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Workflow simulation for operational decision support

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ABSTRACT

Simulation is widely used as a tool for analyzing business processes but is mostly focused on examining abstract steady-state situations. Such analyses are helpful for the initial design of a business process but are less suitable for operational decision making and continuous improvement. Here we describe a *simulation system for operational decision support* in the context of workflow management. To do this we exploit not only the workflow's *design*, but also use logged data describing the system's observed *historic* behavior, and incorporate information extracted about the current *state* of the workflow. Making use of actual data capturing the current state and historic information allows our simulations to accurately predict potential near-future behaviors for different scenarios. The approach is supported by a practical toolset which combines and extends the workflow management system YAWL and the process mining framework ProM.

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1. Introduction

Business process simulation is a powerful tool for process analysis and improvement. One of the main challenges is to create simulation models that *accurately* reflect the real-world process of interest. Moreover, we do not want to use simulation just for answering strategic questions but also for tactical and even operational decision making. To achieve this, different sources of simulation-relevant information need to be leveraged. In this paper, we present a new way of creating a simulation model for a business process supported by a workflow management system, in which we integrate design, historic, and state information.

Fig. 1 illustrates our approach. We consider the setting of a *workflow system* that supports some *real-world process* based on a *workflow and organizational model*. Note that the workflow and organizational models have been designed before enactment and are used for the configuration of the workflow system. During the enactment of the process, the performed activities are recorded in *event logs*. An event log records events related to the offering, start, and completion of work items, e.g., an event may be 'Mary completes the approval activity for insurance claim XY160598 at 16.05 on Monday 21-1-2008'.

The right-hand side of Fig. 1 is concerned with enactment using a workflow system while the left-hand side focuses on analysis using simulation. In order to link enactment and simulation we use three types of information readily available in workflow systems to create and initialize the simulation model.

- *Design information.* The workflow system has been configured based on an explicit process model describing control and data flows. Moreover, the workflow system uses organizational data, e.g., information about users, roles, groups, etc.

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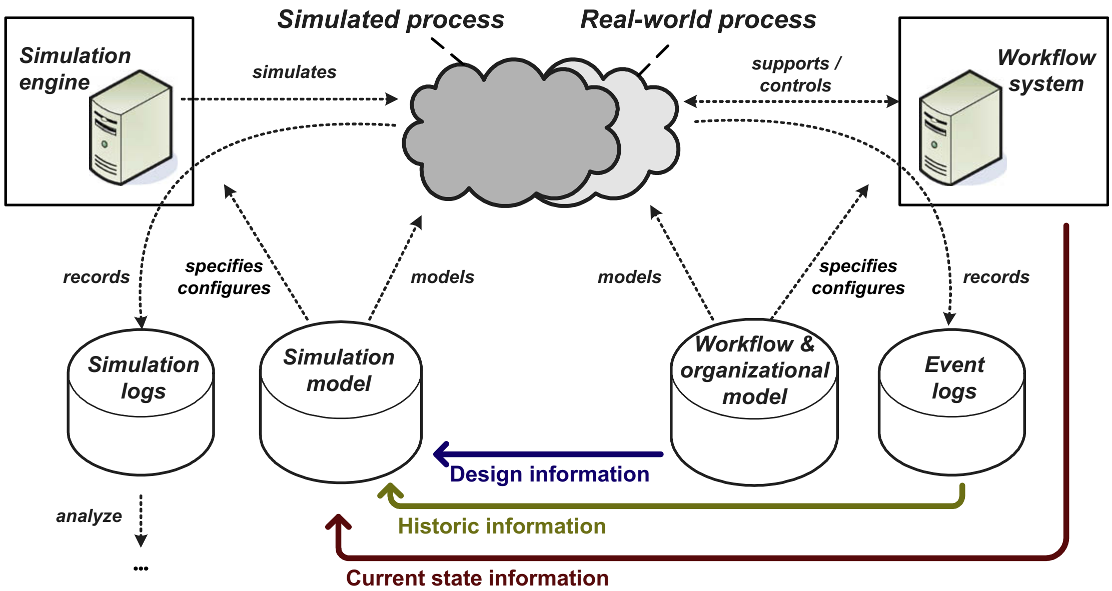

Fig. 1. Overview of our integrated workflow management (right) and simulation (left) system.

- *Historic information.* The workflow system records all events that take place in 'event logs' from which the complete history of the process can be reconstructed. By analyzing historic data, probability distributions for workflow events and their timing can be extracted.
- *State information.* At any point in time, the workflow process is in a particular state. The current state of each process instance is known and can be used to initialize the simulation model. Note that this current state information includes the control-flow state (i.e., 'tokens' in the process model), case data, and resource data (e.g., resource availability).

By merging the above information into a simulation model, it is possible to construct an *accurate model based on observed behavior* rather than a manually-constructed model which approximates the workflow's anticipated behavior. Moreover, the state information supports a 'fast-forward' capability, in which simulation can be used to explore different scenarios with respect to their *effect in the near-future*. In this way, simulation can be used for *operational decision making*.

Based on this approach, the system design in Fig. 1 allows different simulation experiments to be conducted. For the 'as-is' situation, the simulated and real-world processes should overlap as much as possible, i.e., the two process 'clouds' in Fig. 1 need to coincide. For the 'to-be' situation, the observed differences between the simulated and real-world processes can be explored and quantified. In our implementation we ensure that the simulation logs have the same format as the event logs recorded by the workflow system. In this way we can use the *same tools* to analyze both simulated and real-world processes.

To do this, we need state-of-the art *process mining* techniques to analyze the simulation and event logs and to generate the simulation model. To demonstrate the applicability of our approach, we have implemented the system shown in Fig. 1 using ProM [1] and YAWL [2]. YAWL is a workflow management system that, as reported in this paper, has been extended to provide high-quality design, historic, and state information. The process mining framework ProM has been extended to merge the three types of information into a single simulation model. Moreover, ProM is also used to analyze and compare the logs in various ways.

In [3] three common pitfalls in current simulation approaches were presented.

(1) *modeling from scratch rather than using existing artifacts*, which leads to mistakes and unnecessary work,
(2) *focus on design rather than operational decision making*, which is helpful for the initial design of a business process but less suitable for operational decision making and continuous improvement,
(3) *insufficient modeling of resources*, i.e., the behavior or resources is typically modeled in a rather naïve manner.

This paper addresses the first two pitfalls. While addressing the third problem is a challenging research topic in itself [3], we concentrate here on the first two problems. That is, we integrate existing artifacts that can be extracted from a workflow system into a ready-to-use simulation model, and we incorporate the current state of the workflow system in our simulation model to enable short-term simulation.

This paper extends our previous work [20], in that we go into more detail about the architecture of the realized system, describe the generated simulation models and how they can load a specified initial state more closely, and present a new XML file format for workflow states that enables other workflow systems to interface with our tools in a standardized way.

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