

Framework for Value Prediction of Knowledge-based Applications

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Abstract. Knowledge-based applications are characterized by their use of machine-understandable formalizations of expert knowledge. Complex knowledge structures, and the features which exploit them, can have a significant effect on the effort needed to develop such applications. Means to estimate this effort are, however, lacking. Furthermore, precise benefits of such applications, which are directly attributed to specific functionalities, remain unknown.

In this paper we propose a preliminary *Framework for Value Prediction* whose intention is to study and to effectively predict the development effort as well as benefits of knowledge-based applications. The framework consists of five pillars which act as a road map to propose well-defined models. We furthermore discuss our initial experiences with using the framework to adapt existing software cost and benefit estimation models.

Key words: *Framework for Value Prediction*, cost estimation, benefit estimation, knowledge-based technologies

1 Introduction

Knowledge-based applications are maturing and a considerable number of systems and core technological components has left the research labs towards the industry in the last years. These applications differ from classical software applications in that they use some form of formal descriptions of the data on which they operate. This allows various tasks (e.g. data integration, reasoning, or search) to be performed depending on the type, domain or particular use of the application. The added dimension of knowledge representation and associated functionalities clearly sets knowledge-based applications as a distinct class of software, required to be studied in their own right. In order to encourage their wide industrial uptake, methods to assess their potential economic benefit and to predict the total costs of their development and deployment are a must. To tackle this emerging challenge, our work focuses on devising a preliminary predictive *Framework for Value Prediction* customized for knowledge-based applications.

2 The *Framework for Value Prediction*

The general expectation for a framework for value prediction is to identify relevant value drivers (both for cost and benefit) that are measurable in financial terms. Additionally, the predictive framework is expected to define a modular process in which models and methods are applied to best predict the value of the effort to develop, implement, integrate and eventually evaluate benefit factors. The framework is generic and thus customizable to each working domain. A

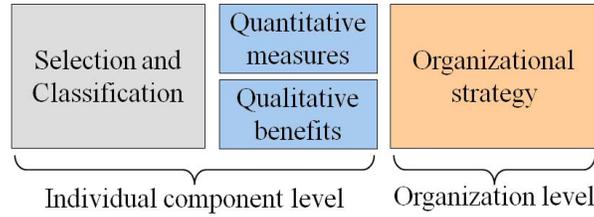


Fig. 1. Levels of the Predictive Framework.

high-level view of the levels of our preliminary *Framework for Value Prediction* is shown in Figure 1. The envisioned framework constitutes of two levels: The first one is the *individual component level*. At this level, the parameters relevant to a domain are assessed and their individual financial values are predicted. The second one is the *organizational level*. On this level an overall integration strategy is devised.

As illustrated in Figure 2, the *Framework for Value Prediction* is structured in three functional parts at both the *individual component level* and the *overall organizational level*. The *individual component level* consists of two parts: the

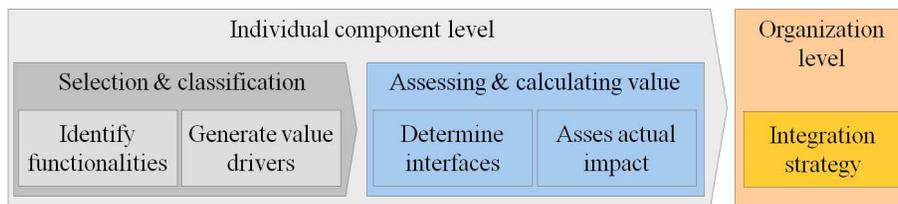


Fig. 2. Parts of the Predictive Framework.

analysis part covering the classification of the application functionalities with domain specific value drivers and the *calculation part*, specifying the qualitative and quantitative values of the functionalities. The values determined for the

individual components are included in the overall organization level to determine their organizational value.

Each part of the framework is represented as a *pillar* which defines methods or models and corresponding outcomes. In defining the framework, clear segregation is made between a *model* and a *method*. Within the framework a *method* is described as a systematic procedure of accomplishing something (e.g. catalogue development as a method to capture requirements). A *model* is described as a set of rules used to generate a specific outcome. Unlike a method, a model has clearly structured inputs and refined values as output. For example the requirements could be generated through a catalogue, which is a method. Qualitative values could be assigned to each variable in the requirements using a model. A graphical overview of each pillar of the framework is presented in Figure 3.

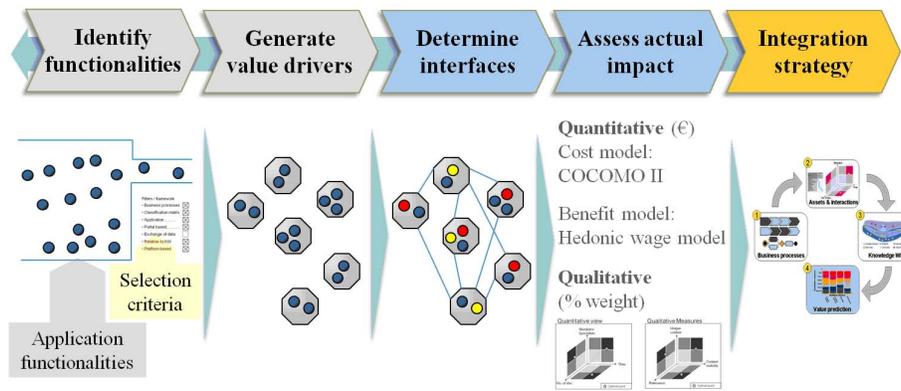


Fig. 3. Five Pillar Predictive Framework.

Pillar-1: Identify Functionalities (Methods Implied) The aim of the first pillar is to drive the domain specific selection criteria based on the functionalities of the application or one module of the application. The most suitable methods to perform the selection are expert interviews, application classification catalogue and requirement engineering.

Pillar-2: Generate Domain Specific Cost and Benefit Drivers (Identification and Relevance) The second pillar of the framework analyzes the domain and generates the relevant value drivers. The number of the drivers is directly related to the accuracy of the predicted value of the costs and benefits. Therefore, depending on the complexity of the domain and the resources for evaluation or validation of the drivers, their number should be between 5 and 15. The expected outcome is the dictionary of all relevant drivers including their detailed description, relevance for the domain and organizational placement. The methods considered best for identification of the drivers are: bottom-up analysis,

top-down analysis, analogy estimation and expert judgment. The validation of the drivers can be based on domain-expert interviews or ethnographic studies.

Pillar-3: Determine Benefit Interfaces (Based on Pillar 1 and 2 Develop Interrelations) The outcome of this pillar are matrix interfaces between value drivers, task level processes and higher level processes (e.g. business processes). The generation of the interfaces can be achieved by employing analogy estimations and expert judgment estimations to identify and then validate possible relations between the outcomes of the first and the second pillar.

Pillar-4: Impact of Benefit Drivers (Identify Models both for Quantitative and Qualitative Measures) In this pillar the value drivers that can be quantified and measured are taken up from the preceding pillar. Each value driver is then run through the relevant cost and benefit models to assign their costs, savings or weighted benefits respectively. Before the drivers can be selected and their cost or benefits are estimated, the selection of the right models is critical.

Pillar-5: Driving Integration Strategy The previous pillars provide the value of individual parameters. In this pillar an overall evaluation at the organizational level is performed, taking into account the results from the preceding pillars. Therefore, the fifth pillar of the framework provides a set of methods to measure organizational profitability and helps the company to analyze the proper balance of possible attraction and retention. The analysis is performed for organizational needs of the overall integration through quantifiable measures. The goal is to define the scope of the application area in relation to the existing organizational structure and then to calculate the overall expected monetary impact [1].

3 Using the Framework for Cost and Benefit Estimation of Knowledge-based Applications

Our initial observations of the process of creating knowledge-based applications pointed out, that their development is divided into two major subtasks which are handled separately: one for creating the underlying knowledge structures and the second one for developing the application itself.

The *Framework for Value Prediction* is used to identify and adapt models to be used to estimate the value of a particular type of application. For cost estimation of knowledge-based applications, we adapted existing parametric cost estimation models from the area of software engineering, such as COCOMO II [2], to reflect aspects that are unique to this specific type of application. The preliminary predictive framework is used to support the selection of a set of cost as well as benefit factors that associate the impact on effort with the functionalities found in knowledge-based applications as explained in the following: At first, functionalities were identified to derive factors that might impact overall costs for

the first and the second pillar of the framework. For the development costs, we considered a top-down strategy to identify these factors: first general functionalities were selected that need to be measured within an application. Subsequently these factors are broken down into more specific, measurable ones. This results in a catalogue which includes a minimal set of functionalities that are inclusive for every knowledge-based application. The catalogue includes components on the user interface, application logic, storage, or reasoning level. Subsequently we proceeded in proposing a set of cost drivers which are domain dependent and based on which software cost estimation models can be adapted. Generic factors which account for the general software development environment such as personnel and project factors (e.g. personnel experience, tool support, multi-site development etc.) are also included at this stage but typically remain the same. Determining interfaces for the cost estimation models should be done at the cost driver level. Determining the interfaces between these drivers requires an expert evaluation on the relationships between them. The input of the experts can then be used to refine the set of cost factors and to account for the relations in the cost model itself. Integrating domain specific cost drivers into the parametric software cost models is accompanied by an analysis of further cost factors that may require changing or are considered to be unnecessary. Finally, this preliminary model requires an evaluation on the structure of the model w.r.t. to the proposed cost drivers as well as an initial set of quantitative values proposed by experts for its statistic refinement.

For the benefit part of the value prediction, both quantitative and qualitative measures were considered. In brief, the above mentioned parametric models are considered for the quantitative factors for both cost and benefit. For the qualitative part of the benefits, other factors are identified (c.f. [3]). Impact-based weighted values attained from domain experts are then assigned to the factors. Based on that, the qualitative factors can be considered for driving the organizational integration strategy in the fifth pillar. The qualitative factors may then be quantified based on their overall organizational impact.

4 Related Work

The framework presented in this paper is derived from a composition of different frameworks, models and methods, which are taken from an array of different application domains. There are three fundamental frameworks that have a significant impact and therefore stand out from others: Aachner's House of Value Creation [4], RFID business case calculation [5] and WIGG'S knowledge management framework [6]. These fundamental frameworks are prominent in their respective domains, but lack the flexibility and customizability required for the domain of knowledge-based applications. Therefore the research focused on defining a modular framework only taking into account relevant parts of the mentioned frameworks. Another aspect, that played a key role in defining the framework, is the classification of value of knowledge-based application components, which is having both intrinsic and extrinsic value at the individual

component level and organizational level of the framework [7, 8, 9, 10]. This classification is derived from the ongoing research effort at Iowa State University in the field of consumer behavior [7, 11]. As the predictive framework for value estimation is still evolving, it requires additional research and controlled deployment before it can be considered for greater adoption.

5 Conclusions & Outlook

We have laid out a preliminary framework and used it to derive models to assess cost and benefit for a general class of applications. Our framework provides an integrated and unified approach to derive preliminary cost and benefit models. This ensures that both are compatible w.r.t. to identified functionalities and that they can be used to effectively assess costs and benefits in quantifiable terms. Our future work will go beyond expert evaluations and will include an evaluation of a selection of quantitative models based on historical data.

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