Event-Driven Process-Centric Performance Prediction via Simulation

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Abstract. Today's fast, competitive and extremely volatile markets exert a great deal of pressure on businesses to react quicker against the changes, and sometimes even before the changes actually happen. A late action can potentially result in a legal compliance failure or violation of service level agreements (SLA's). A business analyst needs to be notified before these failures and violations occur. This paper proposes an approach that enables real-time and process-centric decision support in the form of performance prediction as an application of Event-Driven Business Process Management (EDBPM). The ability of simulations to produce future-events, which are of the same type like the live-events generated by the really executed business process, is utilised. Live-events and simulated future-events can therefore be treated by a Complex-Event Processing (CEP) engine in the same way and parameters representing the historic, current, and future performance of the business process can be easily computed.

Keywords: event-driven business process management, business process simulation, performance decision support, operational excellence, complex event processing.

1 Introduction

In order to achieve an organisation's objectives, tasks are usually carried out in certain ways, i.e. workflows are defined to express activities and their order of execution. This behavioural information is captured in business process models [1].

Business processes need to change and evolve continuously in order to meet the rapidly changing market contexts, user requirements and business imperatives. The ability of reacting pro-actively on these changes is a crucial feature for an organisation. Additionally, business processes are typically composed of parts offered by different providers, spread across different geographical locations, and are managed with different modelling and execution environments. One step towards a continuous Business Process Management (BPM) for such distributed and heterogeneous businesses is the application of Event-Driven Business Process Management (EDBPM) techniques.

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In this paper an EDBPM solution for process-centric performance prediction in real-time is proposed in which simulation is utilised for the purpose of prediction. With this approach it is possible to provide a rather process-centric than data-centric view. The process-centric approach embeds the information into the actual business process context, thereby enables the identification of the root causes of deviations from SLA's by the detection of bottlenecks, exceptions, risks and non-compliances at the process activity level.

This paper is structured as follows: In Section 2, essential background information about BPM in general and EDBPM in particular is provided. Then in Section 3, a solution for event-driven and process-centric performance prediction in real-time is proposed. Work related to that topic is discussed in the following Section 4. The paper is concluded thereafter in Section 5.

2 Event-Driven Business Process Management

Event-Driven Business Process Management (EDBPM) is a recently coined term that emerged from the combination of the two disciplines Business Process Management (BPM) and Complex Event Processing (CEP) [2].

BPM is defined in [3] as follows: *"Supporting business processes using methods, techniques, and software to design, enact, control, and analyze operational processes involving humans, organizations, applications, documents, and other sources of information."*. Part of the definition is BPM's lifecycle which essentially includes four phases as shown in Figure 1: First is the *Configure* phase where the business processes are orchestrated and configured. Second is the *Execute* phase in which the business process is actually executed. Third is the *Analyse* phase where the running business process is monitored and data is collected for quantitative process analysis, process efficiency analysis, etc. The last phase is the *Decide* phase where decisions about the resolution of the identified problems are made and then implemented again in the configuration phase.

CEP, on the other hand, deals with the event-driven behaviour of large, distributed enterprise systems [5], i.e. events produced by the system are captured, selected, aggregated, and eventually abstracted to generate complex events representing high-level information about the situational status of the system. To put it into the BPM lifecycle perspective, a business process is executed as part of the second phase and produces events whenever a state change in the business process occurs. These events are usually of a simple nature and often only comprise raw and direct data information, like process instance id, timestamp, and type of the state change, e.g. `2011-05-26 T 10:45 CET: Activity ''Check availability'' completed, pi-id: 253`, but not the state of the whole system [6]. With CEP these events can be processed and information about the business performance can be computed, e.g. process instance occurrence, activity net working time.

The extraction of performance parameters from live-events is a common application of real-time monitoring of business processes, which is in general called Business Activity Monitoring (BAM) and constitutes the third phase of the

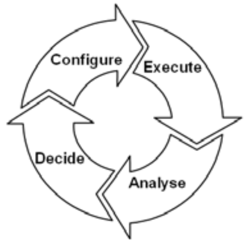

Fig. 1. Loop for continuous business process improvement [4]

BPM lifecycle [6]. BAM, in turn, is often related to EDBPM as the real-time or near real-time approach of monitoring of events with a CEP engine to support BPM suits this task perfectly. Usually single live-events are not of interest in the context of BAM, instead the aggregation of these into performance related parameters is carried out [7]. In this way, flaws within a business process can be detected in real-time and responsible entities can be notified immediately.

As stated in the beginning of this section, EDBPM is an approach to link BPM and CEP. Practically, this is realised by two individual platforms interacting with each other through interfaces or events, one a BPM system, which is to model, manage, and optimise a business, and the other one a CEP engine [8].

3 Event-Driven Performance Prediction via Simulation

The solution proposed in this paper enhances the BAM capabilities of producing real-time performance parameters related to business processes with the ability to further predict the future trends of these parameters. One first approach would be using the existing traditional data-centric Business Intelligence (BI, [9]) tools to predict each parameter individually based on its history only. However, this approach does not consume the workflow information of the business processes, provided by the BPM suites. A number of the performance parameters, such as *process instance occurrence* and *activity net working time*, are workflow independent, i.e. there future development can be predicted directly by analytical approaches. In contrast, other performance parameters, such as *activity throughput* and *end-to-end processing time*, are dependent on the workflow. The beneficial effect of using simulation for predicting these parameters is illustrated in Figure 2. The predicted throughput of *Activity 2* (bottom right graph) is more accurate as it takes the throughput of *Activity 1* into account, which supposedly has a delayed impact on the throughput of *Activity 2*. This way, predictions based on simulations that utilise not only the history data but the workflow information potentially produce better results.

In Figure 3 the framework for providing real-time analytics in the sense of performance predictions via simulation is depicted along with data flow and involved components; Flows of raw data events like live- and future-events are depicted as fine grained arrows; processed performance data as coarse grained arrow; common

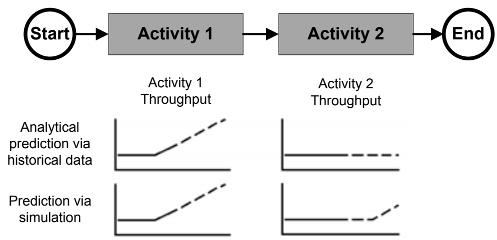

Fig. 2. Beneficial effect of prediction via simulation exemplified

data exchange via services as uninterrupted arrows. In this framework the simulation's ability to produce future-events, which are of the same type as the live-events, is utilised in a way that requires only minimal adaptations in the CEP engine.

The prediction framework operates as follows: The business processes are executed by the "BP Execution Environments" where live events are produced continuously. These real-time events contain raw data like discussed in the previous section. The "Event Processing Engine" captures and aggregates these events to compute the current state of the system as well as performance related data independent from the workflow information. As these parameters change over time, their future development has to be predicted by analytical methods based on their historical data. A simulation engine, e.g. implemented as discrete event simulation [10], takes the current state of the system, the potential devel-

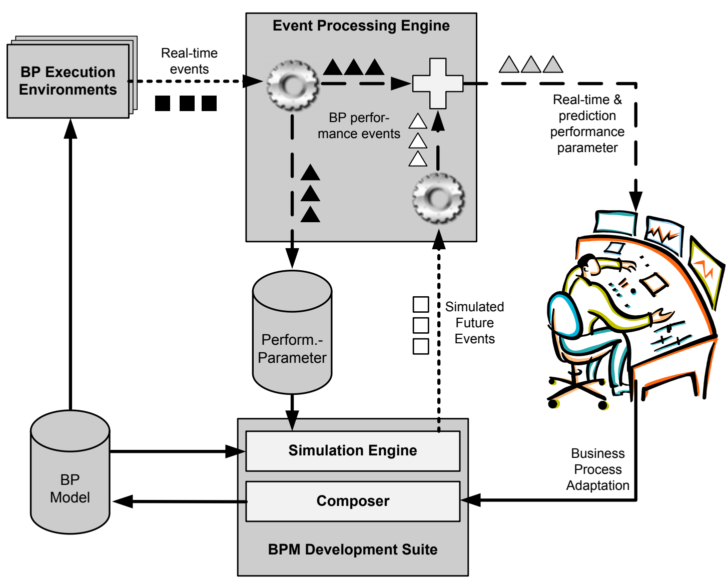

Fig. 3. Data flow of the event-based framework for real-time performance prediction

opment of the workflow independent performance parameters, and the workflow information provided by the business process model as input to simulate the near future. The results are passed in form of raw data events directly back to the "Event Processing Engine". There, these future-events are processed just like the live-events. The available historic, current, and future performance data is then merged and further processed, e.g. by presenting the results in a dashboard, sending warning notifications if a future SLA violation is predicted, or trigger more complex events. The self-adaptation of both, the business processes or the analysis engine would be possible examples for these complex events. Based on the predicted results, responsible causes can be determined and the business process can be pro-actively adapted, accordingly. This way, SLA violations can be avoided and continuous performance decision support for operational excellence is provided.

4 Related Work

Before an event processing is possible the events have to be made available, i.e. the "BP Execution Environment" needs to be able to produce events. Some execution environment do not offer this possibility but only create business logs. To address this problem in [11], the Slipstream framework is introduced which enables event-driven business activity monitoring, taking business logs as input and creating real-time events whenever a state change is noticed.

Also closely related to the paper's topic is the research work in [12]: A business process optimisation loop including simulation as a mean for performance parameter computation and process adaptation is proposed. In this solution a simulation engine is interposed into the event processing in a similar way as proposed in our approach. However, only performance ascertainments and what-if analyses are supported but no predictions.

Common BI tools already offer many possibilities for data-centric performance predictions. These predictions are, however, based on mathematically extracted functions of the historical development of corresponding parameters and do not normally take the workflow information into account [13].

5 Conclusion and Outlook

In this paper an EDBPM solution for process-centric performance prediction in real-time is proposed, for which the ability of simulations to produce future-events similar to live-events is utilised to additionally provide future trend information. The general design benefit of our proposed performance prediction approach is the straightforward integration of the simulation engine: It consumes the processed performance data to create future-events that are transmitted back into the CEP engine.

In contrast to existing performance prediction solutions in BI the paper's approach takes the workflow information available via the business process models into account and is event-driven, i.e. offers process-centric performance prediction in real-time. However, it has not yet been evaluated if and in which way the prediction via simulation is a better approach than a direct parameter prediction based on the parameter's historical data. This examination is considered to be future work.

Furthermore, the next step would be to integrate advanced analyses like optimisations into the loop and, based on their results, an intelligent adaptation of the business process would be performed. Rather than just providing manual decision support, this approach would then enable the framework to automatically react on changes or avoid future violations without any human interaction, e.g. by instant resource rescheduling. The realisation of a feedback loop for this purpose is, however, a very intricate issue in general, e.g. because of the fact that design tools used for adaptation and reconfiguration of business processes are commonly operated manually.

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