From Discovery to Redesign: Leveraging Activity Relationships in Business Process Transformation

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Abstract

Organizations must regularly adapt their business processes in response to evolving goals, norms, or regulations. Redesign ideas and change operations are typically derived from as-is process models discovered from execution data via automated process discovery. A crucial but often overlooked factor in this context is the choice of modeling language: if it does not match the process's characteristics, particularly its level of structuredness, the resulting model may become unnecessarily complex and harder to interpret, or too abstract, missing relevant control-flow details. Moreover, *Business Process Redesign* (BPR) lacks automated support in the implementation of change operations. Structural and contextual consequences are not taken into account when modifying process models. To address the challenges of appropriate process representation and automated, preventive BPR support, we conduct a doctoral research project. We plan to develop an IT artifact that supports process classification and representation according to the level of structuredness, and the automated implementation of change operations, including their assessment regarding structural and contextual consequences. This proposal outlines progress so far, the overall research method and approach, first outcomes and remaining steps, as well as its relation to the state-of-the-art literature.

Keywords

Process Discovery, Process Classification, Business Process Redesign, Activity Relationships

1. Introduction and Motivation

Business processes are subject to constant change [1]—whether due to legislative developments, shifts in business goals toward sustainability objectives, or the pursuit of performance optimizations. Organizations therefore need to regularly engage in *Business Process Redesign* (BPR). A prerequisite for any redesign initiative is a solid understanding of the as-is situation [2, Ch.8]. Traditionally, this understanding was obtained through interviews and manual modeling, which are costly and often incomplete.

Automated Process Discovery addresses this challenge by extracting business process models directly from event logs [3]. These models provide an evidence-based baseline that increases transparency and that can subsequently be used as input for BPR [4]. However, their usefulness depends strongly on the modeling language in which they are expressed. Imperative modeling languages, such as *Business Process Model and Notation* (BPMN), prescribe the control flow of a process while declarative languages, such as the *ConDec* language [5] used for *Declare* [6], allow execution flexibility within defined constraints. The choice depends on the process's *structuredness*: highly structured processes with predictable flows suit imperative models, while loosely structured or knowledge-intensive processes are better captured declaratively [7]. Especially for BPR, where process models form the basis for generating redesign ideas, selecting a modeling language that reflects the appropriate degree of structuredness is fundamental to ensuring that redesign initiatives are grounded in process reality.

However, for redesign decisions to be effective, process models alone are not enough: contextual information about activity relationships contributes significantly to the success of BPR tasks as it supports preventive BPR [8]. Risks and consequences can be assessed before actual implementation. Identifying non-violable relationships is further considered important in the domain of model repair [9]. However, contextual information for BPR has so far been extracted and annotated manually; automated support is missing.

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In the past years, several approaches were introduced to support the implementation of BPR tasks, ranging from manual approaches, such as the change patterns [4] and best practices for BPR [1], to tools offering automated support [10] aiming at optimizing performance and efficiency. Nevertheless, automated support for BPR is still one of the biggest challenges in *Business Process Management* (BPM) [11]. Transformation from the *as-is* to the *to-be* situation is often referred to as the *ATAMO* (And Then A Miracle Occurred) principle [2, Ch.8]. An overview of structural consequences is missing. Moreover, the scattered definition of change operations further hinders automated BPR support. For example, change operations found in the field of process model repair [12, 13] have similar semantics as in BPR but are named differently, making effective BPR more challenging.

In summary, we identify three core challenges: (1) appropriate process representation according to its level of structuredness, (2) integration of contextual information for change operation assessment, and (3) automated support for change operation implementation explaining structural consequences. Based on these observations, the proposed PhD research project targets the following research questions:

RQ1: How can we automatically identify the most appropriate process representation for a given process, based on the characteristics observed in its event log?

RQ2: How can change operations be formalized to modify process behavior at the level of activity relationships?

RQ3: How can we support the assessment of change operations in terms of their feasibility and impact?

We propose the development of an IT artifact that integrates structuredness-aware process discovery, addressing the challenge of finding the most appropriate process representation, with automated support for business process redesign. Users provide an event log as input, from which a process model is automatically generated using the most suitable modeling language. Based on this model, users can derive change operations, which serve as input for the redesign phase. Before applying change operations, a pre-assessment is conducted to evaluate their violability. Subsequently, the structural consequences of the selected change operations are made explicit, enabling transparent process transformation.

We follow the design science research approach [14] and use the methodology of algorithm engineering [15] to formalize the described research problems for algorithm development.

The remainder of this doctoral research proposal is structured as follows. Research methods are presented in section 2. Section 3 introduces the overall research approach. Section 4 presents first results and the roadmap of the project. Related work is discussed in section 5, and section 6 concludes.

2. Methodology

From a methodological point of view, we are following the *Design Science Research* (DSR) methodology [14] to develop the proposed IT artifact. We include a *snowballing literature review approach* [16] to identify change operations for redesigning process behavior (RQ2). Furthermore, we use the hermeneutic approach for a literature review [17] to create an understanding of change operation assessment across different research fields in the area of BPM (RQ3). This combined literature review approach allows for a thorough definition of solution objectives and improved understanding of the research problem.

Based on the theoretical background, we then follow the methodology of *algorithm engineering* [15] for problem formalization (i.e., formalization of change operations and process structuredness) and algorithm design. The development of the proposed artifact is conducted in two phases. First, we focus on RQ1 to find the appropriate representation of a given process. Its output is then used for change operation implementation being developed in a second step. By following the principles of *test-driven development* [18], we iteratively incorporate increasing levels of complexity.

Process classification will be evaluated using both real-world and synthetic event log data, with an expert survey serving as the ground truth for comparison. Following the principles of *technical action research* [19], we collect change operations from a real-world use case and implement them with the proposed IT artifact to assess its feasibility.

3. Approach

We use the *activity relationships matrix* [20] as the core artifact to define a relationship for each pair of activities. It distinguishes between *temporal dependency* (i.e., the order in which activities occur during process execution) and *existential dependency* (i.e., how the occurrence of one activity depends on the occurrence of another). This intermediate process representation enables us to capture more process details compared to abstracted process models. Additionally, it provides a comprehensive analytical framework for examining process behavior and can be translated into various modeling languages such as BPMN or Declare.

Figure 1 shows how the matrix is used in our overall approach. Based on event logs, we discover the matrix and enrich it with contextual information such as *explanatory rationales* [8, 21] to understand the background and motivation behind each process relation. Additionally, we analyze the ratios of relationship types to heuristically classify the process regarding its structuredness and suggest an appropriate modeling language for visualization, since the matrix itself is used for computational analysis only. It can then be translated into visual process models to make the process accessible to stakeholders.

Based on the process model, stakeholders can generate redesign ideas, which are formalized into concrete change operations. By implementing these change operations within the matrix, we can determine structural consequences, i.e., which relationships need to be adjusted so that the process is sound and consistent in itself.

Furthermore, using the contextual information stored for each relation, we can perform an initial assessment of whether a change operation is feasible. By enforcing logical constraints on relations, we can assess whether a change operation is permissible, thus enabling stakeholders to perform more effective preventive redesign. Moreover, we are able to assess change operations regarding organizational risks. If, for example, a change operation affects a relationship that is based on a governmental law, the consequences might be different compared to relationships that exist based on a best practice. Our approach can differentiate such cases.

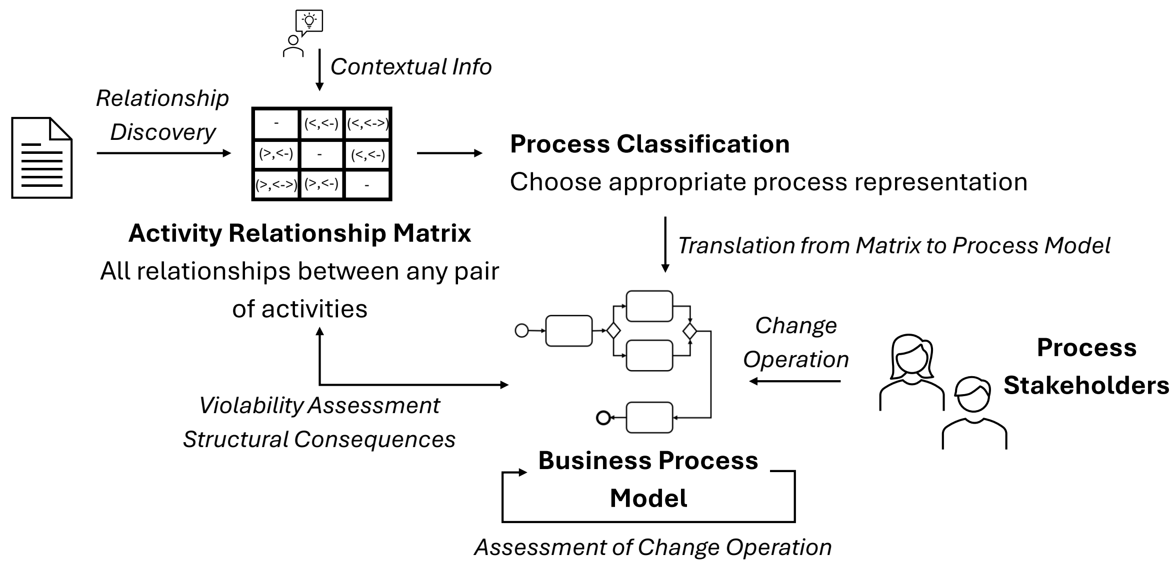

Figure 1: General approach

4. Results and Roadmap

This section summarizes the achieved outcomes so far and outlines the remaining steps to be addressed in the dissertation project. Table 1 provides an overview of the research questions, the assigned work packages, and the current status of achievement.

Table 1
Overview of research questions and assigned work packages including achievements so far (✓: achieved; ○: work in progress)

RQ	Work Package	Achieved?	Publication
RQ1	*WP1 Relationships Discovery:* Based on event log data, an activity relationships matrix should be discovered and stored in an adequate file format.	✓	[22]
	WP2 Process Classification: Algorithm development to assign a modeling language to an event log based on structuredness analysis.	✓	[23]
	WP3 Matrix To Process Model: Translate the activity relationships matrix to different types of process models, e.g., Declare and BPMN.	○	[22]
	WP4 Tool Development: Unified modeling environment for multiple modeling languages of different types and UI development for process classification.	✓	
RQ2	*WP5 Change Operation Review:* Snowballing change operations from literature.	✓	
	WP6 Change Operation Formalization: Change operations are formalized in terms of activity relationships notation, user input, and output.	✓	
RQ3	*WP7 Change Operation Assessment:* Development of a framework to assess change operations to support preventive BPR.	✓	[21]
	WP8 Extracting Contextual Information: Exploration of methods to extract required contextual information (LLM-based approach, questionnaires, context-aware modeling)	○	[24]
	WP9 Change Operation Implementation: Implementation of change operation on a structural level, including violability check.	✓	
	WP10 Final Integration and Testing: Tool development and case study.	○	

We have introduced a discovery algorithm to extract an activity relationships matrix as defined in [20] based on a given event log (WP1) [22]. To improve readability, we chose the YAML format to store the required information for each activity relationship in the process. Discovered matrices can be used for automated process classification according to the level of structuredness (WP2) [23][1].

The proposed classification algorithm already outputs the most appropriate modeling language and automatically translates loosely structured processes from activity relationship matrices to Declare[2] (WP3). We plan to add the translation to BPMN by the end of October 2025.

Regarding tool support (WP4), we have implemented a unified, interactive modeling environment for Declare and BPMN process models that is integrated in a UI that supports users in process classification.

Moreover, WP5 and WP6 can be considered complete. For the resulting list of change operations we got from the snowballing literature review, we have formalized each change operation. Moreover, change operations, including a pre-assessment of locked relationships, are implemented on a matrix level (WP9). We are currently finalizing the tool integration and plan to complete the evaluation by November 2025.

Regarding WP7, we have introduced a conceptual model for business process redesign that defines relevant concepts that need to be taken into account when assessing change operations [21]. It combines different areas of BPM to specify the motivational background of activity relationships, captured by explanatory rationales, and the connection to different types of risks and consequences. For the extraction of explanatory rationales (WP8), we have compared different prompting techniques in combination with different Large Language Models (LLMs) [3] and evaluated the effectiveness of the extraction using questionnaires. We plan do implement a prototypical context-aware process modeling environment and compare all three approaches regarding their feasibility and quality of results by spring 2025.

5. Related Work

Automated Discovery of Intermediate Process Representations. Intermediate process representations are used in process discovery to extract general behavior patterns from event logs. The *footprint matrix* is used by the α algorithms [25, 26, 27] and captures relationships, such as *causality* and *direct succession*. *Directly-follows graphs* (DFG) used in the Heuristics Miner [28], Inductive Miner [29],

[1]The classification algorithm is available on GitHub: https://github.com/INSM-TUM/automated-process-classification
[2]The translation to Declare is available on GitHub: https://github.com/INSM-TUM/event-log-to-declare-json
[3]The results will be published and presented at the international conference on Wirtschaftsinformatik 2025 (WI25).

and Split Miner [30] capture only direct temporal dependencies, often with heuristics for noise handling. *LTL formulae representations* are used in declarative discovery [31, 32] and verification [33]. Komatsu and Horita [34] introduce a method to discover LTL formulae directly from event logs, however, their approach is limited by relying on a pre-defined subset of traces as input.

Intermediate representations usually do not differentiate between different types of existential and temporal dependencies. The activity relationships matrix, however, captures a richer set of dependency types, making it useful for further applications beyond process discovery, such as classification based on structuredness and automated redesign support. Moreover, it allows taking the complete event log as an input for LTL discovery.

Process Classification and Appropriate Process Representation. Process classification based on event log data was first introduced with discovery algorithms for hybrid models [35]. These approaches [36, 37, 38] aim to identify structured and unstructured parts without classifying the entire event log. Our algorithm classifies structuredness based on relationship types and maps the result to appropriate modeling languages for adequate representation instead of using hybrid approaches.

For appropriate process representation, most approaches focus on the user and organizational context [39, 40, 41]. Other criteria include long-term usability and maintainability of process models [42], tool support [43], or specific business process perspectives [44]. However, these approaches largely ignore event log data. Incorporating process execution data is essential, as the chosen language should reflect both representational goals and the process's inherent characteristics, such as structuredness [7].

Business Process Redesign. In the context of business process redesign, various change operations were presented in literature [1, 45, 46, 4]. Moreover, the area of business process repair additionally introduces change operations to modify process behavior [12, 9, 13]. However, there is no unified and formalized overview of change operations. Authors use different terms and concepts, making it difficult for automated support for change operation implementation.

Looking at tools, Fehrer et al. [10] outline a four-step assisted BPR approach for BPMN diagrams. Simulation experiments are used to assess the impact of the applied change operations in terms of performance. Structural and contextual consequences, however, are neglected. The change patterns introduced by Weber et al. [4] also support redesigners in design and run-time, but lack change assessment.

6. Discussion and Conclusion

While the proposed research project addresses the three core problems of appropriate process representation, automated support for business process redesign, and change operation assessment, it comes with limitations. First, we focus on changing process *behavior*, thus excluding the operational view on BPR [1] to better scope the overall project. Second, the view on relationships is still limited. Even though we include contextual process information, such as explanatory rationales, risks, and consequences, the approach lacks a data perspective on the process. Data constraints are currently considered as generic, non-violable constraints that can be locked before performing BPR. Furthermore, the activity relationships matrix introduces a limitation with regard to runtime. While the size of the event log affects relationship discovery, the implementation of change operations slows down as the number of activities increases.

Nevertheless, we believe that our approach contributes towards a more detailed understanding of activity relationships and their motivational background, supporting automated, preventive business process redesign.

Declaration on Generative AI

During the preparation of this work, the author used the unpaid version of ChatGPT in order to improve the structure of sentences and shorten paragraphs. After using this tool, the author reviewed and edited the content as needed and takes full responsibility for the publication's content.

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