Am I Allowed to Change an Activity Relationship? - A Metamodel for Behavioral Business Process Redesign

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Abstract. Business processes are constantly changing due to optimization, changes in legislation, or dissatisfaction among participants. Usually, process models are used as the basis for changing process behavior, but the models only provide limited information about possible risks, consequences, and vulnerability of the relationships between activities. Due to the lack of information, changes are implemented too hastily or not at all. In this paper, we elaborate on the relevant information for evaluating behavioral changes in the process. We present concepts and their relationships in a metamodel and show how the application of the metamodel can help to better assess process changes using the travel reimbursement process at a university. Furthermore, we discuss the potential of the proposed metamodel with regards to semi-automated business process redesign support.

Keywords: Business Process Redesign · Activity Relationships · Vulnerabilities · Process Models.

1 Introduction

Business processes are subject to a dynamically changing environment which is why the redesign of processes is an important task for organizations performed on a regular basis [18]. Business Process Redesign (BPR) is a core part of Business Process Management (BPM) and provides methods, techniques, and tools for modifying process models [7, Ch.8]. Process models represent business processes by specifying activities and relationships between them [31, Ch.1]. Changing relations in process models, i.e., behavioral BPR, is a difficult and challenging task [2], as each modification needs to be evaluated for its feasibility, associated risks, and consequences to maintain consistency and compliance.

Although several approaches, best practices, and guidance for BPR were introduced in recent years [12], process redesign remains one of the greatest challenges in the BPM community [5]. Since there are only a few solutions for automated BPR [5,9], processes are manually redesigned based on process models. However, these models only depict a subset of all activity dependencies, making the impacts in terms of risks and consequences of behavioral changes not apparent to users, i.e., process designers. That is why the implementation of BPR is referred to as the *ATAMO* procedure (And Then, A Miracle Happens) [7, Ch.8], stating that redesigning a business process is “more art than science” [19]. To make the implementation of BPR more tangible, Mansar and Reijers [18] introduce a framework to classify and identify best practices. It explains business processes in the context of BPR, providing support for users at a more general level. Risks and consequences of specific model change operations, as well as the question of the vulnerability of relations, are accordingly omitted.

For the redesign of activity relations, Adamo et al. [2] introduce the concept of explanatory rationales to provide background information on the relationship. Based on the origin or motivation of a relationship, users can evaluate if the relationship is violable. However, as an extension to the modeling language Business Process Model and Notation (BPMN), the approach is restricted in its generic applicability. Risks and consequences are not covered. Revoredo [23] also highlights the importance of distinguishing between changeable and non-changeable process parts when repairing business process models. In contrast to [1], Revoredo considers internal and external regulations as non-changeable and neglects risks and consequences associated with a change operation.

We argue for a more detailed assessment of change operations and thus propose a metamodel for the redesign of process behavior, i.e., the modification of activity relationships. It illustrates the interconnection of dependencies between activities, their contextual origins, and the resulting vulnerability, as well as the risks and consequences associated with a change operation. The presented concepts and their relationships are based on insights from various sub-disciplines of BPM, such as risk-aware BPM (R-BPM) [16,21], BPR [19], context-aware BPM [24,26], and compliance checking [14,10]. This metamodel summarizes all the information about business process relations that is necessary to assess and correctly execute behavioral changes without compromising the soundness of the model. It can be used to guide further research on automated knowledge extraction and developing software-supported guidance for users during process redesign. Further application areas of the metamodel, such as process characterizations or enhancing process flexibility, will be briefly discussed in this paper.

The organization of this paper is as follows. Section 2 discusses related work before a motivating example presented in Section 3 shows the challenges of behavioral BPR. Section 4 explains important concepts fot the metamodel introduced in Section 5. We evaluate our results in Section 6 and conclude in Section 7.

2 Related Work

Various works have been presented to assist users in performing change operations on process models.

Mansar and Reijers [18] introduce a framework that explains the relationship between the business process and its organizational context, the product or services produced by the process (i.e., the business goal), and the customer. They present best practices and discuss them regarding cost, quality, time, and flexibility. Gross et al. [12] provide an extension of the best practice redesign framework. For each component, the authors specify a set of dimensions and characteristics to further facilitate the exploration of process (re)designs. However, guidance on how to perform a change to a process model is still missing. Thus, our paper fills a gap in BPR: investigating an activity relationship's vulnerability and its risks and consequences when performing a change operation.

Zellner [34] presents a framework to identify business process redesign patterns. Each pattern combines a generic redesign activity, such as "separate", with a general element of business processes, e.g., control flow. Nonetheless, users must assess the application of these patterns in each specific case. The presented metamodel in this paper, however, aims to support BPR based on risks and vulnerabilities, indicating possible changes and their implications.

Weber et al. [30,29] introduce 18 change patterns to support the implementation of process model changes during runtime and design-time. In [29], these patterns are used to examine and compare various approaches and frameworks in the field of process change, focusing on flexibility. Despite the overall overview of changing operations, the patterns lack information about the implications of the change regarding risks and consequential actions to ensure model compliance. In the remainder of this paper, we will use *change operation* as a general term to refer to BPR best practices and change patterns.

Fehrer et al. [9] present an approach for assisted business process redesign consisting of four steps: selecting redesign patterns, identifying suitable process parts, creating alternative models, and evaluating the impact. Depending on the data available, they introduce different types of recommendations. Compared to Fehrer et al., we investigate the behavioral process changes from a contextual point of view by addressing risks and consequences.

Related to BPR is the field of business process repair dealing with changing a given process model according to an event log by identifying mismatches between them to improve conformance while staying close to the original model [8]. Presented techniques are optimized for common metrics, such as fitness and generalization. However, initial approaches do not assess the impact of a change in the process model in terms of associated risks and consequences on different contextual layers. First ideas are presented in Armas Cervantes et al. [4] who include an analysis of the impact of each mismatch pattern based on the frequency of the events involved in the pattern. Thus, the authors can prioritize certain repair operations. Domain knowledge is not integrated so far. In contrast, Revoredo [23] integrates domain knowledge by differentiating between changeable and non-changeable parts of the given process model. However, domain experts make this differentiation manually and do not consider risks and consequences.

3 Motivating Example

This section introduces the check-in process at airports as the running example used in this paper, depicted as a BPMN (Business Process Model and Notation) diagram in Fig. 1. The process example shows the need for classifying activity relationships regarding their vulnerability, including risks and consequences.

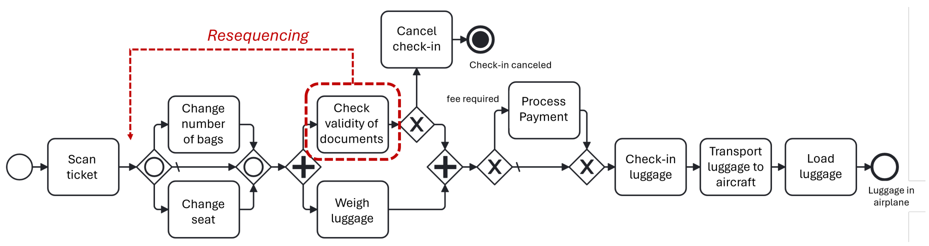

Fig. 1. BPMN process diagram of the check-in process at an airport and a redesign idea marked in red

The process starts with scanning the booked ticket. Afterward, the passenger can ask for late changes, such as changing the number of bags or changing the seat. Then, the luggage is weighed to check for its weight. In parallel, the airport staff checks the documents of the passenger. If the documents are not valid, the check-in is immediately canceled, and the process terminates. Otherwise, the passenger pays the fees for changes or overweight luggage, if necessary, before the luggage is checked in and transported to the transfer vehicles. Finally, the luggage is put in the airplane and the process terminates.

Imagine redesigning the process to improve its efficiency. We apply the change operation "resequencing" as described in [18] of activity "Check validity of documents" as shown in Fig. 1. We want to move this activity right after scanning the ticket, thus changing the activity execution order to perform the critical check of the documents earlier in the process to avoid unnecessary execution of other tasks in case the documents are invalid. The following questions arise:

- Are we allowed to change the execution sequence?
- What risks are associated with the change operation?
- Which other activity relationships are affected when changing the activity ordering?
- What do we have to do to ensure the consistency of the process model?

Answering these questions by only having the process model is challenging since it only shows the general activity execution order. The last two questions are crucial for automated BPR support since they cover mandatory information about what has to be changed to ensure consistency. Contextual information, e.g., a relationship's origin, is missing when assessing the vulnerability of a relationship. Furthermore, it is unclear which activity relationships are affected when changing the ordering. Besides the relationships represented through the control flow, there are also hidden dependencies implicitly given by transitivity or not represented at all. Consider, for example, the relationship between "Weigh luggage" and "Check-in luggage". Currently, weighing the luggage occurs before check-in, but the fact that the luggage is being weighed does not imply the execution of the check-in task. When we resequence the validity check and the cancellation task to identify false documents earlier, the ordering between "Weigh luggage" and "Check-in luggage" does not change, but now the activities co-occur, i.e., they always happen both or none of them, even though they are still executed in sequence since the activity execution order does not change. Such relationships, particularly the existential dependencies, are not given in a BPMN process diagram but are essential for automated BPR support. Thus, we must understand the risks of a changing operation, which relationships are affected, and how to alter them.

4 Background

To collect relevant concepts that need to be considered when assessing a change operation, we first conducted a literature search to identify BPM disciplines related to behavioral BPR. Based on the forward-backward search approach and the initial idea that contextual information supports users in performing BPR tasks presented in [2], we identified the following relevant BPM disciplines: modeling and activity relationships, compliance checking, risk-aware BPM, and context-aware BPM. For each area, we briefly explain the core concepts used in the metamodel presented in the following section.

Business Process Modeling and Activity Relationships. Business Process Modeling deals with the identification, comprehension, and communication of business processes [31]. Its artifact is the business process model, a (visual) representation of the process. It serves as a blueprint for process instances. Modeling languages, such as BPMN, provide a graphical notation to represent activities and their relationships. Relationships are shown by the control flow through direct linking between activities and gateways. Note that not all activity relationships are given explicitly, which is a common problem in business process representations [27]. Often, such relationships are specified in additional descriptions, process artifacts, e.g., data documents, or domain knowledge. Assuming that a relationship encompasses a set of activity dependencies, Sell et al. [27] emphasize the importance of using a dependency model, e.g., [3,6], to explicitly define those relationships. Moreover, process models have a rather descriptive nature and lack explanatory support for users [13]. Adamo et al. [1,2] address the need for providing contextual information on activity relationships. They introduce ontological constraints, i.e., existential dependencies, dealing with the occurrence of activities rather than their temporal ordering to reveal so-called hidden dependencies, i.e., relationships that are not shown in the process model.

Compliance Checking of Business Process Models. The (re)design of business process models requires checking if the model is free of error and if regulations are met [11]. Compliance checking techniques are applied to answer these questions.

We differentiate between *model compliance*, aiming at verifying syntactic and semantic specifications defined by the design properties and *regulatory compliance*, where the business process model compliance is verified towards regulations, e.g., norms. Modeling compliance rules is an opportunity to improve business process models and achieve compliance by design [14]. It highly relates to business process redesign since activity relationships might originate from regulatory compliance rules. Furthermore, it has to be ensured that after a changing operation, the model is compliant with the design properties. Sadiq et al. [25] propose an approach differentiating between business objectives defined by the organization and control objectives capturing regulatory constraints. Based on this approach, Governatori et al. [10] propose a framework to "identify the obligations that will definitely arise in a given process" and which of them are fulfilled or violated. The authors define obligations as regulatory control objectives, i.e., compliance requirements that are mostly specified by external sources, clearly differentiating them from business objectives. Instead of a retrospective checking, the authors address a more proactive way of compliance checking that goes hand in hand with the idea of a preventive approach for business process redesign. Users need to know about violations *before* performing the change operation. The resulting vulnerability, the included risks, and the consequences must be clearly specified.

Risk-Aware Business Process Management. A risk is "the deviation from the expected [...] expressed as [...] potential events [or] consequences" [15, Ch. 3.1] indicating uncertainties and their impact on objectives [28]. Risks are an important phenomenon in BPM and have to be considered when redesigning business processes [21]. Thus, the field of *Risk-Aware BPM* (R-BPM) evolved as the intersection between risk management and BPM [28,16]. R-BPM links process activities to risks and differentiates between *goal risks* threatening the achievement of the business goal, *structural risks* threatening the model's correctness, *data risks* affecting data dependencies or consistency issues, and *organizational risks* threatening compliance rules. Consequences are outcomes of events that can cause further consequences in an escalating manner [15, Ch. 3.6]. Their severity for stakeholders, in combination with the likelihood of a risk occurring, can be used to assess the risk's level of criticality [16]. Consider again the check-in process example at airports. If, for example, the luggage is not weighted, there is a risk that the airplane reaches its maximum capacity and cannot depart due to too much weight. Although this risk has a low probability, its consequences, e.g., delays in airport logistics, lead to severe problems in the process. In this paper, we distinguish between consequences used for defining risks and consequential actions that must be taken to ensure model and regulatory compliance.

Context-Aware Business Process Management. Context is defined as "any information that can be used to characterize the situation of an entity," whereas only context that impacts the control flow, data, and resources is considered relevant [24]. Knowing the internal and external contextual environment of a process is essential to adapt business process behavior. However, business process models are currently designed in isolation, providing prescriptive information about the activity execution order but lacking contextual information [22]. *Context-aware BPM* provides concepts and techniques for context modeling, context learning, and context-aware process operations [22,26]. Different approaches exist to categorize process context. Saidani and Nurcan [26] present four kinds of context, namely location-related context, time-related context, resource-related context, and organization-related context. Rosemann et al. [24] introduce the *onion model*, a context framework differentiating between internal and external context. Whereas the internal layers focus on business objectives, the external layers cover regulatory control objectives for compliance checking [10]. In this paper, we focus on the onion model since it also includes an immediate layer focusing on control flow and central process elements such as data, resources, and applications. Adamo et al. [2] focus on the context of activity relationships, introducing the concept of *explanatory rationales* providing information about the origin and motivation of a relationship. The authors distinguish between norms, goal-related relationships, and the so-called law of nature.

5 Metamodel for Activity Relationship Vulnerability

In general, vulnerability is the quality of being exposed to the possibility of being harmed. In the context of process models, the vulnerability of activity relationships refers to the possibility that this relationship is violated, i.e., changed. It is mainly defined via the origin or motivation of the relationship and includes risks, consequences, and consequential actions. The metamodel in Fig. 2 enhances these concepts given by traditional process models. By analyzing the overlaps between the BPM areas discussed in Section 4 we provide an overview of the information that is needed to assess a change operation for a given process model. The linking between the concepts shown in Fig. 2 and the presented BPM disciplines are highlighted in color so that the influence of the BPM topics on the metamodel can be identified. Concepts related to R-BPM are colored in red, compliance-checking concepts are highlighted in yellow, gray concepts originate from context-aware BPM, and blue-colored concepts relate to process modeling and activity relationships. New concepts that we have added are not colored.

In the following, we introduce the metamodel given in Fig. 2 and illustrate the concepts on our running example (Section 3).

Process, Activities, and Relationships. A business process consists of a finite set of activities that are executed in a coordinated manner to realize a business goal [31]. Dependencies define relationships that exist between any pair of activities. They can be illustrated in an appropriate dependency model, e.g., using the Web Ontology Language (OWL) [6] or the approach introduced in [3]. In our use case, the process describes the check-in procedure at an airport. It consists of nine activities. Several dependencies exist between them, e.g., checking the validity of documents happens *before* canceling the check-in. Such temporal orderings can be derived from process models. Furthermore, the validity check is *required* for a cancellation, indicating an existential dependency that can be identified via interviews as shown in [1].

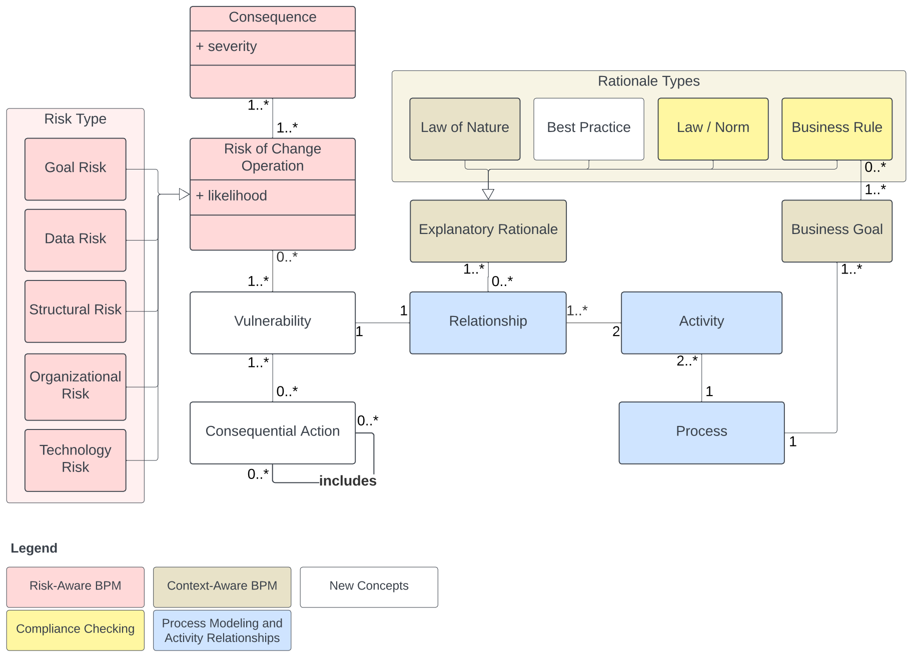

Fig. 2. Metamodel of activity relationships vulnerability for process changes

Explanatory Rationale. Each relationship is further described by explanatory rationales providing contextual information about it, e.g., its origin or motivation [1]. As summarized by the onion model [24], different kinds of context, represented as contextual layers, influence business processes. *Laws and Norms* are usually defined by the external layer. Although laws and norms are different in terms of their consequences, we assign them to the same context layer. For the remainder of this paper, we will use the term *norms* to refer to this category. *Business rules* are defined internally within the organization. Business rules include strategically motivated regulations and relate to the overall goal of the business. *Best practices* are only applied on the immediate layer and are rather a developed way of performing activities based on personal experience than a defined regulation. *Law of nature* as explained in Section 4 can originate from all layers. A law of nature cannot be violated without risking a deadlock that cannot be fixed. Please note that multiple explanatory rationales can apply to a given activity relationship. Several relationships of the process example shown in Fig. 1 are motivated by data dependencies, such as the relationship between "Scan ticket" and "Change seat" (cf. Table 1). To change a seat, it must be known which seat was booked before and to which ticket it belongs. Another law of nature, for instance, exists between transporting the luggage to the aircraft and loading it. The luggage must be physically at the aircraft and ready to be picked up by the staff. How it was transported does not matter.

Table 1. Relationships and their vulnerabilities of the check-in process example, non-violable relationships are marked in gray (D: Data Risk, G: Goal Risk, S: Structural Risk, O: Organizational Risk, LoN: Law of Nature)

	Rationale	**Violable**	**Risk**
Scan Ticket, Change Seat	LoN/Norm/Goal	no	D/G/S/O
Scan Ticket, Check Validity	Norm/Goal	yes	G/S/O
Scan Ticket, Cancel Check-In	LoN/Goal	no	D/G/S
Change Seat, Weigh Luggage	Norm	yes	S/O
Weigh luggage, Load luggage	Norm	yes	S/O
Check-in luggage, Load luggage	LoN	no	D/G/S

Vulnerability. Based on the explanatory rationale, a vulnerability is assigned to the activity relationship. We differentiate between *violable* and *non-violable* relationships. In contrast to a violable activity relationship, a relationship is classified as non-violable if its origin is a law of nature. For example, luggage loading cannot be performed if there is no luggage physically available for loading. Changing the order of these two activities leads to a deadlock as “Load luggage” never gets enabled. Thus, the relationship is marked as *non-violable* (cf. Table 1). In contrast, weighing the luggage before checking in the luggage is violable because it is logically possible to skip this activity. However, it comes with risks. Please note that we refrain from modeling the vulnerability as an attribute of an activity relationship since a violable relationship may be associated with certain risks and consequential actions.

Risk of Change Operation and Likelihood. Process model changes associated with risks. Risks can affect the achievement of the business goal, the structure of the process model, data, technology, or the organization (cf. Section 4). Each risk has a likelihood that helps users assess the severity of violating a relationship. Consider the relationship between “Weigh luggage” and “Load luggage” given in Table 1. Making the luggage weight not mandatory has the risk that the airplane will exceed its maximum weight (organizational risk). Moreover, staff might get hurt because they have to carry weighty luggage (organizational risk).

Consequence and its Severity. If a risk occurs, consequences follow. If the aircraft has too much weight, it cannot take off, causing delays. Passengers might miss their connecting flight and the airline has to deal with compensation. Consequences vary in severity depending on the stakeholder [16]. For example, if the ticket is not scanned before a passenger changes seats, the passenger’s allergies cannot be addressed if specified food preferences do not match the seat. Besides consequences that deal with regulatory or procedural constraints, consequences can also encompass violations in the process model leading to consequential actions.

Consider the resequencing operation again for activity “Check the validity of documents” shown in Fig. 1. Having collected the information from domain experts and structured them according to the metamodel (see Table 1), we can assess a relationship change in terms of vulnerability, risks, and consequences.

Resequencing leads to a change in temporal order between "Scan Ticket" and "Check the validity of documents". As shown in Table 1, we can perform this change operation. However, because the relationship is associated with a structural risk, we know that other activity relationships and dependencies must be changed to ensure model compliance and proper termination. Assuming we resequence both the validity check and the optional cancellation activity, the relationship of "Weigh luggage" and "Load luggage" has to be revisited. As described in Section 3, the existential dependency changes. Whenever the luggage is weighted, it is loaded onto the aircraft. According to Table 1 we can perform the change operation since the relationship originates from a norm[1], i.e., it is violable. Changing this dependency leads to structural and organizational risks.

The example shows that risks and vulnerabilities vary depending on the type of the activity dependency. Moreover, it provides an overview of which relations cannot be changed (highlighted in gray). For example, the relationship between "Scan ticket" and "Change seat" can be changed from an existential point of view, but the temporal order cannot be changed due to the law of nature. Changing the ordering would put the process into a deadlock. At this point, no consequential actions can be performed to recover the process from the damage.

Consequential Actions. If a change operation is performed, several consequential actions can be taken to ensure model and regulatory compliance. Consequential actions addressing model compliance can be checked automatically, whereas consequential actions dealing with regulatory compliance require expert knowledge since they rely on contextual information. Note that a consequential action, e.g., changing another relationship, might include further actions.

6 Evaluation in Context

To evaluate the usability and utility of the proposed metamodel, we conduct a single case study to demonstrate how the presented concepts support the assessment of changing a relationship. We consider the travel reimbursement process at the Technical University of Munich and evaluate the introduced metamodel by looking at three observed change operations that are common practices.

We introduce the use case and changing operations before discussing the results.

6.1 The Travel Reimbursement Process and Change Operations

Based on interviews with administration employees, the travel department, and one employee who has already conducted several travels, we documented the travel reimbursement process. The BPMN process diagram is shown in Fig. 3.

[1] Each aircraft has a maximum weight. Moreover, weighing is required to prevent staff health issues.

If employees want to go on a business trip, they must fill out a travel form and attach appropriate documents proving that it is a business trip as defined by law. This request is then signed by the supervisor. The assistant checks the application, scans it, and mails it to the university's travel department. Scanning is necessary because travel requests could get lost when sending them via postal service. The travel department rechecks the application and approves or rejects it. Employees may only go on a business trip if the application has been accepted. After the trip has been completed, employees can apply for reimbursement of travel expenses. The application is voluntary but must be submitted within the first 6 months after the end of the trip. After the assistant scans the request, it is mailed to the travel department, which checks it. The reimbursable costs will be calculated, and the process ends with initiating the bank transfer.

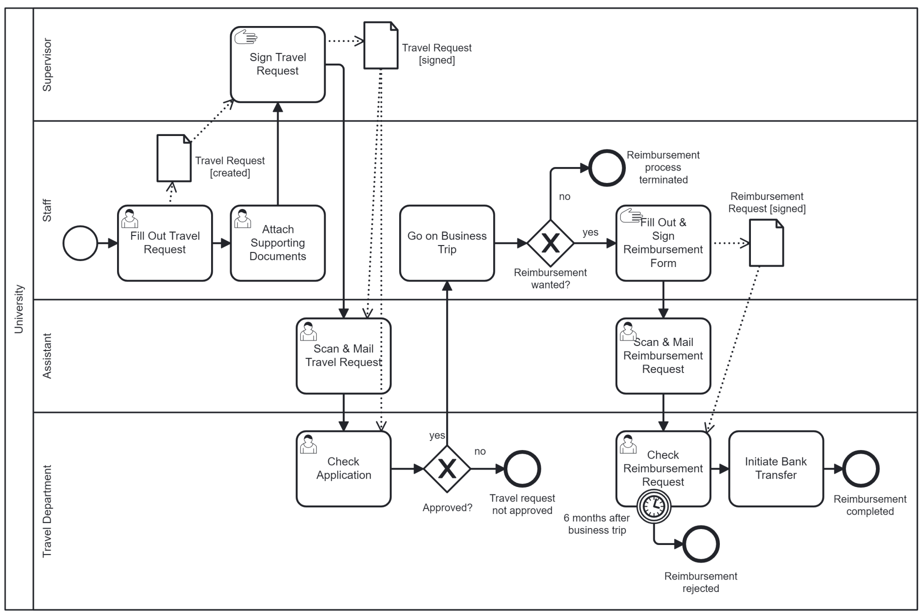

Fig. 3. Travel reimbursement process at universities

The process is primarily determined by the Bavarian Travel Expenses Act[2] and common best practices within the university that have been established over the years. Thus, we identified explanatory rationales by investigating the law and conducting several interviews with the travel department and the administrative assistant. Furthermore, we evaluated each relationship for data dependencies and determined risks, consequences, and severity based on employees' experience.

[2] https://www.lff.bayern.de/themen/reisekosten/reisekosten-allgemeines/ (last access on 18.06.2024)

For this use case, we are examining the following behavioral BPR possibilities:

1) Going on a business trip before the travel request is approved: Parallelize activities “Go on Business Trip”, and the two activities ”Scan & Mail Travel Request” and “Check Application” while preserving the ordering between the latter two.
2) Digitalization of the reimbursement process: Remove activity “Scan & Mail Reimbursement Request” because a software program already checks and forwards the request.
3) Initiate bank transfer before travel request submission: Resequence activities “Initiate Bank Transfer” and “Fill out & Sign Travel Reimbursement Form”.

Due to late invitations or long review processes for conference papers, a business trip request may not always be submitted and reviewed in a timely manner before the trip, resulting in employees may travel without approval. This change is achieved by parallelizing the relevant activities.

The abovementioned process was made digital using a software program that automatically checks travel reimbursement requests. Thus, the manual scan and mail activity is not needed anymore, and it was removed.

The third change operation addresses the employees’ need to have their travel expenses refunded as quickly as possible. In our single-case study, we evaluate this scenario and discuss if the reordering of activities is feasible in this case.

6.2 Results

In the following, we present the results for each scenario. A summary is given in Table 2. Please note that the contextual information presented in Table 2 was identified explicitly for the change operations described above. Thus, the table only shows those activity relationships mentioned in the scenarios above. Long-term relationships are not considered here. For example, the first scenario describes a parallelization between “Go on Business Trip” and the two activities ”Scan & Mail Travel Request” and “Check Application”. Since the ordering between the latter two is preserved, their relationship does not change. Thus, it is not listed in Table 2. Similarly, the relationship between “Fill Out Reimbursement Request” and “Check Reimbursement Request” in the second scenario does not change because the removal of the activity in between does not affect it.

1) Going on a business trip before travel request approval. The ordering between checking the application and going on a business trip is explained via the Travel Expense Act (law). The law clearly defines that going on a business trip without approval is prohibited due to insurance coverage issues. Nevertheless, the explanatory rationale indicates violable relationships, i.e., the parallelization can be performed. It is proven that traveling negatively affects physical health [33]. Typical travel illnesses include gastrointestinal problems like diarrhea, minor injuries, insect bites, or colds[3]. However, more serious illnesses might necessitate a

[3] `https://www.itilite.com/blog/business-travel-challenges` (last access on 01.03.2024)

Table 2. Relationships, vulnerabilities, risks, and consequences of the travel reimbursement process

Relationship	Explanatory Rationale	Violable	Risk (likelihood)	Consequence (severity)
Scenario 1)				
Scan&Mail Travel Request, Go on Business Trip	Business Rule	yes	Organizational (low)	Process delay (low)
Check Application, Go on Business Trip	Norm	yes	Organizational (low)	Costs not covered (high)
Scenario 2)				
Fill Out Reimb. Request, Scan&Mail Reimb. Request	Business Rule	yes	-	-
Scan&Mail Reimb. Request, Check Reimb. Request	Business Rule	yes	-	-
Scenario 3)				
Fill Out Reimb. Request, Initiate Bank Transfer	Law of Nature, Norm	no	Organizational, Goal (high)	Deadlock, Accounting (high)

hospital stay. Most people rank this risk low. However, the consequences can be severe. If the business trip is not approved, the costs will not be covered by the employer's insurance, and the researcher may potentially be left with expenses. The relationship between scanning and mailing the request and going on a business trip is based on a business rule. There is no technical support for handing in travel requests. Thus, the documents are sent via post. Associated risks are of an organizational nature since mailing the documents after going on a business trip might cause delays in the process, which are considered low in severity.

2) Remove Scanning and Mailing of Documents. The origin of the relationships between filling out the reimbursement request, scanning and mailing it, and finally checking it is based on business rules and best practices. Thus, the relationships are violable. The risk of documents getting lost in the post does not exist anymore because the travel request is now handled via an IT system. Thus, there are no associated risks or consequences with deleting the activity "Scan & Mail Reimbursement Request". From a data perspective, checking the request only depends on the "Fill Out & Sign Reimbursement Form" activity. The scanning and mailing of the request can be omitted. To check a request, it has to be created, i.e., it has to exist, which was done in the previous activity. Such contextual analysis of the explanatory rationales reveals optional process parts, e.g., the activity "Scan & Mail Reimbursement Request". In fact, the digitalization of the process did not violate any non-violable relationships. However, a more detailed analysis would have shown that changing the activity to an optional one is also possible; it does not have to be removed.

3) Initiate the bank transfer before submitting a travel request. Bank transfers require data such as the recipient, the amount of money you want to transfer, the recipient's IBAN, and the BIC. To obtain the data, a request must be made orally via a call or in a written format through a formal document. Thus, we can identify two explanatory rationales: a law of nature due to data dependency and a norm, as the travel expense law requires requesting the reimbursement of travel expenses in written form. Since the relation is based on a law of nature, it is non-violable. The risks include organizational risks; if the request is made orally, the university risks the discovery of an error in accounting, which could lead to serious consequences. Additionally, the goal of reimbursed costs is also at risk, as a different order could lead to a deadlock since the bank transfer cannot be initiated. This risk is very high, and the consequences are also severe. Therefore, this change operation should not be performed.

6.3 Discussion

The evaluation shows that explanatory rationales and vulnerabilities not given by the BPMN process diagram can be identified if the contextual environment is accessible via documentation or stakeholders who can be interviewed. Risks and consequences can also be derived in a feasible manner. This shows the usability of the presented metamodel, i.e., it is feasible to collect the required information.

Nevertheless, the information was collected manually. For more complex business processes, we expect this task of information extraction to be extremely cost-intensive and time-consuming. More structured techniques, e.g., questionnaires and interviews, might help identify relevant contextual information.

In the shown use case, we neglect long-term relationships and consequential actions within the process model. Changing an activity relationship might also violate other relationships not explicitly shown in the process model. An overview of all affected relationships and their adjustment is necessary to ensure consistency and proper termination of the process model. Related work [3,1,2] already introduces approaches to capture these dependencies and could be used as a foundation for developing an algorithm for detecting consequential actions as stated in the metamodel.

Besides usability, the evaluation also shows the utility of the metamodel. Differentiating between violable and non-violable relationships helps us decide whether relationships are changeable and supports identifying flexibility in processes. Relationships that are not based on a law of nature are changeable and, thus, offer possibilities for flexible process behavior. The overview of risks and consequences helps to assess the implications of a change operation. Furthermore, it helps to understand the overall process and creates awareness of the individual orderings and dependencies. Although the level of detail in defining risks, consequences, and explanatory rationales depends on the available data, the evaluation shows that the concepts presented provide a sufficient overview. All concepts are correct and relevant to the problem of assessing change operations, which proves the feasible validity of the metamodel according to Lindland et al. [17]. Feasible completeness is also achieved since the metamodel would not benefit significantly from adding more concepts.

7 Conclusion and Future Work

Automatized support for business process redesign is still one of the biggest challenges in the BPM community [5]. This paper focuses on behavioral BPR, i.e., the redesign of activity relationships, and presents a metamodel that introduces essential concepts to assess behavioral change in process models. Changing activity relationships in process models is thus examined more profoundly by defining the relationship's vulnerability based on its origin and motivation and by considering the risks and consequences. Thus, the metamodel represents the first step towards automated support for behavioral BPR. After having defined what we need to know, we can extend our research to extracting the required information from domain knowledge. Currently, we are investigating the potential of large language models and questionnaires to compare automized and manual approaches. Furthermore, approaches such as [20,32] present techniques to derive relevant dependencies based on process models and textual descriptions and can serve as a foundation. Future work includes a formalization of change operations on an activity dependency level as introduced in [3] and an automized dependency detection and downwelling[4] adjustment to recover consequential damages to the process model. Having formalized the dependencies between activity relationships and the concrete change operations, we can then work on a semi-automatized tool that integrates the contextual information when guiding users in BPR tasks.

In this paper, we focus on change operations at the type level. However, change operations can also be performed at an instance level. Risks might change in likelihood, and consequences may change in severity. Consider again the example of making the luggage weighing optional. The likelihood that the airplane reaches its maximum weight with one overweight suitcase is lower compared to implementing the change on a model level. Similarly, the risk of a worker getting back problems because of one overweight suitcase is relatively low. In contrast, the likelihood increases if the worker has to load several overweight suitcases in a row. Furthermore, we only looked at assessing change operation at design time. However, contextual information on activity relationships is even more essential for changing a process at runtime to ensure proper termination. Thus, we see great potential in the presented approach to enhance, for example, the so-called change patterns introduced by Weber et al. [30].

In addition to business process redesign at design and runtime, the metamodel also promises enhanced business process repair. Change operations derived from process behavior observed in the event log can be assessed before implementation. Furthermore, we also see a potential use case in characterizing business processes since identifying process flexibility is supported by the metamodel.

[4] Downwelling in terms of a cascading effect, i.e., a chain of adjustments needed to recover consequential damages

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