Challenges of Smart Business Process Management: An Introduction to the Special Issue

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Abstract

This paper describes the foundations of smart business process management and serves as an editorial to the corresponding special issue. To this end, we introduce a framework that distinguishes three levels of business process management: multi process management, process model management, and process instance management. For each of these levels we identify major contributions of prior research and describe in how far papers assembled in this special issue extend our understanding of smart business process management.

Keywords: Business Process Management, Smart Technologies

1. Introduction

Today's business world is complex and characterized by an extensive division of labor. Products and services are designed and delivered with various actors being involved within the providing organization and beyond. In order to deliver products and services in a smooth way, it is of utmost importance that the coordination between the different actors inside and outside the providing organization is well defined. A first step towards a smooth operation

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is achieving transparency of the business process that results in product and service delivery. This transparency can be achieved by documenting the business process including the various actors involved, the activities they perform, the events and decisions that influence the progress, and the information that is produced and consumed [1, 2].

Division of labor in business processes calls for coordination support by the help of information systems. The specific class of information systems that explicitly support business processes is often referred to as process-aware information systems [3]. Office automation systems [4, 5], workflow management systems [6, 7], and recent business process management systems [1, 2] all support process execution based on a specification of the process as a formal business process model.

Business process management is concerned with all management activities around business processes. In the past, activities in relation to business process management have been conducted by process analysts, process managers and process engineers in a labor-intense fashion with hardly any automatic support except for generating the system configuration from the executable process model. This has been changing in recent years. Various smart techniques have been developed to automate or provide more intelligent support for process stakeholders in various stages of business process management. This special issue provides ten excellent examples of these recent developments towards smart business process management. This editorial presents them in an overarching framework and connects them with the broader spectrum of recent contributions on smart business process management.

2. Business Process Management

In this section, we distinguish three different levels of business process management. Figure 1 shows these three levels and their connections. The top level is often referred to as multi process management. It is concerned with the identification of the major processes of an organization and the regular evaluation of the priorities assigned to these processes. These activities interrelate with questions of strategic management and the overall process organization. The products of multi process management are often stored in a central process repository. The conceptual structure of this repository is also referred to as the process architecture.

The middle level is concerned with the management of a single process.The management activities on this level are often referred to as the

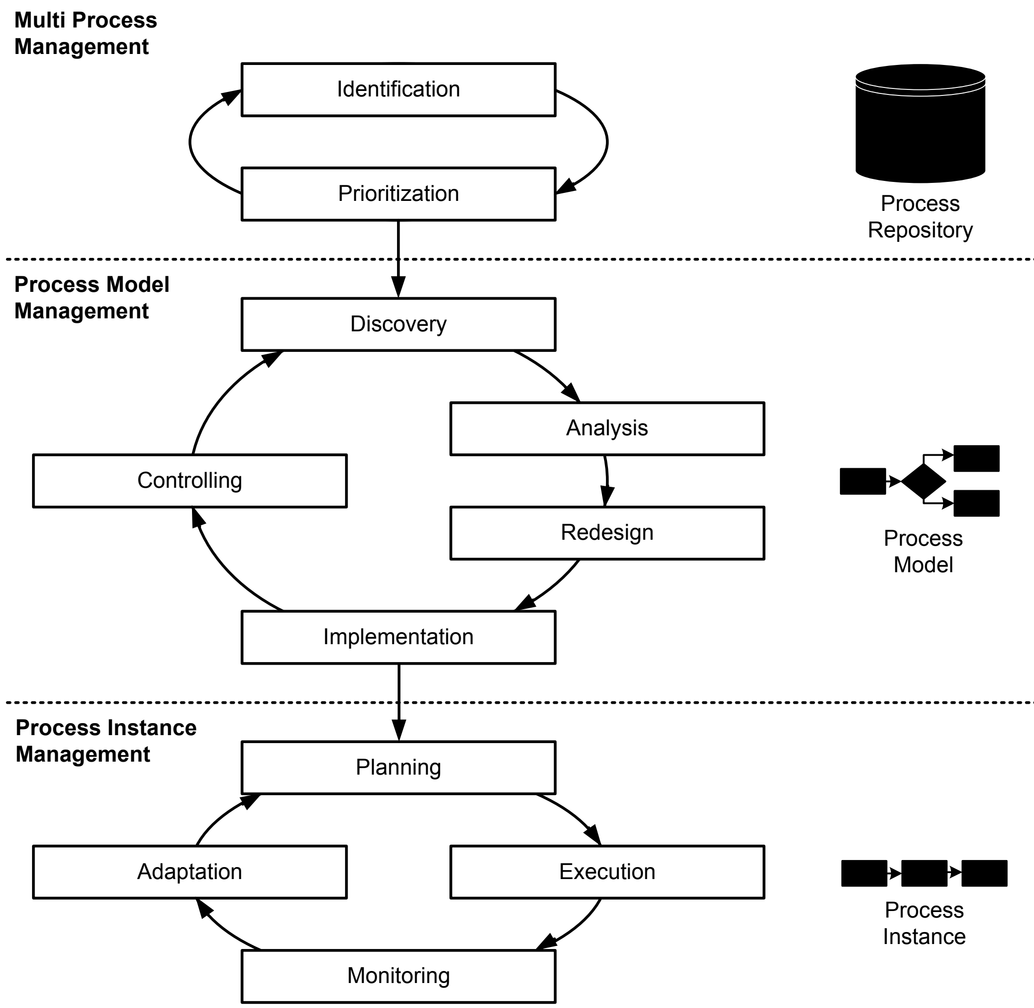

Figure 1: Three Levels of Business Process Management

BPM lifecycle [1]. This lifecycle is started once a process is selected for redesign. First, this process is documented in the discovery phase resulting in an as-is process model. Second, the process is analyzed using qualitative and quantitative analysis techniques. In this way, weaknesses and issues can be uncovered. Third, different directions for redesign are investigated in order to fix the issues and generally improve the performance of the process. This yields a to-be process model as a specification of how the process is meant to operate in the future. Fourth, this to-be process model is taken into implementation. The corresponding information systems are designed or reconfigured and staff is trained to work according to the new setup. Fifth, once the process has been executed for a period of time according to the new design, process controlling checks to which degree performance and conformance objectives are met. Process mining can be used to extract knowledge about how the process operates

The focus of the bottom level is the management of singular process instances. Instances can be planned regarding when their activities are scheduled and which resources should be involved. With or without such a schedule, process activities are executed according to the rules defined in the process model. Process monitoring continuously checks rules such as quality-of-service assertions and trigger alerts if undesired behavior is observed. Such alerts might be the reason for adapting the course of execution for an individual process instance.

Research into process mining [8] has resulted in various automatic analysis techniques that support different activities of business process management. We refer to them as smart business process management.

3. Smart Business Process Management

The Oxford dictionary provides the following three connotations for smart: (i) being clean and tidy, (ii) showing quick-witted intelligence and (iii) being quick[1]. All these meanings together have become a prominent attribute of information technology and analysis techniques in various application domains referred to as smart home, smart health, smart city, smart energy or smart mobility. What is common to these smart technologies is that they integrate sensors, actuators, connectivity and analytics [9]. What they facilitate is

[1] https://en.oxforddictionaries.com/definition/smart

preemptive action and coordination which is grounded in evidence, history data, state information and intelligent algorithms [10]. Since business process management is exactly concerned with coordinated action, there have been attempts to generalize the commonalities of these smart application scenarios in terms of their dynamic adaptation and continuous learning towards smart business process management [11, 12].

This section provides an overview of various techniques that are related to smart business process management. We also clarify how the contributions of this special issue relate to the overall spectrum of research in this area. Next, we explicate the notion of smartness in the context of information systems research. Then, we illustrate the richness of smart business process management by highlighting important contributions for each of the three levels.

3.1. Smart Multi Process Management

Prior research on smart multi process management has mainly focused on supporting repository management. This stream of research was triggered by work on similarity [13] and automatic matching techniques between business process models [14]. These provided the foundation for various automatic refactoring techniques [15] including harmonization of terminology [16], automatic service derivation [17], semantic search [18] or operations of merging business process models [19].

This special issue extends this stream of research with novel contributions on process model matching. Both *Meilicke et al* [20] and *Klinkmüller and Weber* [21] contribute to the effectiveness of automatic techniques for process model matching. The latter, *Klinkmüller and Weber*, contribute to the effectiveness of automatic techniques for process model matching. They investigate the importance of control flow information for the matching problem and combine a novel order relationship score with a bag-of-words approach in their self-configuring OPBOT matcher. The evaluation with standard datasets demonstrates the benefits of OPBOT.

Meilicke et al [20] build on the availability of various matchers from prior research. They introduce a voting technique that integrates process model constraints in a Markov Logic based optimization. Their evaluation demonstrates performance improvements over prior techniques.

This special issue introduces novel directions for smart multi process management. *Kratsch et al* [22] emphasize that various strategies have been proposed for prioritization of processes, but none does appropriately take dependencies in process networks into account. For their D2P2 prioritization approach, they simulate dependency-adjusted process performance using stochastic processes. D2P2 is implemented as a software prototype and evaluated using event logs data from the BPI Challenge.

Polyvyanyy et al [23] present an overall framework for process querying. It describes generic components of a querying architecture and corresponding querying methods. The framework is unique as it also addresses concerns on the level of smart process model management and smart process instance management. Various concepts and methods are aligned with this architecture using a systematic literature review.

3.2. Smart Process Model Management

There is a rich repertoire of prior research on smart process model management. Several challenges and solutions are listed in survey articles including [24, 25, 26]. Various techniques have been proposed to directly support the process of process modeling during the discovery phase, [27] is a recent example. Pattern recognition is used during the analysis phase to detect potential weaknesses [28]. The redesign phase is often supported by heuristics such as the ones summarized in [29]. Also recent technologies like crowdsourcing [30] bear the potential to be used here. The implementation phase is classically supported by workflow management technology [6]. Recent extensions provide smart support for automatic service composition [31] and process configuration [32]. Smart knowledge extraction from process-related data is often referred to as process mining. Contributions on process mining help to automatically discover models from data, check the conformance between model and execution, and derive information on decision probabilities and execution durations [8]. Such information partially informs the controlling phase, in which the process is evaluated relative to its performance and conformance objectives [33].

This special issue complements these diverse streams of research in the following ways. *Claes et al* [34] investigate strategies that help to model business processes in a well organized way. Their Structured Process Modeling Method (SPMM) is supported by an automated modeling strategy selection and a training instrument. The benefits of the method is demonstrated in a controlled experiment with 149 master students.

The work of *Suriadi et al* [35] focuses on resource behavior in business processes. They develop a mining technique that provides insights into the way how resources prioritize their work. The technique is evaluated using synthetic and real-world event logs.

Wynn et al [36] address the problem of exploring performance data of business processes in an effective way using visualisation. They propose a visualisation framework called ProcessProfiler3D for supporting the comparison of process performance based on event logs. Their implementation is validated in a user study with industry partners.

vanden Broucke and De Weerdt [37] develop a robust and flexible heuristic process discovery technique called Fodina. Key features of this technique are good performance in terms of process model quality and the ability to mine duplicate tasks. Fodina is tested on various event logs showing good performance in terms of F-measure.

Martin et al [38] are concerned with the identification of batch behaviour in business processes. They introduce a batch organisation of work identification algorithm called BOWI, which provides insights into batch processing by the help of work metrics. The algorithm is evaluated with synthetic and real-world event logs.

3.3. Smart Process Instance Management

Prior research investigates different management aspects of process instances. The planning phase is considered in different works on scheduling [39, 40], elasticity [41], and semantic technologies [42]. Process execution is typically implemented using state and transition concepts such as provided by Petri nets. Recent research investigates the representation of these concepts by the help of blockchain distributed ledger technologies [43]. Monitoring is an important concern in order to secure that performance and conformance stays within expected ranges. Work on AB-BPM [44] is inspired by AB-testing and combines it with process automation in a self-regulatory way. Adaptation is an important mechanism for handling unforeseen situations. Various works describe approaches to help achieving flexibility at runtime [45].

This special issue extends this stream of research with an approach that helps to predict the behavior of a process instance, which can inform process planning and execution. Evermann et al [46] define their prediction approach based on deep learning. The approach is implemented and evaluated using the BPI 2012 data sets. The results illustrate the impact of various types of information on the prediction performance and the overall viability of the approach.

4. Future Research on Smart Business Process Management

The research reported in this special issue provides a solid foundation for future research into smart business process management. This research will have to address challenges within the three levels of business process management and across them.

There is potential for future research within levels. On the level of the process repository, it is striking to note that research on the integration of repositories with external knowledge resources has come to a pause. Around the year 2000, the MIT Process Handbook [47] provided a promising starting point for helping organizations to discover process innovation opportunities. Mendling et al [26] describe specific challenges in this area including the discovery of ontologies from repositories and the categorization of models.

On the level of singular models, there are various opportunities to integrate existing analysis and redesign techniques with information generated from sensory data. For instance, the potential of process innovation in the retail sector based on RFID technology is highlighted in [48] as much as in the logistic sector based on AIS transponder data in [49]. Social media has been often discussed with a focus on product innovation, but there is also the potential to more intensively leverage it for process innovation, too, e.g. in the public sector [50].

There are also various opportunities for managing process instances in a smarter way using available sensor data. Indeed, many smart initiatives such as smart home, smart health, smart city, smart energy or smart mobility have an inherent behavioral perspective, which has affinity with coordination challenges of business process management. Clearly, smart technologies bear the potential for novel ways of planning, executing, monitoring and adapting process instances based on the integration of sensors, actuators, connectivity and analytics.

Finally, there is also the potential to intensify research that spans across the different levels. Most of the research across levels is currently focused on (i) moving from implementation to execution and (ii) from execution to mining and controlling. What is scarce is research that builds a bridge between the process repository and process instances. Questions in this context might relate to the consistency between the multi process perspective and the process instance perspective: in how far does the abstract description of the process landscape align with what is actually done on the transactional level? Furthermore, novel techniques that generate abstract views on an organization from a process perspective based on instance data could be highly informative to top management, in particular if it provided performance insights.

New information technology keeps on emerging and new concepts and algorithms are developed to work with process-related data. These will shape the way how business processes are managed in the future in a smarter way as we know it today.

Acknowledgements

We thank the authors of the papers collected in this special issue and the editor-in-chief James Marsden for comments on this editorial. The work of Jan Mendling has received funding from the EU H2020 programme under the MSCA-RISE agreement 645751 (RISE BPM).

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