Discovering Organizational Models from Event Logs for Workforce Analytics (Extended Abstract)

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Abstract

This PhD research aims to develop process mining approaches to support workforce analytics and improve business process management. It presents a set of novel data-driven methods to systematically construct and analyze organizational models, which can be utilized for guiding organizational structure design and staff deployment toward process improvement.

Keywords

Process mining, event log, organizational model, workforce analytics, organizational model discovery, conformance checking, business process management

1. Introduction

Organizations today operate in a rapidly changing world. Leaders of organizations need to have a deep insight into their employees in order to streamline business processes and increase competitiveness. Many are exploring opportunities to apply workforce analytics and understand how human resources act in groups [1] to deliver organizational outcomes.

Process mining holds high promise for achieving successful workforce analytics. It enables analysts to exploit event logs — readily available data [2] that records how human resources participated in actual process execution — and extract accurate and timely insights into employee performance and collaboration [3]. A relatively underexplored subfield of process mining, *organizational model mining* [4, 5, 6], is concerned with the study of groups of human resources, specifically how models can be derived from event logs to reflect resource groupings in process execution. However, existing methods for organizational model mining are not fully up to the task of supporting analyses of human resource groups.

Our research reveals three major gaps in the literature, as illustrated in Figure 1. First, event logs recording process execution typically encompass multiple dimensions including case, activity, and time. Existing organizational model mining methods mainly focus on exploiting the activity dimension, but rarely consider the case and time dimensions. This inattention to multidimensional information is limiting, when resource groupings need to be considered across different cases (e.g., specialist groups dedicated to particular customers) or across different time periods (e.g., employees playing the same role but working different shifts). Second,

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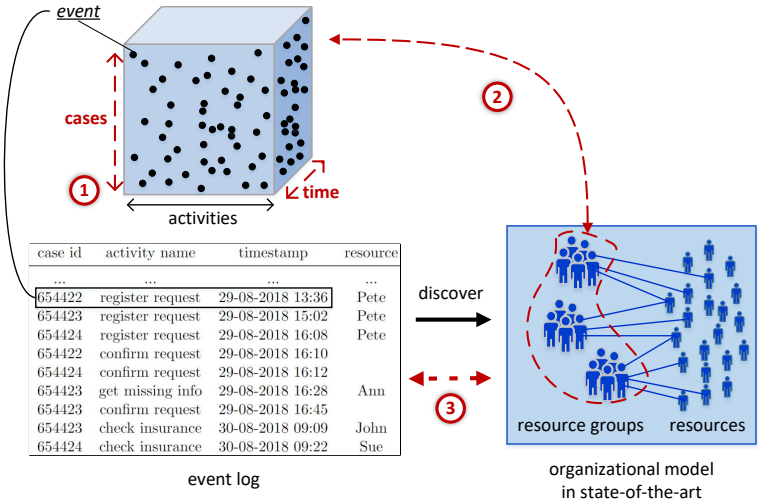
organizational models discovered by existing methods often do not transcend the mere clustering of resources — they do not describe how the discovered resource groups were involved in process execution. Therefore, they are not very helpful in analyzing and understanding the behavior of resource groups. Last but not least, existing methods rely on either domain knowledge or technique-specific, intrinsic measures to evaluate discovered models. A generic evaluation approach, which can assess discovered models against the input event logs, remains absent.



case id	activity name	timestamp	resource
...	...	...	...
654422	register request	29-08-2018 13:36	Pete
654423	register request	29-08-2018 15:02	Pete
654424	register request	29-08-2018 16:08	Pete
654422	confirm request	29-08-2018 16:10	
654424	confirm request	29-08-2018 16:12	
654423	get missing info	29-08-2018 16:28	Ann
654423	confirm request	29-08-2018 16:45	
654423	check insurance	30-08-2018 09:09	John
654424	check insurance	30-08-2018 09:22	Sue

Figure 1: An illustration of the three research gaps identified in state-of-the-art organizational model mining research: (1) lack of consideration for the multidimensional information recorded in event logs; (2) missing interpretation of discovered resource groups in terms of their involvement in process execution; and (3) absence of evaluation between input event logs and discovered models.

2. Research Approach and Outcomes

In light of the identified research gaps, this PhD thesis sets out to develop novel organizational model mining methods. It extends state-of-the-art process mining by addressing several research questions (RQ). Figure 2 provides an overview of the research in this thesis.

RQ1. How can organizational models be discovered from event log data?

First, we propose *a new, rich notion of organizational model* as the foundation of a novel framework for organizational model mining from event logs. Compared to the literature, the new organizational models consider multiple dimensions of process execution, captured by the notion of *execution contexts*, where events (instances of human resource performing activities) are categorized by their respective case types, activity types, and time types. The new organizational models can link relevant process execution information with resource groupings. As such, they can be used to represent more comprehensive knowledge about resource groups and their involvement in processes.

Building on the new notion of organizational model, we introduce *a conceptual framework for organizational model mining*, namely *OrdinoR* [1] [8]. The *OrdinoR* framework formulates

[1] *Ordino* means "to arrange" in Latin; the trailing letter *R* stands for "resources".

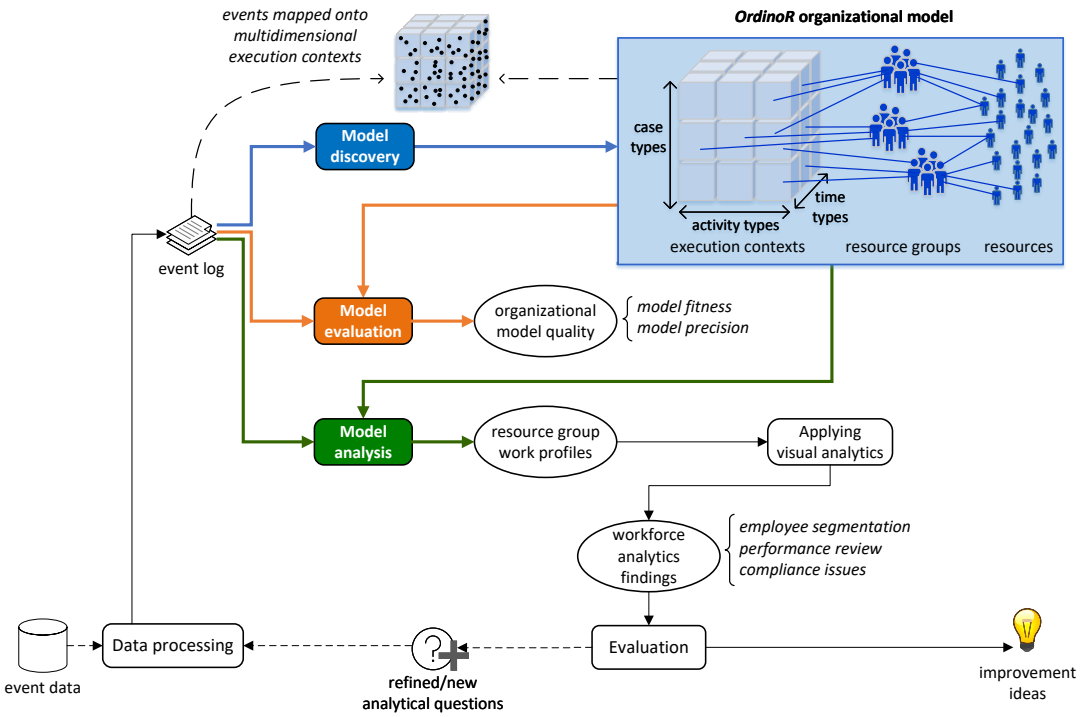


Figure 2: An overview of this PhD research, including the proposed notions and methods, and their usage as process mining techniques in context of the Process Mining Project Methodology [7]. We propose a new, rich notion of organizational model and introduce a novel framework (namely *OrdinoR*) for the discovery, evaluation, and analysis of organizational models using event logs (addressing RQ1). *OrdinoR* organizational models may be applied to derive resource group work profiles and be used to analyze resource group performance in process execution (addressing RQ2).

three types of organizational model mining task, i.e., discovery, evaluation, and analysis. Model discovery aims to construct organizational models to characterize the grouping of resources and their involvement in actual process execution recorded by event logs. Model evaluation aims to assess organizational model quality with respect to an event log. Model analysis aims to examine the performance of resource groups captured in organizational models and provide information to support workforce analytics.

For model discovery, we propose *a systematic approach to discovering organizational models from event logs* [9, 8]. It is capable of incorporating user domain knowledge and constructing organizational models from event logs with a minimum set of standard attributes. Specifically, this approach addresses three concrete model discovery tasks, presenting alternative methods for each task: (i) *learning execution contexts* to characterize the specialization of resources from multiple dimensions, applying decision-tree- and simulated-annealing-based rule induction; (ii) *discovering resource grouping* to identify clusters of resources with shared characteristics, applying hierarchical clustering and model-based clustering; and (iii) *profiling discovered resource groups* to determine resource group capabilities in process execution, by ranking execution contexts where groups had the highest participation and contribution. We then conduct a series of experiments on five real-life event logs to evaluate the proposed model discovery approach

under various configurations.

For model evaluation, we introduce two measures, *fitness* and *precision* [8]. These measures are the first of its kind in process mining, providing a generic basis for assessing the quality of discovered organizational models with respect to event logs. They can be used to evaluate organizational models without relying on domain knowledge of existing organizational models or technique-specific measures.

For model analysis, we formulate a set of *quantitative measures for analyzing the behavior of resource groups* [8] based on an organizational model and an event log, considering resource group workload distribution and the contribution by group members.

Knowing how organizational models may be extracted from event logs and how they represent knowledge about resource groups, the next step is to investigate the application of such models to support workforce analytics. Therefore, this thesis also investigates the following question.
RQ2. How can organizational models be exploited to analyze resource group performance in process execution?

We extend the measures proposed for organizational model analysis and formulate the notion of *resource group work profile* [10]. This notion is developed based on reviewing the management literature on human resource performance measurement. Resource group work profiles encompass an array of *indicators* as informed by the management literature. These indicators can be extracted from event logs and organizational models and be applied to measure various aspects relevant to how resource groups and their members work in process execution. Furthermore, we also introduce an approach to applying visual analytics to work profiles extracted from data. It enables tracking, comparing, and correlating resource groups' performance — across group and individual levels, over different time periods, and related to various process dimensions.

We built open-source software tools [2] [3] to implement the proposed research artifacts. The organizational model discovery methods, as well as the measures for model evaluation and analysis, are implemented in the tools.

3. Conclusion and Future Work

This research contributes to the field of process mining from the organizational perspective [2]. Specifically, it addressed three research gaps concerned with organizational model mining by (i) utilizing multidimensional event log information for model discovery, (ii) improving the interpretability of organizational models by capturing resource group involvement in process execution, and (iii) enabling a generic method for assessing the quality of discovered models with model evaluation and model analysis measures. Furthermore, our approach to extracting and analyzing resource group work profiles presents a novel means to exploit discovered organizational models for analyzing resources and their groupings. This enhances the practical use of organizational model mining.

Outcomes from this research pave a number of avenues for future process mining research. Notably, the model evaluation and model analysis measures form the basis for *conformance checking of organizational models with respect to event logs*, in terms of both *global conformance*

[2]The OrdinoR library for organizational model mining: https://royjy.me/to/ordinor
[3]Prototype performing visual analytics of resource group work profiles: https://royjy.me/to/gwp-demo

and *local diagnostics*. To do so, it will be necessary to investigate questions around encoding existing resource and organizational models in conventional forms (e.g., role-based access control models, rosters, organizational charts) into *OrdinoR* models. Organizational model conformance checking will subsequently inform novel process mining approaches to support using process execution data to guide the design of process-oriented organizational structures (e.g., role designation and employee team composition) and staff deployment alongside evolving business processes. In the meantime, our approach contributes to the precise modeling of resources and resource groups in process execution and therefore will benefit process simulation from the organizational perspective. The integration of process simulation of organizational model mining offers improved solutions to scenario-based workforce planning concerned with processes. Last but not least, the generic definition of *OrdinoR* organizational models allows for extensions to capture more complex relations among resources and their groups, for example, hierarchy in organizations and reporting relations. This opens opportunities to connect organizational model mining with other process mining tasks from the organizational perspective, e.g., discovering social network among resources to capture handover and cooperation [4].

This research also contributes to bridging process mining with the field of human resource management on the topic of workforce analytics. We introduced event logs as a useful data source capturing the execution of end-to-end processes, and how event logs may be exploited for group-oriented workforce analytics using our approaches. This contributes toward addressing some key challenges in workforce analytics, with regard to inconsistent recording of human resource performance and its disconnection from analysis of organizational performance [1].

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