Cost-Aware Business Process Management: A Research Agenda

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Organisations are constantly seeking cost-effective improvements for their business processes. Business process management (BPM) provides organisations with a range of methods, techniques and tools for analysing, managing, and optimising their business operations. However, BPM initiatives within organisations tend to focus on investigating time and resource utilisation inefficiencies, rather than directly on cost inefficiencies. As a result, high-level cost-based managerial decisions are still being made separately from process related decisions. This position paper describes a research agenda that envisages a holistic approach to managing the cost of business operations in a structured manner, by making an explicit link between cost and processes in all phases of the business process management life cycle. We discuss a number of research challenges that need to be addressed in order to realise such an approach as well as findings from some of the initial research outcomes. It is envisioned that the research outcomes will enable organisations to make operational and strategic decisions with confidence based on accurate and real-time cost information about their operations.

Keywords

Cost-aware business process management, cost-aware process design, cost-informed process execution, cost-informed process improvement, log-based cost analysis, research agenda – position paper.

INTRODUCTION

Traditionally, business process management and cost management are considered in isolation, although both disciplines are concerned with identifying ways to ensure efficient and effective business operations. As a result, managerial decisions about cost reductions are made separately from decisions regarding process improvements. To remain competitive, an organisation's core processes must be able to flexibly and efficiently adjust to cost changes as they occur. However, to the best of our knowledge, no sophisticated and integrated cost management practices can be found in process-aware information systems (PAIS), which are inclusive of business process management systems (BPMS).

Business process management (BPM) defines a methodology to design, configure, execute, and diagnose processes within organisations (van der Aalst et al. 2003; Weske 2007). Business processes go through a life cycle of four iterative phases, namely design, implementation, enactment, and diagnosis (Dumas et al. 2005). During the design phase, process models are created based on a detailed requirements analysis of business operations. In the implementation phase, the modelled processes are implemented into operational business processes. After implementation, business processes are executed and execution trails may be recorded in event logs, representing the actual behaviour of the process. Finally, the diagnosis phase is the common denominator for all activities and techniques that encompass the analysis of business processes, the outcomes of which provide feedback for process (re)design activities. Through the iterative application of BPM techniques, processes can be improved in terms of quality, flexibility, time and/or cost (Brand and van der Kolk 1995). Typically, process-aware information systems are not cost-driven. This lack of operational support impedes the ability of organisations to make time-critical, cost-informed decisions at runtime.

Generally, organisations rely on financial data from traditional costing and accounting systems to make cost-related decisions. Management accounting techniques provide decision makers with an ability to plan ahead of time and to make informed strategic decisions based on cost, although it is time consuming to gather relevant data for such analyses. Three of the best-known management accounting techniques are Activity-Based Costing (ABC) (Kaplan and Atkinson 1998), Time-Driven Activity-Based Costing (TDABC) (Kaplan et al. 2007) and Resource Consumption Accounting (RCA) (White 2009). By providing automated solutions that make use of process data required for such management accounting techniques, the data gathering efforts of managers can be lessened. Timely generation of process-based cost reports and cost forecasts becomes achievable when the connection between BPM and management accounting is realised.

Cost is traditionally considered as one of the many non-functional requirements (NFR) for a software system or service, in the same manner as maintainability, usability, reliability, traceability, quality or safety (Chung et al. 2000). However, we position cost as representing an intrinsic perspective that overlays all business processes. An organisation can achieve significant cost savings through real-time cost-informed decision making and hence, we believe that cost cannot be treated as just another NFR to be taken into account after the fact. We argue that cost concerns can and should be explicitly taken into account in each of the BPM life cycle phases to enable cost-informed managerial and operational decisions regarding business operations.

In this paper, we present an innovative research agenda on the topic of cost-aware business process management. We describe how the cost of business operations can be considered as an integral part of a business process management initiative within the different phases of the process life cycle. Accordingly, this paper first describes key research questions as well as an overview of research challenges. The paper also includes a description of initial realisations for some of these challenges and a brief conclusion.

RESEARCH QUESTIONS

In general, this research agenda elaborates on *how cost information can be associated with business processes in their life cycle phases* and as such broaden the scope of BPM. Realising this goal requires a thorough understanding of the kind of cost measures that can and should be associated with business processes in order to make cost-informed process decisions at different phases of the BPM life cycle. For instance, we need to consider how typical cost measures such as raw materials, labour and overhead costs can be linked to processes that are used in producing goods or delivering services. Ideally, such cost measures need to be available at design time (e.g., to make design choices about a cheaper process alternative), at runtime (e.g., selecting a cheaper material or resource) and at post-execution time (e.g. cost reporting and analysis). The first step towards realising this goal is the definition of appropriate data structures for relating cost information to typical BPM artefacts, such as activities or resources. Such a mapping, or *cost model*, will be concretised in a later section, but first the life cycle specific research questions are explained, as represented in

Figure 1.

RQ1. How can process-related cost information enrich process (re)design?

We can imagine a number of ways in which cost information can be utilised during the process design phase, by associating cost information with the process model. First, process models annotated with cost information (e.g., the cost of an activity, the cost of a resource) could improve human interpretation by facilitating communication and discussions about desired characteristics. For instance, activities in BPMN can be colour-coded based on their cost values or expensive regions in the process can be highlighted. Second, process design can be enriched with automated reasoning functionality such as simulation ("what-if" analysis) and, potentially, verification that make use of detailed cost models.

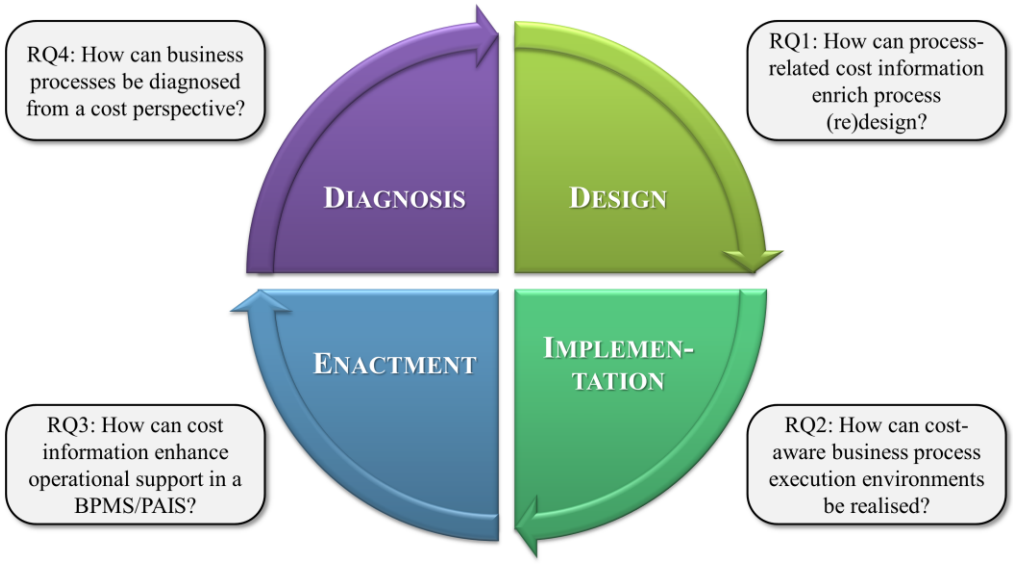


Figure 1. The BPM life cycle and the key research questions for cost-aware business process management.

RQ2. How can cost-aware business process execution environments be realised?

Automation is a fundamental characteristic of a BPMS. Accordingly, cost-aware business process management research should focus on the implementation phase as well. As it is envisaged that processes will rely on cost information for key BPMS functions such as control-flow handling, resource allocation, etc., it is required that BPMS implementations leverage this potential by allowing cost-informed business rules, specified in the design phase, to be enacted. This entails that appropriate connections are put in place between a BPMS and accounting information systems, as well as realising cost-based rules, triggers, resource allocation strategies, etc.

RQ3. How can cost information enhance operational support in a BPMS/PAIS?

BPMS and workflow systems typically provide support during the enactment of business processes. Cost-aware BPM research should explore how operational support can be enriched with functionality that exploits cost information. By making BPMSs cost-aware, informed operational decisions can be made at runtime using static cost data (i.e., cost rates) as well as historical cost figures (i.e., the cost of past process instances). The main challenge relates to the design and implementation of a framework that is capable of keeping track of process-related costs and provides support for cost-based rules.

RQ4. How can business processes be diagnosed from a cost perspective?

The diagnosis phase potentially forms a primary target where a bridge between the BPM domain and management accounting can be most easily constructed. Cost models can be built based on cost information available in accounting or ERP systems, which subsequently can be linked to process execution data stored in event logs. As such, it becomes possible to attach costs to activities, resources, and cases. The first question to be addressed is concerned with finding ways to enhance process reporting and process mining techniques with cost information. There is also a need for new techniques and tools that make use of cost models and event logs for cost-informed business process improvement.

MOTIVATING EXAMPLE

We consider a simplified home loan application and approval process as an example to illustrate the utilisation of cost information through the BPM life cycle (presented in the previous section). Figure 2 depicts the example process model annotated with the relevant cost information.

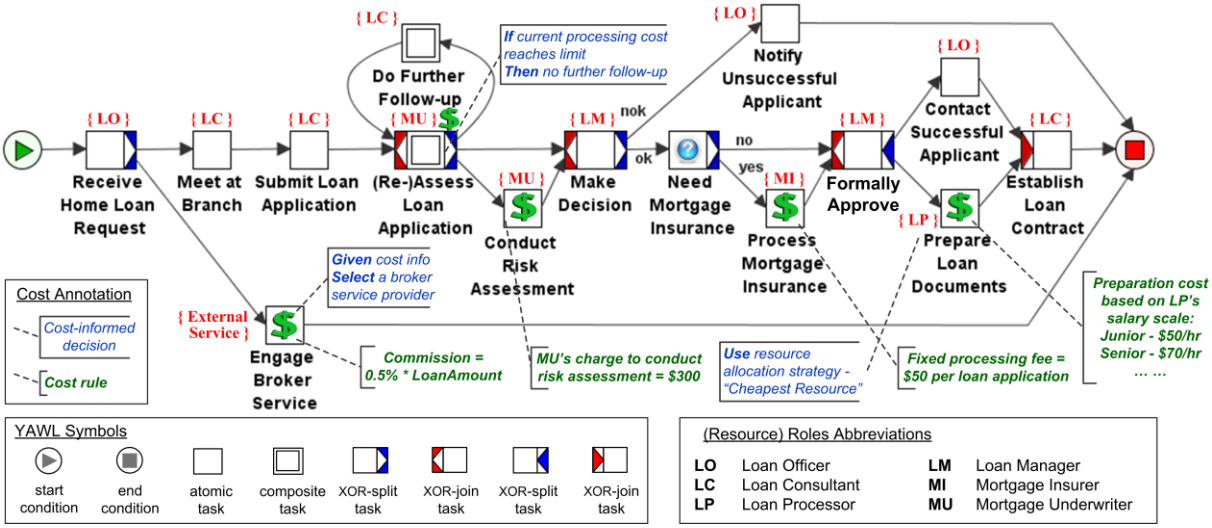


Figure 2. A home loan process modelled in YAWL (annotated with cost information).

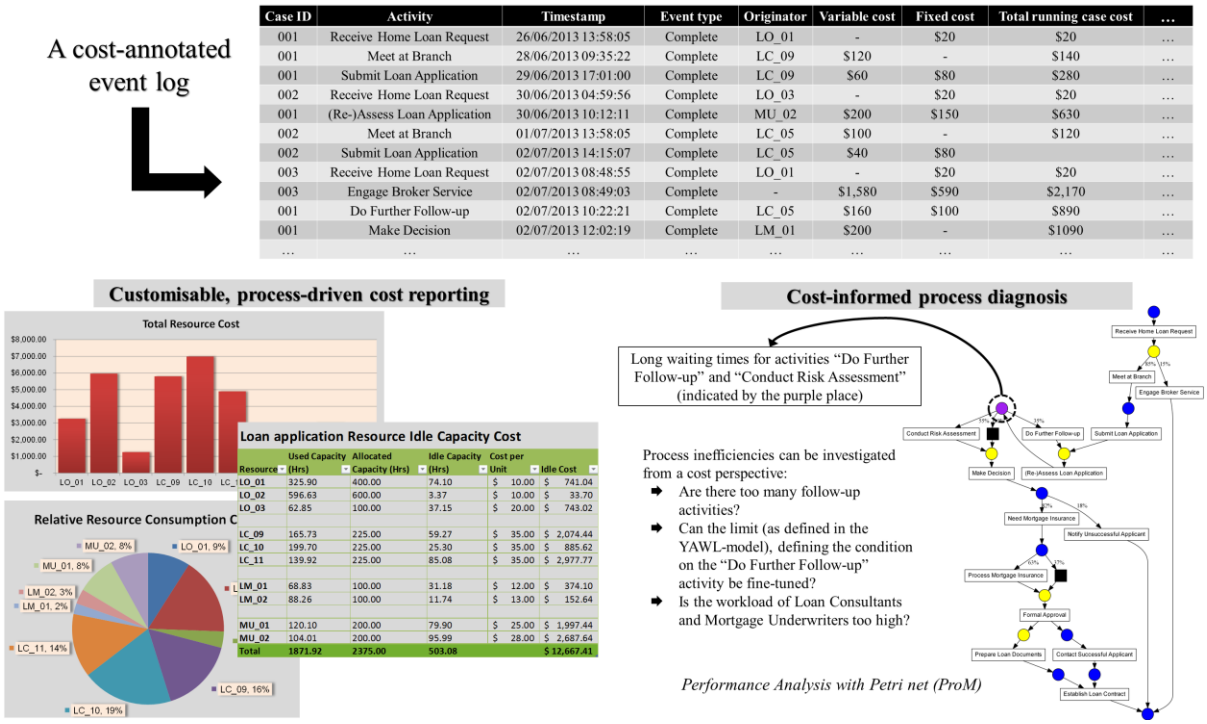
Design. The model is designed using the YAWL workflow language (ter Hofstede et al. 2010). The cost information is specified as attributes in the data and resource definitions of each of the tasks in the process model, and represented as cost annotations in Figure 2. For simplicity, the example considers role-based resource assignment only and each task in the process is assigned to one specific role. With this example, the cost model includes the cost rates of resources and activities at a bank, and of mortgage broker services. These rates can be categorised into: role-based (variable) cost rate of a resource (e.g., bank employees in the role of loan processor are paid based on their salary scales); fixed cost rate of a resource undertaking a certain activity (e.g., a mortgage underwriter charges $300 to conduct risk assessment for a loan case); fixed cost rate for an

activity (e.g., a mortgage insurance processing fee of $50 per loan application); and case-based (variable) cost rate (e.g., a mortgage broker service commission fee of 0.5% of the loan amount).

Implementation. We assume that the cost optimisation strategy for this home loan process is to minimise the cost for processing a loan. We illustrate different categories of cost-informed decisions: process-level decisions to guide the selection of process variant/s (e.g., when executing the "Engage Broker Service" activity, the broker service provider that represents the best value for money will be selected); activity-level decisions to guide which of the succeeding activities to execute (e.g., the "(Re-)Assess Loan Application" activity embeds a cost-based predicate such that if the processing cost to this point reaches a certain limit proportional to the loan amount, then no further follow-up will be conducted); and resource-level decisions to guide resource allocation to activities (e.g., for the execution of the "Prepare Loan Documents" activity, the "Cheapest Resource" resource allocation strategy is applied). The specification of such cost-based rules needs to be supported within the execution environment.

Enactment. The actual realisation of the process will require the availability of up-to-date cost information at runtime. When cost information is made available during execution, we can say that *cost-informed* process enactment is realised. This is because process-, activity-, and resource-level operational decisions can be made based on accurate and timely cost information.

Diagnosis. Finally, either by executing the process model, which would automatically generate a cost-annotated event log in a cost-aware workflow system, or by collecting event logs from the bank's information systems without cost information but supplementing them with a cost model, opportunities arise to diagnose the home loan application process. This is illustrated in Figure 3. The top part of the figure shows a simulated cost-annotated event log for the example process. In addition to control-flow and resource information, events also contain cost measures. Based on these cost measures, a first value-adding activity would be the automated generation of cost accounting-style reports, such as those shown in the bottom-left part of the figure. Because of the availability of process information (e.g. throughput times, resource allocations, etc.) in combination with actual cost amounts, significant information for cost reporting could be realised. Secondly, cost-annotated event logs are an ideal starting point for cost-informed process analysis. An illustration of the "Performance Analysis with Petri net"-plugin in ProM is shown on the right hand side. Inefficiencies identified during process diagnosis, such as the bottleneck identified in Figure 3, can serve as concrete starting points for process improvement, making cost a key driver for redesign. In our example, we might opt to change the resource allocation of the "Do Further Follow-up" and "(Re-)Assess Loan Application" activities.



Case ID	Activity	Timestamp	Event type	Originator	Variable cost	Fixed cost	Total running case cost	…
001	Receive Home Loan Request	26/06/2013 13:58:05	Complete	LO_01	-	$20	$20	…
001	Meet at Branch	28/06/2013 09:35:22	Complete	LC_09	$120	-	$140	…
001	Submit Loan Application	29/06/2013 17:01:00	Complete	LC_09	$60	$80	$280	…
002	Receive Home Loan Request	30/06/2013 04:59:56	Complete	LO_03	-	$20	$20	…
001	(Re-)Assess Loan Application	30/06/2013 10:12:11	Complete	MU_02	$200	$150	$630	…
002	Meet at Branch	01/07/2013 13:58:05	Complete	LC_05	$100	-	$120	…
002	Submit Loan Application	02/07/2013 14:15:07	Complete	LC_05	$40	$80		…
003	Receive Home Loan Request	02/07/2013 08:48:55	Complete	LO_01	-	$20	$20	…
003	Engage Broker Service	02/07/2013 08:49:03	Complete	-	$1,580	$590	$2,170	…
001	Do Further Follow-up	02/07/2013 10:22:21	Complete	LC_05	$160	$100	$890	…
001	Make Decision	02/07/2013 12:02:19	Complete	LM_01	$200	-	$1090	…
…	…	…	…	…	…	…	…	…

Figure 3. Reporting and process diagnosis based on a cost-annotated event log for the home loan process.

RESEARCH CHALLENGES

This section further elaborates on the key research challenges to incorporate the cost perspective within the BPM domain. These challenges are motivated by the four high-level research questions presented earlier. First, we describe the data requirements for associating cost with processes at a general level. Subsequently, research challenges within the different life cycle phases are detailed. For design, the incorporation of the cost view in process model visualisations with the aim of making cost-informed process design choices is discussed. Furthermore, challenges with respect to the implementation of a cost-aware BPMS and with respect to the realization of cost-informed operational support are identified. Finally, challenges related to providing management accounting style cost reporting, cost-based forecasting capabilities, as well as cost-informed event log analysis techniques within the diagnosis phase are discussed.

General Challenge: Associating Cost with Business Processes

Relevant cost measures for business processes need to be identified to understand the true origins of costs involved in business operations. A key challenge is to develop a mechanism through which cost elements can be formally associated with business processes. In order to link cost with process models, we need to determine the data requirements for such an association. This entails a thorough understanding of the relationship between cost and different types of business process artefacts.

Cost model. The mapping between BPM artefacts and accounting terms will require the design of a new artefact, which is the cost model. While an initial realisation of a cost model is discussed later, in general, the association of cost information with business process artefacts such as activities, resources, and cases should be adaptable, i.e., capable of realising a mapping at the right level of granularity, as well as complete, thus associating all relevant costs invoked during process execution with process artefacts. Furthermore, it should accommodate simple cost rates (e.g., time × cost rate) as well as complex cost functions. The availability of a fully specified cost model, together with BPM artefacts such as process models, organisational models and event logs, can provide cost-informed support across the entire BPM life cycle.

Process Design: Enriching Process Design with Cost Information

Incorporating a cost view into the business process design tasks is a promising, yet largely unexplored research area. Two distinct challenges are identified for cost-aware process design. Firstly, process modelling languages and tools should be developed or extended with associated annotations through which cost information can be captured and visualised in process models. Ideally, such cost-annotated process models should be dynamically updated with information extracted from costing systems, execution data or simulations. Secondly, process modellers should be assisted in their tasks by means of cost-informed automated reasoning functionality supporting design decisions.

Cost-annotated process visualisation. While most business process modelling languages largely focus on control-flow modelling and as such typically provide one-dimensional visual support, smarter process design tools could provide modellers with *dynamically generated* alternate views of a process. Given the fact that for a large majority of business processes, cost savings is one of the key discussion points between higher-level management and business (process) analysts, there exists a specific need to develop tools and techniques that allow linking of various elements of process models with cost information. Such considerations might consist of emphasising expensive decisions, expensive paths, costs associated with rework, cancellations, undesired outcomes, etc. This functionality would enhance human interpretation, which would yield easier and better informed communication and discussion about desired characteristics.

Cost-informed design decisions. In addition to cost information-based visual support, supplementary automated reasoning techniques that support process design decisions from a cost perspective are deemed worthwhile. In this context, it could be investigated how for instance process simulation techniques (van der Aalst et al. 2010) could provide more in-depth knowledge about design choices among different process variants. Eventually, the availability of techniques that can assess the cost impact of design decisions will improve the accuracy of process design choices.

Process Implementation: A Cost-Aware Process Execution Environment

True cost-aware process execution poses a couple of critical challenges to the implementation of a BPMS. First, the various elements of a process such as activities and resources should be associated with relevant cost data and cost-based rules. Second, a variety of cost calculations should be made possible at runtime for process instances and their associated activity instances, for instance *time-based* calculations (e.g., salary costs for the time a human resource spends on work item execution), *usage-based* (e.g., payment of a set fee for an expert

witness), *measurement-based* (e.g., per tonne costs of a raw materials), *invocation-based* (e.g., costs incurred in retooling an assembly line for a product run), *fixed cost* (e.g., overhead costs of commencing an activity), or any combination of the above. Finally, such a BPMS should facilitate the logging of cost data and allocate the data to the correct process artefacts, which allow these costs to be incorporated in event logs.

Process Enactment: Cost-Aware Operational Support

In order to make cost-informed decisions during process execution, there is a need for BPMSs to support cost-based process variant selections, cost-informed activity decisions and cost-informed resource allocation decisions *at runtime*. These needs require a BPMS to support different types of cost-informed system-initiated actions or by resource-initiated interactions with the system. Cost-informed operational support can be defined as the ability to use cost information of the current process instance together with cost information of previous instances to provide better decision support at runtime. In addition to simple dashboard-like monitoring functionality, the BPMS should also be enhanced with techniques that allow for answering more complex *prediction and recommendation queries.*

Process Diagnosis: Process-Driven Cost Reporting and Forecasting

Cost reports are the key artefact in the management accounting domain, providing different views (i.e., process, resource, organisational/departmental) of cost data. PAISs are also a source of valuable information for creating cost reports, as their execution logs typically contain fine-grained details about activity execution times, resource utilisation, etc. Accordingly, a particular research challenge is to investigate how the traditional management accounting practice of cost reporting can be improved or enhanced by making use of process-related data available in event logs.

Customisable, process-driven cost report generation. Considering that there are no standardised cost reporting formats, management accountants typically tailor their reports to the applied accounting technique (e.g., ABC, TDABC, or RCA) as well as to their target audience. For instance, the practice of cost reporting often requires appropriate filtering and simplification based on organisational, time, resource, and other perspectives. Accordingly, it is a distinct challenge to develop a holistic framework for generating such customisable cost reports while making use of event logs. We also envisage that by incorporating the cost perspective into BPMS, the resulting cost-aware business process management systems should create opportunities to reduce the effort required to create such reports.

Process-driven cost forecasting. In addition to cost reporting, the management accounting discipline provides value to an organisation's management with cost forecasts. Where cost reports typically reflect an analysis of historical costing data, cost forecasts project these figures into the future. Again, cost-aware BPMSs may be equipped with cost forecasting techniques that *directly* take into account process characteristics, including resource consumption, throughput times, etc. As such, with the association of process and accounting information, operational decision-making can be improved with more accurate and timely forecasts.

Cost-informed process improvement. Cost has already been used as a measure for evaluating the impact of process improvements. Taking this one step further, process improvement methodologies that explore more cost-optimal execution scenarios, for instance based on fine-grained event logs that capture the process execution data in a sufficient level of detail, can be developed. As such, cost information may be directly taken into account in the process improvement stage, which will enhance the identification of and discussion about potential process improvements.

INITIAL RESEARCH OUTCOMES AND REALISATIONS

This section provides an overview of the initial research outcomes of approaches to addressing some of the research challenges discussed in the previous section, with a view towards advancing the general research agenda presented. First and foremost, a fundamental mapping that associates costs to BPM artefacts called a cost model is proposed. In addition, our approach to address research challenges in the enactment and the implementation phases has been realised within the YAWL workflow environment (ter Hofstede et al. 2010). A first realisation of techniques to support research challenges related to the diagnosis phase has been developed as part of the ProM process mining framework (Verbeek et al. 2010). Research challenges related to the process design phase remain as future work.

Cost Model: Associating Costs to BPM Artefacts

Informed by requirements gathered from domain experts and a literature study of costing techniques such as ABC, TDABC and RCA, a conceptual data model for *cost models* was designed (Wynn et al. 2013b). This model specifies how cost information can be associated with business process artefacts by making use of three

core elements, namely cost drivers, cost functions, and mappings. A cost driver defines how cost is associated with one or more process elements (resource, activity, and case data) and the cost rate. The data attributes of cost drivers could be as simple or as complex as an organisation requires it to be. For instance, it could be a variable cost that describes the hourly rate of a resource, but it could also be a dynamic scheme that ties overhead costs to each case depending on seasonal factors that incur more costs to work on activities when they are associated at busy times, or a combination of such cost rates. A cost driver may also specify the cost technique associated with the driver (e.g., ABC, TDABC or RCA) and the cost type (e.g., fixed/variable, materials, overhead, or labour). The allocation of cost to process elements is kept flexible, putting few restrictions on the way incurred costs can be represented. A cost function defines a formula for aggregating various cost elements. It is possible to specify cost functions that incorporate both fixed and variable cost components. A mapping provides a way to relate terms used in management accounting to terms used in a BPMS. For instance, in the home loan process described above, the cost associated with "Prepare Loan Documents" is a variable cost depending on the seniority of the employee who performs the activity and the time it takes for that resource to perform the activity.

Cost-Aware Process Implementation and Enactment in YAWL

A conceptual framework for a cost-aware BPMS with support for cost-driven process enactment has been developed that considers, in general, any BPMS or workflow system can be equipped with a specific, discrete component, *a cost component or module*, which handles all cost-based information and performs system-initiated cost-informed decisions (Wynn et al, 2013a). Figure 4 shows a high-level architecture of such an approach, where the *cost* component would receive notifications from, and interact with, a process enactment/workflow engine at runtime, annotate process logs with calculated cost data, access the cost-enriched process logs for historical cost information, and perform the necessary calculations to enable cost-informed operational support (Wynn et al., 2013a). A first implementation of such a component has been developed for the YAWL system. The *Cost Service* provides two interfaces: one which receives notifications from the workflow engine and participating services at various points in the life-cycle of a process instance, and the other which allows the engine and services to query cost-information, either to request a calculation and have the result returned, or to have returned a complete cost-annotated log of a process instance (or instances). Examples of such functionalities include: providing real-time calculated values for use as input into branching predicates; continuously monitoring for cost overruns and, when detected, manually or dynamically skipping unnecessary or low priority work item(s), or cancelling work item(s) and/or case(s); and notifying administrators when cost thresholds are being approached. Also, the YAWL Resource Service has been extended with *cost-based resource allocation strategies* such as *Cheapest Resource, Cheapest to Start,* and *Cheapest Completer*.

Cost Diagnosis in ProM

Cost-annotated event logs. Process diagnosis activities often rely on event logs reflecting how processes were actually executed. A cost-annotated event log is one where events recorded in a log are enriched with detailed cost information related to each event. Cost models can be used to augment such event logs with cost information. In order to standardise the way costs are associated with event logs, a "cost" extension for the XES event log format has been developed and published as a standard extension by the IEEE taskforce on process mining[1]. A *cost annotation* is an association between a case or a task instance within a case and its cost (e.g., calculated based on the cost drivers/functions within a cost model). A *ProM Cost Annotation Plug-in* has been developed to enable annotation of an event log with cost information supplied from a cost model.

Process-driven cost reporting. A second outcome with respect to process diagnosis consists of the development of a framework for the automated generation of management accounting-style cost reports. This framework has been implemented as a series of *ProM Cost Reporting Plug-ins*. Costs associated with a set of process executions can be visualised by means of tables, charts and graphs. Furthermore, the tool can produce reports that aggregate cost information according to case, cost type, task, or resource attributes. Customised resource cost reports in a tabular format can be generated through the use of different XSLT templates.

Process-driven cost forecasting. The *ProM Cost Prediction Plug-in* represents an initial approach to process-driven cost forecasting. The prototype implementation allows for predicting the total cost of running cases based on the state of the current instance and the cost information known for already completed cases of the process. The transition system approach proposed in (van der Aalst et al. 2011) to predict the completion time for running cases (time prediction) has been extended to realise cost forecasting/prediction. The plug-in uses the cost-annotated log to generate a transition system that can then be used for cost prediction (see Wynn et al., 2013c for details).

[1] http://www.xes-standard.org/cost.xesext

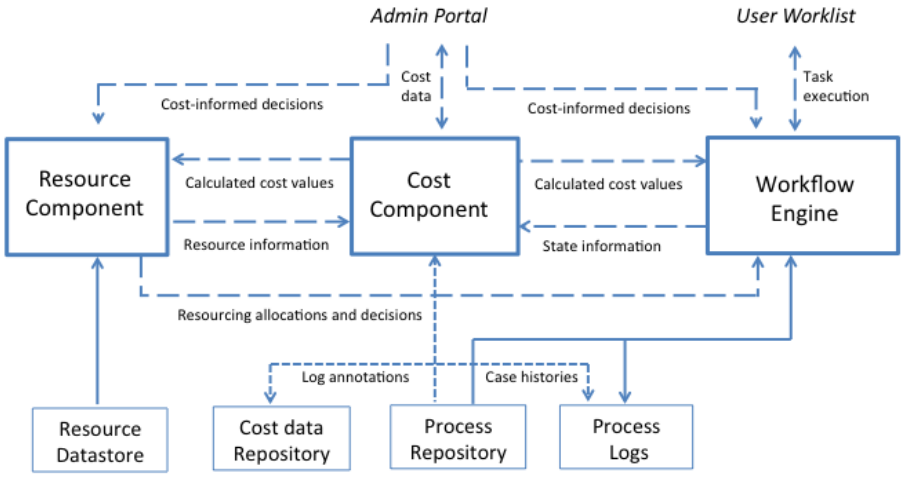


Figure 4. A generalised high-level cost-support architecture.

Cost-informed log analysis. An ongoing research project is concerned with the development of log analysis techniques that make use of detailed cost information for process improvement. In general, the problem can be described as searching for alternative execution scenarios with the main questions being: "Could we have executed a certain business process at a significantly lower total cost, taking into account that certain characteristics are invariable? If yes, what is that cost and how can this be achieved?" Answering these questions involves the development of quantitative techniques that are capable of exploring the environment created from the aggregation of cost information and process execution data. Preliminary research has been conducted regarding the specification of the search space for cost-optimised execution scenarios. Two important elements were identified. First, cost models will need to be enhanced with trade-offs that reflect certain choices that were made implicitly during process execution. These trade-offs are essential in order to avoid trivial cost reduction strategies such as postponing all activities until the cheapest resource becomes available. Other typical trade-offs can be resource-driven, for instance avoiding under- or over-utilisation, or SLA-driven, such as costs associated with deadline transgressions or quality failures. Second, it was found that the search space for finding cost-optimised execution scenarios would often be extremely large. Therefore, a smart configuration of constraints and intelligent algorithmic techniques such as genetic algorithms or simulated annealing are required to make the solving of such optimisation problems feasible. In addition, utilising well-known work assignment policies as a starting point for the evaluation of cost-informed process improvement strategies is being explored.

RELATED WORK AND CONCLUSION

In this paper, we advocate for the full integration of a cost perspective in each phase of the BPM life cycle and present research challenges that need to be addressed in order to realise this vision. Although, to the best of our knowledge, there is no such comprehensive research agenda covering all life cycle phases, the interrelationships between processes, resources and cost are well-recognised in the accounting literature, e.g., in the reports produced by the IFAC (2009) as well as in the process improvement literature, e.g., Kettinger et al. (1997), Reijers and Mansar (2005), and Netjes et al. (2009).

Since the introduction of ERP systems, a number of studies have been conducted on the effects of ERP systems on traditional management accounting practices (e.g., Booth et al. 2000). A survey by Kettinger et al. (1997) points out that Activity Based Costing (ABC) (Cooper and Kaplan 1988) is an often employed technique in the evaluation of business process re-engineering efforts.

Furthermore, we leverage upon existing work in the BPM domain. An information model to link the ARIS accounting structure with Event Driven Process Chains (EPCs) proposed in (vom Brocke et al. 2011) can be used as a starting point for linking cost with a process model during the design phase. The ability to visualise process models from different angles and different levels of granularity has been advocated throughout the BPM discipline (e.g., Brown and Rasmussen 2010). In the area of process mining, this topic has received wide attention, given the natural fit between process discovery and "maps" (van der Aalst 2009). The work by vom Brocke et al. (2010), which proposes a framework for measuring the economic value of processes with a view to assist in process redesign activities is applicable to cost-informed process (re)design and improvement challenges. Vintila et al. (2011) also propose a framework for enterprise systems to have a closer alignment between processes and accounting records for monitoring and reporting purposes. Xi et al. (2008) explored how role-based resource allocation strategies can take into account the cost rates of resources for a more optimal allocation mechanism. Finally, existing work in the area of process mining (van der Aalst 2011) on log analysis

of different perspectives (e.g., control, organisational, case, and time) is highly relevant to addressing the research challenges around detailed cost reporting, cost forecasting and cost prediction.

We believe many organisations can benefit from having real-time process-based cost information at their fingertips during the design, implementation, enactment, and diagnosis phases of a business process's life cycle. Explicit modelling and visualisation of process-related costs, the provision of cost-informed guidance in the redesign of processes, the ability to monitor and predict costs in active business processes, and the ability to carry out cost-informed analysis will yield innovations in the theory and practice of business process management. By creating a direct link between process management and cost management through the use of process models and event logs, the cost-aware BPM framework makes it possible for organisations to make cost informed strategic and operational decisions. In order to achieve the benefits of such a framework, it is necessary that an organisation maintains accurate cost data and also keeps track of the process behaviours in the form of event logs.

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