Modeling and Monitoring Processes exploiting Semantic Reasoning

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Abstract. Data about process executions has witnessed a notable increase in the last decades, due to the growing adoption of Information Technology systems able to trace and store this information. Meanwhile, Semantic Web methodologies and technologies have become more and more robust and able to face the issues posed by a variety of new domains, taking advantage of reasoning services in the "big data" era. In this demo paper we present *ProMo*, a tool for the collaborative modeling and monitoring of Business Process executions. Specifically, by exploiting semantic modeling and reasoning, it enables the reconciliation of business and data layers as well as of static and procedural aspects, thus allowing business analysts to infer knowledge and use it to analyze process executions.

1 Introduction

The last decades have witnessed a rapid and widespread adoption of Information Technology (IT) to support business activities in all phases. As a side effect, IT systems have made available huge quantities of data about process executions, thus enabling (i) to monitor the actual execution and the progress of (instances of) Business Processes (BPs); (ii) to provide statistical analysis; (iii) to detect deviations of process executions from process models (e.g., [1]); and (iv) to identify problems in process executions.

Meanwhile, Semantic Web technologies have known an important growth and have made available powerful reasoning services able to reason on complex domains, as well as technologies able to deal with huge quantities of data. This opens the way to the use of Semantic Web technologies for process modeling and monitoring and for the analysis of processes characterizing complex scenarios as those of large organizations.

In these complex scenarios, knowledge can be classified in two orthogonal ways. First, we distinguish between a *dynamic dimension*, which concerns the procedures and the activities carried out by the organization for realizing specific objectives, and a *static dimension*, which concerns the organization structure (e.g., the role hierarchy), the data structure (e.g., the document organization), and the relationships among these and other domain entities. Then, knowledge can be ascribed to two layers: the *IT layer*, which concerns the actual data items processed by IT systems; and the *business layer*,

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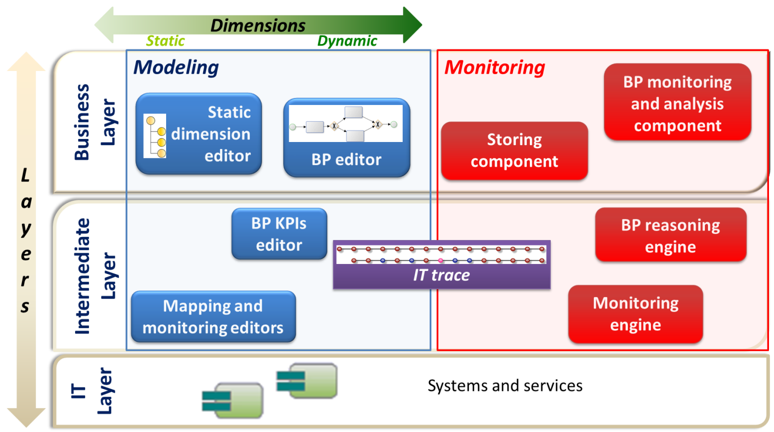

Fig. 1: *ProMo* overview

which concerns the models of the dynamic and static aspects of the organization domain. Given this frame, two main challenges need to be faced: (i) bridging the unavoidable gap between the business and the data layer; and (ii) reconciling the static and dynamic dimensions so to make them available for monitoring and analysis purposes.

In this demo we present and showcase *ProMo*, a tool that exploits Semantic Web technologies to address the above challenges through an integrated representation of knowledge, enabling the collaborative modeling, monitoring and analysis of business processes. By reconciling all these different dimensions and layers, *ProMo* overcomes existing approaches. In the remainder we describe how *ProMo* reconciles the business and IT layers and the static and dynamic dimensions, introducing the *ProMo* main components that will be demonstrated live during the Posters and Demo session.

2 Reconciling Business and IT layers

Aligning the business and IT layers is a difficult task. For example, process monitoring at the IT layer cannot observe data exchanged on paper documents or user activities not mediated by IT systems, and thus brings only partial information on which activities were executed and what data or artifacts they produced. Even when IT data exists, it is not easy to associate it to a specific process instance. Indeed, IT services can be shared by process classes and instances, and traced information can be hard to disambiguate.

ProMo solution to this problem is based on the introduction of an *intermediate layer* (Figure 1), which enables the communication between the business and the IT layers through an intermediate model. Such a model formalizes the relationships between business models and information extracted at the IT layer and relies on the integrated representation of all the information collected about a process execution (the *IT-trace*).

To accomplish its goal, *ProMo* integrates a *modeling* component and a *monitoring* component. At the business level, the *modeling* component provides *MoKi-ProMo*, a customized version of the MediaWiki-based[3] tool MoKi [2] for the collaborative modeling of processes and ontologies. At the intermediate layer *ProMo* provides (i) mapping

[3] http://www.mediawiki.org

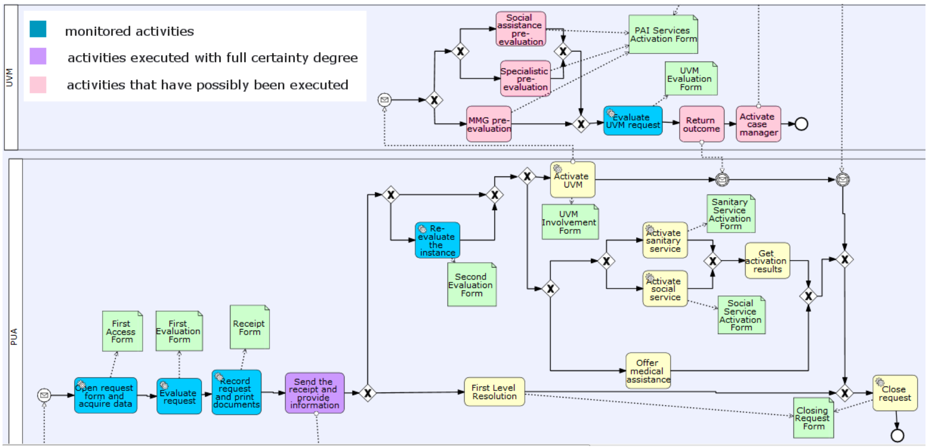

Fig. 2: *MoKi-ProMo* visualization of a reconstructed (partial) trace

and monitoring editors that allow *IT Experts* (taking advantage of the *Domain Experts* modeling) to specify, respectively, aggregation/monitoring rules and the relationships between business models and the information extracted at IT level; and (ii) an editor for defining interesting Key Performance Indicators (KPIs) to be monitored. Specifically, the input required at the intermediate layer is provided by experts by using the DomainObject language [3] for defining mapping properties, an ad-hoc rule language for monitoring rules, and SPARQL queries for business KPIs.

At run-time, whenever an IT-level event occurs, it is captured and handled by the monitoring component. In detail, the event is managed by the monitoring engine, which, based on the specification and rules defined at design-time, correlates and aggregates events, produces new control events, monitors and maps the events to the corresponding one(s) at the business layer and eventually produces the IT-trace. The information in the IT-trace, which in many cases is only partial with respect to a complete execution flow of a designed process model, is hence passed to a reasoning engine. Such an engine, by taking advantage of the business knowledge, reconstructs missing information by applying model-driven satisfiability rules [4] and the reconstructed trace is then visualized by the BP monitoring and analysis component. Figure 2 shows how a reconstructed (partial) execution trace is visualized in *MoKi-ProMo*, pointing out the path possibly taken by the process execution and distinguishing between monitored and reconstructed (with some certainty degree) activities. The reconstructed IT-trace is then recorded in a semantic-based knowledge store, which is then queried by the BP monitoring and analysis component in order to provide monitoring services at business level. An implementation built on top of current Semantic Web technologies aims at coping with large quantities of data and high data rates typical of real application scenarios.

3 Reconciling Static and Dynamic Dimensions

Although different in their nature, static and dynamic knowledge about an organization domain are strictly related and should be jointly considered in order to obtain a comprehensive view of the organization processes. Importantly, reconciliation of these two dimensions should be done both at the business layer, allowing an explicit representation of the links between static and dynamic model elements (e.g., the fact that a process activity operates on a certain document), and at the data layer, allowing the collection, integration and comprehensive querying of static and procedural data.

At the business layer, *ProMo* solution is represented by the modeling component of *MoKi-ProMo*, which allows different experts (e.g., *Business Designers*, *Knowledge Engineers* and *Domain Experts*) to collaboratively model the different static and dynamic aspects describing the domain (see Figure 1). Specifically, *MoKi-ProMo* allows *Domain Experts* and *Knowledge Engineers* to collaboratively model the static aspects of the domain in form of OWL 2 ontologies. Concerning the dynamic aspects, *MoKi-ProMo* customizes the *Oryx* editor[4] for the BPMN modeling of business processes by introducing symbol variations (e.g., special data objects for explicitly capturing data structures). Moreover, *MoKi-ProMo* also provides an interface allowing *Business Analysts* and *Domain Experts* to edit KPIs of interest, thus enabling them to access IT data from a (static and dynamic) business perspective.

At the IT layer, *ProMo* solution consists in exploiting a Domain ontology [5], consisting of an upper-level cross-domain core and a domain-dependent extension, and a BPMN [6] ontology to build an integrated semantic model combining static and procedural knowledge acquired at modeling time, together with knowledge about IT-data. By leveraging scalable Semantic Web technologies for data storage, reasoning and querying, the semantic model enables *Business Analysts* to query asserted and inferred knowledge and bring execution data analysis at business level. In particular, analytical SPARQL queries combining static and dynamic dimensions with data derived from the IT-layer can be formulated and evaluated, such as the number of times a path is followed or an actor instance executes a business activity, or the average time spent by an actor of a given category to complete the process. Experiments carried out in the context of an Italian use case have shown the applicability of the approach in realistic scenarios [5].

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[4] http://bpt.hpi.uni-potsdam.de/Oryx/