Modelling non-functional requirements of business processes

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Abstract

This paper presents an approach to the identification and inclusion of ‘non-functional’ aspects of a business process in modelling for business improvement. The notion of non-functional requirements (NFRs) is borrowed from software engineering, and a method developed in that field for linking NFRs to conceptual models is adapted and applied to business process modelling. Translated into this domain, NFRs are equated with the general or overall quality attributes of a business process, which, though essential aspects of any effective process, are not well captured in a functionally oriented process model. Using an example of a healthcare process (cancer registration in Jordan), we show how an analysis and evaluation of NFRs can be applied to a process model developed with role activity diagramming (RAD) to operationalise desirable quality features more explicitly in the model. This gives a useful extension to RAD and similar modelling methods, as well as providing a basis for business improvement.

Keywords: Non-functional requirements; Business process modelling; Role activity diagramming; Business process improvement

1. Introduction

Organisations exert great efforts to carry out their business processes in a way which meets functional requirements but also produces good overall or general quality of service. Borrowing terminology from software engineering, it might be appropriate to term these general quality attributes ‘non-functional requirements’. It would be useful to have a method of representing these attributes, so that they are modelled more explicitly. Such a method might assist organisations to improve the quality of their business processes.

Many methodologies [4,7,8,10,15,17] have been developed to improve business processes and to investigate how well current business processes have achieved their goals. Techniques used to model business processes have included IDEF, Petri Nets, role activity diagrams (RADs), Role Interaction Diagrams, and Gantt Charts. Generally speaking, these methodologies have a functional emphasis, and concentrate on showing the detail of how activities are carried out or tasks executed. There has been little attempt to model properties which apply to a process as a whole rather than to elements of it.

This paper presents an approach to applying the concept of non-functional requirements (NFRs) to business process modelling, developing in particular an extension to role activity diagramming.

According to Kotonya and Sommerville [9] non-functional requirements can be defined (from the system point of view) as “restrictions or constraints placed on a system service”. Adapting this idea to business processes, and casting it in a more positive formulation, we can regard an NFR for a business process as a desirable general property or quality attribute of a process. Two dimensions of NFRs for business processes can be identified. First, direct-service qualities represent qualities introduced directly to the customers, as for example, service-time, responsiveness, or empathy. Second, indirect-service qualities represent general qualities that enable staff members perform their responsibilities efficiently and effectively, such as system users satis-
faction and information availability. The latter do not produce value for customers directly but enable delivery of direct-service qualities.

A method is developed below for representing NFRs and linking them to a RAD model, using a specific business process in healthcare, namely cancer registration in Jordan, for illustration. The application of role activity diagramming to the cancer registration process is shown method, followed by the method for developing and linking NFRs.

2. Process modelling using role activity diagrams (RADs)

According to Ould [13] a process is “a coherent set of actions carried out by a collaborating set of roles to achieve a goal”. Pidd [14] defines a model as “an external and explicit representation of part of reality as seen by the people who wish to use that model to understand, to change, to manage and to control that part of reality”. Therefore, the main purpose for modelling is to express, represent, understand, or manage a certain process. According to Lin et al. [11], one of the most important objectives of process modelling is to capture existing processes by structurally representing their activities and related elements. Process modelling should facilitate comprehensive understanding of organisational processes. Because business processes are usually complex, as for example in banking or healthcare processes, techniques to express, specify, understand, and model characteristics of these processes need to be sufficiently powerful and flexible, while retaining comprehensi-

RADs [13] are diagrammatic notations to represent and model coordinated behaviour and interactions within a process. According to Ould [13], “RAD shows the roles that play a part in the process, and their component actions and interactions, together with external events and the logic that determines which actions are carried out when. So, it shows the activity of roles in the process and how they collaborate”. RADs can be used to give a visual representation of the roles of all players in a business process, and of the interactions between the roles. According to Giaglis [5], the adoption of role as a primary unit of analysis makes RADs particularly suitable for modelling organisational contexts. Saven [16] adds that the depiction of interactions brings communication aspects of a process to the fore and makes RAD models easy to read and understand. In comparison with UML Activity Diagrams, we see RADs as at the same time conceptually simpler, and more strongly oriented towards business, as distinct from software, processes.

In a RAD, a role involves a sequence of activities which are carried out together within a particular responsibility. “Roles are abstract notations of behaviour describing a desired behaviour within the organisation. They can also include software systems, customers and suppliers”, [16]. Each role is represented in a RAD as a named bounded area containing activities, interactions, and logical elements. Activities are represented as black boxes. Fig. 1 shows an example. Vertical lines linking activities and interactions within a role represent states of the role. Concurrent activities in a role can be represented using up-pointing triangles, and alternative activities shown using down-pointing triangles. Interactions are represented by horizontal lines linking boxes in different roles; a shaded box shows where the interaction is initiated, and a white box shows the receiving end.

3. A RAD model of the process of cancer registration

We will use the process of cancer registration as an illustrative example. The first author studied the administration of cancer care in Jordan as part of his Ph.D. research, under the supervision of the other two authors.

Cancer registration (CR) is the systematic collection and classification of data on all types of cancers and persons diagnosed with cancer. Cancer registries aim to determine the distribution of cancer, monitor the growth of cancer per cancer type, evaluate the current treatment process, and monitor patient survival rates. Cancer registration is part of a wider process of cancer care. Cancer control needs a high degree of collaboration between cancer centres and cancer registries.

The cancer registration process in Jordan is managed by the Jordan cancer registry (JCR) which tracks malignant and some benign cancer cases [12]. The JCR is the official (and only) cancer registry in Jordan. The CR process, in Jordan as elsewhere, involves activities and high levels of interaction among many individuals and groups within several organisations.

The CR process in Jordan was studied as part of a wider modelling of cancer care and registration which focused on activities and interactions within hospitals and between hospitals and the JCR. Cancer registration (CR) is chosen here as a self-contained subprocess within the more general context of cancer care, which provides sufficient illustration for the purposes of the present paper. The investigation at the JCR included observation and some participation in its work, as well as interviews with managers and staff.

The main roles involved in the CR process in Jordan are: (1) JCR (Jordan cancer registry); (2) Laboratories; (3) Registrars; (4) Health Sector. The laboratories and registrars are located in individual hospitals. Table 1 briefly describes the roles, activities and interactions involved in this process. A RAD model of the process of cancer registration is shown as Fig. 1.

4. NFRs in business processes

Non-functional requirements (NFRs), sometimes termed quality, or quality of service, attributes or requirements, have been a topic of interest within systems engineering, software engineering, and requirements engineering for a considerable period of time [1,3,6,9]. Gilb’s influential treatment of them [6] dates back
20 years. NFRs are those general qualities of a software (or other engineered) system, such as reliability, performance, or scalability, which refer to the system as a whole rather than to specific functional capabilities. They are problematic to specify, and also to measure. Nevertheless, much effort has been expended in incorporating NFRs in modern software development methods, including those using UML modelling [19].
While these methods are particularly associated with software or systems engineering, related ideas in the field of quality function deployment (QFD) are capable of broader application in systematically mapping customer needs into the final engineering specification of a product or service.

Learning from these approaches to NFRs, and using them analogically, we suggest it will be useful to identify and model desirable qualities or properties of business processes in general. The objective is not so much to design a technical system, or a product, but to understand and model the quality attributes of the business itself. If this can be done effectively, it might point the way to improvements which could be made in the business processes.

We have developed an approach which models business process NFRs and links them to RAD models of the processes. Our way of proceeding is to model the NFRs of a process and map the NFR model to the functional process model represented by the RADs. Effectively, the NFR model is applied to the functional model by using it to identify activities, interactions, and roles in the functional model which could usefully be modified to deliver or serve the NFRs better.

The production of NFRs is essentially a top-down process which starts from consideration of general qualities or desirable attributes of the business as a whole. These are seen as ‘goals’ for the business, from which sub-goals can be methodically derived. Modelling the business via RADs, by contrast, proceeds in a bottom-up direction, identifying activities and interactions taking place in the business and representing them as a set of interacting roles. Fig. 2 illustrates the general approach. The RAD and NFR modelling are independent of one another; by bringing them together, activity- and goal-focused views of the business can be integrated, to provide a basis for the critique and improvement of the business processes. Systematic matching of the NFRs against the functional process model might reveal omissions or superfluities in the processes which could indicate where improvements might be made.

The method will be explored in detail in the next section, and applied to the cancer registration process, so see if it can be improved.

4.1. A Method for modelling business process NFRs

We have adapted a software engineering approach derived from Cysneiros and Chung and their respective colleagues [3,1,2] as an immediate model for representing and decomposing NFRs and resolving conflicts between goals. Applying their approach to the present purpose of analysing and improving a business process, we propose a six-step method:

1. Elicit NFRs and decompose them into subgoals.
2. Define relationships between goals and subgoals.
3. Identify actors who will achieve NFRs (goals).
4. Operationalise goals.
5. Analyse positive and negative interactions between goals.
6. Select which NFRs to address to achieve process improvement.

<table>
<thead>
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<th>Role</th>
<th>Activities</th>
<th>Interactions</th>
</tr>
</thead>
<tbody>
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<td>JCR</td>
<td>Checking forms, checking if patient and primary cancer site exist in JCR database, saving new cases and new primary cancer sites, generating annual reports, and comparing these reports regionally</td>
<td>Registrar (Medical Records), Laboratory, Health Sectors</td>
</tr>
<tr>
<td>Laboratory</td>
<td>Sending JCR form</td>
<td>JCR</td>
</tr>
<tr>
<td>Registrar</td>
<td>Sending JCR form</td>
<td>JCR</td>
</tr>
<tr>
<td>Health Sector</td>
<td>Receive reports</td>
<td>JCR</td>
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Fig. 2. Linking the non-functional to the functional view.

Table 1
The cancer registration process: roles, activities and interactions

Goal: collection and classification of cancer control data

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4.1.1. Elicit NFRs and decompose them into subgoals

Elicitation of NFRs can proceed through examination of academic literature or business documents, but the most fruitful approach is likely to be observing or interviewing people involved in the business process under investigation. In the CR process, one non-functional requirement which appears critical is “quality of information”. NFRs can be thought of as goals, and an NFR can often be decomposed into sub-goals, whose satisfaction will lead to satisfying the ultimate goal ([2,9], and see Fig. 3). And/or trees can be used to represent a decomposition into subgoals. The root of the tree represents the original NFR (parent goal).

The NFR “quality of information” might be decomposed into (1) completeness of clinical information and (2) accuracy of information (Fig. 4). To determine when a goal or subgoal is satisfied requires identification of measures of satisfaction for each. What the appropriate measure of satisfaction is will depend on the type of goal and the context. For example, to satisfy a ‘quality of information’ NFR in cancer registration will require a different measure from a similarly defined NFR in banking.

In the CR context, Skeet [18] states completeness of information can be accomplished in two ways: (1) completeness of cover, and (2) completeness of detail. He further suggests that accuracy of information can be accomplished through: (1) accuracy of detail, (2) accuracy of reporting, and (3) accuracy of interpretation. Satisfying the completeness and accuracy goals will depend on finding measures for satisfying their respective subgoals.

4.1.2. Define relationships between goals and subgoals

The relationship between a parent NFR and its offspring (subgoals) can be represented as AND- or OR-relationships. In an AND-relationship, depicted by a single arc across the parent-child connecting lines, the parent will be satisfied if only if all its offspring are satisfied (Fig. 5).

In an OR-relationship, depicted by a double arc across the parent-child connecting lines, the parent goal is satisfied if one of its offspring is satisfied (Fig. 6).

4.1.3. Identify actors who will achieve NFRs (goals)

Identifying actor(s) who should be responsible to achieve the identified NFRs will help to link the non-functional view with the functional view, since at the end we need to relate the NFR model with the functional process model. We simply annotate the NFR graph with the name of the responsible actor (Fig. 7).

4.1.4. Operationalise goals

In order for goals to be satisfied, some operation needs to be put in place. Goals can be operationalised in two ways, statically or dynamically [3]. Static operationalisation refers to the provision of data to satisfy an NFR, while dynamic operationalisation refers to the carrying out of actions to satisfy an NFR. In modelling NFRs, static operationalisation can be represented using a dotted circle, and
dynamic operationalisation using a bold circle. An arrow is used to show that satisfaction of a subgoal leads to satisfaction of the parent goal.

For example, completeness of information might be one of the subgoals of a ‘quality of information’ NFR. The subgoal can be further refined into (1) completeness of cover and (2) completeness of detail subgoals. These second level subgoals can be operationalised as follows:

(a) completeness of cover can be achieved in two ways:
   (1) by registering every cancer case within a defined population and (2) by avoiding the inadvertent duplication of patients [18],
   (b) to ensure completeness of details, both personal and clinical information should be complete; and incomplete forms need to be returned to source.

These operationalisations are shown in Fig. 8.

4.1.5. Analyse positive and negative interactions between goals

When qualities (NFRs) are collected for a business process, some of them may be found to conflict with each other while others appear to complement or strengthen one another.

For example, validation of information in cancer registries may conflict with confidentiality of access to information. But validation of information is likely to complement accuracy of information. On the NFR diagrams, dotted lines marked by a plus or minus sign are used to represent positive and negative interactions. An example is shown in Fig. 9.

Process redesigners can use the model to identify the most beneficial operationalised goals with least conflict. They can use the diagrams as a basis for performing a trade-off analysis, which will indirectly reflect on the functional view of the overall business process.

Cysneiros et al. [3] propose a procedure for linking an NFR network to a conceptual model. We can adapt this to business process modelling as follows:
(a) Compare and adjust NFR graphs for the same actor within a process to find and remove conflicting NFRs. For example, compare 'information validation' against 'confidentiality' for the cancer registry within the CR process.

(b) Compare and adjust NFR graphs for the same process to find and remove conflicting NFRs. For example, compare 'information validation' for the cancer registry actor with 'information validation' for the hospital actor.

(c) Perform a pair-wise comparison and adjustment on graphs within the same process that have not already been compared under (a) or (b).

(d) Broaden the checking and adjustment procedure across processes within the overall business process.

4.1.6. Select which NFRs to address to achieve process improvement

When interactions among NFR graphs have been identified, an evaluation can be performed to determine which
NFRs should be addressed by the process improvement team. As a first step, labels can be assigned to each goal in the NFR graphs, as follows:

(a) S if the goal is satisfied.
(b) D if the goal is not satisfied (is denied).
(c) P if the goal is partially satisfied.

This evaluation helps the process improvement team analyse the impact of selecting a particular goal on other goals. It would be counter-productive to select achievement of a particular goal for inclusion in process redesign if satisfying that goal led to a more important goal being denied or only partially satisfied.

By repeating this process, the improvement team can select most beneficial goals which involve the least sacrifice. For instance, confidentiality makes a negative impact on quality of information in the cancer registration process shown in Fig. 9. If confidentiality is judged to have less priority than quality of information NFR, it may be acceptable to have confidentiality partially satisfied in order to achieve satisfaction of the quality of information NFR, as shown in Fig. 10.

4.2. Linking the non-functional view to the functional view

We now sketch a general procedure for linking the NFR graphs to the RAD models.

(a) Find all the NFR graphs that refer to a particular process in the RAD model (i.e., in the example case, the CR process).

(b) Within that set of graphs, find those that refer to particular roles in the RAD model, and proceed to examine each role in turn.

(c) Relate the activities and interactions included in the role to the roots (goals) of the NFRs which correspond to that role.

(d) If the role in the RAD model does not cover the nodes in the NFR graphs, the possibility is raised that this part of the RAD model is deficient, and should be updated by adding or modifying activities or interactions that belong to that role.

(e) If there are actors identified in the NFR graphs which do not correspond to roles in the current RAD model, this indicates that it might be necessary to add a new role to the model to satisfy the unmatched NFR(s).

If adjustments are made to the RAD models, it implies that corresponding changes should be made to the actual processes (that is, to the activities, interactions and roles in them).

At present, the procedure presented is informal. There might be benefits, as we develop it, to use a formal represen-
tation of the improvement steps, perhaps using something similar to the ECA (event-condition-action) notation familiar in database contexts.

To illustrate the process of linking, we will show how part of the Quality of Information NFR graph shown in Fig. 11, can be applied to the RAD model of the CR
process in Jordan (shown in Fig. 1.), to produce the modified RAD model for CR shown in Fig. 12.

The NFR graph (Fig. 11) indicates that the Jordan Cancer Registry should validate its information by performing a consistency check, comparing its data with hospital and laboratory data, and giving laboratories and hospitals access to registry information to check their data entries. Table 2 gives a summary of the actions that need to be carried out by the role ‘JCR’ to achieve the goal ‘quality of information’.

From the original CR process model in Fig. 1 and Table 1, it can be seen that “consistency check” (Action1 in the Table 2) is already satisfied (in the ‘check forms’ activity, near the top of the JCR role); but that the other two actions – “compare own data with data from hospitals and laboratories” and “give laboratories and hospitals access to information” (Action2 and Action3 in the Table 2) – are not satisfied. The RAD model can therefore be improved by adding two interactions in the RAD model, namely “check hospitals and laboratories data by accessing JCR information” and “compare JCR information with laboratories and hospitals information”, as shown by the dotted lines in Fig. 12.

5. Conclusion

We have demonstrated the application of a method for remodelling business processes to achieve better representation and realisation of ‘non-functional’ aspects of processes. The approach has been adapted from methods developed in software engineering for linking non-functional requirements to conceptual models. We have drawn an analogy between non-functional requirements in software terms, to general or overall quality aspects of business processes which are not well captured in functionally oriented process modelling methods.

We have shown how the technique of NFR graphing, including operationalisation of goals, and interaction analysis and evaluation of goals can be applied to produce an NFR model of a business process which can then be applied to a functional model developed using role activity diagramming (RAD). The congruence between the central notion of ‘role’ in RAD and that of ‘actor’ in NFR graphing facilitates the linking process. We used an example from a business process in healthcare (cancer registration in Jordan) to illustrate the argument and show an application of the method.

In future research, we intend to develop and test further the procedures outlined here for producing a NFR model of a business process and linking it to a corresponding functional model in the service of business improvement.

References