Prioritizing Service Functions with Non-Functional Requirements

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Abstract

The early stage of service development primarily has two design phases: acquiring demands/constraints and determining delivering functions. The latter phase is significant in bridging the gap between design and implementation, as service providers in the IT industry have struggled in determining an appropriate combination of functions: IT-enabled functions and practitioners' activities. This paper focuses on non-functional requirements (NFR), and quantifies the value of respective combination of service functions from NFR perspectives by clarifying the relationships between NFRs, qualities and functions. Case studies on educational services show that the approach will provide us with a basis for determining respective function priority.

Keywords

PSS design, Service engineering, Non-functional requirements

1 INTRODUCTION

1.1 Gaps between design and implementation

Transformation from product-based business to service-based business is a trend in the manufacturing industry. Service is designed as an additional value for products: manual, maintenance, or providing communities for users. Service is also designed as an alternative value of products themselves: car sharing or rent-a-car provides a transportation function which automobiles have. Therefore, manufacturers will pursue design of products and services not from the viewpoint of superficial functions, but from values which deliver solidly to customers.

The IT system industry has also been following a service trend. Companies strive to increase efficiency in IT systems, and their investment will focus on outsourcing services or software as a service (SaaS) which replace the IT software and hardware platforms maintained by them. Due to this, there is an ongoing trend of shifting to services in various sectors of conventional software and hardware products.

However, vendors in those sectors have tried finding the most beneficial structure in service systems and designing functions in products and/or services by trial and error. This is attributable to the fact that service systems are composed of quantitative and non-quantitative functions. They are composed of visible functions delivered through software or hardware, and support human activities conducted by help-desk operators or maintenance engineers. However, service designers have mainly focused on realization of visible functional requirements because it is hard to determine the relationship between each functional requirement and the activities. As a consequence, they subsequently notice some non-functional requirements (NFR) are left abandoned and they face the necessity of realizing them. Then, they are forced to reassess requirements and functions to be delivered at the time of implementation.

1.2 Related work for bridging the gap

The study of PSS (Product-Service Systems) has discussed the functional values in products and service systems and how to redesign product functions as service functions [1]. Service Engineering have tried systematizing the ways to design functions to meet the customers' expectations [2, 3]. These approaches decompose the products into functions notionally as a service design framework. However, the decomposition starts from indentifying products' intrinsic functions, so attributes derived from the functions, such as supporting activities may be overlooked.

In Requirements Engineering, requirements elicitation and management have been discussed, and triaging requirements have become issues recently. Sankar and Venkat have focused on bridging the gap between requirements and design for products [4]. Herrmann and Daneva have instituted and contemplated the research area more clearly; how to prioritize requirements based on benefits and cost for the early phase of the software lifecycle [5]. Their classifications are 'fixed importance', 'requirements grouping', 'using relative values instead of absolute ones', 'determining relative values by pair-wise comparison', 'using discrete values instead of a continuous scale', and 'building benefit intervals instead of using one value only'. As these research projects still focus on software/hardware products and classifications are domain specific, further research on standardizing the process should be done by shifting the focus to services.

Therefore, this paper focuses on NFRs for service development, clarifying the relationship between NFRs and degree of quality factors, and the relationship between NFRs and functions. The relationships enable quantification of the value produced from the combination of functions, and they are to provide the basis for prioritizing functions to be delivered.

2 NON-FUNCTIONAL REQUIREMENTS (NFR)

NFRs are essentially requirements which cannot be described in the normal functional description. They are qualitative requirements which contribute to the maturity of

the system: performance of response speed, reusability, reliability, or availability of the system. Usually, functions are designed for realizing requirements because system developments are recognized to be as successful only if such functional requirements are clearly defined. However, unless the goals and background of the system development are written and shared among stakeholders, some functions may not be utilized when they are delivered. Furthermore, if some attributes of the functions are not clearly defined, the system will not attain expected levels of performance or usability and such functional design would have to be reassessed. Defining NFRs in the early design phase will address a large number of problems in the ensuing phases. Although, industries have, through their experience, developed a body of knowledge about NFRs, the academia has been trying to establish a model to explain the value of NFRs and the impact or role of NFRs.

2.1 NFR Standardization

As a yardstick among stakeholders, classifications have been specified mainly in software development. IEEE std 830-1998 was established to specify NFRs for software products to prevent oversight [6]. Their NFRs are performance, safety, security and other quality attributes. ISO09126 also defines items to measure the quality of software [7]. These items are composed of quality attributes and their detailed elements. The quality attributes are functionality, reliability, usability, efficiency, maintainability and transitivity.

2.2 NFR Management

On the other hand, goal-oriented approach has been discussed in academia to comprehend NFRs in system development. The approach enables us to identify not only the basis for users needs, but also to specify the respective functions or activities that will satisfy the needs or expectations [8]. A goal-oriented model provides and overviews of the objectives and the alternatives to achieve the goals. The approach may uncover constraints which may have been disregarded.

The standardization targets on developing a body of knowledge but does tell you how to utilize it whereas as a goal-oriented approach attempts to elicit various requirements from stakeholders to reduce the risks of development reassessment, although decisions on choosing functions differ according to managers' experience.

The approach we propose provides objective design assessment by accommodating good aspects of these activities. As an initial part of our proposed methodology, the next sections describe the way to determine the service boundaries and estimate benefits of service functions within the boundary. The preliminary section of our methodology begins by establishing users' behaviour.

3 IDENTIFYING SERVICE FUNCTIONS AND SYSTEM BOUNDARIES

Unlike with product, service has unique features: intangibility, simultaneity, heterogeneity and perishability. These evanescent features make us realize again that introduction and aftercare of a service are important factors for customer satisfaction. In order to perceive these circumstances in user-oriented way, the authors have proposed a methodology of persona-centric service design [9]. The methodology denotes all stakeholders involved in a service system as personas. Persona is defined in two ways. One is the 'User Persona', who will be the final user of the service. The rest of the stakeholders are denoted as 'Role Personas', who have missions in their organization. A user persona has an 'important value list' and 'use cases for each phase'. A use case divided by each phase of service encounter is a combination of 'scenario' and 'degree of importance'. A role persona has a 'function list', which denotes each function provided to other personas.

The following are persona-oriented methodologies to clarify service system boundaries for business to business (BtoB) and business to customer (BtoC) services.

3.1 System Modelling for BtoC Service

First, personas on the receivers' side are modelled as follows:

1. Collect a mass of individual information on services - how much importance they put on quality - through questionnaires to target a user group.
2. Cluster these collected data and choose an arbitrary group that has characteristics suitable to the target based on business decision-making.
3. Extract important value data from information on quality importance degree by methods such as multivariate analysis. Then, list the extracted results as an important value list.
4. Interview some individuals who are in the group mentioned above and make a list of important values.
5. Compute a degree of similarities with the important values, and identify the person with the highest similarity. Then, complete user persona information by using the use case as supplementary information for the user persona.

   Then, personas on the providers' side and the whole service system are modelled in the following steps.
6. Nominate stakeholders in service providers and receivers, and nominate functions that each persona gives to other persona. Then, make role personas. With interview results, put importance on each function and complete role persona information.
7. Correspond between each use case and a function in role persona one-to-one.
8. Confirm whether each use case based on the process of user persona is at all related to any function of role persona. When there is no corresponding function in role persona, analyzing and extracting role persona would be inappropriate. In this case, extract functions in provider again until they correspond to both sides perfectly.

3.2 System Modelling for BtoB Service

As the behaviour of receivers of BtoB services follows business roles, [10] refines the persona elicitation phase (steps 1-6) and substitutes them with the following steps. The steps add business process-oriented ways to indentify stakeholders and their requirements.

1. Draw the target business process as a set of business activities. Identify groups which are in charge of doing the activities. The groups are usually equivalent to each division in their organization.
2. Draw business goals and categorize them according to balanced score cards (BSC) which have four points of view: financial, process, customer and learning views. Then, set the degree of importance to each sub-goal, and find groups which are related to the goals in the category of business processes. The identification follows the degree of relevance which is calculated from the degree of importance of each goal, using something like an arithmetic-geometric mean alogrithm.
3. Nominate role personas from step 1 which identifies directly related stakeholders and step 2 which identifies indirectly related stakeholders.

Necessary and sufficient stakeholders with functions will be extracted from these steps. As a result, flows of service functions between provider and receiver are clarified as shown in Figure 1, and the service system boundary is identified in persona centric ways.

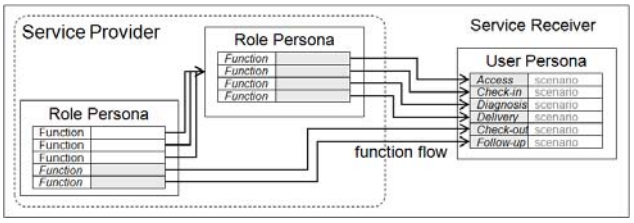

Figure 1: Service Function Flows

The next section shows the latter part of the method: how to acquire hints to optimize service design by assessing the benefit of service systems in various aspects through reframing functions.

4 DESIGN ASSESSMENT

Innovative services will be realized through unbundling and re-bundling service functions in service systems to maximize the total benefit. The NFRs are classified as 'quality requirements' and 'technical requirements' (Figure 2). NFR and quality requirements are treated on an equal basis in some classifications. However, this paper regards technical requirements as equal to functional requirements, so the NFRs are regarded as a superset of functional requirements (FR).

4.1 Relationships between NFR and Quality

Quality contributes to customer satisfaction directly, so qualities are described as metrics which describe personal sensitivity, perception, or tastes. Service qualities in BtoC services are quite sensitivity oriented, though qualities of BtoB services are productivity oriented. So, the relationships are defined as follows.

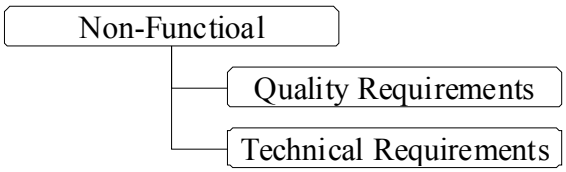

Figure 2: NFR elements

NFR-Quality Requirements for BtoC

The human sense of values has been classified in lexicons and lists [11, 12]. These values will come to the surface as qualitative requirements. In software development, qualitative requirements are classified as non-functional requirements: 'usability', 'security', 'reliability', 'performance', 'portability', and 'customizability' [6]. To some extent, relationships were found between the quality vocabulary and non-functional requirements. Most of the quality elements can be associated with non-functional requirements which regard to their concept. The NFR-quality list is then defined. A part of the list of representing factors is shown in Table 1.

NFR-Quality Requirements for BtoB

Qualities of BtoB services will be described as metrics which directly indicate productivity in their business. For business purposes we introduce NFR categories for BtoB: 'availability', 'performance', 'maintainability' 'assimilation', 'security', and 'environment'. The elements in the table are defined by referencing the guidelines and grades of NFRs which are developed under the consortium of IT vendors [13]. Then, quality factors for BtoB are defined. A part of the list is shown in Table 2.

4.2 Relationships between NFR and Function

From a view of realizing NFRs, NFRs will be visible functions, though some functions will have to be delivered as human activities. The NFRs are then denoted as physical and non-physical functions in Figure 3.

Table 1: Part of NFR – Quality Factors for BtoC

NFR	Quality Factor				
1. usability	low cost	reasonable price	value	low cost	low expenses
2. performance	comfort	refreshment	enjoyment	freedom	carefree
3. security	safety	ease to understand	fairness	justice	kindness
4. reliability	certainty	certainty to complete	processing certainty	source certainty	appropriateness
5. portability	easiness	coziness	comfort	optimism	agility
6. customizability	uniqueness	individual identity	uniqueness of time	locality	originality
	...	...	...	...	...

Table 2: Part of NFR – Quality Factors for BtoB

NFR	Quality Factor				
1. availability	business continuity	fault tolerance	contingency planning	recovery performance	maturity
2. performance	business performance	response performance	performance throughput	resource extensibility	performance guarantee
3. maintainability	operation time	back up	monitoring	recovery method	precaution
4. assimilation	integration schedule	deployment method	data volume migration	medium for migration	rehearsal
5. security	compliance	risk analysis	authentication	device limitation	encryption
6. environment	conformance	place, location	system prerequisite	system characteristics	disaster recovery
	...	...	...	...	...

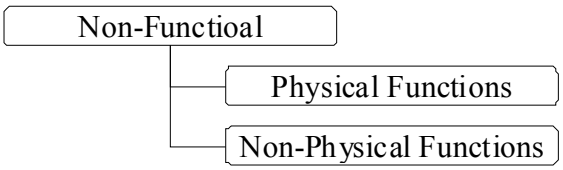

Figure 3: Elements of realizing NFRs

4.3 NFR-Quality and NFR-Function

Using each NFR as a common denominator of 'NFR-Quality' and 'NFR-Function', NFR, quality elements and functions will be associated. Though technical requirements obviously presume specific service functions or activities, quality requirements will be realized in combinations of these functions and activities. Therefore, the relationships are denoted in the model in Figure 4. The relationships are the model which integrates the elements classified in Figure 2 and Figure 3.

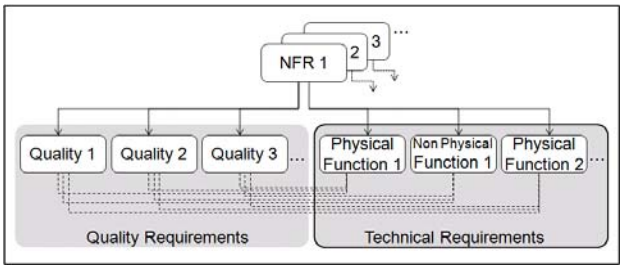

Figure 4: NFR-Quality-Function Relationships

Quantifying Service Values

The effects of service can be evaluated from various perspectives. When service providers promote and propose their services to possible customers, they need to demonstrate those effects, not only the cost value but also other values for customer satisfaction. The factors for customer satisfaction can be dealt with by NFRs, i.e. safety for 'reliability' and speed for 'performance'.

In order to quantify the effectiveness of designed service systems, two attributes are to be set to quality elements and functions respectively in the NFR-quality-function relationships. Degree of importance is an attribute for each quality element, as it contributes to customer satisfaction. In the same way, the second attribute - delivery cost is an attribute for each function will determine the price of the services which may also affect customer satisfaction.

4.4 Design Assessment

Using the models mentioned above, a system is designed through assessment steps which incorporates the procedure identified in Section 3. The respective steps are listed as follows.

1. Use the NFR-quality list, and reconfirm any overlooked quality elements which have to be considered.
2. Define the relationships between quality and function. First, link behaviour/activity of each phase of service encounters and important quality factors in the NFR-quality list. Second, identify service functions which correspond to these behaviour/activities, and match the quality factors and the service functions.
3. Review each relationship by confirming whether the quality factors and the functions are in the same NFR category. Separate the relationship into ones for every NFR, when they are in different NFR categories. (e.g) Increasing performance level may lead to decreasing security level.
4. Set the degree of importance to each quality element and set the delivery cost for each function in the relationships.
5. Select service functions to deliver using the relationship. The selection will quantify the satisfactory quality level and the delivery cost in total. Then, bundle the quality elements with each NFR category to make the expected effects comprehensible. Then, compare the results by changing selection of service functions. This will review redundancy, scarcity and feasibility of delivering service functions from both providers' and receivers' viewpoints.

Modelling and Assessment Tools

In order to assist these steps, the authors have implemented modelling and assessment tools as a part of the value co-creation framework [14]. The framework shown in Figure 5 has modelling tools for service objectives, stakeholder comprehension, relationships of quality and function, and design tools for structure of service systems and assessment tools for the values of service systems. Figure 6 is a screenshot of the NFR-quality-function modelling tool. The tool depicts function flows with usability perspective. Users' scenarios are inserted into the diagram to depict the relationships between users' behaviour and service functions in detail. It explains what quality elements are associated with non-functional requirements, and what outcome is to be expected when patterns of combinations are changed. The middle layer consists of quality elements (or receivers' state parameters: RSPs) which are linked to activities will affect customer satisfaction. The quality elements affect it positively or negatively, when new functions substitute for users' activities. They may improve customer satisfaction if the delivering functions have links to the qualities which target users think important and if these functions are delivered at reasonable cost. They may reduce the customer satisfaction if the delivery functions exert a harmful influence upon other quality factors or if the delivering functions result in an unreasonable high price of services. These assessments, through reframing functions, are exemplified in the following case study.

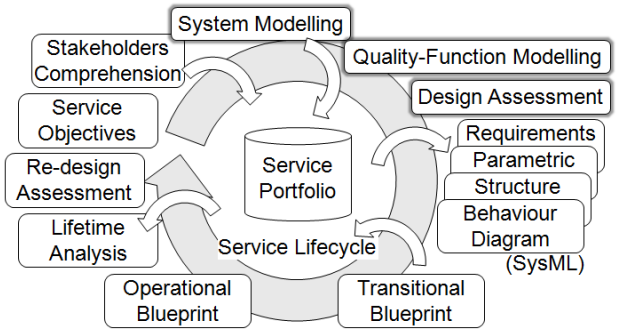

Figure 5: Lifecycle Management Framework

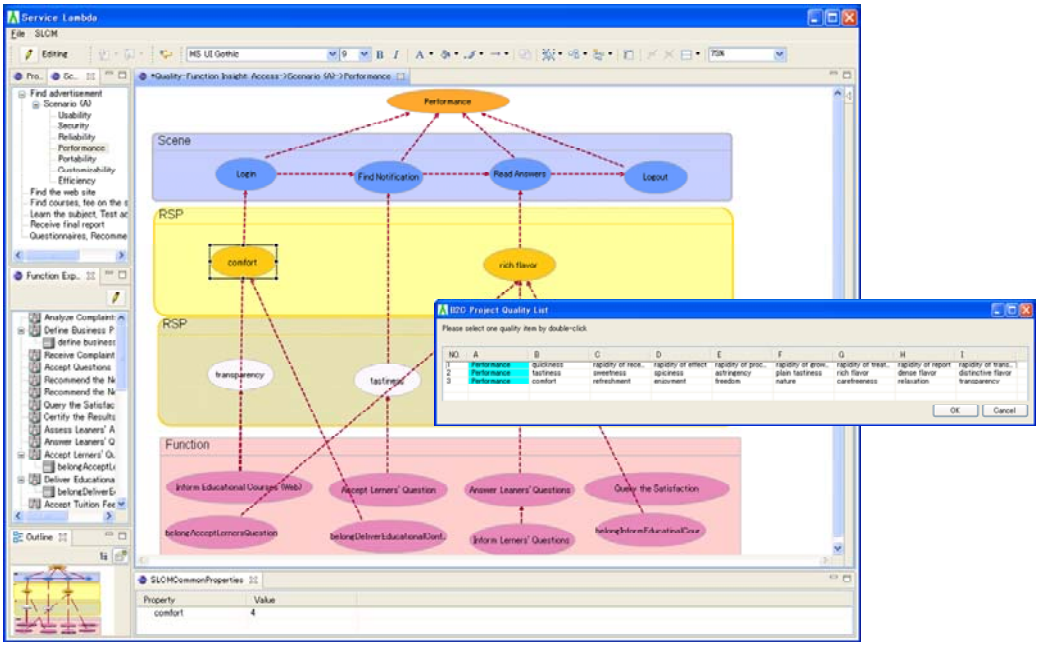

Figure 6: Quality-Function Modelling

5 CASE STUDY

5.1 Software as a Service

The first case study is about e-learning service design as a BtoC service. E-Learning services have replaced conventional classroom education with virtual class, and the electronic material are used instead of text book, although essential functions delivered are the same in both services. The electronic materials are not sold as software product, but as a form of software service. The service will be re-utilized by different clients and delivered as an online service.

Identifying System Boundary

From the list of the users' activities (Table 3), service functions of the provider will be ascertained. In the process of modelling user personas and role personas, the system boundary will be established.

We have applied the methods and tools to different education services in both BtoC and BtoC domains.

Table 3: Users' Activities

Phase of Service Encounter	Users' Activity
1. access	(1) being aware of services
2. check-in	(2) finding popular courses
3. diagnosis	(1) experiencing free-trials (2) comprehend course outline (3) applying for course
4. delivery	(1) logging in/out of the system (2) reading the content (3) taking the tests
5. check-out	(1) asking questions
6. follow-up	(1) considering taking next courses

Then, scope of the service system - the service boundary – is determined as shown in Figure 7, and this scope is to be optimized through reframing service functions.

NFR – Quality Requirements

The user persona's characteristics were established based on the results from questionnaires in Table 4 and in-depth interviews. The target user personas - self-motivated person - are thought to have the ability to study by themselves to some extent. Therefore, they put a high degree of importance on 'usability', 'speed' and 'low price' for activities. Other significant factors are also elicited from the gaps between importance and expectation. Table 5 shows the factors elicited with these steps.

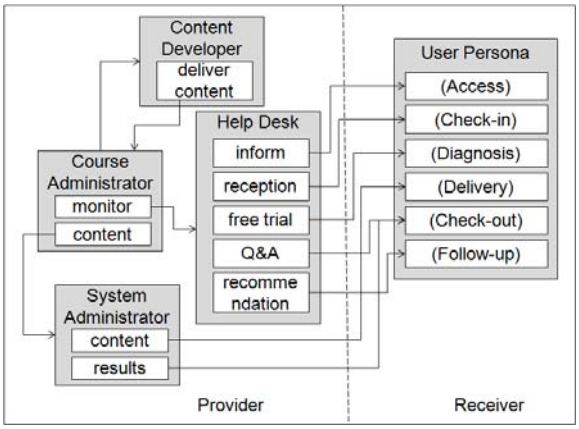

Figure 7: E-learning Service System

Table 4: Quality Factors for the Target

	(high) importance (low)					(high) expectation (low)				
	5	4	3	2	1	5	4	3	2	1
ease	32%	41%	20%	3%	3%	15%	43%	33%	7%	2%
credibility	20%	49%	24%	4%	2%	5%	35%	47%	10%	3%
quickness	21%	42%	31%	3%	3%	10%	36%	45%	8%	2%
appeal	22%	41%	29%	5%	2%	7%	30%	48%	12%	3%
intellectuality	16%	39%	41%	2%	2%	5%	33%	54%	6%	2%
low price	27%	38%	28%	4%	3%	6%	29%	48%	12%	5%
certainty	14%	45%	34%	4%	2%	5%	27%	54%	12%	3%
sincerity	15%	41%	36%	6%	2%	4%	27%	53%	13%	3%
trend	17%	39%	35%	6%	2%	8%	30%	53%	6%	3%
gainfulness	14%	36%	43%	5%	2%	5%	27%	59%	7%	3%

Table 5: Important Quality Requirements

usability	
low cost	reasonable price
performance	
speed	quickness
portability	
easiness	ease

NFR – Quality – Function Modelling

Then, find services function, and find quality factors from the important factors for the user for each activity in Table 3, and link between them as shown in Figure 6.

Design Assessment through Reframing Functions

With these design information, we could estimate changes of the effects of service functions in each non-functional requirement and cost. 'Quick response' scored the same, but 'courteous response' scored much higher in the provider side. Therefore, the function which corresponds to them could include redundant or excessive features to the users. Figure 8 shows the results of not providing the function: comments and reviews for the learners' final tests. This simulation will help to establish the appropriateness of the design and assist in prioritizing requirements in the service systems.

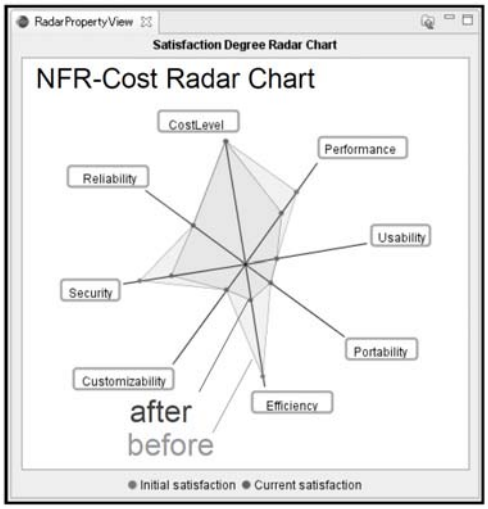

Figure 8: Design Assessment on SaaS Service

5.2 Business Process Outsourcing Service

The second case study is about a business process outsourcing (BPO) service as a BtoB service. Many companies in Japan welcome newly recruited businessmen in April. They take training courses for basic business skills for a month. The courses are not specific to the company, but consist of common skills on business occasions: business manners, skills of PC software/hardware, presentation, or reporting. The instructions are ordinarily instructed by the managers in HR divisions.

Identifying System Boundary

The business process of the training courses consists of the activities in Table 6.

Education vendors can customize the contents or course schedules, and provide these training courses to their clients to replace the client business process.

NFR – Quality Requirements

These activities in the business process are the base determining the service boundary. The NFRs and quality factors were elicited within it. The Table 7 lists some NFR and quality characteristics which are elicited utilizing the Table 2. They are not directly implemented as physical functions. These functions will be realized with functions provided as activities.

Table 6: User-*to-be*'s Activities

Phase of Business Process	Users' Activity
1. plan	(1) training planning (2) post planning
2. grand design	(1) WBS development (2) schedule planning (3) cost planning (4) quality planning
2. grand design	(5) cultural fit (6) best practice benchmarking (7) human resource planning (8) communication planning (9) risk management (10) security/privacy management (11) compliance (12) procurement planning (13) kick-off scheduling
3. procurement	(1) instructors (2) classrooms (3) equipment (4) teaching materials
4. pre-delivery	(1) distribution planning (2) distribution arrangement (3) class guidance (4) place guidance (5) class/member partitioning
5. delivery	(1) checking just before class (2) attendance checking (3) comment on daily report (4) troubleshooting (5) report on class (6) comment on class (7) intermediate report (8) course modification management
6. evaluation	(1) writing final report (2) final report arrangement
7. improvement	(1) budget evaluation (2) employees' performance evaluation

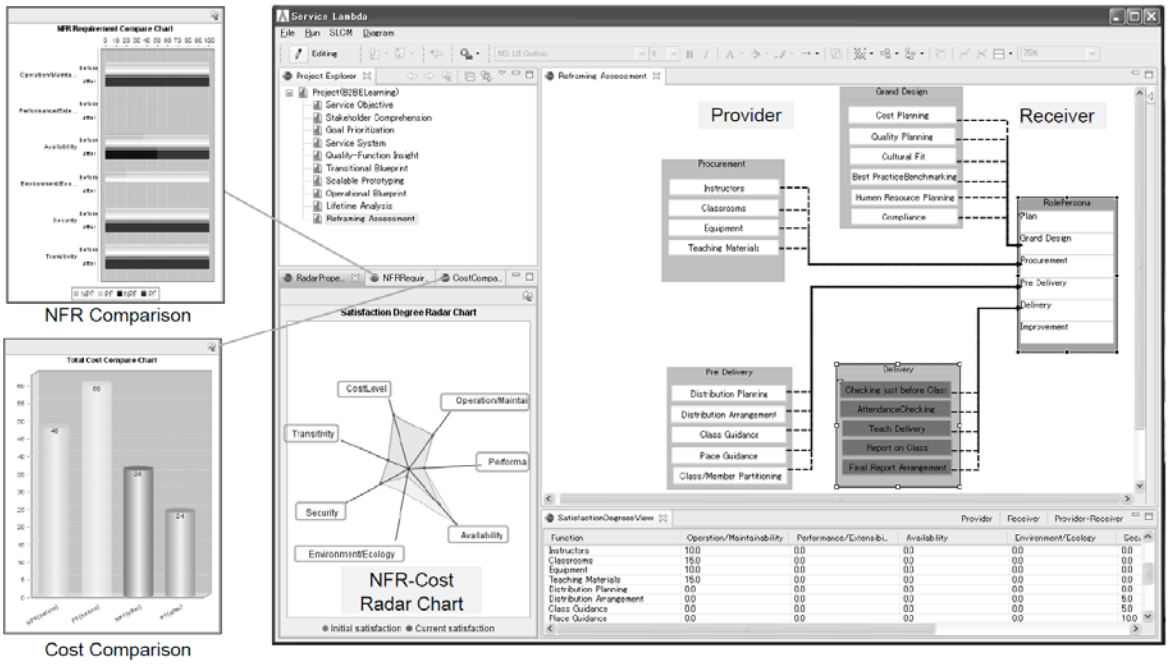

Figure 10: Design Assessment on BPO Service

Table 7: Important Quality Requirements

Availability	
operation schedule	all work days in April
business continuity	providing training classes
business continuity	risk of losing instruction skills
operation/maintainability	
Monitoring	ease of checking attendance
Assimilation	
migration equipment	replacement of classrooms
migration medium	update of vendors' textbook
migration work allotment	ease of task transfer
security	
compliance	compliance
security risk	data leakage risk
access control	management of employees information
data security	management of internal information
environment	
place	convenience of transportation

The degree of importance is set for each quality and delivery cost is set for each function according to the functions and qualities are identified going through respective step by step. Then, we are able to quantify the value of service systems. The following demonstration will assist in reaching a consensus between providers and their expected client.

NFR – Quality – Function Modelling

As shown in the BtoC case study, the relationships between quality factors and functions were established every NFR perspective, using the tool in Figure 6.

Design Assessment through Reframing Functions

Then, the benefits of delivering functions can be assessed. All or parts of the activities from 2 to 6 in Table 6 can be outsourced as shown in Figure 9. For example, activity 5 will not be outsourced when employees from a user's company act as instructors. The outcome of this simulation example is illustrated in Figure 10. The visualized form will contribute for reaching consensus between the education course provider (outsourcer) and the receiver (user company) in when proposing the services.

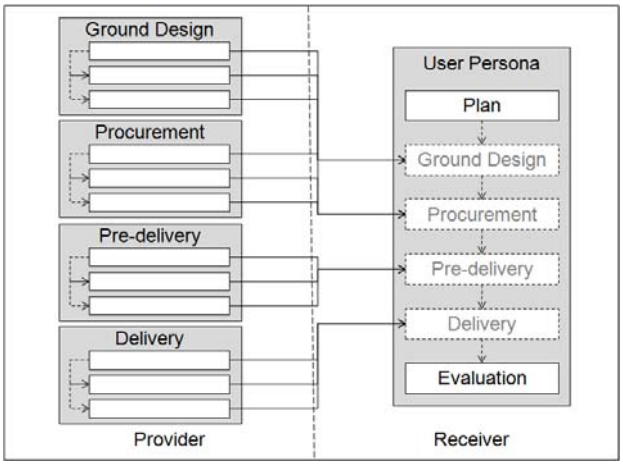

Figure 9: Fully Outsourced Functions

6 CONCLUSION

This paper establishes a framework, which identifies the respective priorities to be delivered. The framework introduces:

(1) the NFR-quality factor lists for BtoC and BtoB, which will reduce the risk of overlooking users' requirements.

(2) the integration models of quality requirements and realizing functions, establishing relationships between users' quality/price requirements for functions and providers delivery costs for them.

Although service decomposition produces a certain number of functions with its diverse relationships pertaining to quality and costs, the NFRs enable categorization of such functions into simple comparative models. In consequence, the framework enables the consideration of both providers' and receivers' demands and the design of feasible service systems.

The case study on SaaS and BPO services are totally different business domains but they show that the approach is applicable to both BtoC and BtoB services.

Decision making has traditionally relied on experience and perceptiveness in many cases. However, the framework will provide the way to a quantitative and objective approach to the value of the respective services and assist in better decision making.

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