Towards Early Consideration of Non-Functional Requirements at the Business Process Level

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ABSTRACT

Non-functional (or quality) requirements are one of the key issues that need to be addressed during the development of any software system. Experience has shown that as the alignment of business processes and the supporting information systems become increasingly close and robust, early consideration of non-functional aspects is needed to considerably reduce subsequent rework. In this paper, we present a method based on quality models and related checklists for integrated treatment of non-functional requirements in a measurable and testable way at the business process level. The benefit of such an early quality consideration consists of closer and more robust alignment between business processes and supporting information systems by providing early conflict solution, easier design derivation, and continuous traceability up to the strategic goals. This will lead to less rework effort during development or maintenance and thus to more flexible business support.

1. INTRODUCTION

In today's enterprises, business strategy, business processes, and business information systems are closely intertwined and are typically not considered separately any more [Allw05] (see also Figure 1). While business processes support the achievement of the underlying strategy, information systems support or even enable successful implementation of these processes. The mapping between business processes and information systems supporting these processes should thus be as close as possible [EmMa95] and as robust as possible [SmFi03] to allow rapid adaptation to any change, especially to organizational changes. Therefore, business processes have become an important source for requirements in information systems (here we use "information systems" in a very broad sense, ranging from one-function services to complex workflow implementations), independently of how the information system is implemented.

Nevertheless, present approaches used in industry typically address only the alignment of business processes and functional (system) requirements, while often neglecting non-functional aspects. Only few companies such as, e.g., [YYOI05] are going to annotate business processes with quality requirements.

In the majority of cases, however, even if non-functional (or quality) requirements (called NFRs) were identified as crucial with regard to the success of a product or project [CNYM99] [DKK+05], they are considered for the first time when the development of the supporting information systems starts – if at all. The Fraunhofer IESE NFR approach [KDP+05] is an example of such a system-targeted NFR elicitation method (see Figure 1).

However, especially for modern implementation strategies, the earliest possible consideration of non-functional requirements is needed to support some important decisions. In the Model Driven Architecture [OMG06], for instance, business processes are considered as parts of the computer independent models (which describe in an abstract manner *what* the system should support) and are used to derive platform (in)dependent models that describe *how* to build the system in a technology (in)dependent manner. Neglecting efficiency requirements in these models, for instance, may cause costly rework because these requirements typically have a great influence on the system architecture.

By contrast, the vision of Business Process Management Systems aims at executing business process descriptions without any additional development effort [SmFi03]. Instead of developing software to support the processes from scratch, an execution engine should be able to perform the processes (as workflows), integrating existing functionality based on service-oriented platforms. In this sophisticated vision, which – of course – still requires that many challenges are solved, business processes will be the only specification a system has to fulfill. This makes an upfront handling of NFRs during process modeling in a measurable and testable manner indispensable. Otherwise, services could only be selected based on their functionality, which might not be sufficient for achieving the intended business process support.

With our currently still evolving method presented in this paper, we thus intend to specify NFRs in a measurable form already at the business process level. We consider NFRs at this level as any required quality of the elements involved in a process needed to assure the process goals achievement. In this context, the often mentioned measurability is crucial, as NFRs such as "The function should be efficient" leave the developers to image what "efficient" might be. This, in turn bears the risk of failing the business goals, even if "efficiency" is explicitly considered as an important requirement.

While the motivation above has shown that NFRs are also needed on the level of business processes, the question of which quality aspects are important at this level and how they influence each other remains. Furthermore, the assurance of their measurability is also an open issue. The key concepts of our method presented in this paper therefore primarily focus on these questions.

As benefits of our approach, we expect from the business point of view:

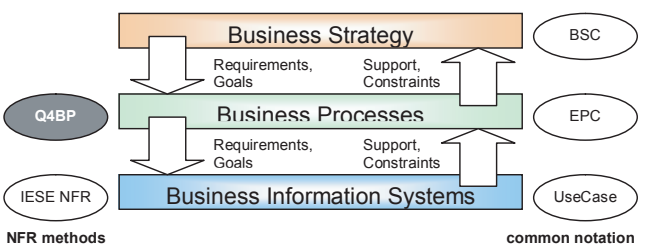
- being able to check whether the strategic goals can be successfully operationalized with the available resources
- less costly rework due to early requirements conflict resolution
- business processes that also fit best to quality needs.

From the IT perspective, we furthermore expect:

- closer alignment due to clearer dependencies on system requirements
- better traceability up to the strategic goals by bridging the gap between these goals and system qualities using NFRs on the business process level.

The remainder of this paper is structured as follows. In section 2 we present some related work. Section 3 briefly explains the basic concepts of our method, while

Figure 1. Requirements on different business levels



its application process is described in section 4. The paper closes with a summary and outlook in section 5.

2. RELATED WORK

Figure 1 depicts, according to [Oest95], how the three business levels (strategy, processes, and information systems) influence each other. Furthermore, common methods and notations are shown (to the left and to the right). Based on the business strategy goals that can be exemplarily specified using the Balanced Scorecard (BSC) [KaNo92], appropriate business processes, which could be specified with Event Driven Process Chains (EPC) [KeNS92], for instance, are derived. These processes are then used themselves to derive requirements for the supporting information systems, e.g., in terms of UseCases.

Publications such as [SmFi03] have identified this alignment of business processes and information systems as a key research aspect, referring to the vision statement that "business processes should be directly and immediately executable – no software development is needed". This emphasizes and underpins the notion of integrating additional requirements, especially quality issues.

Regarding the close and robust alignment of business processes and information systems, key research has already been done [RoSE04] [EtRo05]. All these publications however, solely address and cover the functional aspects, or cover the non-functional aspects in a very generic and not measurable manner [SoWa05], denoting them as soft-goals or organizational goals. Approaches for goal modeling (see [Lams04]) are important to support the expression of quality goals on the strategy level. These quality goals can then serve as a basis or rationale for expressing NFRs on the business process level and, finally, on the information system level. Therefore, the systematic derivation and analysis of NFRs on the business process level with regard to the strategic goals will be important work to be done. However, this is beyond the scope of this paper.

Methodologies addressing system NFRs and change guidance are available [ChNY96], [DKK+05], but do not specifically address the business process level and thus lack the potential support.

A consideration of business process qualities is part of process performance management [WWDV06] [BuGe04]. Performance management defines business relevant indicators, checks if the performed processes really fulfill them, and helps to identify room for improvement. While these indicators are requirements for the processes derived from the strategy (e.g., time and costs), requirements for the resources that are involved in the process execution (e.g., security or capacity constraints for systems, data or employees) are still missing. However, the resources need such requirements in order to be able to provide the required quality.

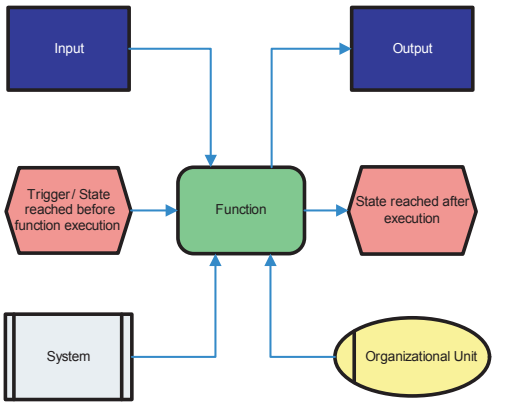
One of the key related research approaches regarding systematic NFR elicitation (the Fraunhofer IESE NFR Method) has been described in numerous publications, as for instance [DKK+05] [KDP+05] [DKKP03] [KeKD03]. By default, this work addresses only NFRs on the system level and is thus not directly applicable to the business process level, where other qualities might be important. Even if some qualities are overlapping on both levels, they are not identical or may even be completely inadequate (e.g., maintainability). However, parts of this work, such as the usage of quality models, checklist-based elicitation, and striving for measurable requirements, are the key fundament on which we have developed our methodology.

3. CONCEPTS OF NON-FUNCTIONAL REQUIREMENTS AT THE BUSINESS PROCESS LEVEL

In this chapter, we present a methodology called Quality Requirements for Business Processes "Q4BP" to address NFRs in a measurable and integrated manner already at the business process level. The goal from the IT perspective is to facilitate easier derivation of information systems from business process models. The goal from the business perspective is to build processes that address the strategic goals in a more suitable manner.

In order to keep our explanations simple, we here focus on enhancements of the notation of EPC. The reasons are that EPCs are widely used in industry and are easy to understand both for IT experts and for business experts. Furthermore, EPCs include all relevant concepts for business process modeling [Allw05] and are thus an appropriate notation for showing the possibilities of our approach. As our approach is intended to work with every business process notation, our future work will address other notations, especially those that are directly executable.

Figure 2. Main elements of EPC



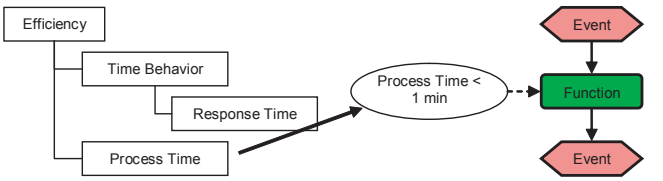
An (extended) EPC typically depicts (see Figure 2) in which order business functions are performed, which states exist before and after each function execution, which organizational units are responsible for a function execution, which information system is used, and which inputs and outputs (in terms of material or data) are handled. EPCs allow specifying business processes on different levels of abstraction and systematically refining them. Furthermore, business rules can be attached. However, this does not refer to NFRs, as business rules are a kind of functional requirement in terms such as "If invoice amount is greater than 1000 $, allow a discount of 10%".

However, in the same manner, our method recommends enriching the process model elements with suitable NFRs derived from an overall quality model for business processes (which is still evolving). This quality model consists of many quality attributes concerning process elements (function, system, data, organization, etc.) that are hierarchically organized. On the top level, the most important attributes are efficiency, reliability, security, usability, and manageability (a subset from ISO 9126 [ISO03] that is modified according to its suitability to business processes). When assigning a value to a quality attribute associated metric, it becomes an NFR. In Figure 3, an excerpt from the quality model (on the left hand side) and an exemplary assignment to a business process element (on the right hand side) are shown.

In order to address the goal of eliciting measurable and testable NFRs, we refined the quality attributes (according to GQM [BaCR94]) in the same manner as the Fraunhofer IESE NFR Method, until a measurable level was reached.

Besides the hierarchical organization, the quality attributes within the model are classified according to the business process elements where attaching them makes sense (see table in Figure 3). Here, "Process time" is considered as a relevant attribute for "Process" and "Function", but not for other process elements. In

Figure 3. Excerpt from the quality model and exemplary usage



	Process	Function	System	Organization	Data or Material
Process time	X	X			
Response time			X		

contrast, "Response time" is only of interest for the "System" that supports the function. Of course, there exist dependencies between quality attributes on the business process level and on the information system level. These dependencies are also handled in our approach (see section 4). Nevertheless, the major part of the requirements for the information system level should not be attached to business processes at this stage but later when development starts. The reason is that we do not want to harm the business orientation by adding too much implementation relevant information. In general, only qualities regarding the process execution and the involved resources are of interest, while internal system qualities such as maintainability are neglected.

The identification of all important quality attributes for business processes is still a part of our current research. Until then, the relevant issues for a specific project have to be gathered using the method described in section 4.

4. APPLYING THE Q4BP METHOD

The procedure for applying our method is a specialization of the Fraunhofer IESE NFR method mentioned in the related work section. It is based on a set of experience-based artifacts, which are tailored to project-specific ones. Figure 4 depicts the main steps and artifacts when applying the method.

In a first step, for each business process modeling project, our reference quality model, which is a structured set of all possible quality attributes for business processes is taken and tailored (including extensions) to the specific needs of the project. This tailoring includes a discussion about the quality attributes that are relevant for the business processes and how these attributes are hierarchically organized or dependent. The tailoring stops when a metric for each attribute can be defined (e.g., minutes for "Process Time"). If quality attributes were found during the tailoring that do not exist in the current experience-based reference quality model, they are added after the tailoring to the experience-based model, too.

The quality model developed is then used to derive checklists that guide the systematic elicitation and specification of measurable NFRs for the business processes. For each high-level quality attribute, all related measurable attributes from a lower level are listed and mapped to the process elements they should be attached to. A section within the checklist might then be, for instance, "Efficiency of functions: Define for each function how long it should take (process time)."

Elicitation and specification require the business process models and enrich them with all non-functional aspects needed to achieve the intended business goals. So far, this procedure is quite similar to the proven Fraunhofer IESE NFR Method.

However, we strive for an easier-to-use method that does not need to be tailored every time it is applied. We assume that the tailoring and the improvement cycle are only needed as long as our reference quality model does not contain all relevant quality attributes concerning business processes. Because of the limited space available to issues described in a business process model, we expect our model to be almost complete one day, so that no individual tailoring will be necessary any more. Then, the reference checklists can be used directly to elicit the NFRs for business processes. Until then, we consider this methodology as a research support to finding all relevant attributes and their dependencies.

One important issue when eliciting requirements is the early detection and resolution of conflicts. As requirements conflicts often lead to change rework during system development, it makes sense to handle them during an earlier phase, in particular on the business process level. Problems can thus be solved business-like and not with regard to technical decisions.

Avoiding conflicts requires the consideration of each possible requirement dependency. Besides trivial dependencies between efficiency requirements, which are already handled in some current performance management approaches [BuGe04], other quality attributes may also affect each other. The reference checklists that contain clues about such dependencies and their underlying quality models are thus a helpful tool to avoid specifying processes that will not work as intended.

In this paper, we distinguish two types of conflicts: conflicts due to vertical and conflicts due to horizontal dependencies. The first type of conflict might occur when (sub-)processes are further refined and an NFR of the upper element conflicts with (the sum of) the lower ones. An example from the "efficiency" area is when the sub-functions including waiting time take more time than the upper process is allowed to take. In this case, either the process has to be performed in another way, reorganizing the sub-functions, or the requirements for the upper process have to be specified less restrictively. At this point, it becomes obvious that non-functional and functional requirements (also in business processes) influence each other. That is why our approach aims at the integrated handling of NFRs within business processes.

The second type of conflict arises from the relationships between different requirements, e.g., between efficiency and security issues: Encryption typically affects the response time of a system, whereas authentification affects the time needed to perform a function that is limited to authorized access. Considering this at the business process level might, for instance, lead to a process where authentification is realized once at its beginning using the system support of single-sign-on.

Besides the dependencies between different kinds of quality attributes attached to one process (element), there might also be relationships between requirements attached to different elements. Figure 5 shows, for instance, that requirements concerning data privacy may influence access control for functions, or the personality traits of the assigned employees. In the other direction, constraints regarding personnel or technical capacities might also influence functions and processes, e.g., inexperienced personnel might have higher requirements regarding the time needed to perform a function.

When business processes are enriched with conflictless NFRs, a helpful starting point for system development is given. The NFRs related to "System" elements are precise enough to adopt them directly during system development. As "Organizational units", "Functions", and "Data/Material" elements also influence the "System", the requirements attached to them also have to be considered for the information system to be developed. Here, we will establish in future work clear dependencies that allow translating them into requirements of the information system level. For instance, the privacy requirement from Figure 5 could lead to a system level requirement describing where the employee data have to be stored and how they should be encrypted.

The method presented in this paper was applied in a large information system company that uses business processes as a substantial element for their requirements specifications. First, we tailored models for efficiency and reliability by brainstorming which related attributes are important in business environments and how they could be measured. We found out that some attributes were very technical and thus appropriate for the information system, while others concerned the underlying processes.

Based on the developed models, we derived checklists by defining elicitation instructions that clearly depicted to which process element an NFR should be attached, how it should be measured, and which conflicts have to be checked and

Figure 4. Applying the Q4BP method

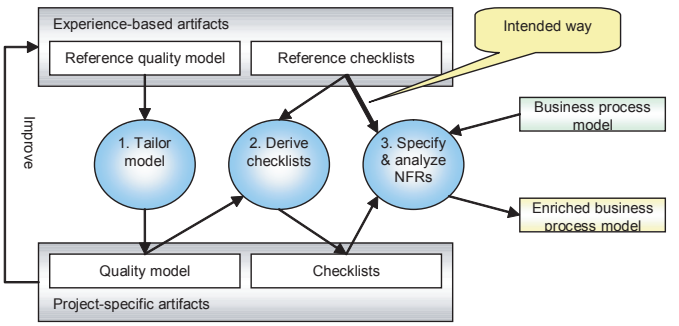
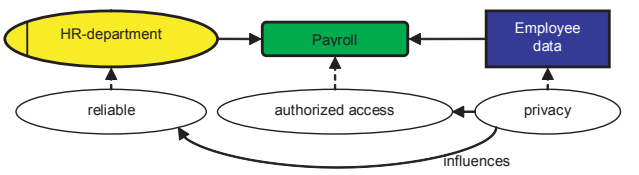


Figure 5. Dependencies between requirements attached to process elements



resolved if necessary. This checklist was then finally used to elicit concrete NFRs for an exemplary business process description. As the elicitation itself required little effort, we expect our method to be a suitable instrument for assuring the required process quality right from the beginning of any information system project.

5. SUMMARY AND OUTLOOK

In summary, our method explicitly addresses the problems of neglecting NFRs in business process and information system alignment as well as those of eliciting imprecise NFRs (e.g., "The process should be efficient"). Furthermore, conflicts between requirements that might lead to unintended process results can be identified and solved early in a business-like and not in a system-oriented manner.

From a business point of view, we see further benefits in being able to check whether or not the strategic goals will be successfully operationalized with the available resources. From an IT perspective, requirements or even design decisions for the system to be built can be derived more easily. The quality requirements defined on the business process level also allow selecting suitable software solutions by better comparing competitors (or their services). Finally, the hierarchical refinement of business processes and the attached NFRs facilitate the assurance that the overall process requirements are guaranteed even if each function is implemented by another system.

As one of our first future work projects, we will extend our method to other business process notations, especially to those that are executable. In this context we strive to build a business process meta model enriched with the relevant quality attributes.

Another important research topic is the identification of dependencies up to strategy goals and down to real information system requirements in order to provide continuous traceability and effective conflict resolution.

In parallel, our general method, the underlying quality model, and the related checklists have to be continuously evaluated and improved. Therefore, we will use our method in industry projects and academic case studies.

With regard to the vision of executable business processes in which "no software development is needed" [SmFi03], NFRs should be paid special attention. To support this vision, we strive to analyze how the identified business process quality requirements can be integrated, automatically assured, and evaluated in a formal and readable notation (such as BPEL [Juri04]).

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