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Decision Support Systems

A framework for efficiently mining the organisational perspective of business processes☆

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ABSTRACT

Process mining aims at discovering processes by extracting knowledge from event logs. Such knowledge may refer to different business process perspectives. The organisational perspective deals, among other things, with the assignment of human resources to process activities. Information about the resources that are involved in process activities can be mined from event logs in order to discover resource assignment conditions, which is valuable for process analysis and redesign. Prior process mining approaches in this context present one of the following issues: (i) they are limited to discovering a restricted set of resource assignment conditions; (ii) they do not aim at providing efficient solutions; or (iii) the discovered process models are difficult to read due to the number of assignment conditions included.

In this paper we address these problems and develop an efficient and effective process mining framework that provides extensive support for the discovery of patterns related to resource assignment. The framework is validated in terms of performance and applicability.

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1. Introduction

Business process management (BPM) is a well accepted method for structuring the activities carried out in an organisation, analysing them for efficiency and effectiveness, and identifying potential for improvement [1]. Processes are not always explicitly defined when the process models are designed. Actual process executions may constitute a valuable input for improving process design. Process mining provides methods for automatic process analysis, among others for discovering processes by extracting knowledge from event logs in form of a process model. Various algorithms are available to discover models capturing the control-flow of a process, related to the behavioural perspective of the process [2, 3]. For perspectives like the organisational perspective, which manages the involvement of human resources in processes, only partial solutions for mining have been developed despite the importance of resource information not only for performance but also for compliance analysis [4–7].

The need to better support the organisational perspective was evidenced by previous approaches that mined this perspective [8–13]. Prior work in this area focused on discovering specific aspects of the organisational perspective such as role models, separation of duty or social networks. However, comprehensive and integrated support for the well-established workflow resource patterns, and specifically in this context for the so-called creation patterns [14], was missing. Furthermore, the close interplay between the organisational and behavioural perspectives was disregarded [15].

In Ref. [16] we addressed these gaps by developing a declarative process mining approach for the organisational perspective, which supports all the creation patterns as well as what we called cross-organisational patterns, which discover how the involvement of resources influences the control-flow of the process.

The research reported in this paper extends our prior work towards an efficient and effective mining framework. As illustrated in Fig. 1, the framework is divided into an event log pre-processing phase, a phase for integrated resource mining including cross-perspective patterns, and a model post-processing phase. We evaluate our approach with an implementation of the three phases; with simulation experiments for measuring performance; and with the application of the approach on a real-life event log for checking its effectiveness.

This research extends our previous work [16] as follows: (i) the developed pre-processing method increases the efficiency of the
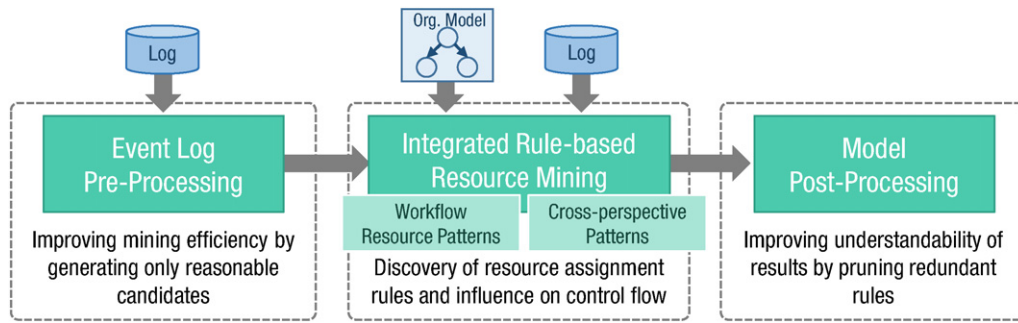
Fig. 1. Framework for discovering resource-aware, declarative process models.

approach; (*ii*) the developed post-processing techniques increase the understandability of the results; (*iii*) a prototype of the entire framework has been implemented using Drools; and (*iv*) the approach has been extensively validated. In addition, the mining approach is explained in more detail. With our work, we complement research on process mining with an extensive support of the organisational perspective.

The remainder of this paper is structured as follows: Section 2 introduces background information. Section 3 describes our process mining approach. Sections 4 and 5 describe the event log preprocessing and postprocessing phases of the framework, respectively. Section 6 explains the evaluations performed. Section 7 describes the related work and Section 8 concludes the paper.

2. Background

In the following we introduce the concepts upon which our approach has been developed.

2.1. Organisational and cross-perspective patterns in processes

The well-known workflow resource patterns [14] capture the various ways in which resources are represented and utilised in business processes. Of specific interest to our research are the creation patterns since they describe different ways in which resources can be assigned to activities. These patterns, which will be referred to as *organisational patterns* from now on, include: *Direct Distribution*, or the ability to specify at design time the identity of the resource that will execute a task. *Role-Based Distribution*, or the ability to specify at design time that a task can only be executed by resources that have a given role. *Organisational Distribution*, or the ability to offer or allocate activity instances to resources based on their organisational position and their organisational relationship with other resources. *Separation of Duties*, or the ability to specify that two tasks must be allocated to different resources in a given process instance. *Case Handling*, or the ability to allocate all the activity instances within a given process instance to the same resource. *Retain Familiar* (a.k.a. *Binding of Duties*), or the ability to allocate an activity instance within a given process instance to the same resource that performed a preceding activity instance. *Capability-Based Distribution*, or the ability to offer or allocate instances of an activity to resources based on their specific capabilities. *Deferred Distribution*, or the ability to defer the specification of the identity of the resource that will execute a task until run time. *History-Based Distribution*, or the ability to offer or allocate activity instances to resources based on their execution history. Note that the creation patterns *Authorisation* and *Automatic Execution* are not in the list because they are not directly related to resource assignment.

It has been identified that process control-flow is intertwined with dependencies upon resource characteristics [15]. For instance, sometimes an activity must be executed eventually before another one for specific resources but not for others. As an example, resources with a certain role (e.g., trainees) must always perform a certain activity (e.g., double-check result) before they can continue with the following activity, but this might not be required for other roles (e.g., supervisors). We call this pattern *Role-Based Sequence*.

A specific collection of such *cross-perspective patterns* capturing these situations has not been defined. Nonetheless, in general, they can be defined by combining the aforementioned organisational patterns with the control-flow patterns described in Ref. [17]. The *Resource-Based Response* pattern, e.g., describes that for a special resource a certain activity has to follow eventually on another activity.

The organisational and cross-perspective patterns constitute the set of patterns to be discovered by our framework.[1]

2.2. Event logs for mining the organisational perspective

Our mining approach takes as input (*i*) *an event log*, i.e., a machine-recorded file that reports on the execution of tasks during the enactment of the instances of a given process; and (*ii*) *organisational background knowledge*, i.e., prior knowledge about the roles, capabilities and the membership of resources to organisational units, among others. In an event log, every process instance corresponds to a sequence (*trace*) of recorded entries, namely, *events*. We require that events contain an explicit reference to the enacted task and to the operating resource. Both conditions are commonly respected in real-world event logs [2]. For instance, the following excerpt of a business trip process event log encoded in the XES logging format [18] shows the recorded information of the *start event* of activity *Apply for trip* performed by resource *ST*.

```
<event>
    <string key="org:resource" value="ST"/>
    <date key="time:timestamp" value="2013-08-06T14:58:00.000+01:00"/>
    <string key="concept:name" value="Apply for trip"/>
    <string key="lifecycle:transition" value="start"/>
</event>
```

2.3. Representing the output of the mining

Since our aim is to discover the patterns explained in Section 2.1, the modelling language to represent the discovered processes must offer the possibility to define (*i*) expressive organisational patterns

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[1] Therefore, when we speak about mining the organisational perspective we refer to both sets of patterns.