PHILharmonicFlows: Research and Design Methodology

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Abstract. In comprehensive case studies we found out that many limitations of existing Process Management Systems (PrMS) can be traced back to the unsatisfactory integration of processes and data. In the PHILharmonicFlows[1] project, we aim at a deep and extensive understanding of the inherent relationships between processes and data, and thus want to overcome some of the fundamental limitations known from activity-centered PrMS. Overall, we target at a comprehensive framework providing integrated access to processes, data, and functions to its users.

1 Introduction

Enterprises spend a lot of time and money for introducing Information Technology (IT) to improve their *effectiveness* and *efficiency* [1]. Effectiveness addresses the distance between business goals and the capabilities offered by IT in order to achieve these goals; i.e., the *alignment of IT* with different business perspectives [2]. These perspectives, in turn, typically comprise business data, business functions, and business processes.

Business data is typically represented by a number of business objects. These cover domain-specific business entities like orders, customers, or products. Each business object, in turn, is represented by a set of attributes. As example consider the delivery date of an order or the name of a customer. In addition, business objects are related to each other; e.g., an order may comprise several products. *Business functions*, in turn, constitute a wide range of (various) activities. Typically, many of them are used to create and delete business objects or to change their properties. As example consider user forms enabling humans to fill in desired property values. Finally, *business processes* comprise a number of related business functions to be executed in order to achieve a certain business goal.

To reach competitive advantages, it is further important to introduce new products and services as quickly as possible at the market. In addition, for dealing with increasing competitive pressure and market dynamics, it should be possible to continuously adapt IT systems in a quick and effective way. Hence, *rapid development* and improved *maintenance* are important success factors. In this context, *process management systems* (PrMS) offer promising perspectives in respect to comprehensive lifecycle support of business processes. In these PrMS,

[1] Process, Humans and Information Linkage for harmonic Business Flows

business processes are modeled in terms of activities required for achieving a particular business goal as well as their control flow defining the order and the constraints for executing these activities [3]. Each activity is then linked with a specific business function of an application service (e.g., business application). In addition, most PrMS handle atomic data elements which are connected with one or more activities reading or writing it. These data elements are also used for process control (i.e., for evaluating routing conditions).
The remainder of this paper is structured as follows. We first motivate the problem addressed in our research in Section 2. In Section 3 a discussion on how process support looks like in today's companies follows. Section 4 then introduces fundamental research questions and expected solutions, while Section 5 investigates related work along a well defined evaluation schema. The relevance of our research is discussed in Section 6. Section 7 describes the research methodology we apply. Finally, Section 8 sketches the solution approach we target at and Section 9 closes with a summary and outlook.

2 Problem Statement

Despite the widespread adoption of existing PrMS, there exist numerous processes not adequately supported by these PrMS. In particular, traditional PrMS have been primarily designed for supporting highly structured, repetitive business processes [4]. For various other processes, in turn, there is a contradiction between the way these processes can be defined and the preferred work practice [5, 6, 7]. These processes are often characterized as "information-centric" [8] or "knowledge-intensive" [9]. Further, they are rather "unstructured" [6] and cannot be "straight-jacked into activities" [9].
Moreover, existing PrMS focus on the business process perspective; i.e., activities and their control flow. Business functions (which are linked with activities) and business data, in turn, are usually out of the control of existing PrMS. For this reason, generic support is only provided for process enactment in existing PrMS. For realizing business functions, specific programming is required. Typically, this consumes more time and efforts as the modeling of the corresponding processes. Moreover, in existing PrMS business functions are treated as "black-boxes". This means, what is done during activity execution is out of the control of existing PrMS; i.e., business data is managed by the invoked business functions themselves. Obviously, this missing link between business data and business process prohibits integrated access to them. Consequently, users cannot access and manage data at any point in time during process execution (assuming proper authorization).

3 Background

Many processes not adequately supported by existing PrMS are more or less hard-coded within specific business applications. Consequently, long develop-

ment cycles arise and even simple process changes require costly code adaptions and high efforts for testing. However, the more specific a business application is, the better it meets the requirements of the respective application domain; i.e., business-IT-alignment is improved. In particular, *tailor-made business applications* requiring a customer-specific programming of all functionalitites typically fit business needs best.
Regarding the support of business processes, companies typically face Mortons fork: Either they can use PrMS to enable rapid development as well as improved maintenance and therefore achieve a high degree of efficiency, or they directly apply tailor-made applications for providing the required effectiveness; i.e., adequate business-IT-alignment (cf. Fig. 1).

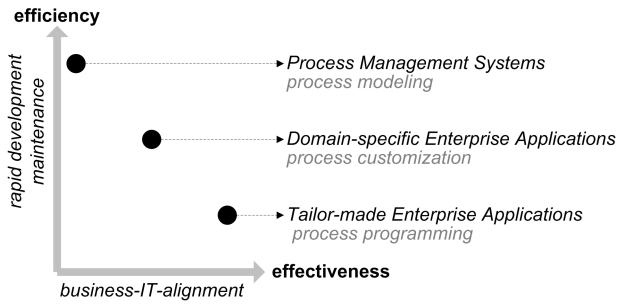

Fig. 1. Dilemma between efficiency and effectiveness

Many companies have achieved considerable benefits from their investments in *domain-specific business applications* (i.e., ERP packages). Regarding the latter, some standard functionality is already pre-implemented. These applications can be customized for the specific needs of an enterprise. Usually, customizability is realized through configuration support (e.g., based on some settings one can configure a particular process variant). Thus, domain-specific business applications constitute a trade-off between effectiveness and efficiency. However, since configurability depends on the range of preconfigured alternatives, domain-specific enterprise applications are huge and complex [10]. An additional problem emerging in this context are the lack of transparency of the configurable processes.

4 Research Questions

Starting with the basic observation that there are business processes not adequately supported by existing PrMS, we define the following research questions:

Research Question 1: What are the common properties of business processes currently not adequately supported by PrMS?
Expected Solution: A collection of characteristic properties relating to different

business perspectives; i.e., the inter-relationships between business processes, business data, business functions, and users.

Research Question 2: Which requirements must be fulfilled by a PrMS to adequately capture these properties?
Expected Solution: A set of elicited requirements for PrMS enabling the support of the identified properties.

Research Question 3: How to support the requirements elicited in an integrated process support framework?
Expected Solution: Concepts, methods and tools for realizing a PrMS enabling process support in tight integration with data to overcome the aforementioned limitations.

5 Related Work

Generally, we believe that the identified limitations of existing PrMS can be traced back to the unsatisfactory integration of processes and data. In particular, many processes necessitate *object-awareness*; i.e., they focus on the processing of business data represented by business objects. The latter comprise a set of object attributes and are related to each other. To understand the inherent relationships between process and data, we investigate on processes currently not adequately supported. This includes a systematic analysis of their properties. In summary, our process analysis has revealed the following major characteristics of object-aware processes:

1. *Object behavior:* The behavior of the involved business objects must be taken into account during process execution.
2. *Object interactions:* Interactions between business objects must be adequately considered; i.e., the behavior of individual objects must be coordinated with the one of related business objects.
3. *Data-driven execution:* Since the progress of a process mainly depends on available business objects and on their attribute values, process execution has to be accomplished in a data-driven manner.
4. *Integrated access:* Authorized users must be able to access and manage process-related objects at any point in time (assuming proper authorization).
5. *Flexible activity execution:* Activities must be executable at different levels of granularity. While one user may work on a particular object instance, another one may process a number of related object instances in one go.

Though there exist several approaches targeting at a tighter integration of business processes and business data [9, 11, 12, 13, 14, 7, 5], as illustrated in Fig. 2, none of them supports all identified properties in an integrated and comprehensive way. In addition, some approaches only deal with the modeling of processes,

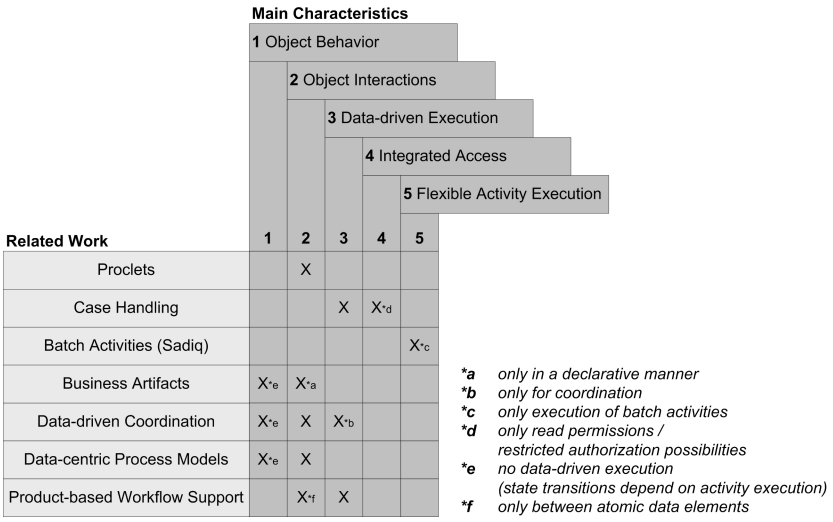

Fig. 2. Characteristics supported by related work

but exclude process execution; e.g., they do not provide a well-defined operational semantics for the automatic enactment of the defined processes. Consequently, existing approaches provide generic support for only few of the identified characteristics.

6 Relevance

Altogether we believe that a tighter integration of the different business perspectives (cf. Fig. 3) will provide an important contribution to overcome some of the fundamental limitations known from contemporary PrMS. For this purpose, we aim at a deep and extensive understanding of the inherent relationships that exist between processes, data, functions, and users in order to enable generic enactment for object-aware process management. Their support could impact the realization of more flexible process management technology in which daily work can be done in a more natural way.

Moreover, we assume that a tighter integration between process and data not only fosters effectivity, but also efficiency. This means, not only generic process support but also generic business functions become possible. In addition to process-oriented views (i.e., work-lists) we aim at the *automatic generation of form-based activities and data-oriented views* (e.g., overview table) at run-time. This way, integrated access to business process, business functions, and business data shall be provided to users.

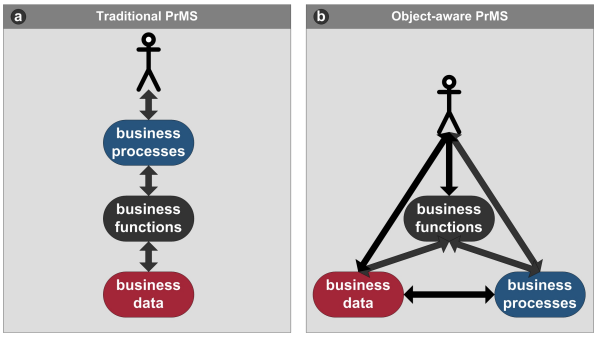

Fig. 3. Business perspectives in object-aware PrMS

7 Research Design and Methods

Regarding research in the field of information technology (IT), there are two kinds of sciences: *design science* and *natural science* [15, 1]. Natural science research is a knowledge-producing activity comprising the two steps *discovery* and *justification* [15]. Design science, in turn, is a knowledge-using activity [15]. It aims at developing IT systems. Here, *building* and *evaluation* as the two major activities [1].

Generally, doing research means applying natural science. Regarding IT, however, design research is considered as being more successful and important. Nevertheless, technology and behavior cannot be separated from each other [1]. Thus, in accordance with [15, 1], it is an opportunity for IT research to make significant contributions by engaging in both. As illustrated in Fig. 4, IT research calls for synergistic efforts between natural and design science research [1].
Our main research activities are as follows (cf. Fig. 5): We start with natural research to identify the characteristic properties of object-aware processes (cf. Research Question 1). To deal with Research Question 2, we evaluate existing approaches (using already available and applicable knowledge) to elicit the requirements for a PrMS supporting the identified properties. Finally, we address Research Question 3 and develop a comprehensive framework and proof-of-concept prototype for object-aware process management based on design research.

7.1 Doing Natural Research: Property Investigation and Justification

To discover the properties of those business processes not adequately supported by current PrMS, we perform a detailed *property investigation* by analyzing these business processes. We then justify our findings with an extensive *literature study*.

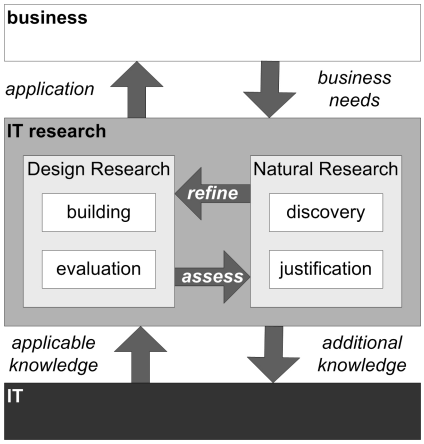

Fig. 4. IT Research [1]

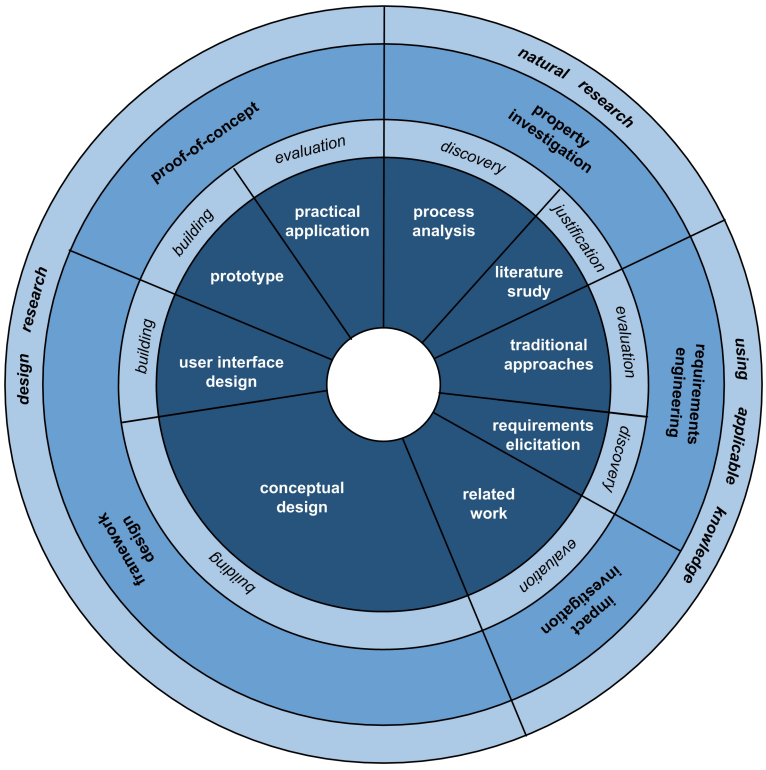

Fig. 5. Research Methodology

Process analysis Data Source: Due to the limitations of contemporary PrMS there exist numerous business applications (e.g., ERP or CRM systems) which are process-aware, but do not rely on PrMS. Instead they contain hard-coded process logic; i.e., process logic interwoven with application code. To ensure that the processes we analyze are not "self-made" examples, but constitute real-world processes of high practical relevance, we select processes as implemented in existing business applications. Amongst others, we analyze the processes implemented in the human resource management system Persis and the conference reviewing system Easychair [16, 17]. In particular, our evaluation is not restricted to the inspection of user interfaces solely. In addition, we rely on extensive practical experiences gathered during the development of contemporary business applications; i.e., we have deep insights into their application code and process logic. Finally, we underpin our results by interviewing system users as well as business consultants being familiar with the respective business applications.

Selection Criteria: We evaluate the processes (and additional features) based on the main business perspectives. These comprise processes, data, functions, and users. In particular, we focus on their interdependencies.

Literature study Ensuring importance: We complement our process analyses by an extensive literature study. This way we want show that other researchers consider some of the properties we identified as being relevant as well.

Ensuring completeness: To not exclude important properties already identified by other researchers, we compare our analysis results with existing literature. However, to set a focus we exclude properties in respect to process change and process evolution. Instead, our focus is on process modeling, execution and monitoring.

Ensuring generalisation: Interestingly, some authors refer to similar application examples as we do, while addressing different properties. Based on these insights we contrast the different application examples with the total set of identified properties. This way, we are able to demonstrate two things: first, the properties are related to each other. Second, broad support for them is required by a variety of processes from different application domains.

7.2 Using applicable knowledge: Requirements Engineering

Concerning Research Question 2, we first discuss to what degree existing PrMS cover the identified properties. More precisely, we evaluate which properties cannot be directly supported when applying traditional imperative and declarative process support paradigms [18]. Based on this evaluation we then elicit the basic requirements as inquired by Research Question 2.

7.3 Doing Design Research: Framework Design and Proof-of-Concept

Hevner et al [1] consider solution design as search process being inherently iterative. This has been confirmed by other authors [19, 20]. Simon [19], in turn, describes the nature of the design process as a "Generate/Test Cycle". The spiral model [20], in turn, defines an approach in which one and the same step is repeated several times, each time improving the results of the previous outcome. For this purpose, we perform iterative walkthroughs. In particular, we revise our solution and improve it step by step. This leads to different development versions. Additionally, we investigate in user interface design [21, 22]. This way, shortcomings concerning the usability of the framework design are identified at early project stages and can be considered in subsequent iterative revisions.
To evaluate our framework we develop a proof-of-concept prototype for the modeling as well as the run-time environment. In addition, we apply the prototype to real-world cases. In particular, we use scenarios from the medical domain, order processing, and house building which are different from the ones we consider in the context of our process analyses. Finally, we elaborate the benefits of our approach when applying it to these processes as well as lessons learned.

8 Contribution

In the course of our *PHILharmonicFlows* project we are developing a *comprehensive framework* supporting the *modeling*, *execution* and *monitoring* of *object-aware processes*. Opposed to traditional process support paradigms, we provide a uniform methodology for modeling processes on well-defined levels of granularity. The proper execution as well as termination of processes at run-time is further ensured by a set of *correctness rules*. In addition, a *well-defined operational semantics* not only enables generic support for process execution, but also *generic* realization of *business functions*. In particular, PHILharmonicFlows enables *integrated access* to business processes, business functions, and business data. For this purpose, we automatically create end-user components like worklists, form-based activities, and overview tables during run-time based on the corresponding models.
One fundamental pillar of our framework enables the processing of individual business objects to enforce object behavior. Like existing work considering object behavior during process execution [12, 23, 11, 24, 8, 13, 25, 14], our approach applies the well established concept of modeling *object behavior* in terms of *states* and state transitions. Opposed to existing approaches, however, PHILharmonicFlows enables a *mapping between attribute values and objects states* and therefore ensures compliance between them [26]. Moreover, this mapping allows us to combine object behavior with *data-driven execution*.
Another fundamental pillar of our framework enables the modeling and execution of processes involving multiple business objects (i.e., objects of the same and of different type). Thereby, we consider their individual behavior as well as their inter-relationships. More precisely, we enable the coordination of object-specific

processes that represent object behavior taking the relationships between the involved business objects into account. Regarding the latter, we obtain a complex process structure comprising inter-related, object-specific processes. Opposed to existing work [12, 7] we *hide this complex structure form modelers as well as from end users*. For this purpose, our approach provides sophisticated concepts for defining *aggregations* abstracting from individual business objects. This way, different *cardinality constraints* can be taken into account. In addition, coordination is not only possible along direct object relations (e.g., a review directly refers to a paper). In fact, in *PHILharmonicFlows* the processing of business objects can be coordinated based on *complex inter-relationships taking transitive as well as transverse relationships* between business objects into account.
The presented execution paradigm applies *data-driven process execution* in a comprehensive way; i.e., in respect to object behavior and object interactions. Since in some situations explicit user decisions and commitments are required, PHILharmonicFlows combines its data-driven execution paradigm with *activity-oriented aspects*. Finally, such tight integration of process and data necessitates advanced concepts for user integration; i.e., process authorization must be compliant with data authorization and vice versa. For this purpose, we introduce an *advanced concept for actor assignment and authorization*.

9 Summary and Outlook

Our basic mission in the PHILharmonicFlows project is to develop generic concepts, methods and tools for realizing *object- and process-aware information systems*. In particular, we aim at the flexible integration of business data, business processes, and business functions to overcome limitations known from purely activity-centered PrMS. In this paper, we report on our overall vision and on the research methodology we apply.
We have already conducted extended process analysis in the areas of human resource management and paper reviewing. In [16, 17] we reported on the basic challenges for integrating processes, data, functions and users, and we described the properties of object-aware process management in detail [27]. Based on a detailed comparison of traditional process support paradigms [18] we elicit the major requirements for object-aware process support [18, 27]. Currently, we are developing a *comprehensive framework for object-aware process management* [27, 26] as well as a *proof-of-concept prototype*. In [27] we give an overview about our framework, whereas [26] reports on our modeling paradigm for integrating processes and data at the micro level (i.e., for realizing object behavior). In future work we elaborate more detailed issues in the context of our framework and apply it to other real world processes for evaluation purpose (i.e., health care, order processing, house building).

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