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Guest editorial

Advances in business process management

M. Weske [a], W.M.P. van der Aalst [b,*], H.M.W. Verbeek [b]

[a] *Hasso Plattner Institute for Software Systems Engineering, University of Potsdam, Potsdam, Germany*
[b] *Department of Information and Technology, Faculty of Technology Management, Eindhoven University of Technology, P.O. Box 513, Eindhoven 5600 MB, Netherlands*

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1. Introduction

This special issue of *Data & Knowledge Engineering* contains extended versions of four papers selected from the best papers of the "International Conference on Business Process Management: On the Application of Formal Methods to Process-Aware Information Systems" that took place in Eindhoven (The Netherlands) in June 2003. To put the contributions to this special issue into a wider perspective, we first provide a brief overview of the scientific and practical issues in the context of Business Process Management (BPM) systems, followed by a brief introduction of the selected papers.

2. Definition of BPM and related topics

Today there is a wide variety of Business Process Management (BPM) systems using labels like Workflow Management (WFM), Case Handling (CH), Enterprise Application Integration (EAI), Enterprise Resource Planning (ERP), Customer Relation Management (CRM), etc., which is creating a lot of confusion. Therefore, we first propose the following definition of a business process management system:

> A generic software system that is driven by explicit process designs to enact and manage operational business processes.

* Corresponding author. Tel.: +31-40-247-4295; fax: +31-40-243-2612.
E-mail addresses: mathias.weske@hpi.uni-potsdam.de (M. Weske), w.m.p.v.d.aalst@tm.tue.nl (W.M.P. van der Aalst), h.m.w.verbeek@tm.tue.nl (H.M.W. Verbeek).

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The system should be process-aware and generic in the sense that it is possible to modify the processes it supports. The process designs are often graphical and the focus is on structured processes that need to handle many cases.

Many people consider business process management to be the 'next step' after the workflow wave of the 1990s. Therefore, we use workflow terminology to define business process management. The Workflow Management Coalition (WfMC) defines workflow as [7]:

> The automation of a business process, in whole or part, during which documents, information or tasks are passed from one participant to another for action, according to a set of procedural rules.

A WorkFlow Management System (WFMS) is defined as [7]:

> A system that defines, creates and manages the execution of workflows through the use of software, running on one or more workflow engines, which is able to interpret the process definition, interact with workflow participants and, where required, invoke the use of Information-Technology (IT) tools and applications.

Note that both definitions emphasize the focus on enactment, i.e., the use of software to support the execution of operational processes. In the last couple of years, many researchers and practitioners started to realize that the traditional focus on enactment is too restrictive. As a result new terms like business process management have been coined. There exist many definitions of business process management, but in most cases it clearly includes workflow management. We define business process management 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.

Note that this definition restricts business process management to operational processes, i.e., processes at the strategic level or processes that cannot be made explicit are excluded. Note that systems supporting business process management need to be 'process aware', i.e., without information about the operational processes at hand little support is possible.

Fig. 1 shows the relationship between workflow management and business process management using the BPM life cycle. This life cycle describes the various phases in support of operational business processes. In the design phase, the processes are (re)designed. In the configuration phase, designs are implemented by configuring a process aware information system (e.g., a workflow management system). After configuration, the enactment phase starts where the operational business processes are executed using the system configured. In the diagnosis phase, the operational processes are analyzed to identify problems and to find possible improvements.

The focus of traditional workflow management (systems) is on the lower half of the BPM life cycle. As a result, there is little support for the diagnosis phase. Moreover, support in the design phase is limited to providing an editor, while analysis and real design support are missing. It is remarkable that few workflow management systems support simulation, verification, and vali-

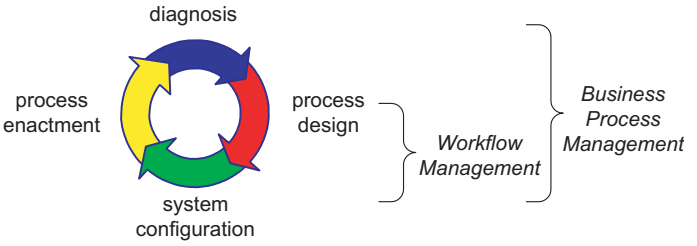

Fig. 1. The BPM life cycle to compare WFM and BPM.

dation of process designs. It is also remarkable that few systems support the collection and interpretation of real-time data. Note that most workflow management systems log data on cases and tasks executed. However, no tools to support any form of diagnosis are offered by the traditional systems.

Currently, many workflow vendors are positioning their systems as business process management systems. Gartner expects the BPM market to grow and also identifies *Business Process Analysis* (BPA) as an important aspect [5]. It is expected that the BPA market will continue to grow. Note that business process analysis covers aspects neglected by traditional workflow products (e.g., diagnosis, simulation, etc.). *Business Activity Monitoring* (BAM) is one of the emerging areas in business process analysis. The goal of BAM tools is to use data logged by the information system to diagnose the operational processes. An example is the ARIS Process Performance Manager (PPM) of IDS Scheer [6]. ARIS PPM extracts information from audit trails (i.e., information logged during the execution of cases) and displays this information in a graphical way (e.g., flow times, bottlenecks, utilization, etc.). Business activity monitoring also includes process mining, i.e., extracting process models from logs [3]. As such, business activity monitoring creates a number of scientific and practical challenges (e.g., which processes can be discovered and how much data is needed to provide useful information).

When it comes to redesigning operational processes, two trends can be identified: *Straight-Through Processing* (STP) and *Case Handling* (CH). Straight-through processing refers to the complete automation of a business process, i.e., handling cases without human involvement, and is often only possible if the process is redesigned. Moreover, straight-through processing is often only possible for a selected set of cases. The latter means that cases are split into two groups:

1. cases that can be handled automatically (in Dutch these cases are called "Gladde gevallen") and
2. cases that require human involvement.

By separating both groups it is often possible to reduce flow time and cut costs. While straight-through processing strives for more automation, case handling addresses the problem that many processes are much too variable or too complex to capture in a process diagram [1]. In case handling, the normal route of a case is modeled, but at the same time other routes are allowed if not explicitly excluded. One way to do this is to make workflows data-driven rather than process-driven and allow for authorizations to skip or undo activities. Also, the focus is on the case as a whole rather than on individual work-items distributed over work-lists.

To summarize: business process management extends the traditional workflow management approach by support for the diagnosis phase (cf. business process analysis and BAM software) and allowing for new ways to support operational processes (cf. case handling and straight-through processing). In the remainder, we focus on the scientific foundations and current technology.

3. BPM in more detail

Based on the definition of business process management just introduced, we provide a characterization of its main concepts. Moreover, the technology currently available is discussed. Some of the key aspects of business process management already mentioned in the previous section are re-visited, and the current state of available technology and emerging standards are discussed.

One of the main aspects and certainly an activity typically carried out in early phases of business process management projects, is the design of business processes. There is a close relationship between business process design and business process modeling, where the former refers to the overall design process involving multiple steps and the latter refers to the actual representation of the business process in terms of a business process model using a process language. To this end, the term business process modeling is used to characterize the identification and (typically rather informal) specification of the business processes at hand. This phase includes modeling of activities and their causal and temporal relationships as well as specific business rules that process executions have to comply with.

Business process modeling has a decade long tradition, and a variety of products are commercially available to support this phase, based on different process languages. Given this situation, it is not surprising that the selection of a particular product is an important step in many BPM projects, and, consequently, appropriate selection criteria have been studied extensively. Besides organizational, economical, and aspects related to the overall IT infrastructure of the enterprise at hand, the expressive power of the process language as well as interfaces to related software systems are important criteria, most prominently interfaces to process enactment systems (such as workflow management systems) and to software responsible for modeling personnel and organizational structures of the enterprise. Not only the expressive power but also a well-defined semantics of the process language deserves a central role during product selection. However, this aspect is considered only in a small number of recent business process management projects.

Business process analysis aims at investigating properties of business processes that are neither obvious nor trivial. To this end, the term analysis is used with a rather broad meaning, including for example simulation and diagnosis, verification and performance analysis. Process simulation facilitates process diagnosis in the sense that by simulating real-world cases, domain experts can acknowledge correct modeling or propose modifications of the original process model. If business process models are expressed in process languages with a clear semantics, their structural properties can be analyzed. If, for example, certain parts of processes can never be reached, an obvious modeling mistake occurred that should be fixed. While basic structural properties of process models have been studied for some time, it is remarkable that few software products actually support them. However, structural analysis of process models requires a clear formal semantics of the underlying process language, which might not be present. In some products, a pragmatic approach to process modeling is preferred to a formal one; especially if the main goal of process

modeling is discussion with domain experts rather than process analysis or process enactment. However, we mention that formal semantics of process languages and intuitiveness and ease of use are not contradicting goals, and recent approaches seem to support this observation.

The next aspect of BPM and traditionally a very strong one, is process enactment. However, before process enactment is discussed, we provide a coarse classification of business processes that paves the way for a discussion of different types of process enactment systems. In the early days of BPM when in the application side business process modeling and in the IT enactment side workflow management were the only options, processes with a static structure were focused. The main reason behind this obvious limitation was as follows: Modeling a process and providing infrastructure for its enactment incurs considerable effort. To provide satisfactory return on investment, a large number of individual cases have to benefit from this new technology. This type of straight-through processes is also called production workflow [8]. While there are successful workflow projects on this type of straight-through processes, this restriction of workflow technology proved fatal for applications in more dynamic environments. In some cases where traditional workflow technology was used in these advanced settings, new workflow solutions were partly circumvented or even neglected. As a response to this situation, considerable work in ad-hoc, flexible, and case-based workflow was (and is being) conducted, both in academia and in industry. Recently, case handling is studied in depth as a new paradigm for supporting knowledge-intensive business processes with loose structuring. Based on the brief characterization of case handling provided above, we mention that in the case handling paradigm knowledge workers enjoy a great degree of freedom in organizing and performing their work which they are knowledgeable about. Some of the concepts of case handling are already present in commercial case handling systems.

Standardization has a long history in workflow management. Fueled by information system heterogeneity that also includes workflow management systems, organizations started to form interest groups aiming at standardizing interfaces between workflow management systems and components, with the goal of enhancing interoperability and fostering the workflow market. The most prominent organization in this context is the Workflow Management Coalition (WfMC) that was formed in 1993 and today has over 300 member organizations, including all major workflow vendors as well as workflow users and interested academia [7]. The basis of WfMC activities is the so called WfMC Reference Architecture that defines standard workflow system components interfaces. Despite the fact that all major vendors are organized in WfMC and a number of important contributions on practical workflow aspects have been made, many people feel that WfMC's ambitious goals have yet to be reached.

A more recent standardization effort in the BPM context is related to the current momentum of eXtensible-Markup-Language (XML) and Web-services technology. Web services is a promising technology to foster interoperability between information system based—conceptually—on the service oriented architecture paradigm [4] and—technologically—on open standards and lightweight protocols and systems. While Web-services technology has not yet reached maturity level, there is considerable effort under way by literally all major software vendors. The need for standardization is clearly acknowledged in this context, and important contributions have been made. However, as sketched in Section 2, recently, a trend of new standards proposals as well as merging of proposals can be experienced in the Web-services context. Besides these recent developments, Web services are seen as an important infrastructure to foster business processes by composing individual Web services to represent complex processes, which can even span multiple

organizations. While Web-services composition is a young discipline and a number of proposals are being discussed, we currently experience what seems to be a slow consolidation of recent standardization effort around Web-services composition, based on the Business Process Execution Language for Web Services (BPEL4WS) and associated proposals. However, at this point, industry seems more involved in standardization than in systems design and development. While there is some controversy on these upcoming standards, it seems that at least industry goes with the flow. In any case, Web services in general and Web-services composition in particular can be expected to play an important role in future business-process systems technology. This will include both processes within organizations and, more strongly, between organizations.

4. Papers in this special issue

As indicated in the introduction, this special issue contains four extended versions of papers presented at the International Conference on Business Process Management: On the Application of Formal Methods to 'Process-Aware' Information Systems (BPM 2003), Eindhoven, The Netherlands, June 26–27, 2003. The conference was held in conjunction with the 24th International Conference on Application and Theory of Petri Nets (ICATPN 2003) and together they attracted 214 participants. For BPM 2003, we received contributions from 27 countries. In total 77 papers were submitted. Of these papers, 25 papers have been accepted for presentation at the conference. These papers have been published in Volume 2678 of Springer's Lecture Notes in Computer Science [2]. Of these 25 contribution, we selected four papers and invited the authors to submit an extended version. Each of the extended versions has been reviewed by three referees. The resulting four papers demonstrate recent advances in business process management.

Stefanie Rinderle, Manfred Reichert, and Peter Dadam of Ulm University, Germany, provide a survey on one of the most prominent research fields in flexible workflow management: dynamic change. Dynamic change in workflow systems has been a very active research area since the mid-1990s. The key problem is how to manage the structural modification of workflow instances while they run. Of course, not all workflow instances can be adapted to a new workflow schema, so the option to adapt a particular workflow instances is governed by consistency criteria. A number of approaches can be found in the literature, differing with respect to, for instance, the workflow language used and the complexity of the consistency checking. The paper by Rinderle et al. presents a thorough analysis and comparison of research results in this area of workflow management. The main contribution of this survey is the presentation and comparison of correctness criteria and consistency criteria.

Gavin Yang of Bell-Labs Research at Lucent Technologies, USA, looks at implementation of process structures. In particular, the concepts, design, and implementation of a process library is introduced, that provides designers of process-oriented information systems with predefined structures and functionality to design and implement integrated and cooperative applications. Key concepts of the process library are inheritance and nesting, two generic concepts that have been used successfully in different areas of computer science. Therefore, an important contribution of the paper is a better understanding of process inheritance, that can be used in different areas of process-oriented applications, including not only business process management but also software engineering and related fields.

Olivier Perrin and Claude Godart of LORIA-INRIA, France, contribute a paper on collaborative work in virtual enterprises to this special issue. Based on a so-called synchronization point model, cooperative process management and coordination support is provided. Basically a synchronization point is an activity that provides mechanisms for managing composition, coordination and synchronization of processes involving multiple organizations, which can form a virtual enterprise. The synchronization point approach introduced by Perrin and Godart also takes into account privacy issues that play an increasingly important role in cross-organizational business processes as well as transactional concepts.

Therani Madhusudan, Leon Zhao, and Byron Marshall of the University of Arizona, USA, address the management of workflow models. Based on methods and techniques from artificial intelligence on the one hand and business process management on the other hand, a conceptual model of workflow cases, combining procedural and declarative presentations is given. The main goal of the work presented in this paper is facilitating the composition of workflow models based on a number of existing workflow models as well as execution information. Using the approach presented by Madhusudan et al., the cost-intensive and error-prone task of workflow modeling can be supported in the sense that knowledge on previous workflow cases and the workflow models involved can be re-used to develop adequate workflow models.

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Prof. Dr. Mathias Weske is a professor of computer science and chair of the business process technology research group at Hasso Plattner Institute for Software Systems Engineering at the University of Potsdam. His research interests include workflow management, business process management, software architectures for process-oriented information systems, service oriented computing, and software product lines.

Prof. Dr. Ir. Wil van der Aalst is a full professor of information systems and head of the Section of Information and Technology of the Department of Technology Management at the Technische Universiteit Eindhoven. Currently he is also an adjunct professor at Queensland University of Technology (QUT) working within the Centre for Information Technology Innovation (CITI). His research interests include workflow management, Petri nets, business process management, process modeling, and process analysis.

Ir. Eric Verbeek is a scientific engineer at the Section of Information and Technology of the Department of Technology Management at the Technische Universiteit Eindhoven. His research interests include workflow management, business process management, and process verification.