for prediction and vision, which would not have been appropriate for an academic outlook. Aspects of the prediction include business requirements, technological developments, Artificial Intelligence (AI), strategic workforce planning, and anticipated market developments. As any prediction is difficult—especially about the future—this part reflects the editor’s personal view and aims to steer further reflections and discussions for the future evolution of Process Mining.

The book concludes with a vision for a Digital Enabled Organization.

Santa Barbara, California, USA

Lars Reinkemeyer

Acknowledgments

Writing this book became an even more inspirational journey than initially anticipated. The first ideas were born with the positive, constructive, and collaborative vibes in the Process Mining community, thought leaders like Alex, Olly, and many more. As exciting operational use cases became public, it felt worthwhile to promote experiences and provide a stage to the growing number of evangelists. Writing to all major Process Mining vendors received positive feedbacks and exceeded the initial target of 10 cases.

A very special thanks is owed to the contributors, without whom this colorful mosaic would never have been possible. You have done great, not only to drive cases in your company, but to share your operational experiences, adopt the standard structure as a corset for your contribution, and deliver perfectly on the happy path.

The two forewords from Hannes Apitzsch and Klaus Straub are a distinction for Process Mining. Innovations require courageous frontrunners as sponsors, and it is highly appreciated to have you providing a Top Management patronage for this topic.

On the academic side, Wil van der Aalst has not only invented this exciting technology, but stirred discussions with insights into the inconvenient truth and novel challenges. Tom Davenport and Seungjin Whang condensed our inspiring discussions and presentations in concise blurbs. Jianwen Su made the book possible by supporting my scholarship and with interesting discussions in his faculty at UCSB.

At Siemens, there have been—besides Hannes Apitzsch—numerous supporters from the very early days. And it reflects an amazing corporate culture to grant a sabbatical, which was approved by Erik Mohr and Dietmar Mauersberger.

When the first seeds for the project disseminated, my friends gave me the courage to start on this adventure. On the journey, Al Gore extended my horizon with his plea for a sustainability revolution. And my father was of great help not only by proofreading the draft version, but also by extending my horizon with his wealth of experiences.

Last but not least I would like to thank my family—including King Jack—for joining me on this very special adventure.

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Abbreviations

ACL	Audit Command Language
AHT	Average Handling Time
AI	Artificial Intelligence
API	Application Programming Interface
A/P	Accounts Payable
A/R	Accounts Receivable
BI	Business Intelligence
BP	Business Process
BPH	Business Process Hygiene
BPM	Business Process Management
BPMN	Business Process Management and Notation
BTO	Build to Order
BVI	Business Volume Indicator
B2B	Business to Business
B2C	Business to Consumer
CoE	Center of Excellence
CT	Computer Tomography
DaaS	Data as a Service
DFG	Direct Flows Graph
DMAIC	Define, Measure, Analyze, Improve, Control
DTO	Digital Twin of an Organization
EDI	Electronic Data Interchange
ERP	Enterprise Resource Planning
ETL	Extract, Transport, Load
EWM	Enterprise Warehouse Management
e2e	end to end
FIFO	First In First Out
GDPR	General Data Protection Regulation
HQ	Headquarter
HR	Human Resources
IoT	Internet of Things
IIoT	Industrial Internet of Things
KPI	Key Performance Indicator

LC	Lead Country
LIFO	Last In First Out
MES	Manufacturing Execution System
ML	Machine Learning
MRT	Magnetic Resonance Tomography
MVP	Minimum Viable Product
NPS	Net Promoter Score
OCR	Optical Character Recognition
OPQ	Opportunities for Perfecting Quality
O2C	Order to Cash
PLM	Product Lifecycle Management
PMI	Process Management Insights
PO	Purchase Order
PoC	Proof of Concept
PPI	Process Performance Indicator
PR	Purchase Requisition
PTP	Procure to Pay
P2P	Purchase to Pay
RCA	Root Cause Analysis
RDS	Relational Database Service
RoI	Return on Investment
RPA	Robotic Process Automation
RPD	Robotic Process Discovery
RPM	Robotic Process Management
SCM	Supply Chain Management
SDI	Smart Data Integration
SLA	Service Level Agreement
SLT	SAP Landscape Transformation
SQL	Structured Query Language
SRM	Supplier Relationship Management
S2P	Source to Pay
UCSB	University of California, Santa Barbara
UI	User Interface

Principles and Value of Process Mining

How do you drive digital transformation without thorough understanding of current processes and complexity drivers? Can you afford to manage the necessary transformations in your organization without using technical possibilities, which allow you to achieve full transparency about actual processes and complexity drivers?

Process Mining is one of the most innovative and maybe the most exciting digital tools supporting companies on their journey towards digital transformation. It provides wholistic insights into actual processes and complexities, thus allowing to identify inefficiencies and effort driver. Imagine a digital tool which allows you to visualize and understand any business process in your organization—from every single process activity to an aggregated global view—based on the actual event logs of activities. Imagine full transparency into process complexities and perfect insights, allowing you to drive transformation and initiate actions such as process redesign, workflow optimization, batch processing, and activity automation with bots, thus increasing the efficiency of internal business processes.

Key Learning #1: Transparency Is a Prerequisite for Digital Transformation

The following chapter describes the fundamental principles of Process Mining and how it is used to create value. The value of Process Mining has been documented in numerous use cases, e.g., due to substitution of process inefficiencies and improvements of sales processes, yielding in savings of millions of euro and further value which has not been quantified. Process Mining can support the transition towards a more efficient and sustainable economy, e.g., in the field of supply chain, by allowing to increase transport efficiency, avoidance of empty transports, optimization of inventories, and reduction of waste. Insights are also used for an optimized transport modal change, thus leading not only to economic but also ecologic value.



Process Mining in a Nutshell

1

Lars Reinkemeyer

Abstract

Fundamentals such as event logs, cases, activities, and process variants are explained. Concrete examples show how Process Mining can be used for business transparency and value. Allowing full transparency based on event logs, the implications of this important change—away from perception based towards a fact-based process management—are discussed. The metaphor of an MRT is used to explain possibilities, benefits, and limitations of Process Mining.

“Process Mining is a process management technique that allows for the analysis of business processes based on event logs.” This definition by Wikipedia embraces the unique approach of Process Mining to allow the analysis of any business process based on digital traces captured in event logs. An event log is a collection of events which have taken place in order to perform a business process. Each event refers to a specific activity that took place at a certain moment in time and can be assigned to a unique case. An event log consists—as a minimum requirement—of a Case ID as a numeric identifier, an Activity as a specification of which activity has taken place and a Timestamp for the precise time of every action taken (see Fig. 1.1).

Further attributes can be added to provide further information about the specific activities. In a corporate environment, event logs are digital traces which are stored for any business activity in databases such as ERP, CRM, SRM, MES, or PLM systems. Each customer offer, order, invoice, etc., is processed in a database where it

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Fig. 1.1 Event log

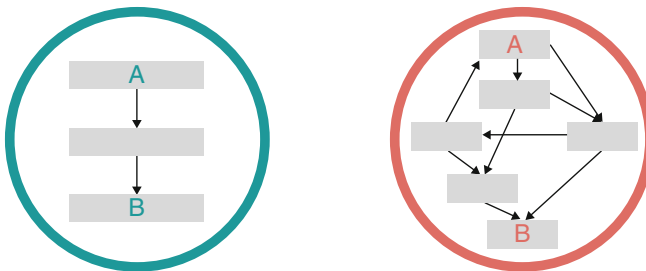
Case ID	Activity	Timestamp
1	Create ticket	January 2, 3:15 PM
1	Screen ticket	January 2, 3:32 PM
1	Repair - simple	January 10, 9:45 AM
1	Close ticket	January 10, 11:34 AM
2	Create ticket	January 2, 4:04 PM
2	Screen ticket	January 2, 4:05 PM
2	Repair - complex	January 3, 1:38 PM
2	Close ticket	January 4, 9:23 AM
3	...	

leaves digital traces. Detailed descriptions of procedures on how to build valuable event logs from data that is stored in relational databases are publicly available.¹

In order to “mine” a process, the digital traces are identified, extracted, and visualized in a form which reflects the actual process flow, thus providing transparency regarding the sequence of activities as they have actually taken place. Processing time and sequence of the events provides a complete picture of each case, allowing to trace process flows, understand delays, separate loops, and identify complexity drivers.

Figure 1.2 shows the principle of Process Mining to visualize simple and complex process flows in the form of different variants: the left picture presents a simple, standardized process flow. The right picture presents a more complex process flow with different variants, reflecting multiple options for how the process can be performed.

While people tend to design and think in the form of simple process flows (left image), reality tends to be more complex with multiple variants (right image). In this respect, it is commonly differentiated between “To-Be” and “As-Is” processes:

**Fig. 1.2** Principle of process variants

¹Example: <http://businessinformatics.be/2016/12/20/from-relational-database-to-valuable-event-logs-for-process-mining-a-procedure/>