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REQUIREMENT ANALYSIS FOR THE IMPROVEMENT OF PRODUCT-SERVICE SYSTEMS

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1. Introduction

As society matures, services are becoming central to economic growth, especially in developed countries. Services, therefore, are becoming increasingly important in many industries. In manufacturing, offering services through a product is regarded as more important than offering only a product. As a result, "Product-Service Systems (PSSs)" [Mont, 2002, Tukker, 2006] that provide values by combining a product and a service have been attracting much attention.
To increase the productivity of services, to analyze developed large-scale and complicated services, or to create new services, a systematic approach to design services is important. The authors, therefore, have carried out fundamental research on "Service Engineering (SE)," which aims at providing design methodology of services from an engineering viewpoint [Arai, 2004]. In SE, a service is defined as *an activity between a service receiver and a service provider to change the state of the receiver* [Arai, 2004]. This definition includes a broader sense than typical definitions in a service management or marketing field, which are used to clarify the difference between services and products (e.g., [Fisk, 2003]). In this definition, most business activities are services, including manufacturing, selling, or maintaining physical products. The term service used in this study, therefore, corresponds to PSSs.

1.1 "Requirements" in the SE context

One of the most important processes in service/PSS design is identifying "requirements" in a service, since a service/PSS should be developed to fulfill specific "customer needs" [Tukker, 2006].
The term "(customer) needs" is often used to represent something that is necessary for life or the reasons for the actions [Maslow, 1987]. "Requirements" is represented to define specified characteristics or specifications, which are more formalized into a precise description of the product. When a product/service is designed to meet customer needs, the needs are translated into requirements, and the requirements are regarded as design targets [Ulrich, 2008].
According to our definition, a service is offered to realize the receiver's state change, and when the state changes to a new desirable one, the receiver is satisfied. Therefore, states that a receiver desires to change should be a design target, that is, "requirements" in a service design. In the SE context, the target receiver's state is represented as a set of parameters called Receiver State Parameters (RSPs) [Arai, 2004]; namely, in this study, requirements are represented as RSPs.

1.2 Continual service improvement focused on requirements

Generally, the value of a service is determined by service receivers [Gronroos, 2000], whose needs are influenced by environment (i.e., trends or situation) with which they are facing [Peach, 2002]. The requirements in the service, therefore, might be changed depending on the environment. In order to

meet such changeable requirements and realize the growth of a service, the key is the continual service improvement adjusted to coincide with the requirements. In this study, such a type of service improvement is called *"Requirement-Oriented Service improvement"*.
Within the requirement-oriented service improvement process, the early phase inevitably includes sub-steps for identifying requirements and analyzing the identified requirements to define specific requirements that should be the focus of the improvement. The scope of this article is to propose a practical method that is used in the early phase.

2. Requirement-Oriented Service Improvement

2.1 Framework of Requirement-Oriented Service Improvement

A systematic framework of the requirement-oriented service improvement is illustrated in Figure 1. The framework is composed of three phases: service evaluation, value analysis and service design. Squares in each phase indicate sub-steps that should be performed by designers.

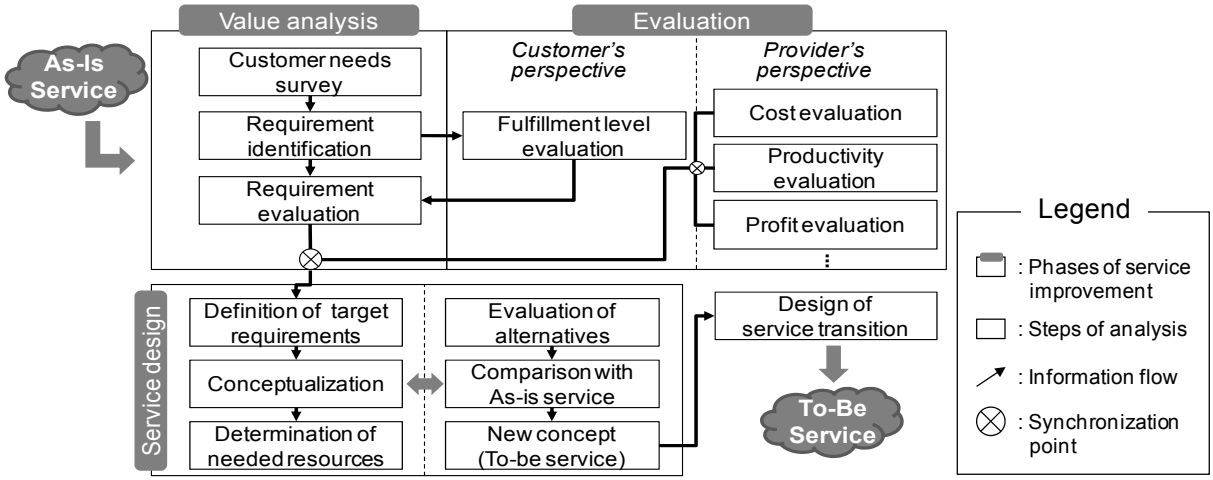


Figure 1. Framework of requirement-oriented service improvement

2.2 Three phases in the framework

2.2.1 Service evaluation

The ideal business or solution forms a win-win relation between a service receiver and a service provider. Service, therefore, must be improved with consideration of the balance of the provider-receiver relation. When the provider design a service that makes the receiver dissatisfied due to an improvement that ignores customer needs, the service will make a loss. On the other hand, the provider should not lose by forcing himself to meet customer needs completely. Hence, the service evaluation phase should include the perspectives of both the customer and the provider.
With respect to the evaluation from the customer's point of view, it is important to clarify the degree to which customers are satisfied, i.e., the fulfillment level of each requirement.
On the other hand, from the provider's perspective, the costs, productivity, and profit of the current service should be evaluated. Some methods for evaluating a service from such criteria have already been proposed, e.g., Activity-Based Costing [Cooper 1988] for cost estimation.

2.2.2 Value analysis

In this phase, designers re-analyze values provided through the service; thus, the first step in this phase is to identify requirements and analyze the identified requirements. Since a service should be designed with a consideration of all requirements that the service should fulfill, exhaustive examination and identification of requirements without omission are important. After that, the identified requirements are analyzed to design a strategy for the improvement.

2.2.3 Service design

Based on the results of requirement analysis in the value analysis phase, designers must first define the requirements that should be targeted in the improvement, for the purpose of finding solutions of service improvement. Subsequently, some specific solutions that can satisfy the requirements are conceptualized. The resources needed to realize the solution are then determined. Here, the term resources includes both physical products and human resources. After that, designers select the best solution among them. The selected solution is then compared with the current service by some criteria. Only when the solution is better than the current service, it can be regarded as suitable for a new concept, i.e. To-be service. The to-be service should be introduced to the current business field smoothly. Therefore, after the new service concept is generated, designers need to consider how to shift the current service to the new service, i.e., they need to design a service transition [ITIL, 2007].

2.3 Scope and challenge

The framework reported above is just an overview of requirement-oriented service improvement. We, therefore, need a more concrete method or procedure to execute each step in the framework.

One of the most important steps in the framework is analyzing the identified requirements to define design targets because this step is a starting point of the improvement process; thus, the step affect the later steps, e.g., steps in the service design phase. However, it is difficult to determine target requirements due to the fact that, normally, a number of requirements are identified when they are thoroughly examined.

In this paper, our scope is set on (1) requirement identification and (2) service improvement strategy design based on the identified requirements. Namely, the scope is the procedure to define the target requirements, i.e., two sub-steps before "Definition of target requirements" in the value analysis phase and "Fulfillment evaluation" in the evaluation phase. The challenge is proposing a concrete method to analyze the identified requirements and to define the target requirements from them.

3. Requirement identification

We have already proposed a method to identify requirements in a service, especially in a B2B service [Akasaka, 2009].

The first step of this method includes market surveys, interviews, or questionnaires to clarify customer needs. Based on the collected data, customer's business activities are modeled visually, and then the modeled activities are translated into a service script. The service script is written in natural language; thus, it enables designers to analyze the customer's behavior in more detail. From the script, designers identify some "key words" that can be considered as important elements for the service. Finally, each key word is associated with required items/qualities and quality elements using a pre-defined vocabulary list. Here, required items refer to what customers want to do, and the required quality is a linguistic expression of customer needs related to the quality of the provided product/service [Akao, 1990], namely, the required items/qualities indicate representations of "customer needs" in a service. On the other hand, quality elements work as criteria for evaluating the quality [Akao, 1990]. Thus, the quality elements could be regarded as requirements in a service, since these are elements that satisfy the required items/qualities, i.e., customer needs.

4. Requirement analysis

4.1 Approach

Each of the identified requirements has its attributes, e.g., whether or not it is fulfilled. Urgency of the need for improving a service is influenced by the attributes of the requirements. For instance, a part of the current service related to an unfulfilled requirement should be improved preferentially compared to a service that already satisfies a requirement. Therefore, "classification" of the requirements is taken as an approach to "analyze" the identified requirements.

For the classification, four perspectives are introduced as attributes of requirements: fulfilment level, Kano quality [Kano, 1984], and the relevance to internal and external environments. The first two

attributes, i.e., the fulfilment level and Kano quality, will help designers clarify the customers' perception towards the requirements. The last two attributes, i.e., the relevance to internal and external environments, enable designers to consider the change of environments or situations where the service is offered. Here, the former two perspectives are evaluated from the customers' viewpoint, and the latter two perspectives are evaluated by the provider.

4.1.1 Fulfillment level of the requirements (1st perspective)

The first perspective is the fulfilment level. It refers to the degree to which the requirements are satisfied. In this study, the fulfillment level of the identified requirements is evaluated qualitatively by the customers' use of the terms "fulfilled", "partially-fulfilled" and "unfulfilled". As reported in 2.2.1., the fulfilment level evaluation is held in the evaluation phase .

4.1.2 Kano quality (2nd perspective)

The second one is Kano quality, which provides quality categories of features in a product/service.
Kano quality [Kano, 1984] is proposed by Kano et al. in the quality management field and is a model to categorize a quality. According to the Kano model, quality attributes are categorized mainly into three types: attractive, one-dimensional and must-be quality. Figure 2 illustrates the features of these three types of quality. The horizontal axis indicates the state of fulfillment. Attractive quality elements have little influence on customer satisfaction, even when they are unfulfilled. On the other hand, must-be quality elements are recognized as a matter of course, and, if they are unfulfilled, customers are deeply dissatisfied. In this study, the identified requirements are classified into three Kano quality types.

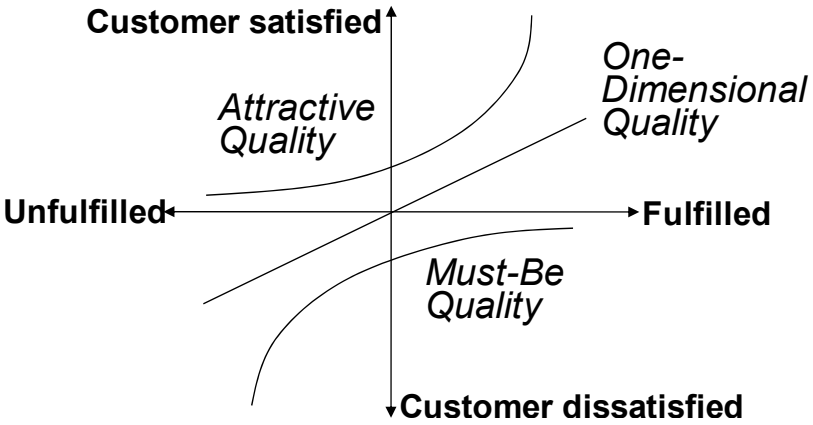


Figure 2. Kano quality

4.1.3 Internal and external environments (3rd and 4th perspectives)

The internal environment of a provider affects the decision to define the target requirements for the improvement of a service. For example, if the provider has a specific strength, e.g., a specific skill or knowledge, it is relatively easy to improve a part of service related to such strength. Furthermore, in general, an external environment, i.e. trends or situation, influences a customer and his/her needs. Therefore, to grasp such environment-related requirements, designers have to analyze the external environment of a provider.
SWOT analysis is a framework to formulate a business strategy by analyzing the external and internal environments of the business [Hill, 1997]. Table 1 shows a typical matrix that is provided in a series of SWOT analysis studies [Weihrich, 1982]. As shown in Table 1, in SWOT analysis, the external environment is analyzed by listing the business Opportunities (O) and Threats (T), and the company's internal environment is assessed for its Strengths (S) and Weaknesses (W).
In our method, designers judge whether or not requirements are related to internal environments, i.e., internal strengths or weaknesses, and any external environments, i.e., external opportunities or threats.

Table 1. SWOT matrix

	Internal Strengths (S)	Internal Weaknesses (W)
External Opportunities (O)	**SO strategy**	**WO strategy**
External Treats (T)	**ST strategy**	**WT strategy**

4.2 Requirements evaluation matrices

This part explains a concrete method to analyze the identified requirements with a comprehensive use of the four perspective reported in 4.1.

4.2.1 Bi-layered matrix

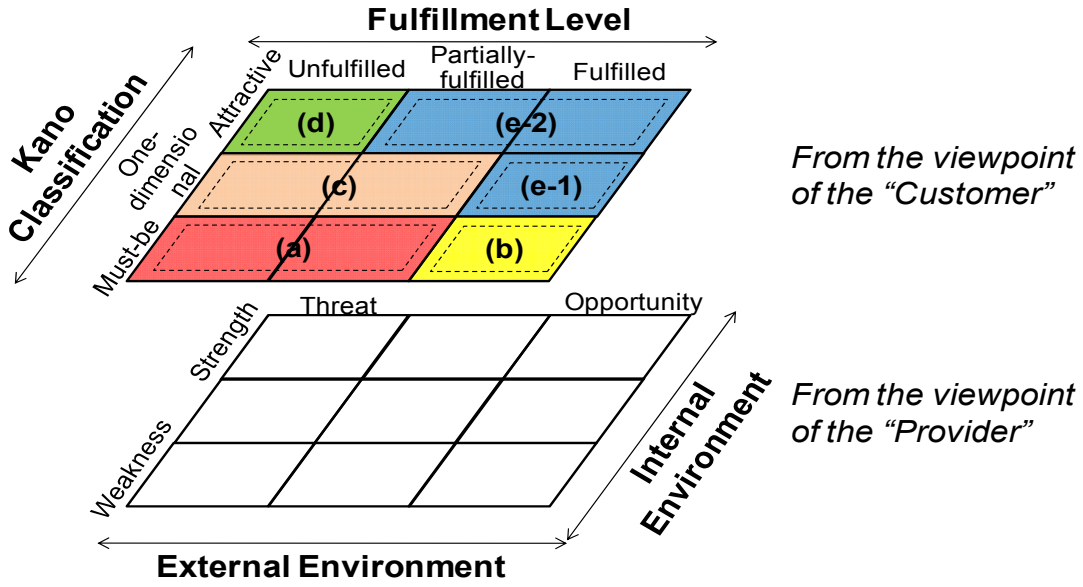


Figure 3. Requirement evaluation matrices

In this study, a bi-layered matrix to classify the identified requirements is developed (see Figure 3). The upper matrix in Figure 3 classifies the requirements from a customer's viewpoint. Thus, its horizontal axis is the fulfillment level, and the other axis is the Kano classification. The lower matrix is almost the same as the SWOT matrix. However, the lower matrix has nine cells, while the original SWOT matrix has only four cells. This is because all of the requirements, including requirements that are not related to internal or external environments, should be categorized to any cells.
The identified requirements are first mapped to a cell in the upper matrix, and they are then mapped to a cell in the lower matrix. All of the requirements are then mapped onto two matrices respectively.

4.2.2 Five important sectors

The nine cells in the upper matrix can be classified into five sectors, (a) to (e), shown in Figure 3.
Referring to the feature of three types of quality noted in the Kano model, sectors (a) and (c) indicate that customers are dissatisfied, that is, the value of the customer satisfaction is negative. On the other hand, sector (e), (e-1) and (e-2), refers to customer satisfaction, namely, the value of customer satisfaction is positive. Sectors (b) and (d) indicate neutrality, neither satisfaction nor dissatisfaction; thus, the value of customer satisfaction is nearly zero. It is noteworthy that, in sector (b), zero is the maximum, and, in contrast, zero is the minimum in sector (d). Therefore, improving a service related to a requirement in sector (d), the value of customer satisfaction can only move to the positive direction, while that is not possible in sector (b).

5. Strategy design for service improvement

5.1 Improvement strategy driven by Kano and SWOT

The Kano classification and SWOT analysis are both considered as valuable for developing design and business strategies.

Some researchers in the mechanical design field have suggested that a product's features should be designed in consideration with its Kano quality. Table 2 is a description of the characteristics of design corresponding to each quality [MacDonald, 2009]. This description can be considered as a kind of design strategy based on the Kano quality.

On the other hand, in a relevant study of SWOT analysis, Weihrich proposed four conceptually alternative strategies corresponding to the four columns in the SWOT matrix [Weihrich, 1982].

Improvement ideas or plans described in the S-O column are called SO strategies. The strategies are means to use internal strengths to take advantage of the opportunities. Thus the company should not hesitate to realize the ideas described as SO strategies.

ST strategies appear in the S-T column. This strategy is based on the strengths of a company that can deal with threats in the external environment. In other words, if a provider can overcome the threats, a differentiated service can be realized.

WO strategies in the W-O column attempt to minimize weaknesses by taking advantage of opportunities. The business plans in the W-O column should be conducted carefully.

WT strategies aim at minimizing weaknesses and avoiding threats. Namely, actions or plans to avoid significant risks are described here.

Table 2. Design types corresponding to the Kano quality

Kano categories	Type of Design
Attractive	**Attractive Design**: A designed product/service provides extra satisfaction to customers. Sometimes, this type of design will be creative.
One-dimensional	**Better Design**: The better a product/service performs for a customer, the more satisfied the customer is.
Must-be	**Essential Design**: A lack of such a feature would result in customer dissatisfaction, and probably make a product/service not as useful to the customers.

5.2 Grand strategy for service improvement

The design types corresponding to each Kano quality derive a grand strategy of service improvement with respect to each of the five important sectors.

There are two types of service improvement strategies: (i) To reduce or eliminate the potential for customer dissatisfaction, and (ii) To increase the degree of customer satisfaction.

5.2.1 To reduce or eliminate the potential for customer dissatisfaction

Sector (a). Improvement to warrant the minimum quality of a service: "- to 0"

Requirements in this sector must be fulfilled to warrant the minimum quality of the service. Anything less will result in customer rejection.

Sector (b). Improvement to maintain the minimum quality

These attributes means that the minimum quality of the service is already assured. However, if a requirement is also related to Treats or Weakness in the lower matrix, designers need to consider and manage several kinds of risks that impede the quality of the service.

5.2.2 Improvement to increase the degree of customer satisfaction

Sector (c). Improvement to eliminate customer dissatisfaction and increase satisfaction from a negative to a positive: "- to 0/+"

A part of service related to a requirement mapped here is now considered as one reason for customer dissatisfaction. To eliminate the dissatisfaction, therefore, designers should improve the part. When such improvements are made, there is a possibility to change the dissatisfaction into satisfaction.

Sector (d). Improvement to add a new value by the attractive design: "0 to +"

Focusing on the requirements mapped here, a novel service might be created, and then the value of the customer satisfaction will be increased. This occurs because fulfilling an attractive quality element means pleasing the customer, i.e., the attractive design.

Sector (e). Improvement to obtain higher customer satisfaction: "+ to ++"

The current services related to requirements mapped here have already created relatively high customer satisfaction. Therefore, the provider does not need to modify the services. However, effective improvement of the service can raise the degree of customer satisfaction dramatically and will be an important source of profits.

Here, sectors (e-1) and (e-2) are different in terms of the design type, namely, (e-1) relates to the better design and (e-2) relates to the attractive design. Therefore, improvements concerning requirements in (e-1) are more realistic, whereas those in (e-2) are more creative.

5.3 More detailed strategy for service improvement

The grand strategies reported in 5.2 are obtained from the mapping result on the upper matrix. It is, therefore, possible to provide more detailed suggestions by combining the mapping result on the lower matrix. In this study, a vector that connects the same requirement between two matrices is descried. The vectors possess four kinds of attributes of the requirement: fulfillment level, Kano quality, and internal and external environments.

Strategies for the vectors are generated by combining the strategies driven by the SWOT matrix with the grand strategies reported in 5.2. A strategy template developed in this study organizes these two strategies, and, thus, it provides suggestions or hints that are more precise to define the target requirements. Namely, the template helps designers define the target requirements for improvement.

6. Case study

The proposed method was applied to a real service, facility construction and maintenance service, in which a utility company was the service receiver. Figure 4 shows the overview of the service.

In this example, the utility company offers a social infrastructure service and maintains lifelines for the public. Thus, the utility company has to operate its facilities safely. A facility construction/ maintenance company constructs and maintains the facilities of the utility company. Furthermore, there are other stakeholders , i.e., a manufacturer and three cooperative firms, who were involved in the service. The focus was to improve the facility construction and maintenance service received by the utility company. Namely, in this case study, requirements in the service were identified, and then the identified requirements were analyzed by using the proposed matrices and strategy template.

6.1 Requirement identification and analysis

First of all, the requirements for the service were identified. In this case study, nearly 50 requirements, e.g., "Reliability of an equipment" and "Accuracy of an inspection," were identified.

To analyze the identified requirements, firstly, the fulfillment level of the requirements was evaluated qualitatively through a discussion with a person involved in the service. Secondly, the identified requirements were classified into three types of Kano quality. Questionnaires were adopted for the objective classification. Table 3 illustrates the results. Thirdly, internal strengths and weaknesses as well as external opportunities and threats were extracted based on the discussions and data collection.

The service provider's internal strength was *an advanced technological capability*. On the other hand, their internal weaknesses were *more poorly constructed technical training within the company than several years before and relatively-weak relationship with the customer, i.e., the utility company.*

The external opportunities for their services were *an increase in disasters caused by climate change and an increase of the difficulty level of construction/repair work because of the complexity of equipments.* (The first one is a risk factor to maintain facilities for the utility company; thus, for the facility construction/maintenance company, this situation will be a chance for their maintenance business.) The external threat for their service was *societal demand for the reduction of the environmental burden.* (Up to now, the facility construction/ maintenance company has been

unconcerned about environmental burden and just focused on safety or output due to the fact that they are involved in public infrastructure.)
Subsequently, the identified requirements were evaluated whether they were related to the above-mentioned S, W, O, and T or not. The results are shown in Table 3. Based on each result, the requirements were mapped to the bi-layered matrix. Vectors to connect the same requirement ware then described. The results are shown in Figure 5. The numbers in each cell indicate how many requirements belong to the cell in the matrices.

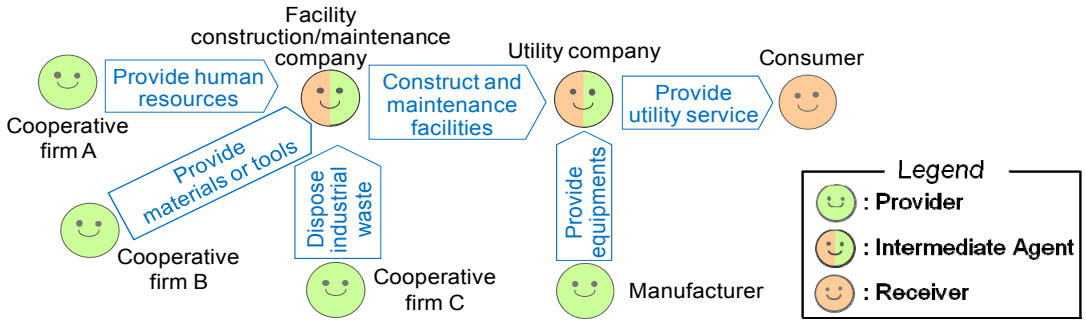


Figure 4. Overview of the case example

Table 3. A part of result of requirement analysis

Requirements	Fulfillment level	Kano Quality	Internal Environment		External Environment	
			Strength	Weakness	Opportunity	Threat
Reliability of equipment	Fulfilled	Must-be	Unrelated	Unrelated	Related	Unrelated
Environmental friendliness of equipment	Unfulfilled	Attractive	Unrelated	Unrelated	Unrelated	Related
Long life of equipment	Unfulfilled	Attractive	Unrelated	Unrelated	Unrelated	Related
Accuracy of inspection	Fulfilled	Must-be	Related	Unrelated	Related	Unrelated
Degree of handing down of skills to younger employees	Partially-fulfilled	Must-be	Unrelated	Related	Unrelated	Unrelated
High capability on self-managing of a team	Fulfilled	One-dimensional	Related	Unrelated	Unrelated	Unrelated
Small amount of waste of materials	Partially-fulfilled	One-dimensional	Unrelated	Unrelated	Unrelated	Related
……	…	…	...	...	...	...

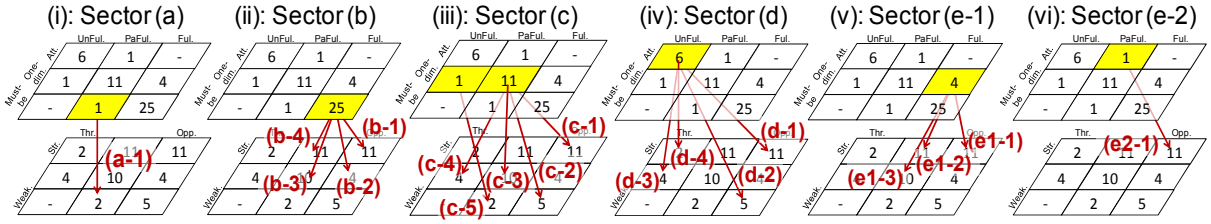
6.2 Determination of the target requirements

The facility construction/maintenance company, which was a service provider in this case, intended to improve its service toward the two objectives described below.

- Fortifying the basics of their current service.
- Providing new values to the service receiver, where the new values must fit into their needs.

Considering the five grand strategies corresponding to the five important sectors, for the first objective, i.e., fortifying the basics of their current service, we analyzed some vectors which start with sectors (a) and (b). As shown in (i) in Figure 5, there was a vector related to sector (a), which represented a requirement "Degree of handing down skills to younger employees." As reported in 6.2, requirements in sector (a) must be fulfilled to warrant the minimum quality of the service, and anything less will result in customer rejection. Therefore, the provider has to improve the "Degree of handing down skills to younger employees" by, e.g., reinforcing education or reorganizing work teams. Meanwhile, we could find 25 requirements that were represented by vectors starting from sector (b). These requirements were considered as the must-be quality elements and have been fulfilled. It means that the minimum quality of the services related to these requirements was assured.

Furthermore, there seems to be no significant risks that impede the quality of the service, since the vectors were not headed to Weakness- or Threat-related cells.
On the other hand, focusing on vectors starting from sector (d) was the most effective way to examine requirements that relate to the second objective, i.e., providing new values to the service receiver. New values might be provided by considering additional services to meet some of these requirements.
Furthermore, observing the mapping result on the lower matrix and using the strategy template helped identify the requirements that deserved attention. In this case, for example, the requirement "Swiftness of modifying a specification," which was translated from customer needs "A specification should be changed or modified swiftly in response to requests," was found in sector (d) in the upper matrix. In the lower matrix, this requirement was mapped to the Opportunity – Strength cell. It means that, according to the strategy template, the requirement was easy to fulfill, since the requirement was not related to the weaknesses and the threats. Therefore, when an immediate improvement is needed for the service provider, conceptualizing a service that meets this requirement was the best way. On the other hand, in sector (d), there was a requirement "Possibility of succession of equipment," which means that equipments in a facility should not be disposed of without reusing. This requirement's vector was headed to the Threat – Strength cell. Referring to the strategy template, there may be risks caused by the threats, when the provider attempts to create a new service that meets the requirement. However, if a provider can overcome the threats, a differentiated service can be realized with providing a new value to the utility company.



(i): Sector (a)		
Vec.	N. of reqs.	Mapped reqs.
(a-1)	1	Degree of handing down skills to younger employees

(ii): Sector (b)		
Vec.	N. of reqs.	Mapped reqs.
(b-1)	5	Accuracy of inspection, etc.
(b-2)	4	Reliability of equipment, etc.
(b-3)	7	Stability of power supply, etc.
(b-4)	9	Risk preventiveness in work, Punctuality in work, etc.

(iii): Sector (c)		
Vec.	N. of reqs.	Mapped reqs.
(c-1)	3	Diversity of work techniques, etc.
(c-2)	4	Flexibility of work, etc.
(c-3)	2	Cheapness of equipment, etc.
(c-4)	2	Small amount of waste of materials, etc.
(c-5)	1	Degree of understanding about other teams

(iv): Sector (d)		
Vec.	N. of reqs.	Mapped reqs.
(d-1)	1	Swiftness of modifying a specification
(d-2)	1	Degree of cooperation for building close relationships with other teams
(d-3)	2	Long life of equipment, etc.
(d-4)	2	Possibility of succession of equipment, etc.

(v): Sector (e-1)		
Vec.	N. of reqs.	Mapped reqs.
(e1-1)	1	Less limitation on work situation
(e1-2)	2	High capability on self-management of a team
(e1-3)	1	Credibility of a work manager

(vi): Sector (e-2)		
Vec.	N. of reqs.	Mapped reqs.
(e2-1)	1	Exactness of modification of a specification

Figure 5. Requirement mapping results

7. Discussion

Once requirements in a service are identified, finding out the target requirements from them is the designer's responsibility, and it depends on the capability of the designers. In many cases, this puts a burden on the designers, since designers have to consider and manage a number of requirements. Furthermore, when the requirements are identified, the characteristics or differences among the requirements are not clear. This situation makes it difficult for designers to define the target requirements in a service improvement, i.e., to build a strategy for the improvement.
Concerning this problem, by using the proposed matrices as a "filter", the requirements are classified, and differences among the requirements are visualized. It helps designers obtain some significant suggestions to build strategy for the service improvement. For example, in the case study, we could find that fulfilling the requirement "Degree of handing down skills to younger employees" was important to warrant the service quality. Meanwhile, designing a new service that meets the

requirement “Possibility of succession of equipment” would be effective to provide a novel value for the customer, i.e., the utility company.
However, the matrices do not provide sufficient information to determine the target requirements, as they do not deal with the data of cost, productivity, and profit evaluations, which can be regarded as important criteria for a service improvement from a provider’s viewpoint. Therefore, future work will include a scheme to combine other evaluation criteria with the proposed method.

8. Conclusion

In this article, we propose a framework of requirement-oriented service improvement. In this study, we concentrate on the early phase of the framework, which is requirement identification, evaluation, and the definition of specific requirements that should be focused on improvement. As a practical method for the phase, the requirement evaluation matrices and the strategy template were developed.
It is difficult for designers to define design targets, i.e. target requirements, in service improvement. To overcome this problem, the proposed method enables designers to obtain some significant suggestions or hints to define the target requirements.

Acknowledgement

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