Action-Oriented Process Mining: From Insights to Actions (Extended Abstract)

Gyunam Park

Process and Data Science Group (PADS), RWTH Aachen University, Ahornstraße 55, Aachen, 52074, Germany

Abstract

This thesis introduces *action-oriented process mining*, a novel approach that *closes the critical gap* between process diagnosis and improvement implementation that has long challenged organizations. Unlike traditional process mining that stops at diagnostics, this research establishes the first comprehensive framework that transforms data-driven insights into concrete actions through three integrated components: object-centric problem monitoring, pattern-based action generation, and data-driven impact evaluation. Implemented as the open-source *ProAct* web application, this framework demonstrates both theoretical significance and practical applicability, setting a new direction for the BPM field.

Keywords

Business Process Management, Process Improvement, Process Mining, Object-Centric Process Mining

1. Introduction

Efforts to improve business processes have evolved from methodologies like business process reengineering, which aimed for radical changes, to approaches like process redesign and lean management addressing incremental improvements [1]. The introduction of Business Process Management (BPM) systems marked a significant shift toward automating organizational functions for process improvements. However, these systems often failed to meet expectations due to their inability to capture the complexity of real-life processes and the high cost of replacing existing systems.

Process mining emerged as a response to these limitations, offering a data-driven approach that analyzes real operational data extracted from information systems [2] without replacing existing systems [3]. Process mining techniques have been instrumental in providing insightful process diagnostics [4, 5, 6]. **Yet a fundamental challenge remains**: despite its effectiveness in diagnosing process-related issues, traditional process mining typically lacks mechanisms for transforming insights into concrete actions for improvement [7]. *This is the critical gap that action-oriented process mining addresses* – bridging diagnosis and implementation by transforming process mining insights into practical actions for process improvement, **thereby completing the BPM lifecycle in a systematic, data-driven way**.

2. Background

The framework for action-oriented process mining [8] consists of three main components, as illustrated in Figure 1: process monitoring, action engine, and impact analysis. The cycle begins with Process-Aware Information Systems (PAIS) like SAP, Microsoft, Oracle, and Salesforce generating event data during business operations. Process monitoring then analyzes this event data against operational problems defined by process managers, producing problem instances that record when and where these issues occur [9]. Note that such problems are defined by process managers based on the insights gained from process mining [10, 11]. These problem instances flow into the action engine, which systematically generates action instances containing recommended interventions to address the identified problems [12]. Action instances specify concrete changes to implement in the PAIS, such as process

Proceedings of the Best BPM Dissertation Award, Doctoral Consortium, and Demonstrations & Resources Forum co-located with 23rd International Conference on Business Process Management (BPM 2025), Seville, Spain, August 31st to September 5th, 2025.
gnpark@pads.rwth-aachen.de (G. Park)
0000-0001-9394-6513 (G. Park)

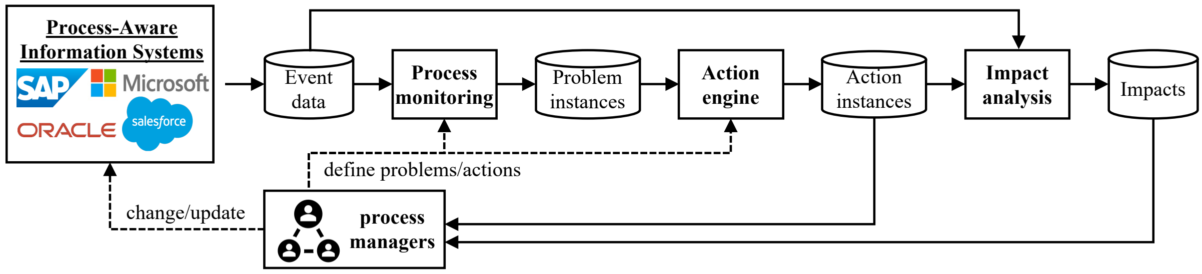

Figure 1: Framework for Action-Oriented Process Mining

adaptations, resource reallocation, business rule modifications, or implementing alerts [13, 14]. After implementation, the impact analysis component evaluates the effects of these actions by analyzing new event data, measuring the structural, operational, and performance impacts [15]. This analysis provides critical feedback to process managers, enabling data-driven decisions for continuous improvement and completing the process improvement cycle.

3. Research Questions

Building upon the action-oriented process mining framework described in the background section, this thesis addresses four fundamental research challenges:

- **RQ1: How can process monitoring techniques accurately identify operational problems in complex, real-life business processes?** The first component of the framework, i.e., process monitoring, faces significant challenges when applied to real-world scenarios. Existing approaches often assume simplistic, single-case processes that fail to capture the dynamic and object-centric nature of real-life business processes where multiple interconnected objects flow through processes simultaneously.
- **RQ2: How can an action engine systematically analyze temporal patterns of operational problems to generate contextually relevant actions?** Once problem instances are identified by the monitoring component, the action engine must translate these insights into concrete improvements. This question explores how to automate the generation of appropriate actions by analyzing temporal patterns of operational problems rather than treating them as isolated incidents, addressing the second key component of the framework.
- **RQ3: How can comprehensive impact analysis techniques be developed to evaluate the structural, operational, and performance effects of actions implemented for process improvement?** This question investigates how to systematically analyze the impacts of process updates, i.e., actions, on different organizational aspects, including the structural elements of a process, the operational state, and performance indicators.
- **RQ4: How can a robust simulation approach be developed that accurately emulates the complexities of real-world processes to effectively evaluate action-oriented process mining techniques?** To validate the framework before operational deployment, we need simulation environments that reliably reproduce real-world complexities. This question examines how to create such environments by incorporating authentic system data and configurations.

Note that **RQ1-3** address the development of efficient techniques for implementing the three main components of the action-oriented process mining framework introduced in the background section, whereas **RQ4** concerns providing an effective testbed for developing and evaluating these techniques.

4. Contributions

The thesis makes the following key contributions, each directly addressing the research questions and advancing the components of the action-oriented process mining framework:

4.1. Object-Centric Process Monitoring (RQ1)

Beyond traditional, single-case process mining, this contribution presents a comprehensive taxonomy of object-centric operational problems that captures the complexity of processes involving multiple interconnected objects. The taxonomy classifies problems into compliance-oriented and performance-oriented categories, providing a foundation for more accurate problem detection. Object-centric problem graphs with formally defined semantics are introduced to visually represent these problems, enabling process managers to define complex operational issues [16, 17]. The developed monitoring engine analyzes object-centric event logs against these problem definitions, *surpassing traditional single-case monitoring methods by providing a more realistic view of operational issues in real-life object-centric processes.*

4.2. Pattern-Based Action Engine (RQ2)

Moving from insights to actionable improvements, a pattern-based approach is developed that systematically transforms problem instances into concrete interventions [18]. A comprehensive taxonomy of actions for process improvement provides a structured way to address different types of operational problems with clear semantics. The action graphs visually represent problem-action relationships, helping process managers understand recommended interventions. By analyzing *temporal dependencies among problem instances*, the engine produces *conflict-free action plans that resolve identified issues while respecting execution constraints*, providing clear implementation guidelines for process managers.

4.3. Data-Driven Impact Analysis (RQ3)

Completing the improvement cycle, a comprehensive approach [19] using Digital Twin Interface Models (DT-IM) [20] is presented. This method identifies changes caused by action instances and performs three distinct analyses: 1) structural impact analysis to identify affected activities and business functions, 2) operational impact analysis to determine affected process instances and business objects, and 3) performance impact analysis to measure changes in key performance indicators [21]. This data-driven approach provides valuable feedback to process managers, *enabling informed decisions about future process improvements and completing the continuous improvement cycle outlined in the framework.*

4.4. Robust Simulation (RQ4)

Bridging theory and practice, a novel simulation approach is developed that directly incorporates data and parameters from real-life information systems [22]. Rather than focusing solely on process flows, the simulation framework integrates the complexity of supporting information systems, including data flows, business rules, and system configurations. By using actual system data, the approach effectively mirrors real-world complexities, *creating a reliable testbed for validating all three components of the action-oriented process mining framework before operational deployment.*

The contributions above have been implemented as an open-source web application, *ProAct*[1], demonstrating both theoretical soundness and practical applicability.

[1] The user manual is available at https://proact.readthedocs.io/en/latest/. *ProAct*'s core analysis functionalities are implemented in python library OCPA [23].

5. Conclusion

This thesis represents **the first comprehensive academic treatment of Action-Oriented Process Mining**, introducing a general framework and presenting a suite of techniques that facilitate its implementation. These techniques address the critical challenges across the entire process improvement lifecycle from problem identification through action generation to impact evaluation.

Key innovations include: (1) object-centric process monitoring that accurately identifies operational problems in complex business processes, overcoming the limitations of traditional approaches; (2) a pattern-based action engine that systematically transforms insights into actionable improvements by analyzing temporal patterns and generating conflict-free action plans; (3) a data-driven impact analysis framework using Digital Twin Interface Models to provide detailed evaluation of implementation effects; and (4) a robust simulation approach creating realistic testing environments by incorporating real system data.

These contributions **address the fundamental gap between process diagnosis and improvement implementation** that has long challenged organizations. By providing a complete methodology that connects monitoring, action planning, and impact assessment, this thesis establishes a foundation for more effective and systematic process improvement. The open-source *ProAct* application implements these contributions, making them accessible to practitioners and researchers.

This research opens a new and important direction within the BPM field. Future work could focus on four key directions: (1) enhancing object-centric problem graphs to incorporate multiple perspectives; (2) integrating the action engine with leading workflow automation platforms; (3) conducting comprehensive case studies in diverse organizational settings; and (4) strategically connecting the framework with established process mining solutions to create a seamless ecosystem. These advancements will help transition this research from a theoretical framework to a practical solution capable of addressing real-world process improvement challenges across diverse organizational contexts.

Declaration on Generative AI

The author acknowledge the use of Grammarly and Claude for grammar checking and language editing to improve the clarity of this manuscript.

References

[1] M. Dumas, M. L. Rosa, J. Mendling, H. A. Reijers, Fundamentals of Business Process Management, Springer, 2018.

[2] A. Berti, G. Park, M. Rafiei, W. M. P. van der Aalst, A generic approach to extract object-centric event data from databases supporting SAP ERP, J. Intell. Inf. Syst. 61 (2023) 835–857.

[3] W. M. P. van der Aalst, Process Mining - Data Science in Action, Springer, 2016.

[4] D. Kretzschmann, G. Park, A. Berti, W. M. P. van der Aalst, Overstock problems in a purchase-to-pay process: An object-centric process mining case study, in: J. P. A. Almeida, C. D. Ciccio, C. Kalloniatis (Eds.), CAiSE Workshops, volume 521 of *LNBIP*, Springer, 2024, pp. 347–359.

[5] G. Park, S. Aydin, C. Ugur, W. M. P. van der Aalst, Analyzing an after-sales service process using object-centric process mining: A case study, in: J. D. Smedt, P. Soffer (Eds.), ICPM Workshops, volume 503 of *LNBIP*, Springer, 2023, pp. 406–418.

[6] G. Park, L. Liss, W. M. van der Aalst, Learning recommendations from educational event data in higher education, Journal of Intelligent Information Systems (2024) 1–20.

[7] G. Park, M. Cho, J. Lee, Leveraging machine learning for automatic topic discovery and forecasting of process mining research: A literature review, Expert Syst. Appl. 239 (2024) 122435.

[8] G. Park, W. M. P. van der Aalst, A general framework for action-oriented process mining, in: A. del-Río-Ortega, H. Leopold, F. M. Santoro (Eds.), BPM Workshops, volume 397 of *LNBIP*, Springer, 2020, pp. 206–218.

[9] G. Park, J. Benzin, W. M. P. van der Aalst, Detecting context-aware deviations in process executions, in: C. D. Ciccio, R. M. Dijkman, A. del-Río-Ortega, S. Rinderle-Ma (Eds.), BPM Forum, volume 458 of *LNBIP*, Springer, 2022, pp. 190–206.
[10] G. Park, J. N. Adams, W. M. P. van der Aalst, Conformance checking and performance analysis using object-centric directly-follows graphs, in: A. Marrella, M. Resinas, M. Jans, M. Rosemann (Eds.), BPM Forum, volume 526 of *LNBIP*, Springer, 2024, pp. 179–196.
[11] J. N. Adams, E. Hastrup-Kiil, G. Park, W. M. P. van der Aalst, Super variants, in: A. Marrella, M. Resinas, M. Jans, M. Rosemann (Eds.), BPM, volume 14940 of *LNCS*, Springer, 2024, pp. 111–128.
[12] G. Park, W. M. P. van der Aalst, Action-oriented process mining: bridging the gap between insights and actions, Progress in Artificial Intelligence (2022).
[13] M. Reichert, B. Weber, Enabling Flexibility in Process-Aware Information Systems - Challenges, Methods, Technologies, Springer, 2012.
[14] G. Park, M. Song, Optimizing resource allocation based on predictive process monitoring, IEEE Access 11 (2023) 38309–38323.
[15] M. Parhizkar, M. Comuzzi, Impact analysis of ERP post-implementation modifications: Design, tool support and evaluation, Comput. Ind. 84 (2017) 25–38.
[16] G. Park, W. M. van der Aalst, Operational process monitoring: An object-centric approach, Computers in Industry 164 (2025) 104170.
[17] G. Park, W. M. P. van der Aalst, Monitoring constraints in business processes using object-centric constraint graphs, in: M. Montali, A. Senderovich, M. Weidlich (Eds.), ICPM Workshops, volume 468 of *LNBIP*, Springer, 2022, pp. 479–492.
[18] G. Park, D. Schuster, W. M. P. van der Aalst, Pattern-based action engine: Generating process management actions using temporal patterns of process-centric problems, Comput. Ind. 153 (2023) 104020.
[19] G. Park, M. Comuzzi, W. M. P. van der Aalst, Analyzing process-aware information system updates using digital twins of organizations, in: R. S. S. Guizzardi, J. Ralyté, X. Franch (Eds.), RCIS, volume 446 of *LNBIP*, Springer, 2022, pp. 159–176.
[20] G. Park, W. M. P. van der Aalst, Realizing A digital twin of an organization using action-oriented process mining, in: C. D. Ciccio, C. D. Francescomarino, P. Soffer (Eds.), ICPM, IEEE, 2021, pp. 104–111.
[21] G. Park, J. N. Adams, W. M. P. van der Aalst, Opera: Object-centric performance analysis, in: J. Ralyté, S. Chakravarthy, M. K. Mohania, M. A. Jeusfeld, K. Karlapalem (Eds.), ER, volume 13607 of *LNCS*, Springer, 2022, pp. 281–292.
[22] G. Park, W. M. P. van der Aalst, Towards reliable business process simulation: A framework to integrate ERP systems, in: A. Augusto, A. Gill, S. Nurcan, I. Reinhartz-Berger, R. Schmidt, J. Zdravkovic (Eds.), BPMDS, volume 421 of *LNBIP*, Springer, 2021, pp. 112–127.
[23] J. N. Adams, G. Park, W. M. P. van der Aalst, ocpa: A python library for object-centric process analysis, Softw. Impacts 14 (2022) 100438.