Designing an Economic-driven Evaluation Framework for Process-oriented Software Technologies

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ABSTRACT

During the last decade there has been a dramatic increase in the number of paradigms, standards and tools that can be used to realize process-oriented information systems. A major problem neglected in software engineering research so far has been the systematic determination of costs, benefits, and risks that are related to the use of these process-oriented software engineering methods and technologies. This task is quite difficult as the added value is influenced by many drivers. This paper sketches an economic-driven evaluation methodology to analyze costs, benefits, and risks of process-oriented software technologies and corresponding projects. We introduce an evaluation meta model and sketch a formalism to describe economic-driven evaluation scenarios.

Categories and Subject Descriptors

H.4 [**Information Systems Applications**]: Miscellaneous

General Terms

Economics, Measurement

Keywords

process-oriented software technology, economic-driven evaluation models, added value, costs, benefits

1. PROBLEM OVERVIEW

Enterprises crave for possibilities to enable the seamless execution and flexible control of their business processes and services. In the automotive industry, a broad spectrum of business processes has to be supported ranging from knowledge-intense engineering processes to administrative financial services. In recent years, there has been an explosion of paradigms (e.g., workflow management, case handling), standards (e.g., BPEL4WS), and tools (e.g., business process modeling tools, workflow management systems) enhancing business process support.

Process-oriented software (SW) technologies operate at two levels [7]: *business process integration* and *business process management* (BPM). The former focuses on technical integration of application systems. Their overall objective is to automate business processes by connecting application systems in a process-oriented manner. Internal and external integration scenarios have to be distinguished. Internal integration considers integration within one enterprise whereas external integration deals with cross-organizational integration. BPM technologies, by contrast, focus on the operational support of business processes. Relevant issues are the design, implementation, and management of process-oriented SW systems, and the use of BPM technology to control process execution, to monitor and analyze real-time process runtime data, and to allow for quick adaptations to evolving requirements.

One problem in practice is the lack of concepts for analyzing the costs, benefits, and risks related to the use of the above mentioned process-oriented SW technologies. First empirical studies have indicated that the total effort for realizing process-oriented SW systems can be significantly reduced when using BPM technology [6]. What is additionally needed is a comprehensive evaluation framework that allows for both qualitative and quantitative conclusions about the use of BPM and process-oriented SW technologies.

The development of such a framework is a complex task that poses a number of challenges. First, we must identify those value drivers that influence the costs, benefits, and risks related to the use process-oriented SW technology. While some value drivers can be ascribed to technical capabilities (e.g., system support for process evolution and process change), others are related to organizational issues (e.g., the level of process maturity). Second, we must identify dependencies between these drivers. Third, we must enable both qualitative and quantitative conclusions. While qualitative conclusions can be based on practical experiences, quantitative estimations additionally require adequate metrics (e.g., to enable the use of financial business ratios). Fourth, we must identify different evaluation scopes and analyze their dependencies. Possible evaluation scopes are, for example, SW development and SW maintenance. Thereby, different evaluation scopes can result in different, perhaps even contradictory conclusions. High costs and low benefits for SW development can be opposed, for example, by low costs and high benefits for SW maintenance. Finally, we

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must compare SW engineering based on "traditional" approaches with SW engineering relying on process-oriented methods and technologies.

In literature (e.g., [10]), many evaluation approaches are discussed for analyzing the costs, benefits, and risks of IT. *Cost-oriented approaches*, for example, focus on the identification and quantification of IT costs. Respective approaches are the value analysis, the zero base budgeting, the work value model, the break even analysis, and the cost effective analysis. *Multi-dimensional approaches* (e.g., the cost benefit analysis and the excess tangible cost method), in turn, do not only consider costs, but additional evaluation dimensions (e.g., benefits), too. *Market-oriented approaches* (e.g., the competitive forces model) assess the impacts of IT on a company's market position. *Strategy-oriented approaches* evaluate the contribution of IT for enterprise strategic objectives. Examples are the approaches of Parsons and McFarlan/McKinney. *Customer-oriented approaches* (e.g., the customer resource life cycle model) analyze the impact of IT from a customer point of view.

Process-oriented approaches, like the hedonic wage model [9], analyze IT towards its role regarding the support of business processes. However, IT is typically evaluated from a mere business process performance perspective looking at efficiency measures such as lead time (also known as cycle time), waiting time, and resource allocation. They ignore other, more intangible facilities arising from process-oriented SW technologies (e.g., impact on organization). Finally, *controlling-oriented approaches* unify concepts such as earned value management and target costing that especially aggregate financial data provided by classic controlling.

Besides there are frameworks that address the assessment of IT from a broader perspective. Value-based SW engineering (VBSE), for example, explicitly adds value considerations to SW engineering principles and practices [4]. The e3 value framework is a requirements-driven evaluation approach that defines a business case based on requirements [3]. The GRAAL framework investigates the alignment of IT to business architectures [11]. The VITAL framework investigates the problem of aligning the services offered by networked ICT with the requirements of networked businesses from a value-oriented perspective [2].

All approaches can be applied to evaluate various facets regarding the (economic) effects of IT. However, none of them can be used to adequately analyze the economic-driven impacts of process-oriented SW technologies (e.g., a technology's impact on organizations or its effective support of evolving business processes).

We have defined a number of research questions that are of particular relevance for the design of our economic-driven evaluation framework:

1. Which value drivers determine the costs, benefits, and risks for the use of process-oriented SW technologies?
2. Which dependencies exist between these value drivers? How can they be made transparent?
3. How can we formally describe value drivers and their dependencies? Formalization becomes necessary in order to ensure a systematic analysis.
4. How can we derive qualitative and quantitative conclusions for process-oriented SW technology? What are suitable metrics that can be used in this context?
5. What effects do process-oriented SW technologies have on the added value of the resulting enterprise applications? This is non-trivial as an application's added value is determined by a quantity of different value drivers not related to the use of process-oriented SW technology.

Section 2 sketches preliminary results of our approach[1]. Section 3 gives an outlook on future work.

2. PRELIMINARY RESULTS

Analyzing the economic impacts that are related to the use of process-oriented SW technologies is complex. One reason for this is the strong impact such technologies have on the organization. The effective use of workflow management systems, for example, requires a deep investigation of the business processes to provide optimal process support. Another reason is that business process support may require the customization of existing information systems and the process-oriented SW technologies they are implemented with. This means that process-oriented SW technologies have to be evaluated both towards their impact on organizations and towards their ability to adopt to the (evolving) requirements of the business processes they support.

2.1 EcoPOST Framework Overview

Our EcoPOST framework is addressing this by proposing two basic evaluation models: the *domain model* (DM) and the *technology impact model* (TIM). The TIM represents an economic-driven evaluation for the use of process-oriented SW technology within a particular organization. This application context is described by the domain model.

Both evaluation models are based on the modeling formalism of System Dynamics [8]. System Dynamics was originally developed to understand the behavior of complex systems. Its underlying assumption is that it is comparatively easy to observe the elementary forces and actions of a system, but difficult to estimate the dynamic interactions of its parts. System Dynamics assumes that feedback structures are the main determinants of a system's behavior. Its basic goal is the understanding of feedback systems. We decided to use System Dynamics as it supports basic requirements for the modeling of economic impacts when compared to other formalisms such as bayesian networks [5]. It allows for the modeling of different types of value flows (e.g., cost flows, benefit flows, and risks flows), the modeling (and structuring) of complex "value networks" (including both technology-driven and organization-driven evaluation variables), and the provision of mechanisms to model both qualitative and quantifiable impacts.

The purpose of the domain model is to provide a precise characterization of the treated evaluation scenario. Considering organization-specific information becomes necessary as a generic evaluation of economic effects is hardly possible. The domain model includes a textual description of an evaluation scenario (project overview, technology use cases) and models of the supported business processes (to facilitate,

[1]The work presented in this paper is part of the EcoPOST project (**Eco**nomic-driven Evaluations of **P**rocess-**o**riented **S**oftware **T**echnologies) conducted at DaimlerChrysler and the University of Twente [1].

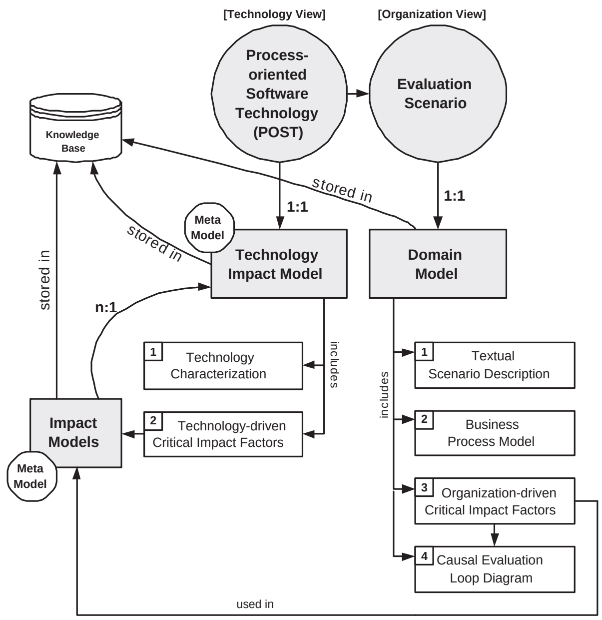

Figure 1: The EcoPOST Evaluation Framework.

among other things, the use of process metrics). It also includes a collection of organization-driven critical impact factors (CIF_{org}). Each CIF_{org} represents an organizational attribute (e.g., process fragmentation, process knowledge, process transparency, or process maturity) that significantly influences a SW technology's economic efficiency. It is one goal of the EcoPOST framework to provide a basic set of CIF_{org} that can be identified in every organization. However, it may be also necessary to identify further CIF_{org} (e.g., by interviews). Finally, a *causal loop diagram* (known from System Dynamics) is used to illustrate dependencies and causal influences of the CIF_{org}. Causal loop diagrams are simple diagrams to illustrate that there is some kind of economic-driven causal influence of one evaluation variable on another (without further quantifying this influence). Evaluation variables are modeled as vertices that can be connected with a directed edge which may be labeled with a "+" or "-" to provide information about the type of causality. A positive edge indicates that the variable at the opposite end of the edge tends to move in the same direction. A negative edge indicates a reverse relationship.

Fig. 2 shows an example that illustrates the notion of causal loop diagrams. Thereby, the variable *process maturity* (e.g., specified by process maturity reference models such as CMMi or SPICE) is assumed to have a positive impact on both the variables *process knowledge* and *process transparency* (due to a systematic process documentation that is required for improving process maturity). This means that an increasing process maturity results in an increasing process knowledge and process transparency. The variable *process fragmentation* negatively affects the two variables *process maturity* and *process transparency*. Finally, the variable "process evolution" negatively affects the variable "process transparency".

The technology impact model (TIM) aggregates economic effects described by a collection of inferior *impact models* (IM). This additional structuring is helpful to further reduce complexity. Consistency is ensured by the basic modeling rules of System Dynamics. Impact models analyze the economic effects of a combination of technology-driven (CIF_{tech}) and organization-driven impact factors. Examples of CIF_{tech} are a technology's representation of process logic or its ability to allow for quick process changes. Both the technology impact model and the inferior impact models are represented by *evaluation flow graphs*, which constitute when compared to causal loop diagrams a more complex diagram type. Evaluation flow graphs distinguish, for example, between quantitative and qualitative edges and explicitly treat the notion of accumulating costs, benefits, and risks. A typical scenario that can be represented by an impact model is described in Section 2.3.

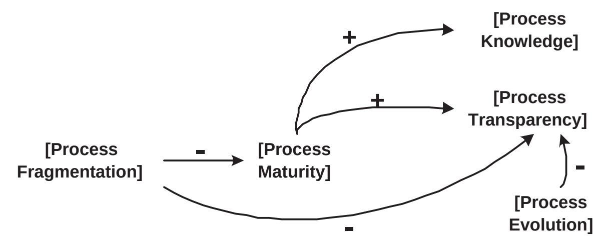

Figure 2: Analyzing Organization-driven Variables.

2.2 EcoPOST Evaluation Meta Model

In this section we present an evaluation meta model that defines the modeling elements that can be used when building evaluation flow graphs (or (technology) impact models). The basic elements of the EcoPOST meta model are shown in Fig. 3. Economic evaluations must consider the notion of accumulating costs, benefits, and risks. Such accumulations are called *value levels*. We distinguish between basic value levels and auxiliary value levels.

Basic value levels represent an aggregated economic conclusion for one evaluation dimension. The meta model distinguishes between *total costs of ownership* (TCO), *total value of ownership* (TVO), and *risks*. TCO represents a cost-centric accumulation, whereas TVO additionally incorporates benefits and risks, and therefore represents a more holistic accumulation. The risk level aggregates the effects of various risk drivers.

Auxiliary value levels represent sub accumulations of basic value levels in order to analyze them in more detail. The TCO level, for example, can be divided into several inferior cost levels to separately analyze single cost drivers. The (technology) impact models unify several auxiliary value levels in order to summarize economic-driven conclusions.

Impact flows are qualitative and quantitative correlations between different value levels. They are represented by directed edges. Thus, each edge represents an impact flow (cf. Fig. 3). Impact flows are value streams, i.e., they indicate that there exists an economic-driven causal influence of one variable (respectively value level) on another. In order to enhance systematic evaluations we additionally distinguish between different types of impact flows:

1. *Negative Cost Flow*: This type represents costs that

can be financially quantified (e.g., costs for customizing out-of-the-box SW, maintenance costs, etc.).

2. *Positive Cost Flow*: This type represents benefits that can be financially quantified (e.g., optimizations of major business processes).

3. *Non-financial Benefit Flow*: This type represents benefits that can be quantified, but not financially (e.g., minor optimizations of administrative processes).

4. *Intangible Benefit Flow*: This type represents benefits that cannot be quantified - neither financially nor non-financially (e.g., improvements in data quality).

5. *Risk Flow*: This type represents non-quantifiable risks (e.g., missing user acceptance).

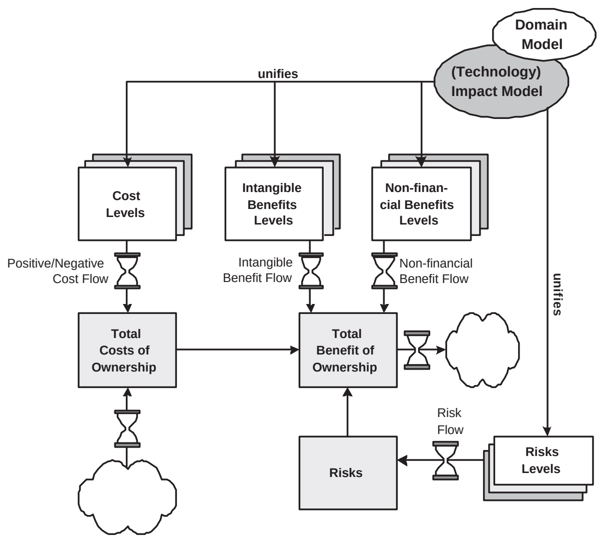

Figure 3: EcoPOST Meta Model.

Altogether, these elements will be used to develop specific EcoPOST evaluation models.

2.3 Example of an Evaluation Scenario

An example of an evaluation scenario that can be analyzed in detail with the EcoPOST evaluation framework is the economical impact that is related to a process-oriented SW technology's capability to effectively deal with evolving business processes. Two evaluation variables are of particular relevance: the variable "process evolution" (organization-driven) and the variable "implementation of process logic" (technology-driven). Both variables can have different values, i.e., the first variable can have the value "frequent process changes" to indicate dynamic process evolution and the second variable can have values such as "hard-wired process logic" or "separation of process logic from application code". One assumption regarding the correlation of these two variables is described in the following. We will use the EcoPOST framework to formally analyze and quantify this scenario.

A separated process logic is advantageous (from an economic-driven point of view), if process logic has to be frequently adapted to process changes. As the part to be changed (i.e., the process logic) is separately available, high costs, e.g., for adopting the application code, can be avoided. A separated process logic is disadvantageous, by contrast, if a business process is static and never or rarely changes. The costs related to the use of process modeling tools and workflow management systems (to enable a separate handling of process logic) may be not justified by the benefits.

However, this is just a simple example. Of course, it is our ambition to analyze more sophisticated scenarios as well (e.g., based on case studies and experiments).

3. FURTHER INVESTIGATIONS

This paper has illustrated our research efforts to design an economic-driven evaluation framework to analyze the costs, benefits and risks of process-oriented SW technology. We have sketched basic ideas of our evaluation framework and introduced an evaluation meta model to formally describe evaluation scenarios. An example has illustrated the basic notion of the used formalism (a special occurrence of System Dynamics). The applicability of the evaluation framework in practice is a particularly critical success factor that has guided our research efforts. Additionally, the use of well-elaborated methods is success critical as well.

Next steps will include the definition of more detailed (technology) impact models as well as their validation. Several case studies and controlled experiments will be accomplished. Future work will also focus on the quantification of evaluation scenarios. This implies the definition and specification of evaluation criteria as well as of suitable metrics to quantify these criteria.

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