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Development and Application of Technology Planning Methods for Service Innovation

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Abstract

Development and Application of Technology Planning Methods for Service Innovation

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During last few years, service innovation has been considered as one of important research topics in the innovation literature. In these days, firms earn money from not only products, but also services. In many industries, services play a substantial part of value creation process. Quite naturally, firms face with this important question: how can we conduct the effective service innovation? The answer, as most management practices do, is the systematic planning.

This doctoral thesis deals with this problem. To plan the service innovation effectively, this thesis deals with six service planning problems at three different categories of innovation planning: ideation, deployment, and design. For each study, several methodologies are suggested, providing the methodological sufficiency for each problem. A concrete framework to effectively employ each methodology is suggested with detailed procedures.

Theme#1 deals with the identification of functional characteristics to develop new services using service tree. This study proposes a tree-based analytic tool that may be used in analyzing a large-scale and complex service process. The proposed service tree analysis consists of three main parts; service tree construction, qualitative analysis, and quantitative analysis. Firstly,

a service tree is constructed depending on how the service elements are selected by the customer. Next, in the qualitative analysis, service elements are characterized as core services, supporting services, and optional services by deducing a minimal service cut set. Lastly, qualitative analysis deals with deriving the impact of each service element based on the Kano model.

Theme#2 deals with new service development with functional heterogeneity. According to the functional characteristics derived from theme 1, i.e., whether the function is core or peripheral, differentiated approach is suggested. For the core function, it is required to maintain the core functionality. Therefore, case-based reasoning (CBR) whose sprit comes from finding similar alternatives is suggested. For the peripheral function, we suggest a modified zigzagging approach in which creativity takes a big seat.

Theme#3 is related to the planning of product-service integration, considering technology interface. This theme firstly focuses on the role of technology in product-service integration and identifies six types of technology interface. According to the technology interface, we suggest an integrated product-service roadmap, with its definition, characteristics, structure, and typology. This theme contributes to the fields in that it firstly focuses on the role of technology in product-service integration, and provides six types of technology interfaces and technology roadmaps.

Theme#4 is related to the technology planning in a big data era, suggesting an association rule mining (ARM)-based technology roadmapping process. Considering layer-dependency in technology roadmaps, this theme suggests an ARM-based roadmapping approach. Using ARM, this theme calculates affinity using a support measure and dependency using a confidence measure. Based on those two measures, two types of roadmaps are developed: keyword portfolio map and keyword relational map. This theme contributes to the fields in that it tries to develop the data-driven approach to the technology roadmap, considering dependency between layers.

Theme#5 focuses on services modularization using QFD. Despite the applicability of modularity, there has been a lack of research on how to modularize the service in a practical perspective. Therefore, this theme suggests a modified QFD and applies it to the service modularization. First,

service is decomposed according to the three dimensions: service outcome, service process, and prerequisite for services. Next, module drivers are identified based on literature review: common module drivers and service-specific module drivers. Next, modified QFD, in which the service elements are listed on the column and the module drivers are listed on the row, is suggested. This theme can provide a managerial implication to the service firms by providing a concrete framework and specific processes.

Theme#6 is related to the service design with FMEA diagnosis. This theme proposes a systematic approach for identifying and evaluating potential failures using a service-specific failure mode and effect analysis (FMEA) and grey relational analysis. The proposed approach consists of two stages: construction of service-specific FMEA and application of grey relational analysis. The first stage, construction of service-specific FMEA, aims at incorporating the service specific characteristics to the traditional FMEA, providing 3 dimensions and 19 sub-dimensions. Then, grey relational analysis is applied to calculate the risk priority of each failure mode.

Keywords: Service innovation, Technology planning, Technology roadmap, Technology management, Decision making

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Chapter 1. Introduction

1.1 Background and motivation

Today, firms compete on not only the basis of physical products, but also the basis of services (Gallouj and Weinstein, 1997; Sundbo, 1995; Gronroos, 2000; Kandampully, 2002). Services are no longer considered as a peripheral in the business environment, but are increasingly seen as core customer offerings. Innovation paradigms have been changed from manufacturing to services, as many practical evidences have proven (Morris and Johnston, 1987; Congram and Epelman, 1995; Mayer et al., 2003).

Given the drastic growth of the service sector, much attention has been paid to the service innovation in both academia and practice. Service innovation is defined as “new or considerably changed service concept, client interaction channel, service delivery system or technological concept that individually, but most likely in combination, leads to one or more new service functions” (Van Ark et al., 2003, p. 16). Substantial amount of research has been conducted regarding service innovation, including service definition (Judd, 1964; Rathmell, 1966; Levitt, 1972; Shostack, 1977; Walters and Bergiel, 1982), service characteristics (Sasser et al.,1978; Chase, 1978; Maister & Lovelock, 1982; Schmenner, 1986; Johnston & Morris, 1984), and service design (Levitt, 1972; Shostack, 1977; Chase, 1978).

Among many research areas of service innovation, what is at the core is the service planning (Scheuing and Johnson, 1989; Edvardsson et al., 1995). In any organization, successful innovations are the result of well-planned work (Kumar, 2004). This is especially true of service industries where a lot of uncertainty exist due to the innate characteristics of services such as intangibility, heterogeneity, inseparability, and heterogeneity (Sasser et al.,1978; Chase, 1978; Maister and Lovelock, 1982; Schmenner, 1986; Johnston and Morris, 1984; Schostack, 1987; Wemmerlov, 1990; Silvestro et al., 1992). Services are generally unstructured and ill-defined (Fitzsimmons and Fitzsimmons, 1994; Tinnilä and Vepsäläinen, 1995), thus need to be systematically planned. This is in line with the discussion of previous literatures that point out the importance of concrete methodology of service planning; successful new services grow from well-designed structures and orchestrated processes (Scheuing and Johnson, 1989; Edvardsson et al., 1995). In addition, firms take benefits from well-developed processes to foresee people's need and the nature of contexts (Kumar, 2004).

Therefore, to guarantee the success in service innovation, how to effectively plan service innovation is a critical question. To answer this question, analytic and systematic methods for service innovation are highly required (Aurich et al., 2010). To effectively plan the innovation, it has been noted that comprehensive frameworks, structured methods, and rigorous tools should be equipped with (Kumar, 2004).

Despite the importance of systematic planning of service innovation, service planning has been relatively neglected in the service management literatures, with a lack of systematic and analytic approach (Tinnilä and Vepsäläinen, 1995; Fitzsimmons and Fitzsimmons, 1994). Even if some studies tried to plan the service innovation effectively, previous works have been subject to the qualitative and expert-based work, not employing an analytic and systematic approach (Lee and Park, 2005). Even if some works has employed analytic approach, those have borrowed the tools and methodologies from the traditional innovation paradigm, such as manufacturing innovation (Rinne, 2004; Fouskas et al., 2005; Kameoka, 2005 ; Chuang, 2007).

However, the study of service management is not simply transferring an accumulated body of theories, tools, and techniques from the manufacturing arena to the arena of service production (Wemmerlöv, 1990). Rather, the study of service innovation should mirror the distinctive features of services, vis-a-vis the manufacturing (Schmenner, 1986). In other words, with the emerging trend of service engineering, service management can take a step further not only to adopt manufacturing-based approaches, but to develop hybrid approaches taking advantages of both marketing and manufacturing approaches (Bullinger et al., 2003). Therefore, what is required in both academics and practices is the use of systematic approach to the service planning, reflecting the innate characteristics of service innovation. The use of systematic planning methods, considered promising and effective for the service innovation planning, is provided in this thesis.

1.2 Purpose

The overall purpose of this thesis is to develop and apply the technology planning methods for service innovation. From the theoretical perspective, this thesis tries to provide a solid framework and method to plan the service innovation, encompassing the broad range of planning processes occurred in service innovation. From the methodological perspective, this thesis tries to fill the void in literature related with the application of methodology in service innovation. The thesis is composed of six themes, each of which is concerned with each of six service planning problems. The objectives of the six themes are as follows.

Theme#1 suggests a service tree analysis to reflect the customer participation in analyzing the service process. This study proposes a tree-based analytic tool that may be used in analyzing a large-scale and complex service process. Using this tree, we categorize service elements as one of three types - core services, supporting services, and optional services - by deducing a minimal service cut set.

Theme#2 aims to develop new services considering functional heterogeneity. According to the functional characteristics, i.e., whether the function is core or peripheral, differentiated approach is suggested. For the core function, case-based reasoning (CBR) whose sprit comes from finding similar alternatives is suggested. For the peripheral function, we suggest a modified zigzagging approach in which creativity takes a big seat.

Theme#3 suggests an integrated roadmap for product-service integration, considering technology interface. To reflect the business dynamics towards product-service integration, this research identifies six types of technology interface and suggests an integrated product-service roadmap, with its definition, characteristics, structure, and typology.

Theme#4 suggests an association rule mining (ARM)-based technology roadmapping to utilize the business data into the planning process, focusing on the measurement of layer-dependency. Using the support measure as an intra-layer relationship and the confidence measure as an inter-layer relationship, keyword relational maps are developed.

Theme#5 aims to develop a method for service modularization using modified quality function deployment (QFD). To modularize services, we conducted both the driver-based approach and the interrelationship -based approach. In the driver-based approach, service-specific module drivers are identified and employed for modularization. In the interrelationship-based approach, relationships among three dimensions of services: service outcome, service process, and prerequisite for services, are measured.

Finally, theme#6 suggests a service-specific failure modes and effect analysis (FMEA) to prevent the service failure and manage the failure modes proactively. This research proposes a systematic approach for identifying and evaluating potential failures using a service-specific FMEA and grey relational analysis (GRA). Construction of service-specific FMEA aims at incorporating the service specific characteristics, providing 3 dimensions and 19 sub-dimensions. The GRA is applied to calculate the risk priority of each failure mode under these interrelated multi-dimensions.

1.3 Scope and framework

Planning, with its general use of terms, encompasses a variety of circumstances. In literatures, the concept of service planning includes a practical perspective, encompassing the general decision-making process of service innovation (Aurich et al, 2010). Therefore, service planning encompasses many processes of decision making in service innovation: identification, definition, and selection of service ideas, even the service realization phase (Aurich et al, 2010). Some authors noted that service innovation process should deal with a variety of processes, such as sense intent, know people, know context, frame insights, explore concepts, make plans, realize offerings, and foster uptake (Kumar, 2004). Even some research argued that service planning should include the monitoring and management process of services (Butler and Boyle, 2000).

Summarizing the previous works regarding broad context of service planning, three sub-categories of service planning are identified: ideation, deployment, and design, as shown in Figure 1-1.

Those sub-categories can be regarded as stages of service planning. First, service planning should deal with ideation. This means new service development should be carefully planned, in order to guarantee the success of innovation (Scheuing and Johnson, 1989; Johne and Storey, 1998; Edvardsson, et al., 1995; Edvardsson and Olsson, 1996; Aurich et al, 2010; Kumar, 2004).

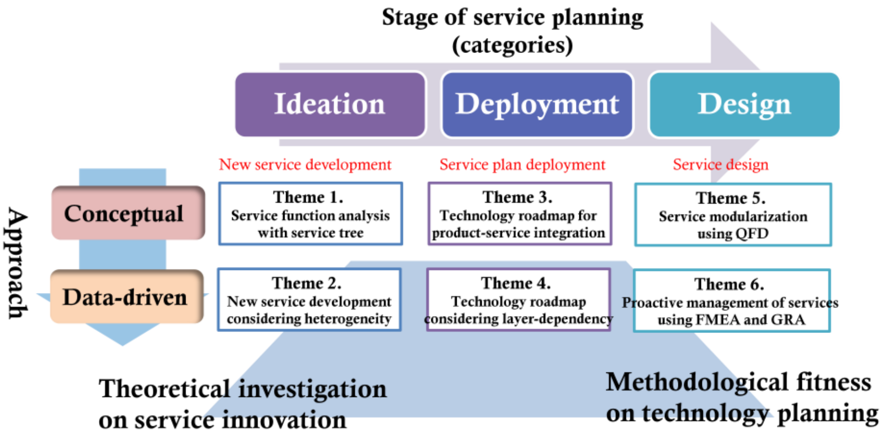


Figure 1- 1 Framework of this paper

Second, service planning should encompass the service deployment which is closely related to the innate meaning of planning (Easingwood and Storey, 1993; Storey and Easingwood, 1994; Aurich et al, 2010; Kumar, 2004). The term, deployment, denotes that service idea should be linked with the future plan, which is a core concept of service planning. Finally, service planning also includes a concept of planning an effective service design (Schneider and Bowen, 1984; Johne and Storey, 1998; Easingwood, 1990; Edvardsson and Olsson, 1996; Aurich et al, 2010; Kumar, 2004). As previous research noted (Butler and Boyle, 2000), even the designing or management process is the target of planning, in order to guarantee the success in the service innovation.

For each category, two types of approach are employed: conceptual approach and data-driven approach, as shown in table 1-1. The first approach is the conceptual approach which explains the service planning using abstract objects, where objects are the constituents of relevant propositions. As many literature noted (Schoemaker and van der Heijden, 1992;Mintzberg, 1994; Premkumar and King, 1994; Ishii et al., 1997; Segars et al., 1998; Feng et al., 1999), conceptual approach has been applied for many planning practices. The second approach is the data-driven approach (Ansoff, 1965; Mintzberg, 1994; Eppinger, 1997; Paparone, 2003; Jin and Chen, 2008; Bresciani et al., 2010) which employs business data to the planning process. This is especially significant in recent business environment where a lot of data is generated and consumed. Using business data, firms can plan the service innovation in an effective and analytic way.

Table 1- 1 Modules and corresponding research topics

Module	Research Theme	Detailed explanation
Planning for Ideation	Service function analysis with service tree	Theme #1. Application of fault tree analysis to the service process: service tree analysis approach (Geum et al., 2009)
	New service development Considering heterogeneity	Theme #2. How to develop new services: an hybrid approach of case-based reasoning and modified zigzagging approach
Planning for Deployment	Technology roadmap for product-service integration	Theme #3. Development of technology roadmap for product-service integration (Geum et al., 2011a)
	Technology roadmap considering dependency	Theme #4. Development of data-driven technology roadmap for product-service integration
Planning for Design	Service modularization using QFD	Theme #5. Modularization of service using modified HoQ approach (Geum et al., 2011b)
	Proactive management of services using FMEA and GRA	Theme #6. A systematic approach for diagnosing the service failure: service-specific FMEA and GRA(Geum et al., 2011c)

1.4 Thesis outline

This thesis is composed of three chapters which encompasses two sub-themes. Therefore, six themes to the service planning, discussed in the previous section are provided in this thesis. The remainder of this thesis is organized as follows.

Chapter 2 provides background both from theoretical and methodological perspective. Theoretical background covers the study of service innovation which is used to explain and define the service planning, the main topic of this thesis. In this section, the definition, characteristics, and three approaches of service innovation are discussed and the role of technology in service innovation is also investigated.

Methodological background covers a variety of methodologies and tools to support the service planning. Eight methods which are applied for each module are explained in detail, in terms of its theoretical background and methodological characteristics.

Chapter 3, 4, and 5 are main bodies of the thesis. Basically, this thesis is organized according to the three categories of service planning: ideation, deployment, and design. Each chapter includes two themes at each different category, and each theme encompasses its own introduction, background, approaches to solving problems, and conclusions. Figure 1-2 depicts the overall structure of this thesis.

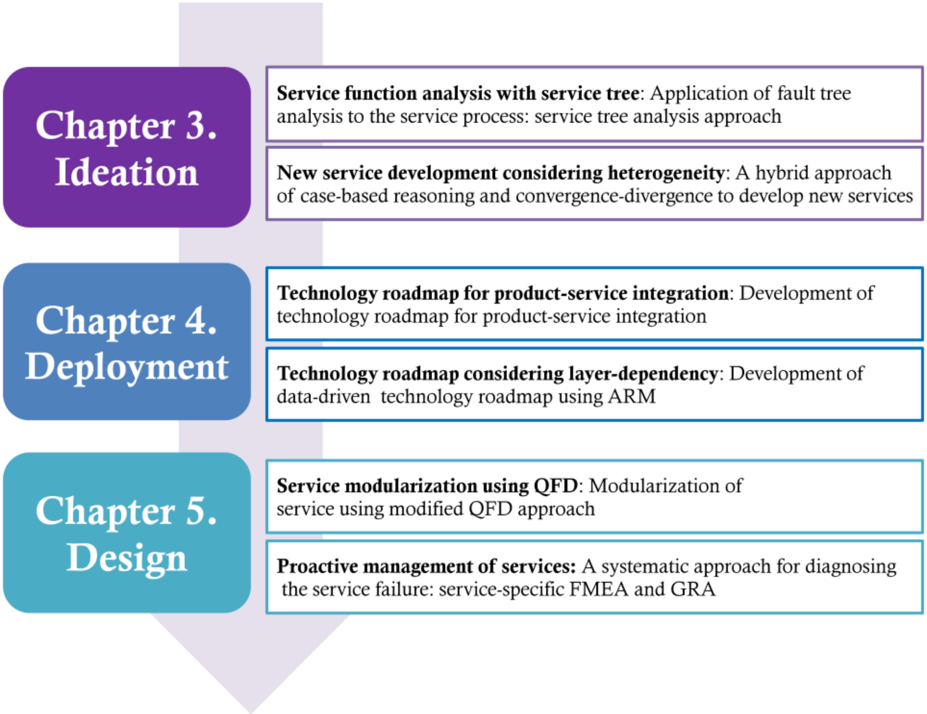


Figure 1- 2 The overall structure of this thesis

Chapter 2. Background

2.1 Theoretical background

To understand what to do in planning the service innovation, the prerequisite is to understand the service innovation itself. Understanding the service innovation provides an important clue to the planning of service innovation, with a help to select, adapt, and modify the appropriate methodologies to plan the service innovation.

2.1.1 Service innovation

Service innovation is defined as “new or considerably changed service concept, client interaction channel, service delivery system or technological concept that individually, but most likely in combination, leads to one or more new service functions” (Van Ark et al., 2003). It generally encompasses four dimensions: (1) new service concept, (2) new client interface, (3) new service delivery system, and (4) new technological options (Den Hertog, 2000).

The notion of service innovation has been discussed with the distinctive characteristics of services, in terms of its theoretical foundations and practical considerations (Drejer, 2004). In terms of its distinctive characteristics, four dimensions are found: intangibility, heterogeneity, inseparability, and perishability (Sasser et al., 1978; Zeithaml et al., 1985; Schmenner, 1986; Edvardsson et al., 2005). First, intangibility denotes that services are activities and not physical objects. Second, heterogeneity means that performance of service varies from producer to producer, from customer to customer. Third, inseparability denotes that production and consumption happens simultaneously. Finally, perishability means that service cannot be kept in stock.

Besides those innate characteristics, there is another important issue to explain the service innovation: customer-oriented characteristic. As a co-producer (Edvardsson et al., 1995; Fitzsimmons and Fitzsimmons, 1994; Fließa and Kleinaltenkamp, 2004) and a partial employee (Bateson, 1985; Kelley et al., 1992), customers play an important role in many areas of service innovation, including new service development, service operations, and service planning. Therefore, much effort should be devoted to the consideration of customer contact, customer role, and customer experience in the service innovation.

To treat service innovation, three different approaches exist (Drejer, 2004), as summarized in Table 2-1. The first approach is the assimilation approach (Archibugi et al., 1994; Djellal and Gallouj, 2000; Hughes and Wood, 2000) which deals with similarities than differences with respect to a range of basic dimensions of innovation processes of services (Sirilli and Evangelista, 1998; Hughes and Wood, 2000). This approach is based on the assumption that service innovation stems from manufacturing innovation, thus should be investigated based on the similarity between services and manufacturing. The representative example is the second European Community Innovation Survey (CIS II) in 1997, which is confined to applying definitions of and questionnaires for services, which were intended for manufacturing activities (Djellal and Gallouj, 2000).

The second approach is demarcation approach (Sundbo, 1998, 2000; Sundbo and Gallouj, 1998, 2000; Gallouj , 2000; Djellal and Gallouj, 2001) which does not compare innovation in services directly with innovation in manufacturing, but rather study distinctive features of service. In this approach, distinctive characteristics such as intangibility, heterogeneity, inseparability, and perishability are considered to be important to explain the service innovation. This approach is mainly conducted via an autonomous survey such as Innovation in Services and Services in Innovation" (SI4S) in 1997.

The final approach is synthesis approach (Gallouj and Weinstein, 1997; Preissl, 2000), which suggests the combined approach of service innovation and manufacturing innovation. As Drejer (2004) noted, an integrative approach to overcoming the manufacturing-service dichotomy is a promising research step for service innovation.

In this thesis, demarcation approach is mainly employed, since service planning should mirror the distinctive characteristics of service itself to guarantee the success of innovation. In some part of thesis, synthesis approach is also used to explain how to plan the product-service integration effectively.

Table 2- 1 Three approaches for service innovation

Category	Characteristics	Example
Assimilation approach	- Focusing on similarity of services and products in terms of innovation processes (Sirilli and Evangelista, 1998; Hughes and Wood, 2000) - Conducted via a subordinate survey	- The second European Community Innovation Survey (CIS II) in 1997, applying definitions of and questionnaires from manufacturing (Djellal and Gallouj, 2000) - Follow-up on the CIS I survey (1993) which explored manufacturing firms' technological product innovation
Demarcation approach	- Not comparing innovation in services directly with innovation in manufacturing, but rather to study distinctive features of service - Conducted via a autonomous survey	- European project on "Innovation in Services and Services in Innovation" (SI4S) in 1997 - Broadened to encompass not only product and process innovation, but also internal organisational innovation and external relational innovation (Sundbo, 1998, 2000; Sundbo and Gallouj, 1998; Djellal and Gallouj, 2001)
Synthesis approach	- Suggesting that service innovation brings to the forefront hitherto neglected elements of innovation that are of relevance for manufacturing	- Found in the work of Gallouj and Weinstein (1997), who aim at developing an integrative approach to innovation which encompasses manufacturing and services and applies to both technological and non-technological innovation

2.1.2 Technology in service innovation

To deal with the service innovation, technology has been considered as an important factor, facilitating the effective customer-supplier interaction and efficient service operations (Kandampully, 2002; Menor et al., 2002; Van Riel and Lievens, 2004). Especially, accelerations in information technology significantly promote the service innovation, providing a clear technology-driven motive to the innovation. Now, it is generally believed that service systems are value-creation networks composed of people, technology, and organizations (Maglio et al., 2006).

Technology occupies a substantial part of service innovation, providing effective and efficient means to the service operations. Traditionally, technology has been discussed in a product-related term. This is natural since technology has long been developed for products. For product perspective, technology has been regarded as a means for enhancing the digital convergence (Koga, 1988) or a means for managing the new product development process (Schilling and Hill, 1998; Ulrich and Eppinger, 1995; Wheelwright and Clark, 1995).

However, with the rise of service industry, technology has been successfully implemented and utilized for both employees and employers in recent service business. Investment in ICT more than doubled between 1995 and 1999 to $510 billion in the US alone (Curran and Meuter, 2005). Especially, services are major users of ICTs, which the most important technological changes of the past 20 years have been associated to (Amable and Palombarini, 1998). Therefore, some studies argued technical characteristics of services. One of the major features of service activities is the fact that the technologies involved usually take the form of knowledge and skills embodied in individuals and implemented directly when each transaction occurs (Gallouj and Weinstein, 1997).

In service industry, technology has been considered as a means for providing new types of business such as customization (Bitner et al., 2000), new transaction or process (Bitner et al., 2000; Froehle and Roth, 2004), or new types of service encounter (Bitner et al., 2000; Froehle and Roth, 2004). Recently, many firms provide the technology-based communication channel to provide the customer service. Especially, information technology (IT) takes a significant role in terms of managing the customer service.

The role of technology can be a little bit differentiated according to the stage of value delivery. In the pre-purchase step, technology is generally applied for the design of integration. For example, technology in this step can contribute to the customization of products or services according to the customer needs. In the purchase step, technology is generally applied for the interaction for providing the new process or transaction, making virtual interaction between products and service in the practical level. Finally, in the post-purchase step, technology can contribute for management of products or services. Since the customer already purchased the products or services, technology plays a key role in administration or customer services.

2.2 Methodological background

To plan the service innovation, what is required is the use of concrete methodologies which are suitable to solve the problems. However, the use of methodology cannot be simply transferring an accumulated body of tools and techniques from the manufacturing arena to the arena of service production (Wemmerlöv, 1990). Rather, it should be adapted and modified according to the service context.

Since this thesis encompasses three modules - planning for ideation, planning for deployment and planning for design - many different methodologies are employed for each problem context, as shown in Table 2-2. The detailed explanation of each method is represented in each theme, since the understanding of each theme should be guaranteed to understand the utility and sufficiency of each method.

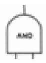
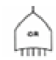
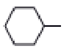
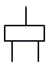
Table 2- 2 Methodologies used in this thesis

Module	Purpose	Methodologies
Planning for Ideation	Identifying possible solutions	- Fault tree analysis (FTA) - Case-based reasoning (CBR) - Axiomatic design
Planning for Deployment	Linking the resources to the action	- Technology roadmap (TRM) - Association rule mining (ARM)
Planning for Design	Designing service operations effectively	- Quality function deployment (QFD) - Failure modes and effect analysis (FMEA) - Grey relational analysis

2.2.1 Fault tree analysis

FTA is a method for determining combinations of elements whose fundamental concept is to translate a physical system into a structured logic diagram in which certain causes lead to one specified TOP event of interest (Lee et al., 1985; Bennetts, 1975). Commonly used symbols to construct the fault tree are described in Table 2-3.

Table 2- 3 Symbols to construct the fault tree

Symbol	Name	Definition
	AND	Failure happens when the N subordinate event are happened simultaneously
	OR	Failure happens when at least one of subordinate event is happened
	Condition	Condition is represented
	Basic event	Basic events that cannot be decomposed
	Intermediate event	Intermediate events

FTA is mainly based on two assumptions. The first assumption is the possibility assumption, i.e. the system failure behavior is fully characterized in the context of possibility measures. The second assumption is the binary-state assumption, which denotes that the system demonstrates only two crisp states: fully functioning or completely failed. At any time the system is in one of the two states (Huang et al., 2004).

FTA begins with the statement of failure. Then, potential first-level contributors should be identified and linked using appropriate logic gates. The AND gate is used where all input events must occur for the output event to occur, and the OR gate is used when only one of the occurrences of the input events results in occurrence of the output event. Then, these steps will be repeated until the basic events cannot be separated further.

After constructing fault tree, both qualitative and quantitative analysis are followed. The main objective of qualitative analysis is to find minimal cut sets which are the smallest group that can result in the top event, failure. On the other hand, quantitative analysis is made to estimate the probability of occurrence of higher level events. How to calculate the probability of top event occurrence is described in the following equations for AND and OR gates respectively, where denotes the probability that event i occurs and Q denotes the probability or failure rate of the relevant gate. Equation [2-1] describes the probability in case of AND gate linkage, whereas [2-2] describes of OR gates.

$$Q = \prod_{i=1}^{n} q_i \qquad [2\text{- }1]$$

$$Q = 1 - \prod_{i=1}^{n} (1 - q_i) \qquad [2\text{- }2]$$

2.2.2 Case-based reasoning

CBR is a problem solving paradigm which automates reasoning and machine learning by remembering previous similar situations and reusing them (Aamodt and Plaza, 1994). A new problem is solved by finding a similar past case, and reusing it to suggest a solution in the new situation, as follows (Aamodt and Plaza, 1994).

- Presentation: Describing the current problem
- Retrieval: Retrieving the closest matching cases
- Adaptation: Using the current problem and closest matching cases to generate a solution
- Validation: Validating the solution through feedback from the user
- Update: Adding the new problem and solution to the case data base

CBR is based on the similarity assumption: Most similar cases are most useful for solving the target problem, i.e. the retrieval distance is commensurate with the adaptation distance. (The most similar case is the easiest to adapt) (Smyth and Keane, 1998). Therefore, similarity assumption really only holds when feature similarity directly reflects deeper similarities in the domain theories of two systems of concepts. (Smyth and Keane, 1998).

A CBR system involves the following three components: a case representation scheme, a similarity metric, and a case-retrieval mechanism (Wu et al., 2006). First, the representation scheme considers the case as a model composed of a set of attributes, which characterize it for a particular application; second, a similarity metric is employed to measure the similarity between the case and those in the database, and, finally, a case-retrieval mechanism is employed to retrieve the most similar case which is suitable for identifying a solution to the target problem (Wu et al., 2008). Figure 2-1 shows the structure of CBR system.

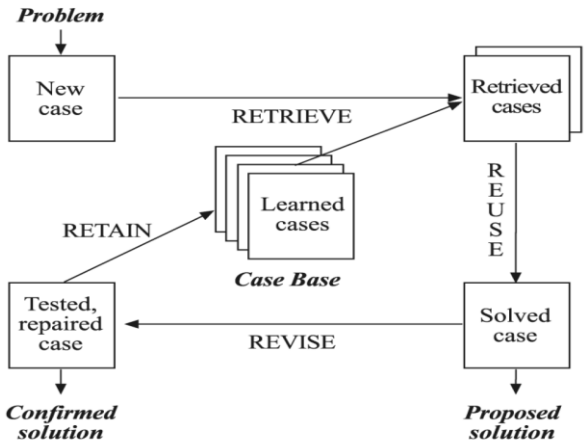


Figure 2- 1 The structure of CBR system (Belecheanu et al., 2003)

Given its power in deriving similar cases for which solutions have been found, CBR has been used for solving problems in many different areas, including planning, diagnosis and design. Trousse and Visser (1993) reviewed the use of CBR in solving problems in intelligent computer–aided–design systems. CBR has also been employed in product design to retrieve data or design details about existing products (Belecheanu et al., 2003; Wu et al., 2006; Wu et al., 2008). Changchien and Lin (2005) have developed and implemented a CBR system for marketing plans.

2.2.3 Zigzagging decomposition in axiomatic design

The axiomatic design, a popular engineering design method, is best summarized and understood by the following concepts (Lu and Liu, 2011). First, the axiomatic design classifies the whole design activity into four primary domains: CA domain, functional requirements (FR) domain, design parameter (DP) domain, and PV domain, to categorize different types of design decisions (Heo and Lee, 2007). Second, an iterative zigzagging design process is conducted when decomposing higher-level abstract decisions into lower-level detailed ones across layers. Third, two generic design axioms, namely the Independence Axiom and the Information Axiom, guide the comparison and selection of good design decisions (Lu and Liu, 2011).

In axiomatic design, it is assumed that the design for a product is characterized by design parameters. In this theory, two important axioms are identified. The first axiom is the independence axiom, which states that a good design maintains the independence of the functional requirements. The second axiom, the information axiom, establishes information content as a relative measure for evaluating and comparing alternative solutions that satisfy the independence axiom, i.e. minimize the information contents (Suh, 1998). Independence axiom, which is a key concept of axiomatic design, requires that FRs be independent of one another, which enables each FR to be satisfied without affecting any of the other FRs (Suh, 2001). The mapping process between the domains can be expressed as shown in equation [2-3]. The relationship between these two vectors can be written as

$$FR_i = A_{ij} DP_j \qquad [2\text{-}3]$$

where [A] is a matrix defined as the design matrix that characterizes the product design.

The design process of axiomatic design is a mapping from What to How domains (Mohsen and Cekecek, 2000). The mapping between the functional requirements (FRs) and physical domains (DPs) is executed in a zigzagging hierarchy (What-How- What -How…) as shown in Figure 2-2. The decomposition of FRs and DPs cannot be done by remaining in a single domain, but can only be done through zigzagging between the domains (Suh, 1998). The independence axiom in axiomatic design requires us to create a complete and independent set of FRs, 'what we want to achieve' and corresponding DPs, 'how we achieve it' (Heo and Lee, 2007).

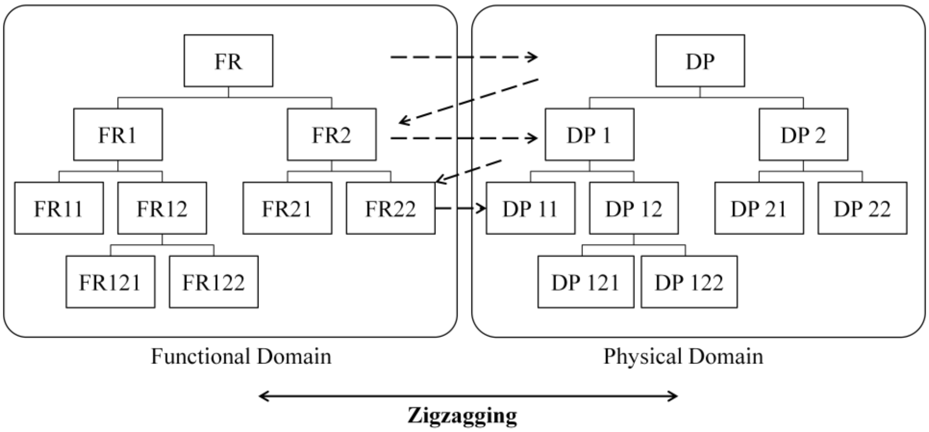


Figure 2- 2 Zigzagging decomposition of axiomatic design

2.2.4 Technology roadmap

Technology roadmap is one of the most widely used methods for supporting the strategic management of technology (Lee and Park, 2005; Phaal et al., 2004; Rinne, 2004). It provides a graphical means for exploring and communicating the relationships among markets, products, and technologies over time, linking the business strategy to the evolution of the product features (Albright and Kappel, 2003; Lee and Park, 2005), as shown in Figure 2-3.

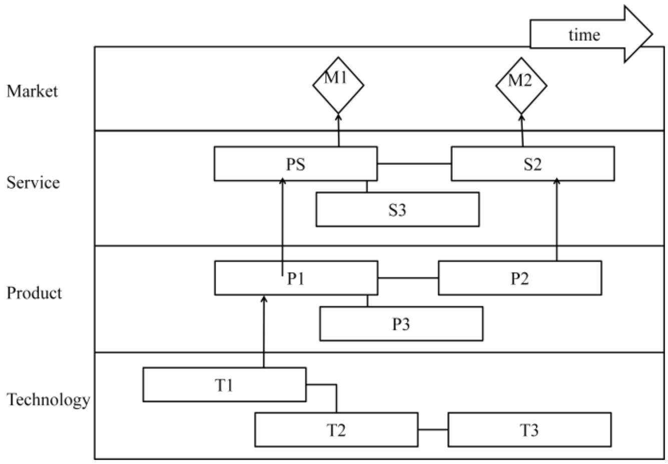


Figure 2- 3 The generic structure of technology roadmap

It is a time-based chart, comprising a number of layers such as market, product and technology. Since the roadmap is a time-based layered chart, it represents the evolutionary pattern of markets, products and technologies, together with the linkages and discontinuities between themselves (Phaal et al., 2004). In developing technology roadmaps, it is assumed that two types of technological innovation happen in practice. The first is technology-driven innovation and the second is market-pull innovation. In addition, participants are assumed to have enough information regarding external market circumstances and internal product and technology resources.

The basic purpose of roadmap is to provide the strategic management of technology in a dynamic business environment, working as a management tool for planning, forecasting, and administration (Lee and Park, 2005). In particular, it includes product planning, service/capability planning, strategic planning, long range planning, knowledge asset planning, program planning, process planning, and integration planning (Phaal et al., 2004).

Recently, the scope of technology roadmap has been extended to the wide application, integrating other strategic processes such as R&D planning (McCarthy et al., 2001), knowledge management (Brown and O'Hare, 2001), or new product development (Petrick and Echols, 2004). In addition, revised technology roadmaps for disruptive technology are also suggested (Vojak and Chambers, 2004; Walsh, 2004). To support the supplier involvement in product development, technology roadmaps can be sometimes adapted or shared (McIvor et al., 2006). Industrial or sectoral applications also have been conducted, implementing the suitable technology roadmap for the specific industry or sector (Daim and Oliver, 2008; Kim et al., 2009; Yasunaga et al., 2009).

In terms of product-service integration, a few approach have contributed in the field in that they provides the service layer as well as product layers (Fouskas et al., 2005; Kameoka, 2005; Nakamura et al., 2006; An et al., 2008). Fouskas et al. (2005) suggested a mobile business roadmap, providing the dimensions for mobile business and related research issues. These dimensions include technology, service, value and enablers, with the detailed thematic categories for each dimension. Kameoka (2005) introduced a service layer into the conventional roadmaps, comprising market, service, product, technology, and R&D. Extended from this, Nakamura et al. (2006) integrated the service layer to the traditional technology roadmap, representing the role of service in the manufacturing industry. An et al. (2008) suggested the product-service integrated roadmap as a tool for strategic management of product-service integration, locating the product and service in the same level, just below the market/customer layer.

2.2.5 Association rule mining

ARM is one of the most important and well researched techniques of data mining. This identifies associations among a set of product items frequently purchased together, and is used as a widespread approach for market basket analysis (Agrawal et al., 1993; Liu and Shih, 2005). It aims to extract interesting correlations, frequent patterns, associations or casual structures among sets of items in the transaction databases or other data repositories (Agrawal et al., 1993; Kotsiantis and Kanellopoulos, 2006). The main advantages of ARM are in the ease of application and interpretation. Compared to other data analytic methods in management research, ARM is not bound by the strict, and often untenable, assumptions such as the linearity, normality, and residual equal variance (Weinzimmer et al., 1994; Aguinis et al., 2012). The main assumption of ARM is that joint occurrence of two or more products in most baskets imply that these products are complements in purchase (if not in consumption), and therefore, purchase of one will lead to purchase of others (Kamakura, 2012).

ARM generates association rules that represent interesting relationships among items in a given data set (Han and Kamber, 2001). A rule is generally expressed as {X Y}, which means the transaction including item X also includes item Y. In ARM, there are three major types of association rules: support, confidence, and lift, as represented in [2-4], [2-5], and [2-6].

$$Support(X \rightarrow Y) = P(X \cap Y) = \frac{N(X \cap Y)}{N} \qquad [2\text{-}4]$$

$$Confidence(X \rightarrow Y) = \frac{P(X \cap Y)}{P(X)} = \frac{N(X \cap Y)}{N(X)} \qquad [2\text{-}5]$$

$$Lift(X \rightarrow Y) = \frac{P(Y \mid X)}{P(Y)} = \frac{N(X \cap Y) \cdot N}{N(X)N(Y)} \qquad [2\text{-}6]$$

Firstly, the support measures the ratio of the number of transactions that include both items X and Y. Therefore, this implies the usefulness of discovered rules by the probability of co-occurrence of item X and Y in a give set. Secondly, the confidence measures the ratio of the number of transactions containing item Y, given in transactions containing item X. Therefore, the confidence can be represented as the conditional probability of Y given X. Statistically; this denotes the certainty of the rule. Finally, the life measures the statistical dependence between item X and Y, calculated by dividing the confidence by the probability P(Y). If the lift value is greater than one, it shows the positive correlation.

2.2.6 Quality function deployment

QFD is a method for developing design quality that aims at satisfying the customer by translating their needs into functional requirements as design targets or engineering parameters for the production stage (Akao, 1990; Mazur, 1993).

QFD has several assumptions. First, each scale value of the relationship between a customer need and a design characteristic, which represents a psychophysical transformation function with a slope, assumed to be constant (Schmidt, 1997). Another assumption of QFD is founded by the linear additive model that transfers customer needs into design attribute measures (Schmidt, 1997). Third, design requirements can be divided into more detailed descriptors in a way to avoid dependency (Karsak, 2004).

It has used in many different arenas, such as product development (Huang and Mak, 2002; Karsak, 2004; Mazur, 1993), quality management (Chen, 2010; Hongen and Xianwei, 1996), manufacturing strategy development (Jia and Bai, 2011), and modularization (Kamrani, 2002; Kreng and Lee, 2004b). The matrix-like structure of house of quality (HoQ) – a widely used structure of QFD tool – enables objects with similar characteristics to be clustered, illustrating that opportunities for modularity that exist in various contexts (Erixon, 1998; Kamrani, 2002; Kreng and Lee, 2004b). The structure of HoQ is illustrated in Figure 2-4.

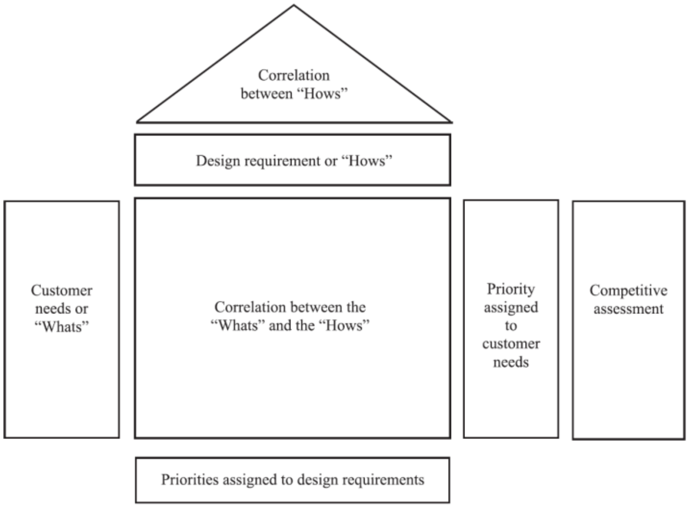


Figure 2- 4 The structure of HoQ (Tan and Pawitra, 2001)

2.2.7 Failure modes and effect analysis

FMEA is a technique which predicts the potential failure modes of a product with the effects and the criticality of failures (Teng and Ho, 1996). It firstly emerged from studies conducted by NASA, and then has spread to manufacturing industries (Puente et al., 2002). Since the basic function of FMEA is to find, prioritize, and minimize the failures, it is widely used in the various manufacturing areas as a solution to the reliability problems (Rhee and Ishii, 2003; Dale and Shaw, 1990; Vandenbrande, 1998). Recently, the scope of FMEA has extended by a wide array of applications in services (Chuang, 2007).

Generally, the baseline assumption of FMEA is that diagnostics will help prevent a more serious failure (Kmenta and Ishii, 2004). In terms of methodological perspective, several assumptions exist for the FMEA analysis. First, failures are independent (Sun et al., 2006). Second, scales of the three indexes: severity, occurrence and detection indexes have the same metric (Franceschini and Galetto, 2001). Finally, three failure mode indexes are all equally important (Franceschini and Galetto, 2001). Those assumptions and numeric data interpretation brings about the simplification of the RPN calculation.

FMEA begins with identifying failures. A product is defective when it is out of normal conditions, and becomes incapable of meeting its minimum performance (Stamatis, 2003). The widely-accepted FMEA procedure can be summarized as follows (Puente et al., 2002).

(1) Identify all potential failure modes of the system.

(2) Relate the possible causes, effects and hazards of each failure.

(3) Calculate the risk priority number (RPN) of the failure modes relative to their probability of occurring, criticality (or severity) of failure, and ease of detection, as shown in the equation [2-7].

(4) Provide suitable follow-up or corrective actions for each type of failure mode.

(5) Monitor the modified process and recalculated

$$RPN = S \times O \times D \qquad [2\text{- }7]$$

Where S = severity, O=occurrence, D=detection

There has been a hot debate on how to prioritize identified failures

(Ben-Daya and Raouf, 1996; Bowles and Peláez, 1995; Chang et al., 1999). Criticism concentrates on the assessment of RPN: whether it satisfies the usual requirements of measurement, whether the relation is appropriate, how it deals with the different impact of severity, occurrence, and detection in the risk implication, why the multiplication is used, and how the effect of production quantity is reflected. To cope with these problems, a number of research have been conducted to provide more multilateral consideration for prioritization as previously mentioned. However, the key problem remains as it was. With scoring methods, the risk implication may be totally different even if the final RPN is identical. A new and advanced approach is required to tackle this issue, and thus provide mangers with a more multilateral and practical assessment method.

2.2.8 Grey relational analysis

Grey relational analysis (GRA) defines situations with no information as black, and those with perfect information as white. However, neither of these idealized situations ever occurs in real world problems. In fact, situations between these extremes are described as being grey. Here, grey system means that a system in which part of information is known and part of information is unknown (Chan and Tong, 2007). GRA allows us to work on past experiences without need to have a complete dataset. GRA is one of the grey theory methods that use the grey relational coefficient (GRC) and the grey relations grade (GRG) to assess the overall similarity degree between two data tuples (Hsu and Huang, 2007).

GRA is a part of grey theory, dealing with multiple criteria decision making (MCDM) problem, which consists of complicated interrelationship between multiple factors (Pillay and Wang, 2003; Tay and Lim, 2006). Since it is a simple and data-driven method useful for making decisions by analyzing various relationships (Tay and Lim, 2006), it has been used for various decision making problem (Pillay and Wang, 2003; Tay and Lim, 2006; Kelley and Davis, 1994; Lewis and McCann, 2004). Compared to the other methods, it has competitive advantages in terms of effective processing of uncertainty, multi-input, discrete data, and data incompleteness (Bowles and Peláez, 1995; Pillay and Wang, 2003).

GRA has no special requirement or regarding sample size or specific probability assumptions. GRA primarily uses discrete measurements to evaluate the distance between two sequences and to explore the extent of their relationship. The original numerals normalized into numerals between zero and one. That is, the transformed numerals are scale-invariant (Wang and Tong, 2003). The analytic procedure of GRA is normally composed of four parts: grey relational generating, reference sequence definition, grey relational coefficient calculation, and finally, grey relational grade calculation (Chang et al., 1999; Pillay and Wang, 2003), as described below. Prior to the introduction, the comparative sequence denotes the sequences that should be evaluated with GRA. This is the target to be evaluated. The reference sequence is the original reference that is compared with the comparative sequence. Normally, the reference sequence is defined as a vector consisting of *(1,1, ...,1,...,1)*. The GRA aims to find the alternative whose comparability sequence is the closest to the reference sequence.

(1) Grey relational generating

As the first stage, all values for every alternative are processed into a comparability sequence, in a process analogous to normalization in order to prevent some attributes to be neglected.

Suppose that there are *m* alternatives and *n* attributes. Let the vector of reference sequence and comparability sequences be represented as

$X_0 = (x_{01}, x_{02}, \dots, x_{0n})$ and $X_i = (x_{i1}, x_{i2}, \dots, x_{in})$, respectively.

Yi is the original vector for value of attribute of each alternative and further translated to the comparability sequence after normalization process.

The tenet of GRA is simple. If a particular comparability sequence is more important than the other comparability sequences to the reference sequence, then the grey relational grade for that comparability sequence and reference sequence will be higher than other grey relational grades. GRA is actually a measurement of absolute value of data difference between sequences, and it could be used to measure correlation between sequences.

Firstly, where there are m alternatives and n attributes, the *i*th alternative can be expressed as $Y_i = (y_{i1}, y_{i2}, \dots, y_{in})$ where y_{ij} is the value of attribute *j* of alternative *i*. The term Y_i can be translated into the comparability sequence $X_0 = (x_{01}, x_{02}, \dots, x_{0n})$ using equation [2-8].

$$x_{ij} = \frac{y_{ij} - Min\{y_{ij}, i = 1,2,..., m\}}{Max\{y_{ij}, i = 1,2,..., m\} - Min\{y_{ij}, i = 1,2,..., m\}}$$

$$x_{ij} = \frac{Max\{y_{ij}, i = 1,2,..., m\} - y_{ij}}{Max\{y_{ij}, i = 1,2,..., m\} - Min\{y_{ij}, i = 1,2,..., m\}}$$

$$x_{ij} = 1 - \frac{\left| y_{ij} - y_j^* \right|}{Max\{y_{ij}, i = 1,2,..., m\} - Min\{y_{ij}, i = 1,2,..., m\}} \qquad [2\text{- }8]$$

$$for \quad i = 1,2,...m \quad j = 1,2,.., n$$

The first equation is used for the-larger-the-better attributes, and the second one is used for the-smaller-the-better attributes and finally, the last equation is used for the-closer-to-the-desired-value-y*- the better.

(2) Reference sequence definition

In order to identify the relationship between the comparative series, reference sequence is established and expressed as $X_0 = (x_{01}, x_{02}, \ldots, x_{0n})$. As a result of the first stage, all values will be scaled into [0, 1]. If the value x_{ij} which has been processed by grey relational generating procedure, is equal to 1 or nearer to 1, the value of alternative *i* is the best one for the attribute *j*, which means the alternative will be the best choice. Therefore, the reference sequence is set as $X_0 = (x_{01}, x_{02}, \ldots, x_{0n}) = (1,1, \ldots ,1)$.

(3) Grey relational coefficient calculation

This step is used for determining how close the comparative sequence x_{ij} is to the reference sequence x_{0j}. The larger the coefficients, the closer x_{ij}

and x_{0j}. The relational coefficient can be expressed as

$$\gamma(x_{0j}, x_{ij}) = \frac{\Delta_{\min} + \xi\,\Delta_{\max}}{\Delta_{ij} + \zeta\,\Delta_{\max}} \qquad [2\text{-}9]$$

where

$$\Delta_{ij} = \left|x_{0j} - x_{ij}\right|$$

$$\Delta_{\min} = \mathrm{Min}\left\{\Delta_{ij},\ \ i = 1,2,.,m, j = 1,2,..,n\right\}$$

$$\Delta_{\max} = \mathrm{Max}\left\{\Delta_{ij},\ \ i = 1,2,.,m, j = 1,2,..,n\right\}$$

ξ is the distinguishing coefficient, $\xi \in (0,1)$, expanding or compressing the range of the grey relational coefficient.

(4) Grey relational grade calculation

To find the degree of relation, the weighting coefficient of the decision factors must be first decided in order to be used in the [2-10]. Here, $\Gamma(X_0, X_i)$ is the grey relational grade between X_i and $X_,$ representing the level of correlation between the reference sequence and the comparability sequence. It indicates the degree of similarity between the comparability sequence and the reference. Therefore, the higher the grey relational grade is, the better the alternative is.

$$\Gamma(X_0, X_i) = \sum_{j=1}^{n} w_j \gamma(x_{oj}, x_{ij}) \qquad [2\text{-}10]$$

$$i = 1, 2, ..., m$$

where w_j is the weighting coefficient of factors, and $\sum_{j=1}^{n} w_j = 1$.

The GRA, with its flexibility, can be usefully incorporated with FMEA in calculating the risk priority. When it comes to the application of the service setting proposed in this research, the utility of GRA becomes more valuable than before, due to the multilateral consideration regarding service characteristics. Since the proposed service-specific FMEA consists of many interrelated different dimensions, the use of GRA fits to the service-specific FMEA, providing a simple, flexible and straightforward way.

Chapter 3. Planning for Ideation

This chapter deals with the planning for ideation of service innovation. To plan a new service, what has to be first done is the ideation process. The question of "what has to be developed to achieve a desired value for our company, and how we can identify the opportunities" is a critical decision problem. However, the ideation process is often called the fuzzy front end, due to a lack of well-defined processes, reliable information, and proven decision rules (Dahl and Moreau, 2002). Therefore, more reliable and systematic techniques are required to provide meaningful new service ideas.

In most management literatures, the focus of previous studies has been on how to replace existing functions with new ones, or with new combinations of functions. This is especially true where service innovation is incremental, and services are refreshed or renewed by a number of minor changes. Incremental innovation is the innovation conducted by substitution or addition of characteristics. In this type of innovation, the general structure of the service system remains the same, but the system is changed marginally through the addition of new elements (Gallouj and Weinstein, 1997).

Many evidences are found in practice. In service industries, new service functions are added onto the basic service to generate new services. For example, checkout packing services in supermarkets and the introduction of computer aided route selection services by car-hire companies can be considered incremental innovations (Gallouj and Weinstein, 1997). In addition, many new service packages are introduced in the hotel and air transport industries based on incremental innovation.

Since many new services are developed based on incremental innovation, most operation-oriented studies on new service development are closely associated with the techniques and tools to analyze and describe services (Johnson et al., 2000), such as structured analysis and design (Congram and Epelman, 1995), function analysis (Berkley, 1996), and quality function deployment (Chandy and Vilcassim, 1994). As many literature noted, the commonality of these studies is the analysis of service functions. It also appears that services are easier to improve than products by replacing a current function with another, since functions are not so tightly coupled as they are in products. Therefore, new services can be designed by combining existing functions or by identifying alternative functions for existing functions (Kindström and Kowalkowski, 2009).

This means that new service development should be conducted based on existing functions, which means the identification of functional characteristics is highly imperative for new service ideation. In addition, differentiated approach for developing new services is required, according to the functional characteristics. This chapter, therefore, deals with two important issues. The first theme, section 3.1, deals with the service function analysis with service tree, covering the identification of functional characteristics. The second theme, section 3.2, deals with the hybrid approach of new service development according to their functional characteristics.

3.1 Service function analysis with service tree

3.1.1 Introduction

Due to the rapid changes throughout the service industry, complexity of the service process has significantly increased. Consequently, in-depth analysis of the service process becomes imperative for those who are in charge of service operations (Morris and Johnston, 1987; Congram and Epelman, 1995; Mayer et al., 2003).

Although several attempts to analyze the service process have been made, however, it has been widely recognized that a powerful analytical tool is missing in the service sector (Silvestro et al., 1992; Tinnilä and Vepsäläinen, 1995). Service process analysis should mirror the following distinctive features of services, vis-a-vis the manufacturing (Schmenner, 1986). First and foremost, as a co-producer (Edvardsson et al., 1995; Fitzsimmons and Fitzsimmons, 1994) or partial employee (Bateson, 1985; Kelley et al., 1992), the customer may take an active part in the service operation (Fließa and Kleinaltenkamp, 2004). As services cannot be separated from customers (Chase, 1978; Lovelock and Young, 1979; Kellogg and Nie, 1995; Zeithaml and Bitner, 2000; Fließa and Kleinaltenkamp, 2004), customer participation perspectives should be captured in the service process. Secondly, service firms have faced with limited analytical and quantitative tools to systemically describe the service processes (Tinnilä and Vepsäläinen, 1995; Fitzsimmons and Fitzsimmons, 1994). Thus, quantitative analysis as well as qualitative analysis should be made to provide operational and strategic implications.

The primary objective of this article is to propose a tree structure that can be a resolution of the above mentioned limitations. The tree structure has been recognized as an effective representation method to visualize the complex process. Most importantly, the Boolean logic of the tree can mirror customers' decision; elements with an AND gate can be interpreted as "always selected by customers" whereas elements with an OR gate as "optionally selected by customers". In addition, as the Boolean logic tree is also capable of identifying critical events, analytical power of the Boolean logic tree can be applied in the service process to quantitatively measure the characteristics and impacts of the service elements. This is exactly how fault tree analysis (FTA) works in the manufacturing area.

However, FTA cannot be directly applied to the service process, since it aims to identify the faults and their influences in a particular system, not to analyze the system itself. Thus, this study proposes the adapted version of FTA to the service process analysis: service tree analysis (STA).

3.1.2 Service process analysis

A service process includes the steps, tasks, and mechanisms that are necessary for service delivery to occur (Booms and Bitner, 1981). The result of the service process is a customer outcome; that is, a customer is either satisfied or dissatisfied with the service delivery experience (Mayer et al., 2003). Therefore, it has been considered that customer participation is an essential factor in the service process (Chase, 1978; Lovelock and Young, 1979; Kellogg and Nie, 1995; Zeithaml and Bitner, 2000; Fließa and Kleinaltenkamp, 2004). Thus, it is evident that customer participation should be considered when analyzing the service process, as it is critical toward understanding and improving the service process.

Some attempts to analyze the service process with a systemic way have been made in various ways. To name a few, such tools as Fishbone diagram (Ishikawa, 1985), service blueprint (Shostack, 1984), process flowchart (Bohl, 1971), process simulation (Law and Kelton, 1991), and IDEF (US Air Force, 1981) are representative, as shown in Table 3-1.

Table 3- 1 Methods for service process analysis

Type	Definition	Advantages
Fishbone diagram (Ishikawa, 1985)	A tool to classify the cause of a target problem with a shape of fishbone	Tracking causes of service Dissatisfaction
Service blueprint (Shostack,1984)	A tool to describe the service delivery process and its tasks as a flow, dividing the service behavior areas	Identifying the flow according to the service behavior area
Process flowchart (Bohl, 1971)	A tool to track the service flow, describing the tasks of each step.	Identifying service flow and describing communication
Process simulation (Law and Kelton, 1991)	A tool to develop and execute the practical model experiments using computer	Enabling the multiple execution and multiple scenario selection
IDEF (US Air Force, 1981)	A tool to represent the functions, activities or processes within the modeled system	Providing a means for complete and consistent modeling of functions required by a system

Despite the advantages of these methods, common limitations are found from a viewpoint of service process analysis. Firstly, these methods lack the viewpoint of customer's evaluation and choice for each service element. Although service blueprint depicts the customer interaction with the form of "line of interaction", this simply discriminates the area of customer action from that of supplier. Therefore, even the service blueprint lacks the perspective of customer's evaluation and choice for each service element.

This should be dealt with very profoundly since customer participation has been considered as an essential factor in service processes (Chase, 1978; Lovelock and Young, 1979; Kellogg and Nie, 1995; Zeithaml and Bitner, 2000; Fließa and Kleinaltenkamp, 2004). Secondly, there is a lack of viewpoint to identify and classify the characteristics of each service elements and to coordinate with the service system. There have been attempts to divide service elements into specific notations such as core services and other peripheral services (Hill, 1986; Lovelock, 1991). However, practical guidelines on how to classify the service elements into core and peripheral services with a systemic way has not been considered, relying on the conceptual and subjective judgment. Finally, quantitative assessment has been neglected. Due to the characteristics of service such as intangibility, perishability, inseparability of production and consumption (Shostack, 1977; Sasser et al., 1978), service process analysis has been faced with some difficulties to deduce the quantitative information.

3.1.3 Proposed approach: service tree

3.1.3.1 Overall Process

The overall process of the proposed approach is shown in Figure 3-1.

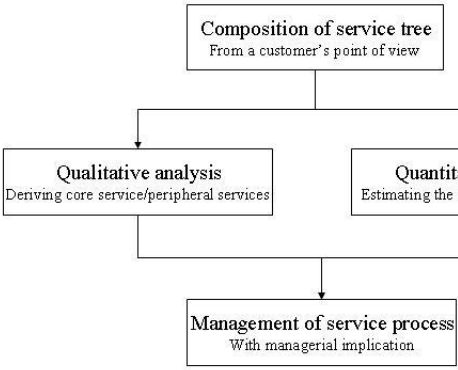


Figure 3- 1 The overall process

The proposed approach starts with composition of the service tree, as shown in Table 3-2. Firstly, a target service is decomposed into several service elements according to the functional process that customer experiences. These decomposed service elements are restructured to original service system with tree-shaped Boolean logic structure; If the service elements are essential in customer's point of view and every customer chooses them, those are linked with an AND gate. If they are selectively chosen by customers, those services are linked with an OR gate. This procedure is repeated until there are no element can be separated. The complete tree is named as service tree.

After constructing a service tree, a qualitative analysis is followed, identifying core and peripheral services by finding minimal service cut set. The core service is what customer actually wants to receive in a target service process whereas the peripheral service is provided in order to make customers satisfied. Identification of the service elements is based on the AND/OR gates the tree has. How to derive the core and peripheral service is described in the qualitative analysis phase.

Table 3- 2 Key concepts of the service tree

Step	FTA	STA
Tree construction	- Composed of the potential causes of the system failure. - AND gate : system failure happens if the two elements happen simultaneously - OR gate : system failure happens if at least one element happens.	- Composed of the functional elements of the service system. - AND gate : If the customer requisitely chooses the subordinate service elements - OR gate : If the customer optionally chooses the subordinate service elements
Qualitative analysis	- Minimal Cut Set : defined as critical events - If the events are linked with only OR gate, they are considered as critical causes of system failure.	- Minimal Service Cut Set : defined as critical events - If the events are linked with only AND gate, they are considered as core services
Quantitative analysis	Considering failure rate $Q=\prod_{i=1}^{n} q_i$ (AND) $Q=1-\prod_{i=1}^{n}(1-q_i)$ (OR)	Considering satisfaction rate From Kano analysis, the weight $a_i = \frac{A+O}{A+O+M+I}$ is employed. $Q=\prod_{i=1}^{n} a_i \times q_i$ (AND) $Q=1-\prod_{i=1}^{n}(1-a_i \times q_i)$ (OR)

Finally, a quantitative analysis is executed to measure the influence of each service element on the service process. Traditional probabilistic calculation of FTA is employed with some modification. To illustrate the characteristics of service elements, Kano analysis is conducted. The result of Kano analysis is used as a weight of probabilistic calculation.

3.1.3.2 Detailed procedures

Composition of the service tree

The crucial part of this study encompasses the structural difference between products and services. A product is composed of tangible elements, thus it can be decomposed into parts. Failure in a product arises from failure of its parts. Therefore, the elements in a fault tree are the faults of target system, composing the causes of the system failure. In other words, system failure is located as a top event, implying how the faults of each sub-component can cause the overall defect of the total system. For instance, if the target system is an air conditioner, fault of air-conditioner, 'power shut down' can be a top event. The tree is composed of the potential failure of sub-components which can cause the top event such as 'electricity problem, 'component obsolescence', and 'problem of component linkage'.

On the contrary, since service is composed of intangible process, failure in a service happens when there is a failure in a sub-process. Therefore, in the service tree, the target for tree construction is the service process or service system itself. Unsurprisingly, the element of tree is each sub-process of the top event. Thus, service system itself should be located at the top event, with the service element at each node. For instance, if the target service system is a restaurant service, the top level element should be a ‘restaurant service’. First level elements of this tree are ‘appointment’, ‘visit’, ‘waiting’, ‘ordering’, ‘being served’, and so on. In other words, the service tree is not for the assembly of the faults but for the re-construction of target service system. Basic premise of decomposition is that it should be based on the path of customer action, by which the customer follows. Each path of customer action is articulated based on sub-activities composing each path.

The composition procedure of the service tree is as follows:

1. Locate the target service system as the top event;
2. Separate the service system to some basic elements and link them with AND/OR gates. If the subordinate services are essential in customer’s point of view and every customer chooses them, those services are linked with an AND gate. If they are optionally chosen by customers, those services are linked with an OR gate;
3. Repeat these procedures until the basic element cannot be separated to any other element.

An example of the service tree is described in Figure 3-2.

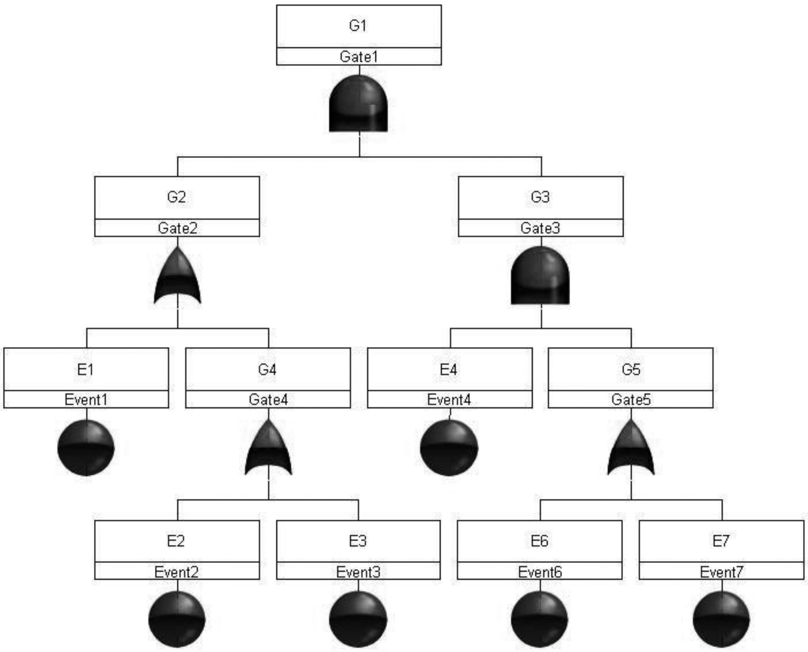


Figure 3- 2 Example of service tree

Qualitative Analysis

This section deals with how to derive core services and peripheral services using the proposed service tree with a systemic method. As the service tree is already constructed depending on whether the service element is always taken by customer or not, it implies how the service element is related to the basic functionality of a target service system. Here is the procedure to identify core services and peripheral services from the service tree.

1. Deduce the minimal cut set from the composed service tree using the traditional method of FTA (see Appendix A);
2. Define the Minimal Service Cut Set (MSCS) as common elements in the minimal cut set. MSCS is the set of essential elements of the

target service process which are always taken from the customers;

3. Define core services as each element of MSCS;
4. Define other service elements as peripheral service. If the peripheral service directly adheres to the core service, define it as the supporting service. If not, define it as the optional service.

In this context, the core service is defined as what customer actually wants to receive in a target service process. The supporting service is referred to a service which is not directly related to the core functionality but helps relevant core service work well. The optional service is defined as an additional service which is not directly connected to the main functionality but is related to the attractive service which can make customers more satisfied.

Let us take an example for qualitative analysis using the proposed service tree in Figure 3-2. As shown in the Appendix A, minimal cut sets are (E1, E4, E6), (E1, E4, E7), (E2, E4, E6), (E2, E4, E7), (E3, E4, E6), and (E3, E4, E7). According to the definition of MSCS, the common element of minimal cut set, (E4), becomes MSCS. E4 is defined as core service because it is an element of MSCS. Other elements turned out to be peripheral services. E6 and E7 which are connected to E4 become supporting services, and the remaining E1, E2, and E3 are classified as optional services.

The identification of core functions and peripheral functions is based on the minimal cut set of fault tree analysis. However, it should be noted that minimal cut set is not always clearly derived. The conventional approach to obtain the minimal cut sets is to take the Boolean logic expression for the top event and transform it into the sum of products form. If the fault tree contains repeated events then the minimal cut sets cannot be directly obtained (Sinnamon and Andrews, 1996).

Quantitative Analysis

In FTA, the quantitative analysis deals with estimating the probability of occurrence of the top event. However, when adjusted in the service process, estimating overall satisfaction according to the value of each service element is not focused on, as it is widely believed that sum of satisfaction of each element does not represent the overall satisfaction in the service process. For example, service is regarded to be failed when one critical service is dissatisfied even if almost service elements are satisfied, which is also connected with moments of truth that few interaction when customers invest a high amount of emotional energy should be managed carefully (Carlzon, 1987).

Thus, quantitative analysis is conducted not for estimating overall satisfaction rate itself, but for sensitivity analysis that estimates how much the overall satisfaction grows according to the improvement of a particular service element. The extent of improvement plays as an indicator that shows the influence on the service process. Quantitative analysis consists of two steps. The first step is to set the weight for each service element using the customer satisfaction coefficient, as it is widely believed that increases of satisfaction of each service do not guarantee the linear increase of total satisfaction in service fields. After setting the weight for each service element, probability calculation is followed in the second step.

(1) Weight setting for each service element

Kano model (Kano et al., 1984) has been widely used for weight setting to adjust the non-linear growth of customer satisfaction (Berger et al, 1993; Islam and Liu, 1995; Matzler and Hinterhuber, 1998; Tan and Shen, 2000; Tan and Pawitra, 2001). In this study, the method of Matzler and Hinterhuber (1998) is taken as a weight method since it indicates how strongly the total service process can be influenced by each service element. They proposed the customer satisfaction (CS) coefficient which consists of the two equations.

$$\frac{A+O}{A+O+M+I} \qquad [3\text{- }1]$$

where A denotes "attractive", O for "one-dimensional", M for "must-be", and I for "indifferent" attributes in the Kano analysis. As we examine the satisfaction rate, the extent of satisfaction is taken as the weight of attributes in this study.

(2) Measurement of influence

With the underlying assumption that each service element is independent, each weight derived from the previous stage is multiplied by each satisfaction level of service elements according to the revised formula described below.

Equation [3-2] describes the calculation for AND gate whereas equation [3-3] for OR gates, where q_i denotes the satisfaction of service element i , a_i denotes the weight for the service element i, and Q denotes the satisfaction of the relevant gate.

$$Q = \coprod_{i=1}^{n} a_i \times q_i \qquad [3\text{- }2]$$

$$Q = q - \prod_{i=1}^{n} (1 - a_i \times q_i) \qquad [3\text{- }3]$$

3.1.4 Case study

3.1.4.1 Case overview

The working of the proposed approach is provided with the help of a case study of a hospital service. In this case study, service tree construction for the hospital service was conducted by three experts in the field of hospital services. To find out the weight of each service element, a survey of Kano analysis was conducted on graduate students between the ages of 22 and 30. Total 53 respondents replied, showing 54% of response rate.

3.1.4.2 Case implementation

Composition of the service tree

In this stage, the service tree is reconstructed according to Boolean logic to determine whether one service is always taken by the customer or not. Firstly, hospital service itself is located as the top event. Then, hospital services are broken down into Visit", "Registration", "Medical examination", and

“Payment”. They should be linked with an AND gate because these elements are always happened when customers enter the target service system. For the second level contributors, there are two subordinate services - “payment through machine” and “payment through person” which are not selected simultaneously under the payment service. Therefore, these service elements are linked with the OR gate. The final tree is described in Figure 3-3. Likewise, the service tree is constructed until the events cannot be separate further.

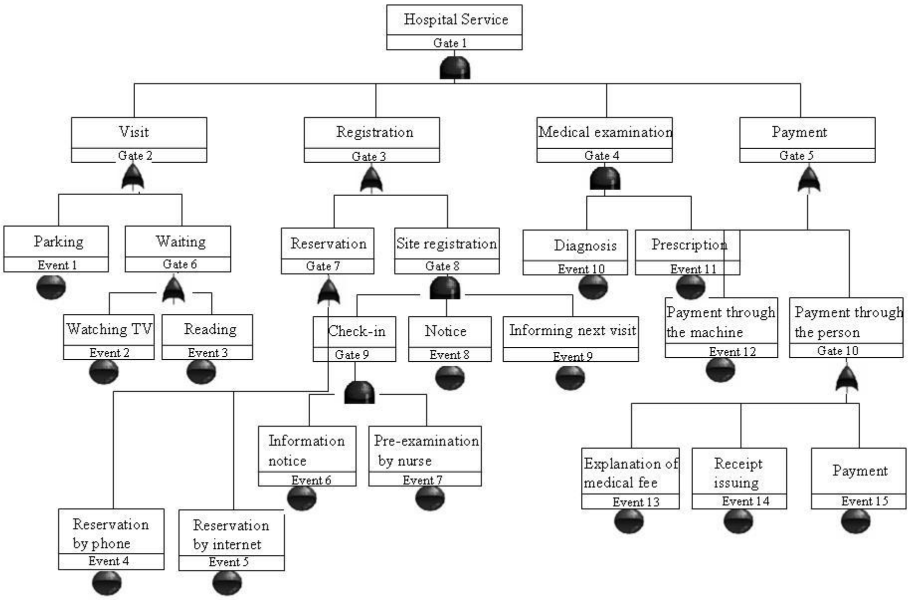


Figure 3- 3 The final tree for hospital services

Qualitative analysis

MSCS was found to (diagnosis, prescription), thus the elements of MSCS – diagnosis, and prescription –turned out to be core services while the remaining services to be peripheral services. Services which are directly connected with core services are identified as supporting services. In this case study, no supporting service is found. Optional services turned out remaining services, which are not directly connected with core services, such as parking, reservation, and payment. The result of qualitative analysis on hospital service is described in Table 3-3.

Table 3- 3 The result of qualitative analysis on hospital service

<table>
<tr><th colspan="2">Type</th><th>Service element</th></tr>
<tr><td colspan="2">Core service</td><td>diagnosis, prescription</td></tr>
<tr><td rowspan="2">peripheral service</td><td>Supporting service</td><td>None</td></tr>
<tr><td>Optional service</td><td>Parking, Watching TV, Reading, Reservation by the phone, Reservation by the internet, Information notice, Pre-examination by nurse, Check in Notice, Informing of next visit site, Medical examination by interview, Payment through the machine, Explanation of medical fee, Receipt issuing, payment through the person</td></tr>
</table>

Quantitative analysis

To find out the weight of each service element, a survey of Kano analysis was conducted, as mentioned above. The result of Kano analysis and the derived weights of each service element are described in Table 3-4. To execute the sensitivity analysis, initial satisfactions of all services are supposed to be 0.6, and changed to 0.8 respectively. Table 3-5 shows the results according to the adjustment of the element satisfaction weight according to equation [3-2] and [3-3].

Table 3- 4 The result of Kano analysis and the derived weights

Service element	Kano Result				coefficient of satisfaction
	M	O	A	I	
Parking service	0	12	41	0	1
Supporting TV service	6	24	11	12	0.66
Supporting reading material	5	21	19	8	0.75
Reservation by the phone	0	16	31	6	0.89
Reservation by the internet	0	11	40	2	0.96
Information notice	8	18	6	21	0.45
Pre-examination by nurse	12	17	9	15	0.49
Notice	10	8	11	24	0.36
Informing of next visit site	2	23	21	7	0.83
Diagnosis	49	3	0	1	0.06
Prescription	49	4	0	0	0.08
Payment through the machine	0	8	39	6	0.89
Explanation of medical fee	7	24	19	3	0.81
Receipt issuing	24	18	9	2	0.51
Payment	47	4	0	2	0.08

Core services such as diagnosis and prescription show an improvement of 33.67%, whereas the peripheral services show 0~10%. This means that improvement of core services is sensitive to total satisfaction than that of peripheral services. In addition, relative impact of the peripheral services was also analyzed. Among the peripheral services, ‘reservation by phone’ and ‘reservation by internet’, and ‘payment through machine’ turned out to be influential relatively. Therefore, if these services are improved, the total satisfaction will be highly improved over other peripheral services. However, services such as ‘payment’, ‘notice’, and ‘informing of next visit site’ turned out to be irrelevant to the customer satisfaction.

Table 3- 5 Changes of customer satisfaction

Services	Coefficient	Overall service satisfaction		Change of satisfaction
		P=0.6	P=0.8	
Parking Service	1	0.00101	0.00109	7.92%
Supporting TV service	0.66	0.00101	0.00105	3.96%
Supporting reading material	0.75	0.00101	0.00106	4.95%
Reservation by Phone	0.89	0.00101	0.00111	9.9%
Reservation by Internet	0.96	0.00101	0.00113	11.88%
Information notice	0.45	0.00101	0.00101	0%
Pre-examination by nurse	0.49	0.00101	0.00101	0%
Notice	0.36	0.00101	0.00101	0%
Informing of next visit site	0.83	0.00101	0.00101	0%
Diagnosis	0.06	0.00101	0.00135	33.67%
Prescription	0.08	0.00101	0.00135	33.67%
Payment through machine	0.89	0.00101	0.00109	7.92%
Explanation of medical fee	0.81	0.00101	0.00107	5.94%
Receipt issuing	0.51	0.00101	0.00104	2.97%
Payment	0.08	0.00101	0.00102	0.99%

3.1.5 Implications

3.1.5.1 Differentiation according to the purpose and strategy

The identified service elements can be effectively managed according to the firm's circumstances or strategies. In general, derived core services and relevant supporting services should be managed simultaneously since the supporting service aims to support the functionality of the relevant core service. In the same context, optional services can play as attractiveness factors to provide customers with unexpected pleasure in the service process. In a broad sense, the proposed approach can be used as a tool for strategic management of a firm. If the firm focuses on the improvement of basic functionality, what is at its central interest should be the core service. In the same context, if the firm focuses on differentiation, what is at its core should be the optional service providing unexpected pleasure. In addition, the level of customization and standardization can also be determined. Services which are generally used by most customers have a chance to be standardized whereas services with limited customers have a chance to be customized.

Another differentiation can be possible according to the purpose of analysis. For managers who want to develop new services, qualitative analysis which focuses on identifying the characteristics of each service element and determining core services and optional services might be more helpful. Kano analysis can be conducted to different market segments to identify the stratified needs of various market segments. With the market segment-based Kano analysis, service elements which show the characteristic alteration are identified. For example, one service elements are determined to be a core service in a one segment and an optional service in another segment. This service element can be a clue to a differentiation strategy in new service development. On the contrary, for managers who want to improve the current service process from the efficiency perspective or who want to improve the customer satisfaction, quantitative analysis might be more helpful. In order to improve the productivity of service process or customer satisfaction, relative contribution of each element as well as the characteristic should be identified. Sensitivity analysis can be also employed to find relative impact in case of changes of service element, functional structure and external environment.

3.1.5.2 Result dependency according to the scope and depth

When used in a practical context, the scope of analysis can be flexibly differentiated according to the purpose or strategy. If the purpose of analysis is to identify the characteristics of each unit service or to improve the specific unit service, narrowing down the scope to be focused would accelerate the specific analysis. However, if the purpose is to see the overall composition of service process, a broader scope might help the service process to be understood easily. Depth of decomposition can be also an issue.

Similar to the scope of analysis, it relies on the purpose or strategy of analysis. If the purpose of analysis is identifying the detailed characteristics of each unit service or improving the specific unit service, depth of decomposition should be larger than that of investigating the overall composition of service process.

3.1.6 Conclusion

This study is unique and even exploratory in that it first adopts the notion of tree analysis in structuring a large-scale, complex service system. Further, the proposed service tree provides a systemic approach from customer participation perspective, which makes the service process to be managed efficiently. The suggested service tree is expected to practically help service managers to identify core and peripheral service and to understand the influence of each service element with systemic guidelines.

Despite the contribution mentioned above, this research is still subject to some limitations. Firstly, constitution of the service tree has inevitable weakness from being subjective to some extent. Since there is no guideline to decide the structural level of the service process, subjectivity of structural shape of the service tree might be unavoidable. Thus, further research should deal with how to improve the subjective aspects of tree construction. Secondly, XOR gate should be considered in the future research. In traditional fault tree, XOR gate is used when failure happens when only one of N subordinate event is happened whereas OR gate is used when failure happens when at least one of N subordinate event is happened. Since, in many cases, XOR gate is considered as a basic and important condition in the process analysis, consideration of XOR gate is expected to enable the service process to be analyzed with more elaborate and practical ways. Finally, dynamic time-series analysis can be also an important application of proposed approach, as it can provide the pattern of time-dependent changes. With the time series analysis, periodic tracking can be conducted. For example, if the satisfaction of certain service component falls continuously, it can be considered as a possible improvement mode for long term improvement. On the other hand, if the satisfaction of certain service component falls temporarily, it can be considered as a short-tem accident.

3.2 New Service development considering heterogeneity

3.2.1 Introduction

Generally, successful new services grow from well-designed structures and orchestrated processes (Scheuing and Johnson, 1989; Edvardsson et al., 1995). However, previous literature has shown the prevalence of qualitative and subjective methods in developing new service concepts (Schlicksupp, 1977; Tax and Stuart, 1997; Ulrich and Eppinger, 1995). Extended from qualitative methods, some researchers have tried to employ systematic methods, such as creative combination of existing functions (Perkes and Riihela, 2004), platform-based approach (Meyer and DeTore, 2001), case-based reasoning (Wu et al., 2006), theory of inventive problem solving (TRIZ) (Chai et al., 2005; Zhang et al., 2005), and morphology analysis (Kim et al., 2008).

The focus of previous studies has been on how to replace existing functions with new ones, or with new combinations of functions. This is especially true where service innovation is incremental, and services are refreshed or renewed by a number of minor changes. In this type of innovation, the general structure of the service system remains the same, but the system is changed marginally through the addition of new elements (Gallouj and Weinstein, 1997). Many evidences are found in practice. For example, checkout packing services in supermarkets and the introduction of computer-aided route selection services by car-hire companies can be considered incremental innovations (Gallouj and Weinstein, 1997). In addition, many new service packages are introduced in the hotel and air transport industries based on incremental innovation.

Since many new services are developed based on incremental innovation, most operation-oriented studies on new service development are closely associated with the tools to analyze current services (Johnson et al., 2000), such as structured analysis and design (Congram and Epelman, 1995), function analysis (Berkley, 1996), and quality function deployment (Chandy and Vilcassim, 1994). As many literature noted, the commonality of these studies is the analysis of service functions. It also appears that services are easier to improve than products by replacing a current function with another, since functions are not so tightly coupled as they are in products. Therefore, new services can be designed by combining existing services (or service functions) or by identifying alternative solutions for existing problems (Kindström and Kowalkowski, 2009), with the analysis of service functions.

Surprisingly, these research streams share a common limitation - the lack of a differentiated approach based on considering services' functional characteristics, which would seem to be imperative for new service development. According to Berkley (1996), functions are classified into basic functions and supporting functions. Basic functions encompass some actions the consumer wants to be performed to fulfill the basic needs, whereas supporting functions (sometimes called aesthetic, esteem, or sell functions) are not essential, but are important for building consumer acceptance. Therefore, functional heterogeneity should be carefully dealt with, when developing new service concepts. If a service function plays a core role in a particular service, what is required is to identify a similar alternative that does not affect its core functionality, whereas, if it only plays a peripheral role, a more creative solution would be to search for a more interesting alternative - in summary, in developing new services, core functions require similarity and peripheral functions would benefit from creativity. Despite the fact, however, previous research on new service development has neglected the heterogeneity of service functions, simply applying a single method for developing new service concepts.

We therefore suggest a hybrid approach to differentiating new service development according to the functional characteristics involved. To search for alternatives for core functionality, we propose a case-based reasoning method, which focuses on identifying similarity, but suggest using a modified zigzagging approach - in which creativity plays an important part - to identify alternatives for peripheral functions. A Kano analysis is used to reveal whether a function is core or peripheral.

3.2.2 Related works

3.2.2.1. New service generation

The competitive state of the market means that service firms constantly need to develop new offerings, and generating new service concepts is the first and most important stage in new service development (NSD) (Johne and Storey, 1998; Kelly and Storey, 2000; Edvardsson et al., 2011). But, despite its importance, most approaches to NSD proposed in the literature concentrate on qualitative and subjective methods (Wu et al., 2006), revealing the need for a more systematic approach to generating new service ideas to meet customer needs (Kelly and Storey, 2000).

Most research into developing new service concepts starts by analyzing existing services and focuses on incremental innovation (Kindström and Kowalkowski, 2009). Previous research has contributed to the field by proposing various kinds of methodologies as being specifically relevant for different purposes (Pugh, 1991; Cross, 1994; Liu and Bligh, 2003; Chai et al, 2005; Wu et al., 2006), but these approaches still have a common problem, in not being differentiated according to functional characteristics. Thus most previous research takes a single approach to all service functions, which may not work in practice, since services consist of several functions which have distinctive characteristics, some of which we can consider as core and others as peripheral, revealing the need for a differentiated approach that considers new service development differently according to the characteristics of each service function.

3.2.2.2. Kano analysis

The Kano model categorizes the attributes of a product or service into six types according to how well they satisfy customer needs (Kano et al., 1984): must-be requirements (M), one-dimensional requirements (O), attractive requirements (A), indifferent requirements (I), reversal requirements (R), and questionable requirements (Q) as Figure 3-4 shows (Kim et al., 2008).

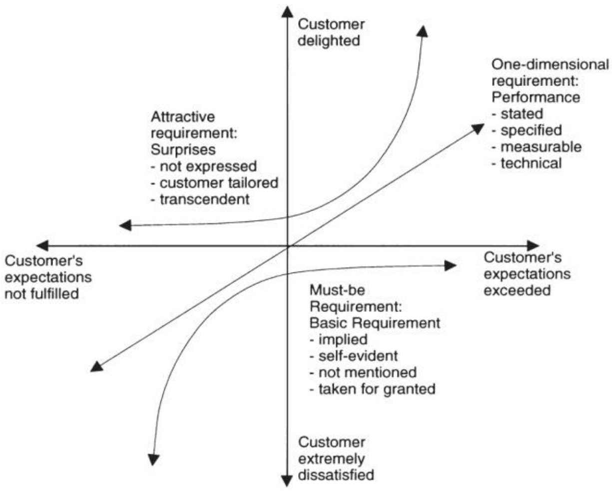


Figure 3- 4 Kano model (Matzler and Hinterhuber, 1998)

Among these types, those most frequently seen as important in practice are must-be attributes (M), one-dimensional attributes (O), and attractive attributes (A). Must-be attributes are considered as basic requirements for the service: customers become dissatisfied when the performance of this attribute is low, and their satisfaction levels will not rise above neutral even if it is high. For the one-dimensional attributes, customer satisfaction is a linear function of that attribute's performance, while for attractive attributes, customer satisfaction increases super-linearly with increasing attribute performance - but there is no corresponding decrease in satisfaction with decreasing attribute performance (Tan and Pawitra, 2001).

3.2.3 Hybrid approach to the NSD considering heterogeneity

3.2.3.1 Overall Process

Figure 3-5 shows the overall organization of our suggested approach. Firstly, the existing service is analyzed and its service functions are derived. Then the Kano model is used to categorize the attributes of the listed service functions as either ‘must-be’ (core) or ‘attractive’ (peripheral). After these characteristics have been determined, alternatives for each are found. Following a differentiated approach, a case-based reasoning is employed to find alternative service functions for core functions, and revised zigzagging analysis is conducted to list alternatives in the case of peripheral functions. By replacing each specific function in the current service with newly found functions, new service concepts can be successfully derived which have novel features, but which still fulfill the utility of core functions.

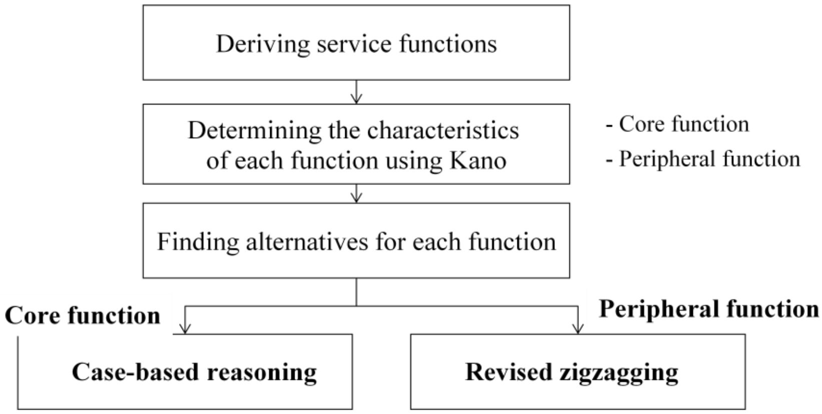


Figure 3- 5 Overall process of this research

3.2.3.2 Detailed Procedures

Deriving service functions

Services often consist of separable functions, and their execution can be seen as a sequential process of multiple functions between service providers and customers. A function is a generic statement of what needs to be accomplished, and may entail some action that the consumer wants performed, or will be intended to give the consumer sensory satisfaction (Berkley, 1996). So a service function can be identified by asking what it does for the consumer. Supplementary techniques such as Function Analysis System Technique (FAST) can be used to isolate basic functions by applying a series of questions.

Some obstacles exist to deriving service functions: in contrast to manufacturing situations, services cannot be easily disassembled, since (in many cases) service-delivery system elements are interrelated, so all parts of the service system must be addressed simultaneously (Berkley, 1996), which will often require in-depth investigation of customers' answers. Function decomposition methods can analyze services into functional levels, and identify and list individual service functions.

Determining the characteristics of each function: Kano analysis

The next step is to determine the characteristics of each function, with the aim of identifying the direction of further service development. If the service function to be developed is a core function, it cannot be replaced with totally new function; rather, the goal should be to develop it without affecting the performance of the whole service. If the function to be developed is not a core function, it can be freely replaced with a novel function that can fulfill the same customer needs via a different route. To decide the direction of further service development, we need to determine what the characteristics of each function are.

For each service function, a pair of questions is formulated which customers can answer in one of five different ways (Kano et al., 1984; Matzler and Hinterhuber, 1998). As a result, each service function is categorized as having one of six types of attributes: must-be, one-dimensional, attractive, indifferent, reverse or questionable. The model is adjusted to determine must-be and attractive functions only, since these two attributes are critical to determining the service's future development direction. A 'must-be' service function represents an imperative attribute, which customers value highly because it is essential to the service provision and so can be considered as a 'core function', while a service function the Kano model determines as having attractive attributes can be called a non-essential 'peripheral' function, that does not affect the core functionality of the service.

Finding alternatives for each function

To identify solutions for developing each service element, this study employs an approach that is differentiated according to its functional characteristics. Table 3-6 summarizes the differentiated approach for core and attractive functions in terms of their characteristics and the appropriate development methodologies.

Table 3- 6 Methodology for each function

	Core function	Attractive function
Target	Similar function	'Something new' function
Methodology	Case-based reasoning	Modified zigzagging approach
Characteristics	- Finding similar functions to the existing service	- Finding the upper level utility (what) - Finding the another lower level function (how)

(1) Core (Must-be) function

If customers regard a service function as essential, its main functionality must be maintained as much as possible so as not to damage customer satisfaction - so finding alternatives for core functions must be based on similarity. A case-based reasoning approach is employed to derive similar functions from an existing database, and the most similar service is selected as the alternative.

To apply the CBR to find new alternative solutions for core functions, the first step is to prepare a service database from which the CBR can find the solution. A keyword vector is prepared for all services, in which service documents are converted into keyword vectors, composed of the keyword's normalized frequency in the keyword feature list. This method aligns with that used by a number of studies on knowledge discovery in texts, and is based on the assumption that any given document can be represented by a set of relevant keywords (Yoon and Park, 2005).

$$S_i = \begin{bmatrix} f_{11} & f_{12} & \cdots & \cdots & f_{1m-1} & f_{1m} \\ f_{21} & f_{22} & \cdots & \cdots & f_{2m-1} & f_{2m} \\ f_{31} & f_{23} & \cdots & \cdots & f_{3m-1} & f_{3m} \\ \cdots & \cdots & \cdots & \cdots & \cdots & \cdots \\ f_{n1} & f_{n2} & \cdots & \cdots & f_{nm-1} & f_{mn} \end{bmatrix} \qquad [3\text{-}4]$$

n=number of documents

m=number of keywords used to explain the service document

After preparing the service database, CBR is applied to find the best solution for new service development. Since the database is developed in keyword vector form, the traditional application of CBR analysis is transformed, as shown in Table 3-7. As the problem is to identify new opportunities for new service development, the input is the keyword vector of the current service, and the output is the keyword vector of the most similar alternative service. The selection process is based on the calculation of similarity between current service documents and those of possible alternative service solutions. Many kinds of similarity metrics can be employed, such as the Pearson coefficient, Euclidean distance, and cosine-based similarity measures. After calculating the similarity, the most similar services are identified and selected as candidates which could provide alternatives to the original core function to be included in the new service design.

Table 3- 7 CBR application in this study

Elements of CBR	Interpretation in this study
Problem	New service development
Input	Keyword vector of current service
Selection criteria	Keyword similarity between the current service and possible solutions
Assessment method	Calculating the similarity measure of service
Output	Alternative services (keyword vector of most similar service)

(2) Peripheral functions

For peripheral functions - those which customers find attractive but which are non-essential - the alternative will often not necessarily be a similar function: rather, providing a novel and unexpected function is encouraged. Adapting a zigzagging model can allow for finding a new alternative to replace the current peripheral function from a different service.

In order to make use of the zigzagging approach to the ideation of new services, firstly we start with a peripheral function. Then, the utility, i.e. what the customer wants to achieve from this function, is explored and identified - e.g., if the current peripheral function is a music alarm, the utility is 'to provide notification of the time'. After the utility has been identified, another substitute function which offers the same utility can be chosen in the lower level. At this step, it is important to propose solution-neutral functions. The solution-neutral means that we should not confirm the functions which are biased by the utility to be selected. This process is repeated until we reach the desired alternative functions. The detailed processes are described as follows.

- Step 1) Start with a peripheral function
- Step 2) Explore the corresponding utility which the customer wants to achieve using this function
- Step 3) Explore the possible functions which are necessitated for satisfying the identified utility.
- Step 4) Choose another utility of the alternative (sub-level) functions.
- Step 5) Explore alternative functions for satisfying the utility
- Step 6) Repeat this process until reaching the desired alternative functions

This repeated process makes a hierarchical tree of functions and utility, respectively. Therefore, as the zigzagging approach does, we call this tree as a 'function-utility tree,' as shown in Figure 3-6. Note that this tree seems to be hierarchical in terms of its structure, but not really hierarchical in terms of its meaning.

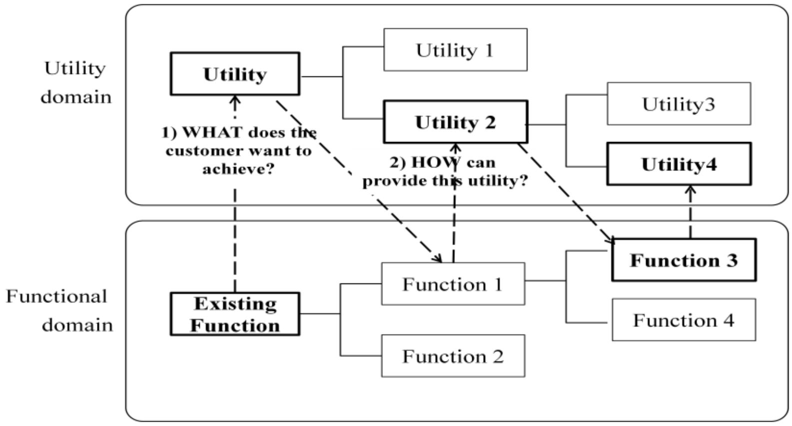


Figure 3- 6 Process of modified zigzagging approach

Despite the advantages of proposed approach, traditional methods such as brainstorming are still considered as powerful methods in terms of providing a variety of ideas. Especially, the use of brainstorming can considerably increase the quality and quantity of ideas produced by group members (Osborn, 1957). However, the use of suggested methods can consider the functional characteristics in terms of ideation process. The use of those methods can lower the variety of ideas but provide a focused approach. In addition, operational errors can be reduced compared to brainstorming method, since those methods provides a systematic procedure to generate new ideas. In other words, the performance of those methods is less affected by individuals' capability due to the systematic procedures. Therefore, one should select appropriate methods based on the in-depth consideration for the strength and weakness of each method.

It should be clearly noted that both CBR and zigzagging methods are not considered to be substitutes for brainstorming. Rather, brainstorming can be integrated to the CBR and zigzagging method to provide more effective results. For example, when conducting analogical thinking based on the similar cases in the CBR process, brainstorming can be effectively utilized to generate new ideas. Similarly, when conducting zigzagging process, upper-level utility and lower level functions can be explored with the help of brainstorming.

3.2.4 Case study: Mobile Application Service

3.2.4.1 Case overview

We conducted a case study to illustrate the working of our proposed approach, and selected smartphone application services (mobile services) as the target service for several reasons. First, the proliferating number of smartphone applications reflects fast-changing customer needs; second, smartphone applications have massive databases of their service information; and finally the mobile services field has been identified as important to analyze owing to the accessibility of these databases (such as AppStore). According to Apple Inc, over half a million application services were available in AppStore at December 2011 and 25 billion applications downloads were made in 2012. To illustrate the proposed approach in more detail, we selected 'iReaditNow' as our target service for analysis.

iReaditNow is a service which manages and records reading activity - when users want to know more about a book they are currently reading (or have read in the past) iReaditNow searches and retrieves information about the book from the web and adds the book to a list. Readers can mark the dates they started and finished the book, and check statistics of how many books they have read over a month or year in graphs.

3.2.4.2 Case implementation

Service function analysis

To develop a new and creative service without damaging the utility that iReaditNow's users currently enjoy, we use the Kano model to analyze and classify current service functions according to their functional characteristics: Table 3-8 shows the service functions identified in the target application and their Kano characteristics

Table 3- 8 Service functions of iReaditNow and their Kano attributes

Service function	Description	Kano attribute
Keep record of reading activity	-Search books in online search engine -Retrieve information of the book including author, ISBN code, the number of page, publisher	Must-be
Record impressions of the book	-Save the underlines or quotes from the book -Record the thoughts and feelings felt -Rate the book using a five star system	Must-be
Share with friends	-Share the specific record of a book with friends via E-mail, Facebook or Twitter	Attractive
Check the statistics of reading activity	-Check the graphs of reading activity for a year and a week respectively - Find out the number of books read by ratings	Attractive

Since the target service aims at keeping a record of users' reading, logging the books read and their impressions of the books are clearly essential functions. In contrast, the Kano analysis determined that checking reading statistics and sharing information and impressions with friends were attractive functions which customers didn't expect but which satisfied them when they are offered. After the service functions were all identified and appropriately classified in the Kano model, we applied two different approaches for core (must-be) and peripheral (attractive) functions respectively - the CBR approach for core functions and the revised zigzagging approach for peripheral functions.

CBR approach for core service

The CBR approach was applied to the core functions derived from Kano analysis. First, a case database of several hundred similar application services was set up. For ‘iReaditNow’, 310 relevant application services were collected from Appstore, ranging from reading-list services to logging services for wine or movies. To collect this massive database, we employed an automated algorithm (programmed in Java), to take data about services from their official AppStore service descriptions. The algorithm automatically ‘crawled’ all the service information using key search terms - such as ‘reading’, ‘log’, ‘record’, ‘list’, etc. - after which relevant cases were sorted out and established as the final dataset.

Second, a keyword vector was built using relevant terms such as ‘record’, ‘underline’ or ‘ISBN’. Since the data collected in the final dataset was in ‘natural’ language, transforming it into machine-readable keyword language vectors was unavoidable. We therefore broke the service documents down into structured data to be analyzed, selecting the keywords via a two-step process of quantitative filtering and qualitative adjustment. Quantitative filtering - the preliminary step - identified the high-frequency keywords in each service document, and TextAnalyst 2.1 text-mining software was used to extract them. The next step involved qualitative adjustment by experts, who identify the keywords with high frequencies and made judgments about their relevance to guarantee meaningful results. As a result, 310 vectors, based on 21 keywords, were developed for each service.

The next step involved calculating the similarity between these services and the target service. In this study, we chose the cosine similarity metric for this purpose. There are many different similarity measures such as Minkowski metric (Ichino and Yaguchi, 1994), cosine coefficient (Salton, 1968, 1989; Meadow, 1992), and Jaccard coefficient (Jain and Dubes, 1988). Among them, cosine similarity is used for this study. Since cosine similarity is easy to interpret and simple to compute for sparse vectors, it is widely used in text mining and information retrieval (Frakes and Baeza-Yates, 1992; Salton and McGill, 1983). Equation [3-5] shows how it was employed to compare the target service and possible alternatives.

$$\text{Cosine similarity} = \frac{\mathrm{A} \cdot \mathrm{B}}{|\mathrm{A}||\mathrm{B}|} = \frac{\sum_{i=1}^{n} A_i \times B_i}{\sqrt{\sum_{i=1}^{n} (A_i)^2} \sqrt{\sum_{i=1}^{n} (B_i)^2}} \qquad [3\text{-}5]$$

where, A_i is the keyword vector of the target service,

B_i is the keyword vector of keyword in an alternative service

Table 3-9 shows the result of this calculation and the top ten alternative services in terms of their cosine similarity. These alternatives were analyzed to find out if their core functions were appropriate to replace the existing function of keeping records of books read. Table 3-10 lists some of the most convincing results from the CBR analysis of the ten applications.

Table 3- 9 The results of CBR analysis (top 10 cosine similarity)

Alternative service	Cosine similarity
FriendItem LT - Social Book	0.6544
BookManiaLite	0.5750
Cellar - manage your wine collection in style	0.5535
DVDpedia	0.5175
Wine DB	0.5126
Faveous - Social Bookmarking	0.5121
my reads	0.5059
Find-BOOK	0.4980
Movie reminder	0.4928
Book memo	0.4658

Table 3- 10 The result of in-depth analysis for 10 alternative services

Functions	Alternative service	Description of alternatives
Keep records of reading activity	FriendItem LT - Social Book	Categorizing books into 'Have read', 'Reading now' and 'To read'. It can also group books such as 'Own', 'Want', 'Borrowed'
	BookMania	Recording the book by typing, which makes it able to log any kind of books.
	Movie reminder	Showing filmography of the actors who appeared in the movie you logged. It can be applied to 'iReaditNow' to add a feature to list the author's past works.
	Book memo	Tagging their books with customized tags and manage the books
Record impressions of the book	BookMania Lite	Categorizing memos into 'Summary', 'Wise saying' and 'Thoughts'
	Wine DB	Checking out previously uploaded reviews of the wine they logged. It can be applied to 'iReaditNow' to show the existing reviews.

Modified zigzagging approach for peripheral functions

Since 'Check the statistics of reading activity' was identified as a peripheral function, it could be replaced with alternatives by going upwards to identify the functions' utility and then going downwards to find a wide range of alternative functions with more creativity.

Investigating the needs of the 'check the statistics of reading activity' function more deeply, 'information' was selected as the utility users ultimately desired. After the discovery of the utility, we carried out a zigzagging process to identify alternative service functions which also offered the information utility. This led us to identify three alternative functions, which provided price information, provided map information of a nearby bookstore, and provide author information - not just from reading activity but also from different services.

Then, the utility of three functions are again identified using zigzagging approach. We discovered that 'purchase' was the utility that three functions ultimately want to provide to the customer. After the discovery of the utility again, two service functions are identified: provide payment modules and deal with security problems. Seen from this case example, five service functions are identified, as shown in Figure 3-7. By zigzagging the process of 'WHAT-HOW", ideas moves from the original function to the utility, and from the utility to the alternative functions. Using this process, new service concepts could be identified, considering the customer utility. This can be considered as a creative ideation process, since we search the new service concept not from identifying the similar function but from exploring the utility customers ultimately desired. This zigzagging process can help to users by guiding the path of creative thinking.

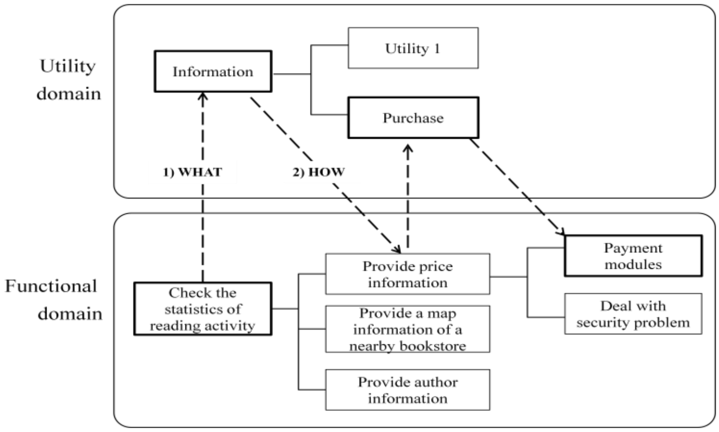


Figure 3- 7 Function-utility tree for iReaditNow

3.2.5 Conclusion

This study proposes a hybrid approach to reflect the heterogeneity of service functions, which consists of three main steps: identification of current service functions; determination of functional characteristics; and application of a differentiated approach. A list of functions is identified by analyzing current services, after which the Kano model is employed to identify the functional characteristics, determining whether a service function is core or peripheral. The final step is to apply differentiated methodology for each function. Where the function is core, we suggest a case-based reasoning method whose main focus is to identify similarity: to find alternatives for attractive functions, we suggest a revised zigzagging approach, designed to identify creative alternatives.

This study contributes to research in two ways. First, from the theoretical perspective, we propose a differentiated approach according to functions' characteristics, which we believe is significant, since most previous researches have considered service functions as homogeneous, and so employed single methodologies to develop new services. Given that service functions are, in fact, heterogeneous, we suggest a hybrid approach that can be used selectively, according to functional characteristics. From the methodological perspective, this theme employs a creative combination of two different approaches within one framework, and also extends the application area of both case-based reasoning and zigzagging approach into service concept development.

Despite this contribution, this study still has some limitations. First, the suggested case-based reasoning approach employs a keyword-based approach to identify similar functions - although this yields results, other approaches could also be used, such as employing some evaluation criteria to determine similar functions. Second, in conducting the revised zigzagging approach, we provide only rough guidelines to finding utility and corresponding functions - we suggest this process could be further improved by using automated algorithms such as semantic networks. So another fruitful avenue for future research would be to employ relevant methodologies to automate the process of identifying utility and functions.

Chapter 4. Planning for Deployment

This chapter deals with the planning for deployment. The result of chapter 3, the new service idea derived from planning for ideation, is now employed as an input for this chapter. After the ideation process, firms have to consider this question: "how to develop this derived idea? And how to link current resources with the future to develop this new service concept?" This chapter deals with these questions. In this chapter, the new service idea derived from the previous chapter is now deployed as a form of service strategy.

To plan the innovation, the use of technology roadmap occupies a big seat in technology management. As a means for guiding the strategic management of technology, technology roadmap has been widely accepted in both industry and academia (Lee and Park, 2005; Phaal et al., 2004; Rinne, 2004). Currently, with the emergence of service innovation, the research direction of technology roadmap has been turned to the co-evolutionary and integrative planning of products and services (Kameoka, 2005; Nakamura et al., 2006).

However, the implementation of technology roadmap for service innovation should cover the various kinds of circumstances, with the consideration of technological role to mediate the service innovation. In service industry, technology has been applied as a form of different utility, for example, providing new types of business such as customization (Bitner et al., 2000), new transaction or process (Bitner et al., 2000; Froehle and

Roth, 2004), or new types of service encounter (Bitner et al., 2000; Froehle and Roth, 2004). Therefore, in planning the service innovation, different business circumstances for service innovation should be mirrored, since many phenomena of service innovation is significantly affected by the infusion of technology (Bitner et al., 2000).

Therefore, this chapter deals with this issue: development of the technology roadmap in the various context of service innovation. For this purpose, section 4.1 deals with the service planning with technology interface, which considers the different types of technological role in product service integration and corresponding technology planning process. By suggesting an integrated technology roadmap, this theme explains how to plan the service innovation in the circumstances that products and services are closely associated to provide the desired value to the customers. The section 4.2 caters for the methodology for incorporating business data to the service planning process, considering layer-dependency. The use of various business data is expected to help the managers to plan the service innovation more effectively, finding the utility of each data source for the planning of service innovation. Utilizing the business data, this paper focuses on measuring the layer-dependency of technology roadmap, which has been neglected in the previous research.

4.1 Technology roadmap for product-service integration

4.1.1 Introduction

Today, the body of literature has been almost unanimous in integrating services into their core products to provide the desired value to the customer (Goedkoop et al., 1999; Mont, 2002; Manzini and Vezolli, 2003; Sundin et al., 2006). A variety of relevant concepts, therefore, have been proposed thus far. To illustrate, the list includes such concepts as service package (Fitzsimmons and Fitzsimmons, 1994), functional product (Kumar and Kumar, 2004), integrated product and service offering (IPSO) (Sundin et al., 2006), and product-service system (PSS) (Goedkoop et al., 1999; Mont, 2002; Tukker, 2004; Baines et al., 2007)

This phenomenon is not only limited to the academia, but also diffused towards the practical business environment (Sundin et al., 2006). Evidences can be found in many practical cases. Not only selling the iPod, Apple provides the corresponding downloading service, iTunes. Extended to the music downloading service, Apple now sells a variety of application via the online market, Appstore. Xerox's copy machine business is another famous case for product-service integration. Xerox has changed their competitiveness from copy machine manufacturing to the document management by setting up consulting sector.

What is notable in recent product-service integration is the role of technology. Technology triggers the digital convergence or divergence which enables the full-scale integration of product, service, and technology (Bore´s et al., 2003). It has already been the basic force behind the both product innovation and service innovation, changing the ways in which firms interact with their customers (Bitner, 2001; Auernhammer and Stabe, 2002). For this reason, strategic management of technology cannot be neglected in consideration of product-service integration. Rather, technology should be emphasized as a key driver for product-service integration, illustrating the structural and longitudinal interaction between technology, product, and service. However, even product-service integration is all around the industry, there are limited approach to planning the strategic management of the integrated offerings, with consideration of technological role.

As a means for guiding the strategic management of technology, technology roadmap has been widely accepted in both industry and academia (Lee and Park, 2005; Phaal et al., 2004; Rinne, 2004). Even a number of technology roadmaps have contributed to the strategic management of technology in a variety of applications, the research direction should be turned to the co-evolutionary and integrative planning of products and services. Even some research already considered the service layer as well as the product layer (Kameoka, 2005; Nakamura et al., 2006), these research are still limited to the simple addition of service layer into the traditional roadmap. Extended from the previous research, An et al. (2008) proposes a design method for integrated roadmap in which the product and service are jointly developed during the design phase. However, it still remains a void in the literature how to develop an integrated roadmap with consideration of technological role in product-service integration. More importantly, existing literature on product-service roadmaps has focused on the generic and simplified structure of integrated roadmap, not suggesting the differentiated structure according to the specific circumstances. However, in practice, what is at the core is to accommodate the different managerial needs and environmental conditions by flexibly altering the generic structure of roadmap or the roadmapping process (Lee and Park, 2005).

In response, the main purpose of this study is twofold. Firstly, this study aims to suggest the integrated roadmap for product-service integration, with the technology acting as a significant interface between products and services. The suggested product-service integrated roadmap represents the structural and longitudinal interaction between technology, product, and service. In the integrated roadmap, each layer does not work individually but simultaneously and dynamically collaborates each other to provide the ultimate goal – the integrated offering for products and service. Secondly, following on the generic structure, this study proposes the six types of product-service integrated roadmap according to the technological role in integrating products and service. Although the suggested roadmap is useful and flexible to integrate products and services, the potential benefit may not be fully exploited if the specific difference in product-service integration is not fully incorporated. Therefore, this study suggests six types of integrated roadmap and relevant guidance for strategic management of suggested roadmap, differentiating the roadmapping process, planning precedence, supporting tools, and relevant implications.

4.1.2 Product-service integration

Due to the flourishing and dynamic market environment, a single product is no more treated enough to satisfy the customer needs and business requirements. Quite naturally, a concept of product-service integration has been emerged to deal with this issue. Even the “integration” has received a lot of attention recently, the concept of simultaneous provision of products and services has long been discussed in the literature. Also, even in practice, integration of products and services has been a matter of grave concern for both manufacturers and service providers (Park and Lee, 2011).

Bundling is a concept from marketing perspective, providing the two or more products and services in a single package to fulfil customer needs (Guiltinan, 1987). It is a product-oriented concept in that supplementary services are provided together for the purpose of sales promotion of products as well as bundling of two or more products (Park and Lee, 2011). Extended from bundling, service package has been proposed as more service-oriented concept which is provided for the purpose of sale promotion (Fitzsimmons and Fitzsimmons, 1994). It consists of the five components: supporting facility, facilitating goods, information, explicit services, and implicit services. In a similar context, Frambach et al. (1997) suggested the concept of product service as a set of service secondarily provided with product, emphasizing the product-dependence.

Despite the benefit achieved from integration, however, doubts have been cast on the simple and additive integration of products and service. Above concepts are skewed to the addition of service into their core products, with the aim of sales promotion through differentiation (Park and Lee, 2011). Emphasizing the fact that the service is no more treated as an add-on, more systematic approach for integration has been suggested. The concept of "solution" was proposed as a bundle of products with added software and service (Galbraith, 2002), differentiated from other concepts in terms of early-integration for customization. A functional product is another example of systematic integration in which the value is delivered via the function, not via the product (Alonso-Rasgado et al., 2004). A product-service system (PSS) is defined as "a system of products, services, networks of players and supporting infrastructure that continuously strives to be competitive, satisfy customer needs and have a lower environmental impact than traditional business models" (Goedkoop et al., 1999). What is at the core in PSS is "sustainability" which aims to lower the environmental impacts by providing the functions with the alternative scenarios of product use (Mont, 2002).

4.1.3 Product-Service Integrated Roadmap

4.1.3.1 Overall process

To deal with the dynamics and variations of product-service integration, this study firstly investigates the technological interface that drives the product-service integration and suggests a new type of technology roadmap for product-service integration. Figure 4-1 shows the research framework of this study.

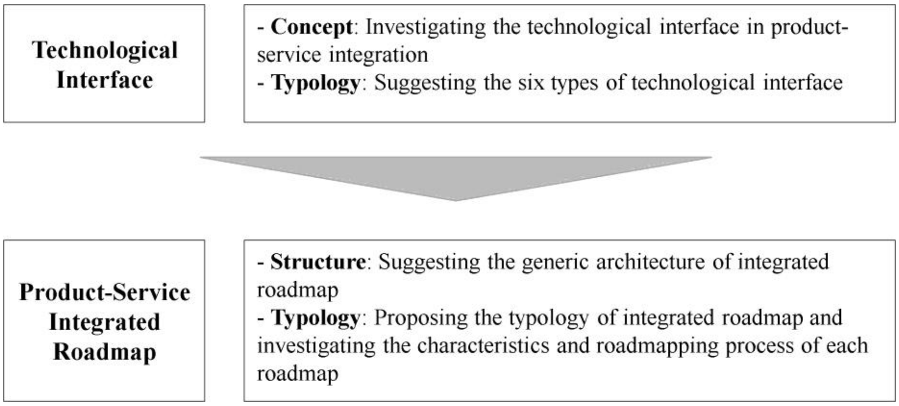


Figure 4- 1 Research framework of this study

Firstly, the concept and typology of technological interface in product-service integration is suggested based on literatures and practical evidences. Following on the structure and characteristics of technological interface, this study suggests a new type of technology roadmap which enables the planning of strategic management of product-service integration from the technological perspective. It is named as "product-service integrated roadmap" in which the product layers and service layers are located at the same level. As well as the conceptual suggestion, the architecture of integrated roadmap is suggested. Finally, this study proposes a typology of product-service integrated roadmap and differentiates the characteristics, roadmapping process, and corresponding implications of each type of roadmap.

4.1.3.2 Technology interface in product-service integration

Concept and characteristics

Technological interface in this study is defined as the "technology-based virtual area in which the product and services are integrated to achieve the increased customer value and sustainability". Therefore, the major role of technological interface is the construction of interaction between the products and services, shaping the areas of intersection between products and services (Auernhammer and Stabe, 2002).

In term of direct linkage between the products and service, technology also plays a variety of roles in product-service integration. Technology provides the customization process (Bitner et al., 2000), effective administration of products (Stock and Tatikonda, 2004), and effective customer service based on technology-based communication channel (Bitner et al., 2000; Froehle and Roth, 2004). Technology also enables the new types of transaction (Bitner et al., 2000).

Typology of technological interface in product-service integration

To differentiate the technological interface, this study classifies the technological interface into three major types according to the level of technological participation: technology as an enabler, technology as a mediator, and technology as a facilitator, as shown in Figure 4-2. Each type is further classified into two sub-types; therefore, six types of technological interface are suggested, as shown in Table 4-1.

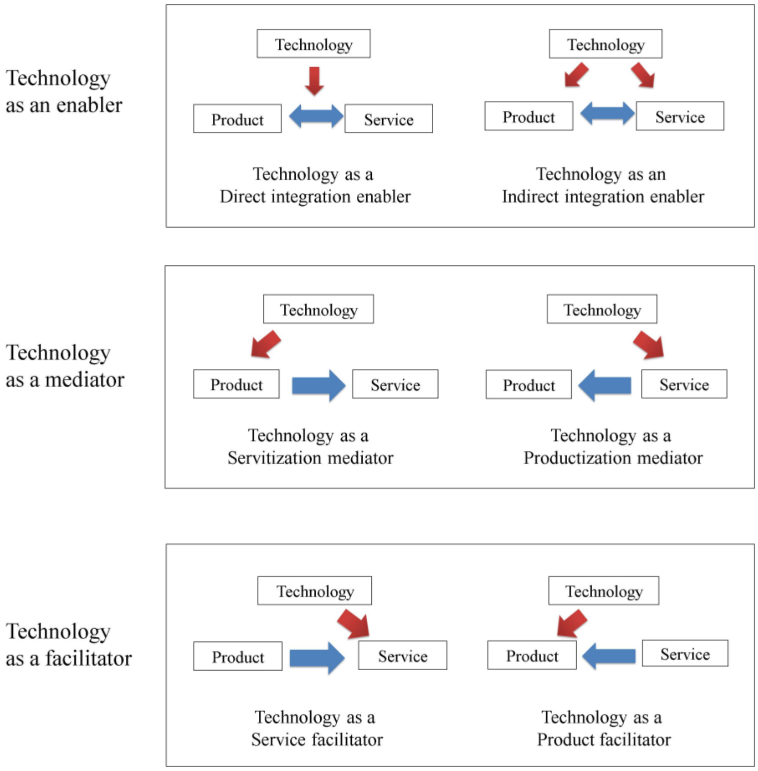


Figure 4- 2 Types of technology interface

Firstly, technology as an enabler means that technology provides the direct means for integration, which means that product-service integration cannot be realized without the help of technology. This can be further classified into two different types: technology as a direct integration enabler and technology as an indirect integration enabler, according to the level of technological participation. The second type is the technology as a mediator. The term "mediator" means that even the technology is not the direct means for integration, it provides the intermediary by providing the virtual linkage embedded in a product or service. In this type, technology is firstly applied to a product or a service, and then the integration is realized by technology-embedded products or services. Therefore, the case of mediator can be further classified into two parts: technology as a servitization mediator and technology as a productization mediator. The final type is the technology as a facilitator. In this type, technology facilitates the effective integration of products and services, by providing the additional help such as providing the virtual space or interfaces. Also, it can be further classified into two different types: technology as a product facilitator and technology as a service facilitator.

Generally, there are many cases for product-service integration in the new product development (NPD) process. When developing new products, developers conduct many service-related tests and experiments for the reliability management. Many practical cases can be considered this type, for example, services related to the reliability engineering, maintenance services, installation services, and training services. Those are generally considered at the early stage of product development process. Since the main purpose of this reliability management is to provide a reliable product and technologies. Since services are employed to support the provision of reliable product in this case, this can be considered 'technology as a product facilitator.' However, it should be clearly noted that the categorization is not a fixed one, thus can be changed according to the context. For example, if technology is mainly applied to the provision of services, it can be sometimes considered as 'technology as a service facilitator.

Table 4- 1 Types of technological interface

Technological role		Characteristics	Example
Enabler	Direct integration enabler	- Technology directly enables the integration of products and services. Even the individual product or service is not technology-embedded; the integration can be realized.	Dell customization - Enabled by the information technology between customer and company during the direct sales process
	Indirect integration enabler	- Technology indirectly enables the integration of products and services by being applied to the products and services and providing the means for integration.	U-healthcare service - Enabled by the technology-infused wearing, signal transferring technology, and information management system
Mediator	Servitization mediator	- Technology mediates the product-originated integration, firstly applied to the product and then the technology-embedded product is servitized to gain the competitive advantages.	Xerox control system - Technology is firstly applied to the product, enabling the transaction, security, messaging, or intelligent agent.
	Productization mediator	- Technology mediates the service-originated integration, firstly applied to the service and the service is productized to provide the more valuable information.	ATM (Automated Teller Machine) - Technology firstly applied to the banking system. Then, the automated banking system is evolved toward ATM.
Facilitator	Service facilitator	- Technology and products are independently applied to the services, facilitating the product-service integration.	Maintenance service of water-purifier - The service is achieved by the information system to manage the service.
	Product facilitator	- Technology facilitates the integration of products and services, especially the integration towards the product. (Related with reliability management, product management services)	Contents-making or create-a book service - The personalized album or diary is made for the customers, collecting the information from the blog or social network service.

4.1.3.3 Technology roadmap for product-service integration

Basic structure and characteristics

Following on the differentiation of the technological interface, the product-service integrated roadmap is designed as depicted in Figure 4-3, taking the issue of product-service integration. The suggested roadmap mainly consists of five layers: market, service, technology, product, and R&D. Since this study aims at the strategic planning of product-service integration from the perspective of technological role, the main focus lies in the relationship between product, technology, and service layers.

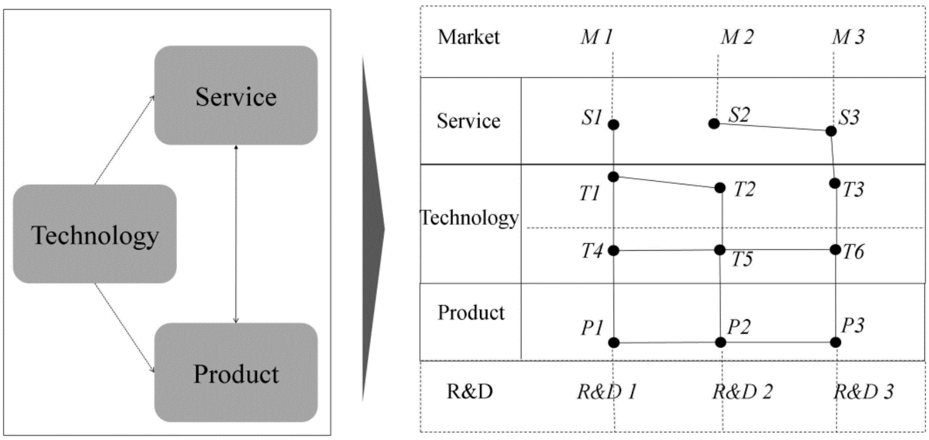


Figure 4- 3 Concept of product-service integrated roadmap

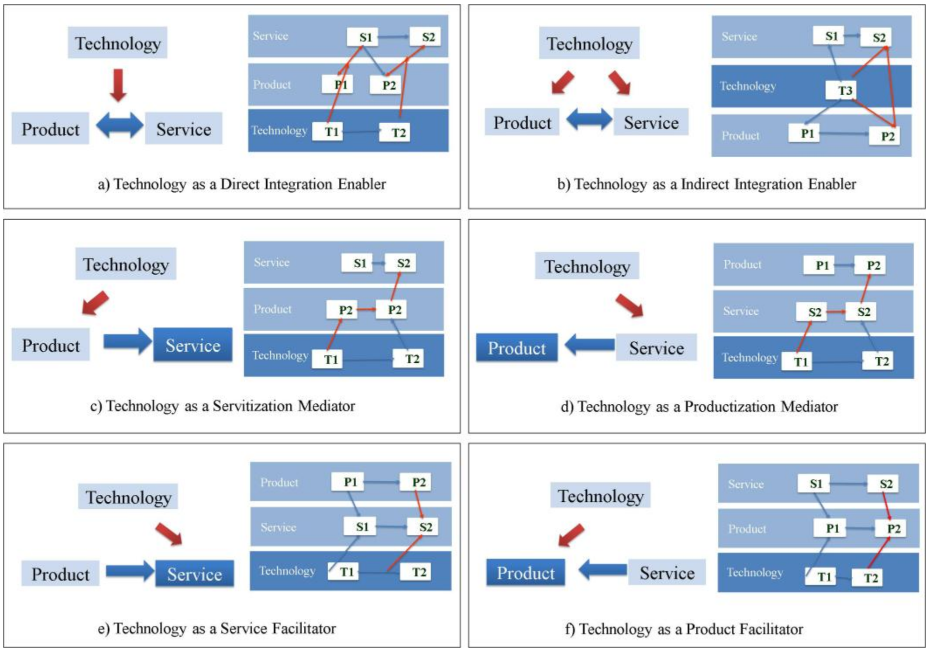
What is notable in the suggested structure is twofold. Firstly, the service layer exists at the same level of the product layer. This concept is based on the previous approach (Nakamura et al., 2006; An et al., 2008), considering the service layer as important as the product layer. Secondly, the interaction of product layer and service layer is triggered by the technology layer, emphasizing the role of technology in product-service integration. In short, the product, service, and technology layers are closely linked together, with the technology layer acting as an important acting point.

Typology

Since the technological role in product-service integration is different, the development of integrated offering cannot be simply represented as a single structure. Even if Figure 4-5 shows the basic structure of integrated roadmap, this basic structure only provides the clue that the product layer and the service layer are collaborated by the technological trigger. Rather, the suggested roadmap should be extended and differentiated according to the technological role when it comes to the practical application. Although the suggested structure of integrated roadmap is useful and flexible to incorporate the service and business, the benefit may not be fully exploited if the specific difference in product-service integration is not fully incorporated.

(1) Macro level: Structure

Figure 4-5 shows six types of product-service integrated roadmap based on the technological interface. Mainly, six types of integrated roadmaps are different in terms of the hierarchy of the layers, the direction of linkages between each layer, and the precedence of roadmapping process to implement the product-service integration. The red arrow represented in Figure 4-4 shows the main path of integration.



a) Technology as a Direct Integration Enabler

b) Technology as a Indirect Integration Enabler

c) Technology as a Servitization Mediator

d) Technology as a Productization Mediator

e) Technology as a Service Facilitator

f) Technology as a Product Facilitator

Figure 4- 4 Six types of roadmap based on the technological interface

Firstly, Figure 4-4(a) refers to the case of “technology as a direct enabler”. Since the technology directly enables integration of products and services, the product layer and the service layer are placed adjacently, representing the close relations in integration opportunities. Here, the technology is applied to the virtual and integrated features of product and services, fostering the integrative process. Since the technology is applied to the integrative features of products and services, sometimes a virtual layer might be incorporated to represent the integrative opportunities of product-service integration.

Figure 4-4 (b) represents the case of “technology as an indirect enabler" where technology is individually applied to the products and service, making the technology-based intermediates between products and services. Therefore, the technology layer is located at the middle of two different domains: product layer and service layer, acting as an interfacing point. Even it is not clearly mentioned that it is a case of technology-enabled product-service integration, literatures have taken the form of integrated roadmap with product layer and service layer (An et al., 2008; Abe et al., 2009). Abe et al. (2009) illustrates the business model for impaired walking support system, considering the business as a kind of service concept. An et al. (2008) provides the case example of mobile communication service as a form of product-service integration, as it involves a device and a large array of applications and services.

Figure 4-4 (c) shows the case of technology acting as a "servitization mediator". Since the technology-embedded product provides the chance of servitization, main evolution path exists from technology to product, and finally to service. Therefore, the hierarchy of integrated roadmap follows this evolutionary state of product-service integration: technology-product-service.

Figure 4-4 (d), which is a case of "technology as a productization mediator" provides the similar structure with servitization mediator except the location of the product layer and service layer. Since this type implies the technology-originated productization case, the technology layer affects to the service layer first, and then, the service is evolved to the product. Relevant examples can be found in previous literature. Kameoka (2005) suggests a new type of strategic roadmap, adding a service layer on the product layer. In Nakamura et al. (2006), a strategic roadmap for the businesses using the electronic tags is suggested with the market/customer, business/services, infrastructure, technologies, and regulation layer.

Figure 4-4 (e) is a case of “technology as a product facilitator”. In this type, technology and service are applied directly to the product, making the product as more diversified and collaborative form of integration. Thus, the service layer is located at the centre of the layers, enabling the product layer and the technology layer be more effectively incorporated.

Similarly, the composition of Figure 4-4 (f), a service facilitator, is same as Figure 4-4 (e), except the layer composition of product and service. Even it is not mentioned as the exact term “integration”, there has been relevant concepts with the product facilitator or the service facilitator, illustrated in several roadmaps. Wells et al. (2004) suggested a roadmap for e-commerce to capture and share the technology intelligence for products and services, using the technology layer, the access device layer, and the mobile service layers as the core layers for e-commerce roadmap.

(2) Micro-Level: Roadmapping process

What is at the core in differentiating the roadmaps is the impact and direction of relationships between products, services, and technologies. Therefore, to effectively elucidate the relationship, a concrete methodology is required for roadmapping and building the required collaboration. As a good and reliable starting point, some methods have been used as a supporting tool for roadmapping (Phaal et al., 2004; An et al., 2008), such as QFD and linking grid.

As a representative and concrete methodology, the linking grid has been considered as a good supporting tool to elucidate the cross-functional collaboration and relations. In this roadmapping process, the role of linking grids is to identify and assess the relationships between the various layers. Thus, the attempt to using different linking grids contributes to the customization or differentiation of roadmapping process. The relationships derived from the linking-grids are reflected into the low-level roadmap, which identifies the characteristic-level relationship of products, services, and technologies, as shown in Table 4-2.

Table 4- 2 Characteristics of technology roadmap

Type	Roadmapping process	Method
Direct Integration Enabler	1) Planning the product-service interaction 2) Planning the PS feature- technology	Combined linking grid
Indirect Integration Enabler	1) Planning the Technology-product 2) Planning the Technology-service 3) Planning the Product-service	Combined linking grid
Servitization Mediator	1) Planning the Technology-product 2) Planning the Product-service	Evolutionary linking grid
Productization Mediator	1) Planning the Technology-service 2) Planning the Service-product	Evolutionary linking grid
Service Facilitator	1) Planning the Technology-service 2) Planning the Product-service	Independent linking grid
Product Facilitator	1) Planning the Technology-product 2) Planning the Service-product	Independent linking grid

Figure 4-5 shows the basic structure and the differentiated feature of roadmapping process each roadmap.

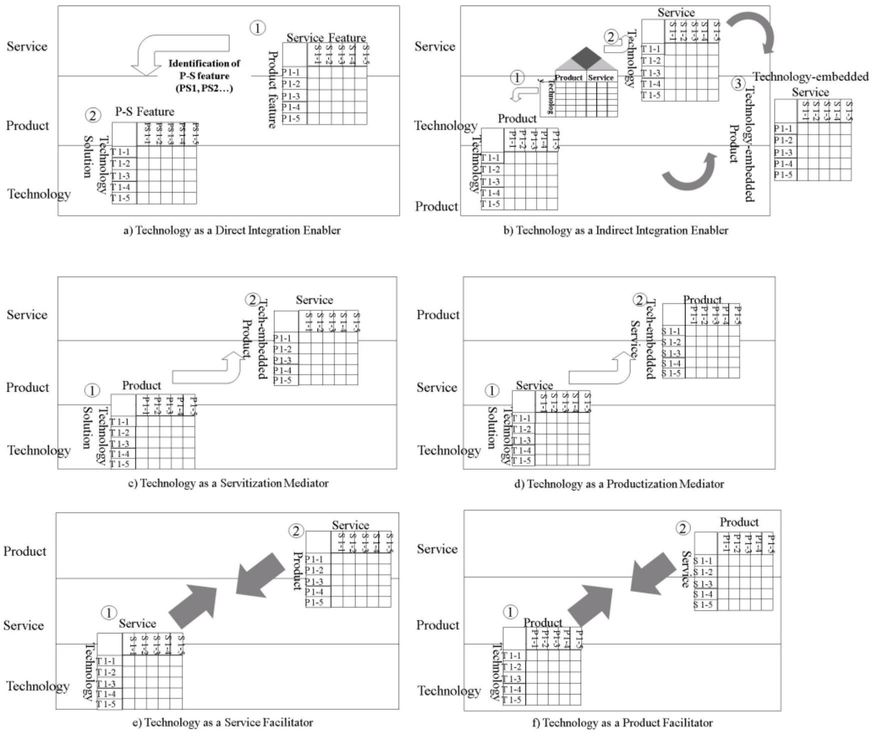


Figure 4- 5 Differentiated roadmapping process for each type

The first type is the “technology as a direct integration enabler”, as shown in Figure 4-5(a). Since the technology is directly applied to the integrated feature, the construction of integrated feature should be the first planning step. The related features of products and services derived from the first linking grid are then analyzed with the technology factor. This stepwise linking grid can provide the full-scale integration between products, services, and technology, fostering the integrated roadmap.

Secondly, in the case of “technology as an indirect integration enabler” in Figure 4-5 (b), linking grid for products and services is combined and used simultaneously. Therefore, the individual linking grid is combined to provide the relationship between products and services. Letting the technology as a left space of linking grid, the roof matrix identifies the feature-to-feature relationships, divided according to the following three parts: product-to-product, service-to-service and product-to-service relationships.

In the case of “technology as a servitization mediator”, illustrated in Figure 4-5 (c), the most important feature of this type is the direction of planning. Since the technology-embedded product provides the platform for integration, the relations between technology-product are identified first. Following on the first linking grid, the following linking grid should represent the relations between technology-embedded product and service. Therefore, the roadmapping process is supported by a series of linking grid, i.e. “evolutionary linking grid”. This is same in “Technology as a productization mediator”, illustrated in Figure 4-5(d).

Figure 4-5 (e) shows the case of ‘technology as a service facilitator’. Since the technology and products individually affects to the service to be delivered, the relations between technology-service and product-service are identified from the separate linking grid. Therefore, the linking grid used in this type can be said to be an “individual linking grid” which the technologies and products are applied to the services individually with no internal relationship between themselves. This is same in ‘technology as a product facilitator’ which is shown in figure 4-5(f).

4.1.4 Case study

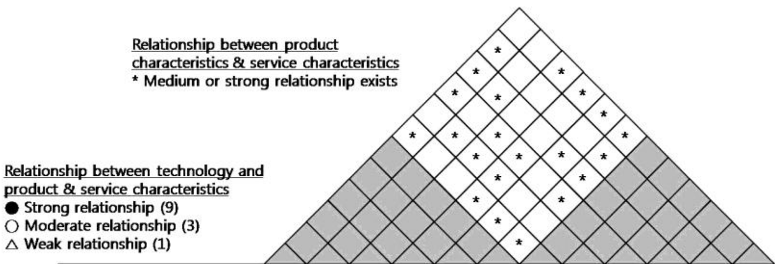
4.1.4.1 Case overview

In order to illustrate the applicability of the proposed approach, a simple case study was conducted for a case study of product-service integration. As a case study, U-healthcare service is taken as an example of “technology as an indirect enabler”. U-healthcare service is a new paradigm in the medical care provided with ubiquitous sensor network (USN) for the disabled and elderly people (Kim and Kim, 2006).

For the u-healthcare, various types of health monitoring sensors for real application exist to measure the health data such as a wearable computer or a wrist phone as one of the future products. Before the development plan was established for all components to develop the micro-level roadmap, a facilitated workshop was held to validate the matching of technology, product, and service characteristics of u-healthcare and tried to measure the relationships between themselves to establish the micro-level roadmap. Since this type of technological interface is related to both products and services, the relationship between technology-embedded products and technology embedded-services are measured by the roof matrix of combined QFD.

4.1.4.2 Case implementation

Figure 4-6 shows the roadmapping process of u-healthcare service. The relationships are identified from the QFD-liked matrix achieving from combination of two linking-grids. The intermediate technological solutions affect to the both products and services. For example, medical tag technology affects to both the product side and the service side: RFID for the product side and personal identification or information transmission for the service side. The technology for the embedded Linux enables most of the monitoring system such as pulse monitoring or information transmission. As well, it enables the development of products such as a vital sign sensor or a mobility sensor.



Technology/Product and service characteristics	Vital sign sensor	Bar code	RFID	Web server	Weight of wearing	Sensor mobility	Pulse information monitoring	Personal identification	Information transmission	Excise management	Sleeping management	E-commerce
Embedded Linux	●		○		△	●	●		●	○	○	△
Medical tag	○	△	●		○	○		●	●			
Micro computer	●			△	●		●		○			●
Human-computer interface based on bio signal	●		△	○	△	○	●			●	●	
Broadband	△	△	●		○	●		△	●			○
IPv6	○			●		○		△	●			○

Figure 4- 6 Roadmapping process of u-healthcare service

After the planning processes were repeated for the components, a final workshop was held to synthesize the plans for the entire products, services, and technological components to fix development targets, to design the integration and relevant development works, to construct the integrated roadmap. Two types of integrated roadmap were built: a macro roadmap which emphasized the item and depicted its future trend, and a micro TRM, focusing on the item's components and describing the development strategies for the progress according to the performance measures. The relationships between the combined linking grids are reflected to the micro-level roadmap as shown in Figure 4-7. Letting the technology characteristics of technological components as the trigger, the technology affects both products and services.

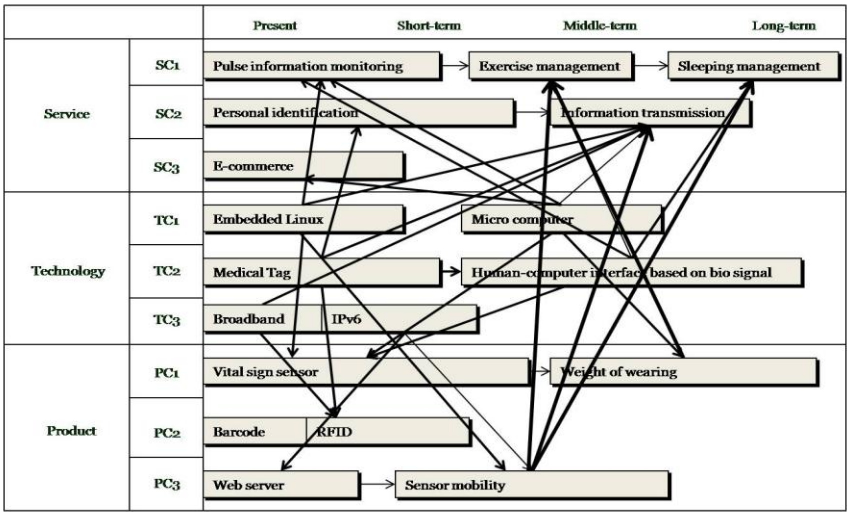


Figure 4- 7 micro-level roadmap for u-healthcare services

4.1.5 Conclusions

This study contributes to the fields for both academic and practical perspectives. For the academic perspective, this study suggests a new type of technology roadmap: product-service integrated roadmap by employing both the product layer and the service layer equally, using the technology layer as a main intermediate. The incorporation of product-service integration in technology roadmap has a significant value in terms of accommodating the current paradigm of business environment. From the practical perspective, as well, this study suggests the six types of integrated roadmap in order to help the real-world planning of integrated roadmap. It helps the firms flexibly select the appropriate types of integrated roadmap according to their purpose, integration type, and current business environments.

Despite its significant and meaningful contribution, however, the current research is subject to some limitations. Firstly, even though six types of integrated roadmaps provide the specified structure according to the technological interface, they are still subject to the generalization problem. Architectures of technology roadmap can be affected according to the industry characteristics, domain characteristics, or external environments. Secondly, there is a room for further works in terms of technological interface. Even this typology is achieved by in-depth understanding of both academic backgrounds and practical cases, more effective representation might exists in terms of schematic relationship between products, services, and technology.

4.2 Technology roadmap considering layer-dependency

4.2.1 Introduction

With the help of information technology (IT), many kinds of business transaction happens in an electric form, which enables the massive database to be generated and consumed (Lynch, 2008; Linoff and Berry, 2011). Therefore, firms identify the business trends based on the business-related data. Many types of data exist. In online marketplaces, customer needs and requirements are represented as a form of customer reviews or forums (Brown et al., 2011). Products and services of a firm can be identified by many types of documents such as service descriptions in a mobile open market or product/service manuals.

The active incorporation of these massive data, quite naturally, becomes an imperative and vital process in a recent business environment (Bughin et al., 2011; Lavalle et al., 2011; Manyika et al., 2011). Especially, big data is not simply utilized for the reactive process but for the proactive process which enables the planning for future trends to be realized. Therefore, these data should be aggressively utilized for the strategic planning of the future business, which is a representative proactive planning process. In both academia and practice, what is at the core in strategic planning is the technology roadmap. It has long been considered as a prominent tool for the strategic planning of technology (Phaal et al. 2004; Lee and Park 2005). It enables a firm to carry out its R&D activities in a systematic manner, laying out explicit plans about what technologies to develop when and how.

However, technology roadmapping still remains as a subjective and qualitative tasks conducted by some experts, despite the existence of meaningful and massive database (Lee et al., 2008). Expert knowledge, of course, often still plays a decisive role, and may be more desirable due to the strategic nature of technology roadmap (Kostoff et al., 2004). However, the active incorporation of big-data cannot be simply neglected since it can deliver essential and unexpected information that enables the effective roadmapping (Kostoff and Schaller, 2001; Lee et al., 2008).

Responding to the necessity of data-driven roadmapping, there has been few research to the analytic approach to technology roadmapping (Lee et al., 2008; Yoon et al., 2008; Lee et al., 2009). In these studies, what has been mainly discussed is the quantification of relationships between planning elements, which is a critical step in technology roadmapping. However, previous studies surprisingly converged to a common limitation: a lack of dependency measurement. Previous studies have focused on measuring the relationship using keyword similarity by simply calculating the frequency of keyword occurrence (Lee et al., 2008; Yoon et al., 2008; Lee et al., 2009). However, the tenet of technology roadmap stems from identifying links among market, service, product, and technologies of a specific firm – in other words, links among different layers. This means, measuring "causal" relationship between layers, i.e., measuring "dependency" relationship is the core and critical information to be incorporated.

To solve this problem, the use of association rule mining (ARM) fit the purpose. The essence of ARM comes from the identification of relationship and potential associations from huge amount of data (Agrawal et al., 1993; Snchez et al., 2009; Huang et al., 2011). These rules can be effective in uncovering unknown relationships which can be a seed for further decision making (Huang et al., 2011). Especially, ARM is capable of capturing the dependency information using the confidence measure, which can be effectively implemented in the technology roadmap.

In response, this study suggests an association rule mining (ARM)-based technology roadmap to identify the relationship among different layers, facilitating the developing process of data-driven technology roadmap. Using ARM, two types of associations are measured and employed: support and confidence. The support measures the ratio of the number of transactions that include specific two items, which can be expressed as item affinity. The confidence measures the ratio of the number of transactions containing a specific item, given in transactions containing another item, thus can represent the dependency relationship. The advantage of expressing the dependency relationship in ARM provides an excellent methodological sufficiency for the technology roadmap whose core value stems from the dependency relationship between each layer. The use of ARM, therefore, can address the limitations of previous research by measuring and analyzing the layer-dependency in the technology roadmap.

4.2.2 ARM-based technology roadmap

4.2.2.1 Assumptions

The tenet of this study starts from the fact that business documents can be effectively utilized for identifying the current trends and planning for the future. Therefore, each business document is represented as a set of keyword. Each layer consists of several keywords that represent the characteristics of products, services, and technologies. To develop the data-driven technology roadmap, some assumptions should be made. This study employs two types of assumptions: document-related assumption and keyword-related assumption, as shown in Table 4-3.

Table 4- 3 Assumptions for data-driven technology roadmap

Type	Assumption
Document-related assumptions	· A specific document employed contains both product-related and service-related keywords · The keyword represents the contents of document well · Frequency and existence of keyword attributes represent the importance of each keyword
Keyword-related assumptions	· If a keyword P1 and keyword P2 frequently happens simultaneously, keyword P1 and keyword P2 have a strong relationship · If a keyword P1 happens frequently given a keyword P2 happens, keyword P1 and keyword P2 have a strong relationship

4.2.2.2 Overall process

This paper suggests a data-driven technology roadmap which provides the quantitative assessment of relationships by employing ARM. ARM and technology roadmap has complementary characteristics in terms of providing data-driven technology roadmap in terms of their characteristics, purpose, operational procedures, and analytic objects, as shown in Table 4-4. For this reason, the challenge of marrying the technology roadmap and ARM appears worth the effort.

Table 4- 4 Characteristics of technology roadmap and ARM

Method	Technology roadmap	ARM
Characteristics	Qualitative & Visionary	Quantitative & Analytic
Purpose	Planning	Operations
Operated by	Mostly conducted by expert judgments	Mostly conducted by automatic algorithms
Object	Relationship between elements	Relationship between elements

The overall process of this study is composed of five steps, as shown in Figure 4-8. Firstly, data utilized for the technology roadmap is identified. For each layer, appropriate data sources are identified to provide the data-driven technology roadmap. The second step is to identify the keyword list for each layer. Based on the text-mining analysis for each document, keywords which represent the document are identified, and corresponding keyword vectors are identified. Following on the keyword-vector, an ARM technique is employed for measuring both inter-layer relationship and intra-layer relationship, which measures the keyword relations and dependency among keywords. The support measures the co-occurrence of two keywords whereas the confidence measures the dependency of two keywords. After measuring each rule, keyword relational maps are developed, combining affinity and causality into a 2-dimensional map. For the intra-layer relationship, affinity map is developed whereas the causality map is constructed for the inter-layer relationship.

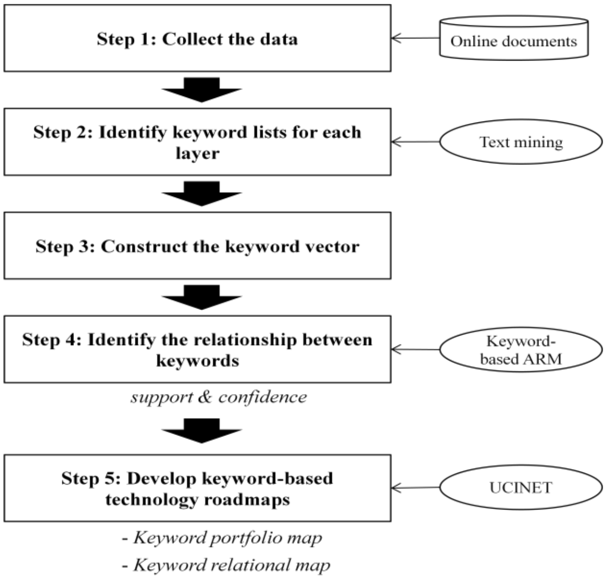


Figure 4- 8 The overall process of this study

4.2.2.3 Detailed Procedures

Collect the data

First and foremost, development of data-driven technology roadmap starts with data selection. Each layer of technology roadmap - market, service, product, and technology – should be represented by a set of keywords. Therefore, selecting appropriate data sources to represent innate characteristic of each layer is of great importance. Table 4-5 shows the types of layer-specific data sources for technology roadmaps.

Table 4- 5 Types of data for technology roadmap

Layer	Required information	Required data	Available source (ex. Mobile service)
Market	- What customers want to receive - Who is the potential customer	- Customer opinion - Customer review - Customer idea for new service	http://itunes.apple.com/kr/app/twitter/id333903271?mt=8 http://discussions.apple.com/ http://appcomments.com http://modmyi.com/forums http://iphoneapplicationlist.com/forum http://www.iphonewoners.com http://appstorehq.com
	- How the social trends changes	- News and reports - Trend magazine	
Service	- What function the current service provides - What utility the future customer wants	- Service description - Service manual (for installation or use)	http://appshopper.com http://iphoneappsplus.com http://appstorehq.com https://market.android.com
Product	- What function the current product provides - What utility the future customer wants	- Product description -Product manual (for installation or use)	http://appshopper.com http://reviews.cnet.com http://www.techradar.com/reviews/phones/mobile-phones/ http://thesmartphoneforum.com/ http://forum.brighthand.com/
Technology	- What aspects the technology provides - What technological aspects the future products wants	-Technology description - Patents - Academic papers	http://uspto.gov http://thesmartphoneforum.com/ http://forum.brighthand.com/

Identify keyword lists for each layer

After selecting data sources, the next step is to select appropriate keywords for each layer. This is based on the assumption that a document can be expressed by a set of relevant keywords. A number of studies on knowledge discovery in texts have been based on this assumption (Yoon and Park, 2005). This process is very important to determine the quality of data-driven technology roadmap.

This process is conducted via two-step process. The first step is quantitative collection of keywords by employing a text-mining technique. In this step, keywords are extracted from documents containing customer needs and product/service features. The text-mining package, Text analyst 2.1, is used to extract the keywords. However, keywords extracted from the text mining technique are insufficient to describe the market or service characteristics. For this purpose, as the second step, a qualitative filtering process - screening and repetition process - is conducted. In this step, expert judgment plays a key role in defining the keywords. Experts again selected appropriate keywords and filtered the keywords based on their judgments. Overly general or insignificant keywords are also excluded. The final set of keywords is derived, accounting for abbreviations, synonyms, and singular and plural forms of words. Note that keywords are domain-specific as well as firm-specific.

Construct the keyword vector

The next step is to construct the keyword vector for each document. Suppose that there are *d* documents. In *d* documents, we identify *k* product keywords and *n* service keywords. In this situation, the keyword vector is constructed, as shown in equation 1. Here, p_{dk} =1 means that a document *d* contains a product keyword *k*, and p_{dk} = 0 means that a document does not. Similarly, s_{dk+n} =1 denotes that a document *d* contains a service keyword *n*, and s_{dk+n} = 0 means a document does not.

$$\begin{bmatrix} document\,1 \\ document\,2 \\ \cdots \\ document\,d \end{bmatrix} = \begin{bmatrix} p_{11} & p_{12} & \cdots & p_{1k} & s_{1k+1} & s_{1k+2} & \cdots & s_{1k+n} \\ p_{21} & p_{22} & \cdots & p_{2k} & s_{21} & s_{22} & \cdots & s_{2k+n} \\ \cdots & \cdots & \cdots & \cdots & \cdots & \cdots & \cdots & \cdots \\ p_{d1} & p_{d2} & \cdots & p_{dk} & s_{dk+1} & s_{dk+2} & \cdots & s_{dk+n} \end{bmatrix} \quad [4\text{- }1]$$

where *d* = number of documents

k = number of product keywords

n = number of service keywords

p_{ij}, =1 : a document *i* contains a product keyword *j*

s_{ij} =1 : a document *i* contains a service keyword *j*

Identify layer-relationships

The next step is to identify the relationships among different layers. In this study, two types of association rules are identified from ARM: support and confidence. Now let us consider how these measures can be effectively used for developing the data-driven technology roadmap. The support measures the affinity between two keywords, which means "how closely the two keywords are interrelated." Therefore, when developing a technology roadmap, this can be applied for the horizontal axis, which shows the recent trends of a specific products or services. Furthermore, measuring affinity can also provide patterns of keyword generation, if applied with the dynamic analysis. This characteristic fits for the development of each layer, since each layer provides the relations of each product or each service in a static perspective. Also, each layer can represent the evolutionary change of a certain product line or service line.

On the contrary, the confidence measures the dependency between two elements, which means "how frequently a specific keyword happens given another keyword happens." This can be considered as the conditional probability of Y given X, which is closely related to the dependency of two keywords. This can be effectively applied for measuring the relationship between different layers (e.g. relationship between product layer and product layer), since it mainly reflects dependency between the two. For example, development of a product element is mainly dependent on the existence of a technology element, which implies the needs for measuring the dependency between the two. Therefore, confidence is effectively applied for the development of vertical axis of technology roadmap by identifying the causal relationship among layers.

Develop the keyword relational map

Based on the result of ARM, a technology roadmap is developed. In this study, two types of map are developed: keyword portfolio map and keyword relational map. In the keyword portfolio map, four types of keyword pairs are identified according to their support and confidence. In the keyword relational map, a 2-dimensional map is developed using support as an intra-layer affinity relationship and confidence as an inter-layer dependency relationship.

1) Keyword portfolio map

Based on the association result, this paper suggests a keyword portfolio map to represent the level of confidence and support within each keyword pair, as shown in Figure 4-9. The matrix is divided into four quadrants: interactive keywords, causal keyword, family keywords, and unrelated keywords.

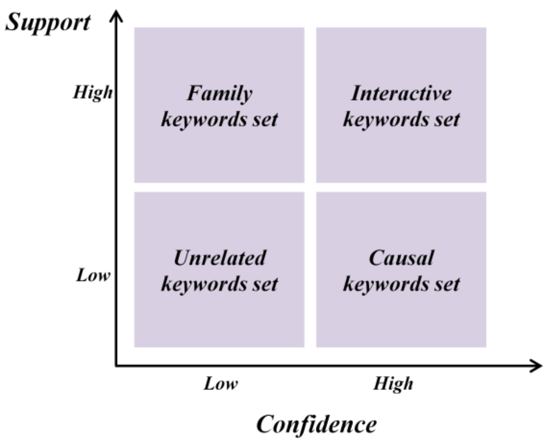


Figure 4- 9 Keyword portfolio matrix

Type 1. Interactive keywords set

'Interactive' quadrant is characterized by high confidence and high support for a certain keyword pair, implying that those two keywords show high level of co-occurrence and high level of dependency. This means those keywords are closely associated in terms of their characteristics and functions. In addition, those keywords are highly dependent in terms of their occurrence, in other words. Therefore, keyword pairs in this quadrant require co-development when firms plan new products or services.

Type 2. Causal keywords set

The second type is a causal keywords set. Keyword pairs in this quadrant are not so tightly coupled in terms of their occurrence. However, there exists dependency between two keywords, i.e., when a specific keyword A exists, keyword B is frequently likely to exist. In this case, keyword A plays an important role in providing B or supports an additional utility for providing B. This means the causal relationship between two keywords should be considered when developing new products or services.

Type 3. Family keywords set

The third quadrant is named as family keywords set, which is characterized by high support and low confidence for a certain keyword pair, implying that those two keywords show high level of co-occurrence and low level of dependency. As easily identified from its name, keyword pairs in this quadrant are frequently occurred together, despite their low causal relationship. Therefore, those keywords share similar characteristics, provide similar functions, or provide similar customer utility. Therefore, when developing new services, those keywords should be considered as family.

Type 4. Unrelated keywords set

The final quadrant is named as unrelated keywords set. Those keywords are unrelated in terms of their co-occurrence and dependency. Therefore, there is no need to consider the relationship between those keywords.

2) Keyword network map

Based on the measurement conducted in the previous stage, support and confidence of a specific keyword set are represented as a form of graph. Since support represents the affinity of two keywords, this is drawn in the horizontal axis, i.e. within the layer. On the contrary, since the confidence measures the dependency or causality of two keywords, this is represented in the vertical axis to show the dependency between two layers, i.e. across the layer. The dependency represents how a product (or a service) happens if a certain service (or product) exists. Types of relationships and corresponding measures are represented in Table 4-6.

Table 4- 6 Types of relationships and corresponding measures

Index	Relations	Meaning	Axis of roadmap
Support	Co-occurrence	Affinity	Horizontal
Confidence	Dependency	Causality	Vertical

Based on this relationship, a keyword relational map is constructed, as shown in Figure 4-10.

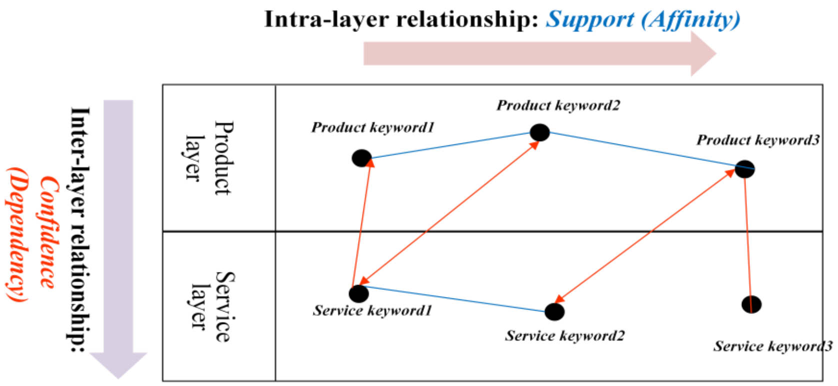


Figure 4- 10 Structure of a keyword relational map

Based on this graph, a technology roadmap is developed. The keyword relational map is a keyword-level roadmap, i.e. a micro-level roadmap. By aggregating keyword-level information into a product-level or service-level, more practical information can be derived. For example, relationship between products and services and relationship between products and technologies are identified. In addition, the keyword-relational map can be extended to the dynamic level roadmap by linking each snapshot for a certain timeline. This dynamic level keyword relational map could represent the dynamic changes of markets, products, services, and technologies.

4.2.3 Case study

4.2.3.1 Case overview

To illustrate the working of proposed approach, a simple case study was conducted. In this case study, we employ the Appstore database which is an ample source of current mobile application services. The subject of case study is selected as the mobile applications (apps) related to the social networking services of Apple's App Store. Now suppose that a manager of a specific company who wants to develop the new products or services try to setup the development plan. For this purpose, he wants to develop the technology roadmap for developing social networking services. What has to be done is to analyze the current database related to the social networking services. Since this case is conducted for the illustrative purpose, we develop a product layer and a service layer of technology roadmap.

4.2.3.2 Case implementation

Data and Pre-processing

As an initial step, we collected the document to represent the product information and service information to develop the technology roadmap. Therefore, this study downloaded the application services in Appstore, from the category of utility. For effective analysis, the amount of data should not be too many nor too few, and should be adjusted at a certain level. Therefore, we selected randomly selected 300 service documents of utility categories to provide moderate level of data in order to provide the effective result. To collect the data, a computer-based system using JAVA is used to automatically collect data from the Web. Since this case is conducted for the illustrative purpose, we develop a product layer and a service layer of technology roadmap.

Identification of keyword list

The second step is to identify the keyword list for each layer. Since two layers - a product layer and a service layer – are developed for the illustrative purpose, keywords representing product features and service features are identified. This is based on the assumption that a document can be expressed by a set of relevant keywords. A number of studies on knowledge discovery in texts have been based on the assumption that a set of keywords in a document represents the topics of the given document (Yoon and Park, 2005).

First, a quantitative process is conducted to derive the keyword by automatic collection using a text-mining technique 'Text analyst 2.1.' For 300 documents downloaded from the utility category, we collected frequent keywords. Frequent keywords seem to represent core functionality of each service, showing what kinds of keywords (or concepts) a firm should develop. Following on this step, a qualitative filtering process - screening and repetition process - is conducted using expert judgments. For this process, experts whose experience is more than 5 years in developing new mobile services are invited to adjust the keyword selection process. Experts are required to remove unrelated or meaningless keywords from the list, and add keywords which seem to be important to the new service development for the utility category.

How to select keywords for each layer is closely related to the application domain. When selecting product keywords, keywords related to the product specification (e.g. wifi), product performance (e.g. battery life), and device characteristics (e.g. speaker) should be included. Those keywords should be relevant for the utility category. Similarly, when selecting service keywords, keywords related to the service function and customer utility should be selected. For example, keywords such as e-mail and password are relevant for the service function whereas keywords such as interface and notification are related to the customer utility. The final keyword list after two-step process is listed in Table 4-7. Note that two types of keywords – product keywords and service keywords − are prepared, since this case study is conducted for those two layers for the illustrative purpose.

Table 4- 7 Keyword list of this case study

Type	Keyword list
Product keyword	Battery (BT), device (DE), mac (MA), wifi (WF), keyboard (KB), text (TX), camera (CM), flashlight (FL), mms (MM), system (SY), server (SV), audio (AU), dialer (DI), desktop (DT), volume (VO), tv (TV), video (VI), memory (ME), brightness (BR), product (PD), Bluetooth (BT), speaker (SP), barcode (BC), GPS (GP), battery life (BL), radar (RD), webcam (WC)
Service keyword	Photo (PT), email (EM), auto (AT), conversion (CV), music (MU), theme (TH), interface (IF), password (PW), browser (BW), converter (CT), location (LC), safari (SF), SMS (SM), calculator (CC), movie (MV), software (SW), itunes (IT), ringtones (RT), timer (TM), feedback (FB), unit converter (UC), playback, (PB) notification (NT), lauguage (LG)

Construction of keyword vectorwifi

Based on keywords, downloaded documents are then transferred to the keyword vector, more specifically; a document-keyword vector in which the row consists of documents and column consists of keywords. This vector is prepared for all documents, in which service documents are converted into keyword vectors, composed of the keyword's existence in the keyword feature list. This is based on assumptions that any given document can be represented by a set of relevant keywords (Yoon and Park, 2005). Since there are 300 documents and 51 keywords (27 product keywords and 24 service keywords), a 300 * 51 matrix is constructed. Each cell is filled with a corresponding value according as whether the keyword appears in a certain document or not. The role of this keyword vector is to identify what kinds of keywords exist in each document.

To calculate the association rule, this document-keyword vector should be converted to a keyword-keyword vector to represent the support and confidence between keywords. First, product-product relationship and service-service relationship are calculated based on the support measure. Second, relationships between product keywords and service keywords are measured via the confidence measure to measuring dependency.

Calculate the associations

Based on the keyword vector, support and confidence information is calculated as follows. Suppose P is the product keyword and S is the service keywords, support and confidence is calculated as follows.

$$Support(P \rightarrow S) = \frac{N(P \cap S)}{N} \quad [4\text{-}2]$$

$$Confidence(P \rightarrow S) = \frac{P(P \cap S)}{P(P)} = \frac{N(P \cap S)}{N(P)} \quad [4\text{-}3]$$

Based on the calculus for support and confidence, associations between keywords are identified. The result of measuring the association rule is shown in Appendix B.

Develop a keyword-portfolio map

Based on the associations, a keyword portfolio map is developed, as shown in Figure 4-11.

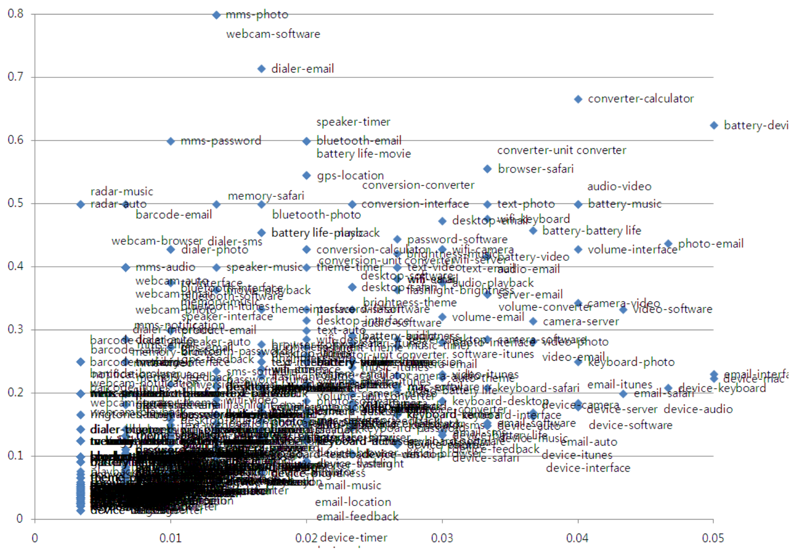


Figure 4- 11 Keyword portfolio map for utility category

As shown in this figure, keyword pairs are distributed in the keyword portfolio map. Table 4-8 shows the type of keyword pair and its representative pairs. The cutoff value is set as 0.03 for support value and 0.4 for confidence value.

Table 4- 8 Result of keyword portfolio matrix

Type	Keyword pair
Interactive	battery-device, battery-video, battery-battery life, battery-music, wifi-keyboard, keyboard-email,text-photo, audio-video, audio-email, volume-interface, photo-email, browser-safari, converter-calculator,converter-unit converter
Causal	wifi-camera, wifi-server, mms-photo, mms-password, dialer-photo, dialer-email, dialer-sms, desktop-email, memory-safari, brightness-music, bluetooth-photo, bluetooth-email, speaker-timer, barcode-email, gps-location, battery life-music, battery life-movie, battery life-playback, radar-auto, radar-music, webcam-software, conversion-interface, conversion-converter, conversion-calculator, conversion-unit converter, password-software
Family	device-mac, device-keyboard, device-camera, device-server, device-audio, device-video, device-email, device-auto, device-music, device-interface, device-software, device-itunes, keyboard-photo, keyboard-safari, camera-server, camera-video, camera-software, server-email, volume-converter, video-photo, video-email, video-software, email-auto, email-interface, email-safari, mail-software, email-itunes
Unrelated	email-music, email-location, email-feedback, device-theme, device-timer, barcode-safari, notification-language, memory-playback, movie-feedback, timer-language (etc)

Develop a keyword-relational map

Based on the associations, a keyword-relational map is developed. To visualize the relationship between keywords, we employed UCINET, graphical software to represent the relationship between elements. Using the affinity as intra-layer relationship and the dependency as inter-layer relationship, a 2-dimensional map is developed.

Figure 4-12 shows the result of developing a keyword-relational map. To provide more clear information, we set the cutoff value as 0.4, which means keyword relationships more than 0.4 are only described in the figure.

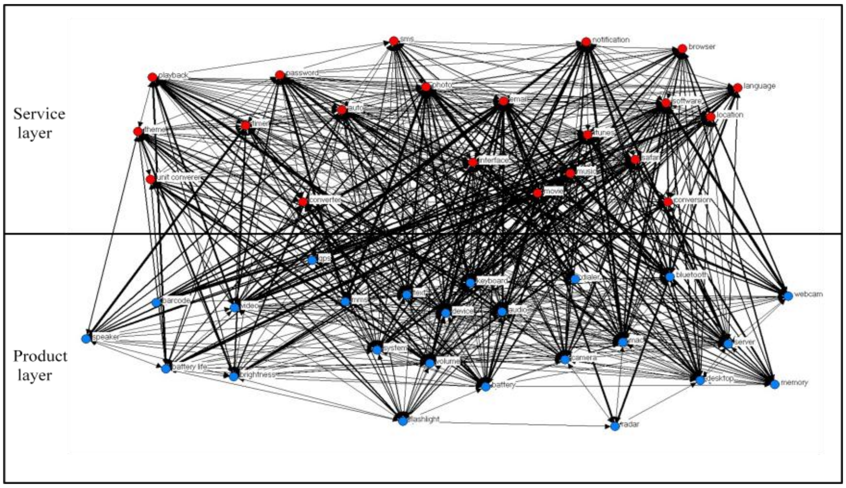


Figure 4- 12 Result of developing a keyword-relational map (cutoff=0.4)

As a result, many interesting implications can be identified. Many different kinds of keywords can be identified. First, many interesting phenomena are found in terms of product influences towards the service development. A battery life is determined as a critical importance to the development of interactive services, such as music, iTumes, and videos. These services are provided to the customer not only for a certain time, but also for all the time. Therefore, to develop new services which are operated for long time basis, increase of battery life should be considered as an important issue. Also, a product element, speaker, affects significantly to the timer services or music services. It is quite natural since the timer or music is highly related to the functional performance of audio devices.

Some relationships which seem to be unrelated are also found. For example, a product keyword, mms, is closely related to the service keywords, photo and password. These keywords seem to be unrelated but strongly linked. However, use of mms is generally executed for sending data such as photos or long sentences. Development of data-sending product attributes is thus closely related to the development of data-related services, including the security issues. Similarly, a product attribute, video, is also related to the e-mail or music, which seems to be unrelated. This can be interpreted in the same context.

From the perspective of new service development, many interesting phenomenon can be found. First, notification services should be developed with the in-depth consideration of various product elements, such as video, battery, barcode, flashlight, device, keyboard, audio, and camera. This means that development of new notification service requires these prerequisites of product attributes. In addition, it can be assumed that notification services can be applied to various product elements.

In terms of network centrality, service elements such as e-mail, photo, movie, software, location, and notification have strong relationships between other elements. When investigating product elements, keywords such as keyboard, audio, speaker, battery, and memory show a strong relationship. In most nodes, mutual interactions between product elements and service elements are identified, which means new products (or new services) are not developed after developing new services (or new products). The development process of a certain product or service is not sequential or dependent, but conducted in a parallel process, considering both the product attributes and service attributes. This is linked with the recent promising phenomenon of product-service system in which products and services are integrated to satisfy customers.

In order to show more clear view, we develop the keyword-relational map using more increased cutoff value, 0.6. The result is shown in Figure 4-13.

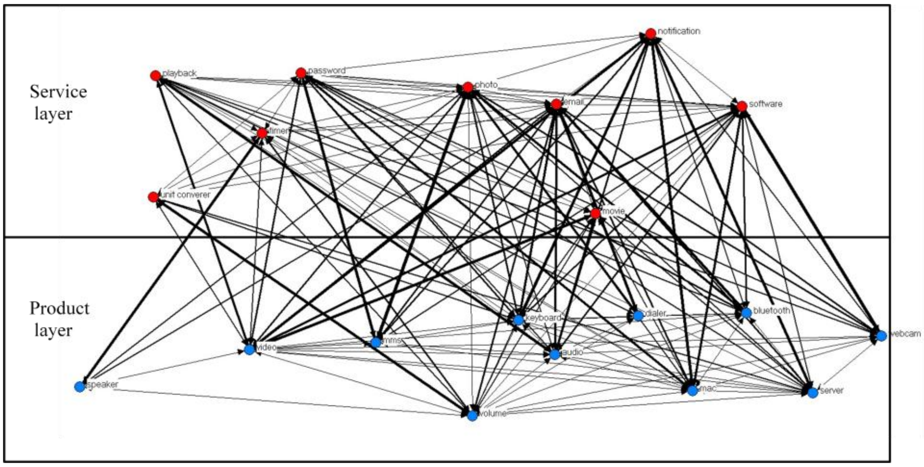


Figure 4- 13 Result of developing a keyword-relational map (cutoff=0.6)

In the service layer, e-mail is shown as a critical element and shows a strong interaction with most nodes in a map, not only with the product elements, but also with the service elements. As mentioned earlier, notification services are also closely related to the various product elements, which implies the close relationships with product elements are required to develop new notification services, and vice versa. In the product layer, mms is related with other service elements, which means it is highly affected by the development of other service elements, and vice versa. Product elements such as video and speaker show a strong relationship between service developments. This denotes the changes of product roles. Traditionally, a speaker is used for developing products or technological elements of a product, such as qualified voice communications. However, now this product attribute is employed for supporting relevant services or facilitating the effective service operations.

4.2.4 Conclusion

This theme contributes to the fields in manifold. First, from the theoretical perspective, this theme firstly provides an ARM-based roadmapping process to effectively visualize the dependency relationship between different layers. Using ARM, this theme addresses the shortcomings of previous research that simply measures similarities between two elements. Considering the characteristics of inter-layer relationship, we suggests a concept of measuring "dependency" to develop the technology roadmap, and provides a way of measuring dependency between two elements using ARM. In addition, this theme also suggests the usage of business data into the planning process, by indicating layer-specific data sources that can be used for systematic planning. From the methodological perspective, this theme combines the ARM and the technology roadmap to support the data-driven business planning. Thus, this theme extends the application area of ARM by applying this into the technology roadmapping process.

Despite the contribution, however, this theme is subject to some limitations. First, since the development of technology roadmap mainly focuses on the relationship between two elements, associations are calculated for a keyword pair, i.e. relationship between two keywords. However, using ARM, associations among several keywords can be calculated. Relationships among more than two keywords can provide more detailed but practical information to the firm. Second, the case study of this theme is simply conducted for the product layer and the service layer which are considered as most important and key areas to the technology roadmap. Future research should cover more diversified case study, covering a variety of data sources of technology roadmap. Finally, currently, a keyword-relational map is constructed for a certain period, not representing the dynamic changes among period. Therefore, a systematic way of considering dynamics in developing technology roadmap from the keyword relational map is still unexplored should be covered by future research.

Chapter 5. Planning for Design

This chapter deals with the planning for design. In this chapter, the planned new service idea, i.e. deployed service concepts, are specified in the context of service design. Even if the design issues seem to be unrelated to the service planning, many studies argued that the concept of service planning includes a practical perspective, encompassing the general decision-making process of service innovation (Aurich et al, 2010). Therefore, service planning encompasses many process of decision making in service innovation: identification, definition, and selection of service ideas, even the service realization phase (Aurich et al, 2010). Therefore, to achieve success for service innovation, it should be imperative to plan an effective service design (Schneider and Bowen, 1984 ; Johne and Storey, 1998; Easingwood, 1990; Edvardsson and Olsson, 1996; Aurich et al, 2010; Kumar, 2004). As previous research noted (Butler and Boyle, 2000), even the monitoring or management process is the target of planning, in order to guarantee the success in the service innovation.

This growing awareness of the need to re-operationalise service management material has led to develop many related operational/design issues of service management, including many topics such as 1) linking operational performance to business drivers, 2) developing tools for performance improvement, 3) dealing with service recovery, 4) designing services and service technology, 5) designing service encounter, and 6) managing service capacity (Johnston, 2005). Among many issues, this paper selected two important design issues of service innovation.

Section 5.1 deals with the service design issue with modularization. Modularization has been suggested to have a wider array of benefits ranging from development to production, such as economies of scale, increased feasibility of change, increased product variety, decreased lead-times, ease of design and testing, and easier product diagnosis and maintenance (Pahl and Beitz, 1988; Kusiak and Huang, 1996; Gershenson et al., 2003; Meyer and Lehnerd, 1997; Wang, 2009). Therefore, since the applicability of modularization concept has been already suggested in the context of service innovation (Sundbo, 1994), the study of service modularization worth the effort to plan the service innovation effectively. Section 5.2 deals with the proactive service management using service diagnosis. In service management literature, the proactive management is a critical issue, which emphasizes the prevention of problems (Stamatis, 2003), rather than identification of a solution after the failure happens. This is particularly true of service industries where many dissatisfied customers silently switch providers or initiate a negative word of mouth rather than express dissatisfaction following a service failure (Agbonifoh and Edoreh, 1986, Tax and Brown, 1998; Lewis and Spyrankopoulos, 2001). Due to this reason, prevention of service failures should be treated as the first and foremost issue, which is discussed in the section 5.2.

5.1 Service modularization using QFD

5.1.1 Introduction

Modularity has been at the core of strategic innovation in manufacturing over the past decade. Arising from the decomposition of a product into subassemblies and components (Gershenson et al., 2003), modularity has been defined as the degree to which a product's architecture is composed of modules between which there are minimal interactions – indeed, a key facet of modularity is based on the notion of functional independence - that each function should be independent of all the others. It has been suggested to have a wider array of benefits ranging from development to production, such as economies of scale, increased feasibility of change, increased product variety, decreased lead-times, ease of design and testing, and easier product diagnosis and maintenance (Pahl and Beitz, 1988; Kusiak and Huang, 1996; Gershenson et al., 2003; Meyer and Lehnerd, 1997; Wang, 2009).

Given these advantages, modularity is considered to have the potential to play a vital role in the service sector from various perspectives. Firstly, modularization starts with the decomposition of a target into its components, so adopting this procedure allows for the systematic analysis of services. Although much attention has been given to the in-depth understanding of service structures, their decomposition of services has rarely been examined – either by academia or practice – because of their essential intangibility. Secondly, given its process-based nature (Levitt, 1972;

Hill, 1977; Shostack, 1987), service can be considered as a set of functional flows, and modularizing its functions can be expected to lead to various advantages from operational efficiency to effective new service development. Finally, the service system can be understood as an interrelated set of numerous constituents: processes constituted of operational system activities, customers that work as inputs or co-producers of the service system, and resources that encompass related prerequisites for service realization, which this study considers to include products.

The concept of service modularization was first introduced by Sundbo (1994), who proposed both its feasibility and its potential advantages. However, the inherent difficulty in modeling services has meant that there has been little research in the area (Pekkarinen and Ulkuniemi, 2008). The existing literature on service modularization has focuses on the development of product modules from the service and maintenance perspective, rather than on service modularization itself (Gershenson et al., 2003), although some authors have extended the concept of product-based service modularity to apply in some service industries (Van Hoek and Weken, 1998). While modularity in services can be seen differently, it is commonly considered as a way of developing services and managing heterogeneity or variability in demand, which is why it deserves further research attention (Pekkarinen and Ulkuniemi, 2008).

But while such studies have tried to focus on service modularity, they do so mostly at the conceptual level – the important question of how to modularize services in practical terms has rarely been dealt with (Gershenson and Prasad, 1997; Meyer and DeTore, 2001). The lack of available methodology has meant that the study of service modularization in practical setting has faced the difficulties of working without a solid theoretical framework. So, a methodology to consider the inherent characteristics of services and to deal with service modularity is highly needed.

The study of service modularity has to address two important aspects. First (as the previous literature notes), the concept of service modularity can be defined differently according to a firm's strategic and operational goals. It can be used to manage demand heterogeneity, service customization, or the efficiency of functional units. Therefore, it should be considered alongside the service-specific module-drivers that define its strategic and/or operational focus in a specific service firm context. Second, since the concept of service involves multi-dimensional and interrelated service prerequisites, processes and outcomes (Edvardsson and Olsson, 1996), identifying the relationships between these constituent elements is a key issue in service modularization.

This study uses and adapts the QFD structure to consider the modularization of services from two perspectives: a driver-based approach and an interrelationship-based approach. In the driver-based approach, the HoQ relationship matrix provides a means to analyze relationships between service constituents and their drivers, with the latter working as the decision criteria for modularization throughout the entire service life cycle, by identifying service processes with similar characteristics. In the interrelationship-based approach, a HoQ (House of Quality) roof matrix structure is used to identify interrelationships between the component elements of a multi-dimensional and interrelated nature of the service concept outlined above. A roof matrix is considered to play a key role in its successful modularization.

5.1.2 Modularity in services

In product terms, a module can be defined as a component (or component group) that provides a separate functionality within a single product, and can be removed from a product 'non-destructively' (Allen and Carlson-Skalak, 1998). Many attempts have been made to modularize product design so as to make the most of these advantages, and a variety of methods and tools have been developed for identifying modules, such as Fractal Product Design (FPD) (Kahmeyer et al., 1994), Modular Product Development (MPD) (Pahl and Beitz, 1996), Modeling the Product Modularity (MPM) (Huang and Kusiak, 1998), Modular Function Deployment (MFD) (Erixon, 1998), and Design Structure Matrix (DSM) (Pimmler and Eppinger, 1994). These attempts can be classified into two basic types: driver-based or the interrelationship-based approaches.

The first set (such as MFD) evaluates the opportunities for modularization according to the various underlying criteria, which may include a firm's circumstances or strategies, or the innate characteristics of a specific service. But as service involves total systems composed of different interacting elements, the latter type (which includes many methods such as

FPD, MPD, MPM, and DSM) approaches modularization according to the existing interrelationship between parts or sub-processes. This study adopts a two-fold approach to capture strategic advantages (by considering modular drivers), as well as operational advantages (by considering the interrelationships between service system components).

The concept of modularization has been applied to the service industry as well. The concept of service modularization was firstly introduced by Sundbo (1994), who noted it as a growing tendency in an empirical investigation of the sector. Modularization allows firms to combine rationality and cost saving with focusing on the customer needs. Service modularization can be based on delivery processes - since services are, by nature, process offerings – and may differ according to the firm type; for example, mass services are more likely to be modularized than professional services.

Mass-service firms have recently tried to modularize their service offerings so as to benefit from economies of scale. However, little research has addressed service modularization due to innate difficulties of service modeling, and most of it has focused on the case of service and maintenance of products (Gershenson and Prasad, 1997; Gershenson et al., 2003). The level of abstraction of the service process, the labor operation involved, and the effect of service aspects on specific product attribute have been mentioned as important factors in designing service modularity. Holmqvist and Persson (2004) noted the importance of service integration in product development, and that service-related cost meant that service requirements should be taken into account when modularizing.

5.1.3 Proposed approach

5.1.3.1 Overall Process

Figure 5-1 illustrates the overall process and the four phases of our proposed approach: selecting module drivers for target services, decomposing the service, developing the HoQ structure, and choosing module candidates. This approach broadly aligns with the on five-step process defined in the previous literature to define modules: define service functions, identify drivers for variety, assess impact of drivers on functions, define candidate module using module types, and specify module variants (Böhmann et al., 2003).

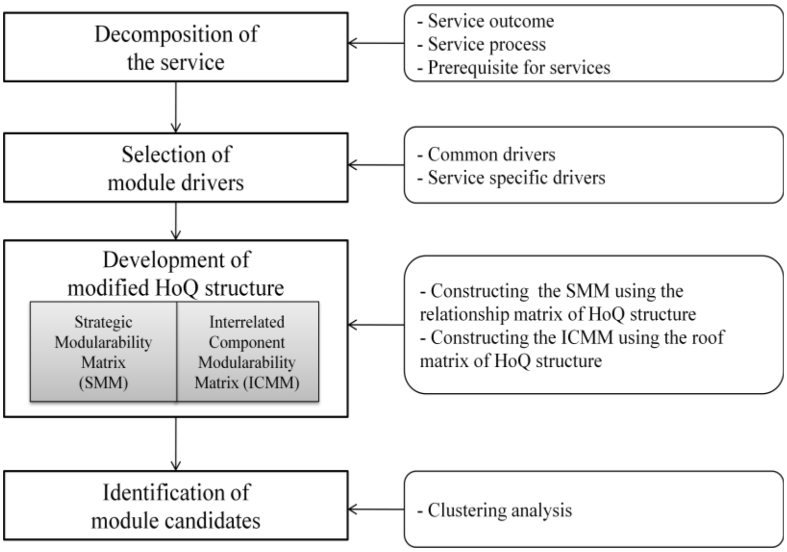


Figure 5- 1 Overall process of this study

5.1.3.2 Detailed Procedures

Decomposition of services

In general terms, modularization starts with the decomposition of a target into subassemblies and components (Gershenson et al., 2003), but this is more complex in service cases for many reasons. Shostack (1992) noted that "describing a service is one of the most difficult aspects of dealing with a service" and there is also no tradition of technical drafting in service - terms such as "specification," "tolerance," or "standard operating procedures" are rarely used in the service context (Congram and Epelman, 1995), and service methodology has rarely been addressed in either academic or practical settings, because of the innate intangibility of the service concept. The essentially interrelated nature of service is a further barrier to description, as services are not merely sets of sub-assemblies around a single dimension. To address these difficulties, the decomposition phase must mirror the complex interrelations involved in service by employing a methodology that is capable of capturing the relevant interrelationships.

This study adopts the framework developed by Edvardsson and Olsson (1996) which regards services as composed of three dimensions: customer outcome, customer process, and prerequisites for the service. The service can be classified in many ways depending on situation and purpose – permanent or temporary, tangible or intangible. The customer outcome covers the judgment of the recipient of the service in terms of its value and quality. In terms of customer process, services have been widely treated as process-offering (Levitt, 1972; Hill, 1977; Shostack, 1987) with have customer outcome as their result. But the processes involved differ from those in manufactured products mainly in terms of how the customers' presence affects the value and quality of the result (which is why the service process is often referred as a "customer process"). For the third dimension - the resource structure behind service delivery– we follow Edvardsson and Olsson (1996) again in considering service company's staff, its customers, and physical/technical environment and control elements of a firm.

Selection of module drivers

There have been many attempts to modularize product architectures using the concept of module drivers (Erixon, 1998; Blackenfelt and Stake, 1999; Kreng and Lee, 2004b), with Erixon's work as the most notable effort, which proposed MFD for identifying an appropriate set of module drivers and a changing set of criteria behind modularization throughout the product's entire life cycle. These drivers can be seen as generic, but may be complemented by company specific factors such as strategy, financial limitations, legal restrictions and so on (Erixon, 1998). Table 5-1 shows Erixon's proposed set of module drivers (Erixon, 1998; Blackenfelt and Stake, 1999), which we use as the first set of drivers in this study (labeled 'Common'), and which can be selected or prioritized according to company-specific environments or strategies.

Table 5- 1 Common module drivers (adapted from Erixon, 1998)

Dimension	Module driver	Description
Design and development	Carry-over	The unit will be used in a future service generation.
	Technology-push	The unit is likely to go throughout a major shift or improvement of technology during the service life cycle. This is often caused by externally decided changes which are difficult to plan, but must be estimated.
	Planned Service Change	The unit is scheduled to go through some changes according to an internally decided plan.
Variance	Technical specification	The unit varies in terms of function or performance between different services in the family.
	Styling	The unit varies in terms of color and shape between different services in the family.
Manufacturing	Common unit	The unit will be used across the whole service family.
	Process / Org.	The unit suits a special process or has suitable work content for a group.
Quality	Separate testing	The unit should be tested separately.
Purchase	Supplier available	The unit may be out-sourced.
After-sales	Service / maintenance	The unit needs to be easily serviced and maintained during the life of the services.
	Upgrading	The unit may be replaced for another part with different function or performance.
	Recycling	The unit needs special attention when the service has serviced its life.

We conducted a comprehensive literature review to identify another set 'service-specific module drivers' that need to be considered when modularizing a focal service based on its specific characteristics, and identified a total of 17 factors which are summarized and listed in Table 5-2 (along with their references). In practical application, selection of module drivers will depend on firm strategy, and they can be weighted according to strategic priorities, so that weighted cluster average can be calculated. For example, a firm aiming to achieve mass customization will give high rating to module drivers accounting for such factors as degree of customization, level of self-service, and degree of customer participation, while a firm with a strategic focus on self-service improvement will prioritize module drivers such as labor intensity level, possibility of self service, task specialization, and degree of service visibility.

Development of modified HoQ structure

Modifying and then employing the HoQ structure provides a valuable starting point for visualizing the components of a total system and their interrelationships. In this step, service can be modularized according to driver-based and interrelationship-based approach, as shown in Figure 5-2. Firstly, the relationships between the drivers and the decomposed service elements – which are divided according to the three dimensions of service outcome, process, and prerequisites - should be identified and assessed one by one. The structure of HoQ, which is an underlying methodology of this study, is modified and applied according to the contents. As noted above, the HoQ relationship matrix identifies the possibility of modularization from a strategic point of view (and is thus labeled the Strategic Modularability Matrix (SMM)).

Table 5- 2 Service-specific module drivers

Dimension	Module driver	Description	Reference
Service process	Degree of customization	The degree of flexibility in providing customer-specific customization	Possibility of mix in consumption point (Silvestro and Johnston, 1992; Kellogg and Nie,1995; Johne and Storey,1998)
	Degree of customer participation	The degree to which customers participate in the service process	Customer-participation as a co-producer or participant (Fitzsimmons and Fitzsimmons, 1994; Edvardsson and Olsson, 1996;
	Degree of possibility of self service	The chance to which customers can execute the service on their own.	Schneider and Bowen, 1984; Kelley et al., 1992; Kellogg and Nie ,1995; Johne and Storey,1998)
	Degree of routinisation	The degree to which the service process happens routinely	Service as processes rather than objects (Edvardsson and Olsson, 1996; Syson and Perks, 2004)
	Degree of service-visibility	The degree to which the service process is visible to the customer	Service divided into the front-office and the back-office, according to the visibility to the customers (Shostack, 1987)
	Degree of contact frequency	The degree of frequent contact between customers and suppliers	Importance of service encounter (Czepiel, Solomon,and Surprenant 1985;
	Degree of moment of truth	The degree of high-impact activity that provides an essential and primary impact to the overall quality	Carlzon, 1987)
	Degree of specialized task	The degree of task complexity with respect to the specialty	Service as an employee-process (Johne and Storey,1998) Service as processes rather than objects (Edvardsson and Olsson, 1996; Syson and

			Perks, 2004)
Service outcome	Degree of standardization	The degree to which the service output is standardized	Service heterogeneity (de Brentani, 1989; Johne and Storey,1998)
	Degree of heterogeneity in output	The degree to which the service output is heterogeneous	
	Degree of variability in demand	The degree to which the service output is expected to be variable according to customer action	
	Degree of customer/server contact	The degree to which contact between customers and servers is possible	Customer contact (Chase, 1981) Customer-participation as a co-producer or participant (Fitzsimmons and Fitzsimmons, 1994; Kellogg and Nie,1995; Edvardsson and Olsson, 1996; Johne and Storey,1998)
Prerequisite for services	Facility Location	The degree that facility is located distributed or centralized.	Resource-dependent
	Facility Layout	The degree to which the facility layout is arranged.	
	Degree of worker diagnostic skill	The degree to which the process requires the high diagnostic skill of workers	Service as an employee-process (Johne and Storey,1998)
	Degree of worker interpersonal skill	The degree to which the process requires the high interpersonal skill of workers	
	Degree of worker operational skill	The degree to which the process requires the high operational skill of workers	

The driver-based approach allows for the incorporation of strategy and motivation, as based on the MFD method proposed by Erixon (1998).

Secondly, the relationships between the decomposed service components within each dimension should be also assessed one by one in three roof matrices. The distinguishing element here is the consideration of the relationship(s) between the three different dimensions – the whole roof matrix identifies the component-to-component relationships, but is again divided into the service outcome, process, and prerequisites dimensions. The HoQ roof matrix (in this study labeled the Interrelated Components Modularability Matrix (ICMM)) analyzes relationships between different dimensions and their sub-components across the full range of both intra-dimension and inter-dimension relationships.

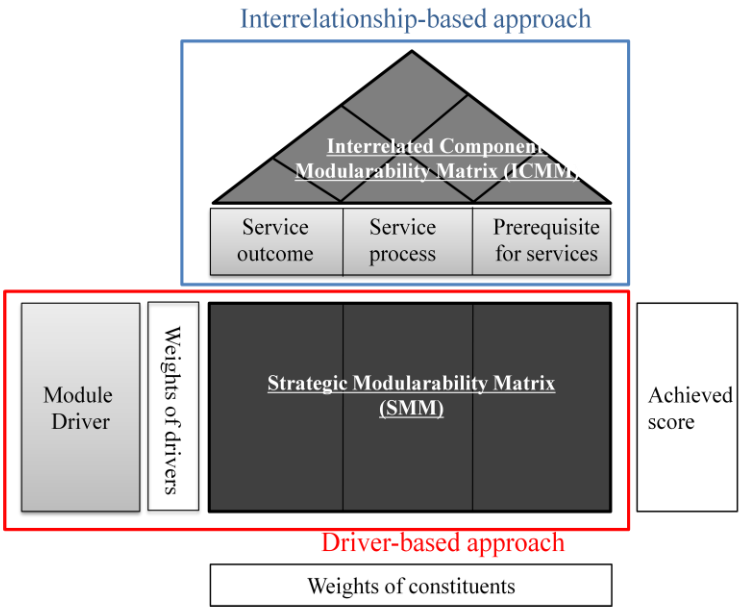


Figure 5- 2 The final output of this step

Identification of module candidates

The final stage involves identifying module candidates using clustering analysis to indicate the what-how relations between a set of functional requirements and a set of design parameters (Tseng and Jiao, 1997). One of the most commonly used methods is based on hierarchical clustering; the procedure is heuristic in nature and consists of two major components - an association measure to define relationships between entities and a clustering method to identify clusters (Gupta, 1991).

Firstly, the set of module candidates is identified from the SMM, reflecting whichever module driver perspective aligns with the firm's strategy, or whichever criterion is driving the move for modularization. Another set of module candidates is identified from the ICCM, which (as Figure 5-3 shows) consists of six sections, enabling the service interrelationship to be analyzed. Considering the inter-dimensional relationships allows a service module to be derived that can encompass all the necessary service constituents. By taking account of the full set of appropriate service process, outcome and resource dimensions, this procedure allows the service process and its related resources to be managed together in a holistic manner so the service system can achieve the desired outcome.

5.1.4 Case study: Restaurant services

5.1.4.1 Case overview

We tested the applicability of the proposed approach in a case study in a restaurant service context, a setting we chose for three reasons. First, it is a typical mass service that previous studies have considered as having good prospects of being modularized (Sundbo, 1994). Second, it is a setting where process, outcome and resource elements are highly interdependent, illustrating the interrelatedness of service systems' feature. Third, while it may seem simple and familiar, it represents a service process that is getting bigger and more complex, where modularization is important to firms seeking to create competitive advantages. We chose as our specific target a big family restaurant that is still expanding.

5.1.4.2 Case implementation

Decomposition of services

As a basis for understanding the restaurant's current service, Figure 5-3 shows its service blueprint, depicting the roles of the consumers, service providers, and supporting services in two-dimensions, with the horizontal axis representing the chronology of actions and the vertical delineating the different service areas (Shostack, 1984; Fließa and Kleinaltenkamp, 2004). Service decomposition was based on this blueprint, and the decomposed service elements are described in Table 5-3.

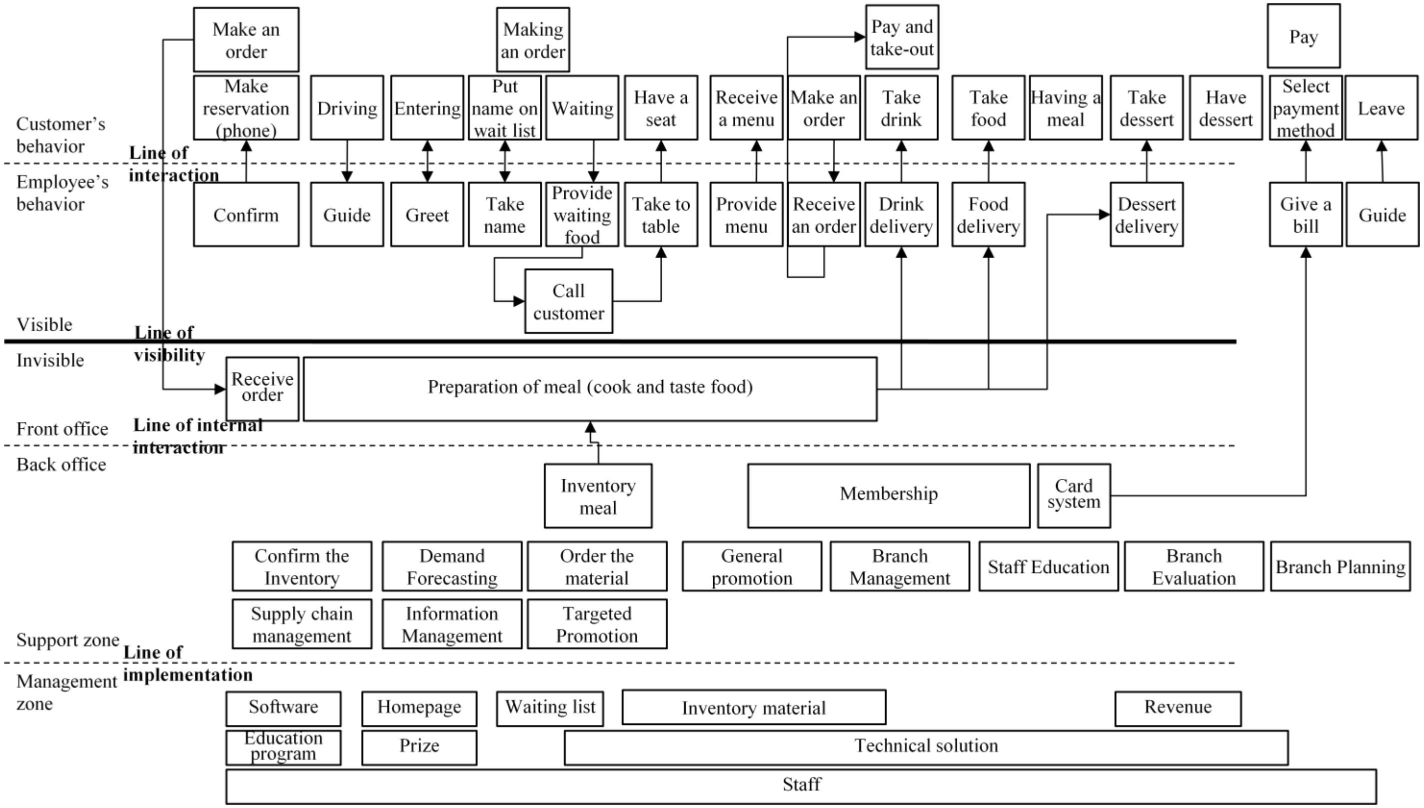


Figure 5- 3 Service blueprint of restaurant services

Table 5- 3 Decomposed service elements

No	Elements	No	Elements
1	Confirming a reservation by phone	34	Bill
2	Ushering to the parking lot	35	Beverage
3	Greetings	36	Food
4	Taking customer’s name	37	Dessert
5	Providing some food or drink (waiting)	38	Membership
6	Taking to their table	39	Image
7	Taking a menu board	40	Customer relationship
8	Receiving an order	41	Customer information
9	Taking a beverage	42	Customer satisfaction
10	Taking food	43	Software (reservation system etc..)
11	Taking dessert	44	Education program
12	Calling customer's name	45	Homepage
13	Cleaning the table	46	Prize
14	Giving a bill	47	Radiotelegraph
15	Showing the way to drive out	48	Management system
16	Paying & leaving	49	Staff
17	Paying and take-out	50	Parking lot
18	Preparation of meal	51	Payment system
19	Contacting with media and PR	52	Dish
20	Ordering the material	53	Material
21	Preparation of inventory meal	54	Tableware
22	Supply chain management	55	Table
23	Confirming inventory material	56	Chair
24	Forecasting demand	57	Special waiting food
25	General promotion & ad advertisement	58	Credit card/ point card system
26	Permitting the opening of branches	59	Inventory meal
27	Educating the staff and chef	60	Inventory material
28	Evaluating the branches	61	Desk (reception desk)
29	Planning the expansion of branches	62	Waiting list (sheet)
30	Gathering the information of customer	63	CRM technology
31	Targeted promotion (anniversary, birthday)	64	Interior
32	Managing the internet homepage	65	Menu board
33	Revenue		

Development of HoQ

After this, a HoQ was constructed, as shown in Figure 5-4. After the development of HoQ, a hierarchical clustering analysis was conducted to determine the module candidates. The clustering analysis is conducted for both SMM and ICCM matrices. The meaningful results among the derived module candidates from the HoQ matrix are shown in Table 5-4.

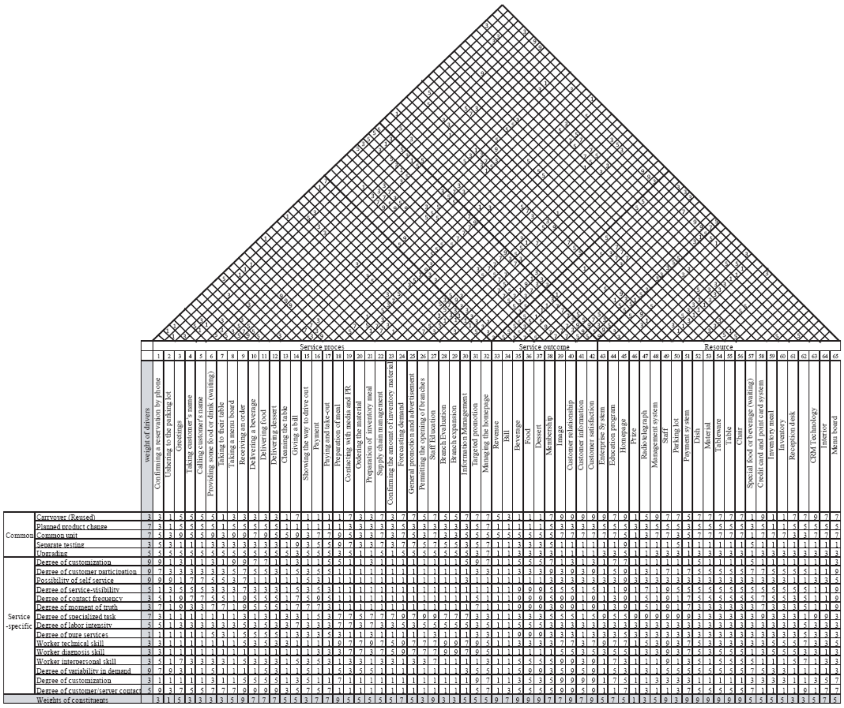


Figure 5- 4 Result of HoQ

Table 5- 4 Result of deriving module candidates

	Module candidates	Relevant elements
Module from SMM	1) General Management	48 , 63 , 43 , 64, 22, 25, 27, 24, 28 ,29, 26, 19
	2) Inventory Management	23, 20, 21, 47, 50
	3) Reception	4, 5, 7, 15
	4) Payment	16, 14, 17
	5) Customer Guiding	12, 62, 61, 3, 6, 53, 54, 55, 56, 41, 39
	6) Customer Management	40 , 42, 49, 58, 51, 38, 65, 45, 1
	7) Order Management	8, 10, 11, 32, 38, 30
	8) Actual service	35, 36, 37, 57
Module from ICMM	1) Facility	54. 55, 56, 58, 64, 45
	2) Waiting Management	47, 6, 61 , 12, 62, 2, 4, 50
	3) Welcome Process	3, 15, 13, 57, 5
	4) Branch Management	28, 29, 32, 26
	5) Inventory Management	20, 21, 59, 60, 23, 24, 53
	6) Education	27 , 44
	7) General Management	19, 25, 43, 31, 41, 63, 30, 38
	8) Serving	9, 10, 35, 36, 37, 8, 18

5.1.4.3 Implication

General context

Since the service-specific module drivers reflect the service characteristics, modularized services can be characterized based on the levels of each driver, as shown in Table 5-5.

- If a service module shows high levels of both customer participation and of frequency of contact, it can be thought as *customer-contact* related module.

- A module showing high degree of self-service indicates that this is area that can be improved in terms of self-service, while a high degree of standardization implies that its operation does not need specific knowledge and can be standardized according to rules.
- A module requiring high-levels of worker-skill can be characterized as *labor-intensive*, and can be differentiated according to the types of skills required to realize the service.
- A module that shows high dependency on the layout or location of the facility can be classed as *facility-dependent* and should be managed based on the facility characteristics.

Table 5- 5 Module characteristics - General

Module	Characteristics
Customer contact module	High degree of customer participation High degree of contact frequency High degree of moment of truth High degree of customer/server contact
Self service module	High degree of possibility of self service High/low degree of standardization
Labor intensive module	High degree of worker diagnostic skill High degree of worker interpersonal skill High degree of worker operational skill
Facility-dependent module	High degree of facility location High degree of facility layout

Service Modularity according to the employee skill

Services can be modularized according to the level of skill required of the relevant worker, which can provide high levels of operational efficiency.

There are three types of module drivers – relating to the degrees of workers' diagnostic, interpersonal and operational skills - and since they denote the overall characteristics of services in terms of the labor involved, they can be classified as shown in Table 5-6. In general, professional services are focused on people and processes and so will show high scores for customer contact time, customization and employee discretion (Tinnilä and Vepsäläinen, 1995), and so can be characterized as having high levels of worker diagnostic skill, customer contact, and customization.

In contrast, communication-based services will imply intensive communication between customers and service providers, and so require high degrees of interpersonal skills and will also present the high frequency of contact. Operational services are characterized by high degrees of workers' operational skill, but lower levels of customer contact: they are also likely to be highly standardized (or to be able to become so). In effect, operational services have similar characteristics to factory-delivered services.

Table 5- 6 Module characteristics according to worker's skills

Module	Characteristics
Professional service	High degree of worker diagnostic skill High degree of customer contact High level of customization
Communication-based service	High degree of worker interpersonal skill High degree of customer contact High degree of contact frequency
Operational service	High degree of worker operational skill Low degree of customer contact High degree of standardization

Service modularity according to the customer contact

Another possible categorization of services and service delivery is in terms of customer contact, where the underlying notion is that, by their presence, interaction and/or participation, the customer influences the service process in some way (Kellogg and Nie, 1995), so considering the level of contact between them and service providers can offer the latter significant implications for improving service systems.

Where a service module shows high levels of both customer contact and self-service possibility, the characteristics of the contact with customer should be checked. If the contact relates to simple instruction or operational notification, the service module may be able to be delivered by self-services (in effect, removing a substantial customer contact element). But if supplying the service involves identifying problems that might require in-depth investigation, self-service is unlikely to be an option, as it cannot substitute for worker expertise and decision-making abilities.

The option to move towards self-service can also be analyzed according to the level of service standardization. If customer contact involves high level of standard interactions with customers, the modules will normally be related to operational services, and automating operational procedures or introducing a greater degree of self-service may allow employee participation to be reduced.

5.1.5 Conclusion

This study contributes to the field by filling a service literature void in terms of reviewing and applying service-specific module drivers to the service modularization. The approach proposed here allows for more flexible modularization by the selective application of module drivers, which can be weighted according to the service firm's characteristics, circumstances and strategies.

This study also contributes by analyzing services according to three different dimensions to reflect the interdependent nature of service offerings, thus providing a more concrete framework to help service managers to consider the interrelationship between the dimensions so understand the current status of their firms' offering. Modularizing services through the three different dimensions provides a holistic view of the service system, incorporating not only the service process but also its various constituents and the customer perspectives involved, allowing the processes and the required resources to be managed together to improve the outcomes for customers. We expect the conceptual framework for service modularization out study offers, and our illustration of its practical application, to provide service designers with a specific modularization method that can help them identify modular structures that will yield both operational efficiency and service flexibility.

Nevertheless, our research is still subject to some limitations which should be complemented in future research. First, a fruitful area for future research would be to discover more about how to refine the proposed approach according to service type for its more diversified application. Schmenner (1986) has provided a four-fold classification of services - service factory, service shop, mass service, and professional service – each of which has distinctive characteristic, and a differentiated modularization approach would allow for modularization to be more context-specific.

Another fruitful avenue for future research is to identify the types of module or modularity which are especially appropriative for application to services, which would provide useful finding for managers of service firms. Since the current thinking about modularization has, for most parts, simply been transferred from manufacturing to service, there are likely to be some shortcomings to be addressed; identifying and formulating a service-specific modularity can be expected to improve ideas about how to structure modularity in the service sector.

Finally, this study currently deals with the setting of service operations, which aims to provide operational efficiency. However, the proposed approach can be effectively applied to new service development (NSD), as the main advantage of modularity is to provide variety by creatively combining functional modules. Such future work regarding NSD, therefore, is likely to make the current proposed approach both more concrete and more fecund.

5.2 Proactive management of services

5.2.1 Introduction

In any organization, failures in a system should be identified, evaluated, and improved under a well-defined framework. Traditionally, the management over the system failure is linked to the solution of an existing problem. However, the paradigm has now changed; the major concern of failure analysis is to emphasize the prevention of problems linked to the proactive treatment of the system (Stamatis, 2003), rather than finding a solution after the failure happens.

This is particularly true of service industries where many dissatisfied customers silently switch providers or initiate a negative word of mouth rather than express dissatisfaction following a service failure (Agbonifoh and Edoreh, 1986, Tax and Brown, 1998; Lewis and Spyrankopoulos, 2001). Failures in a service system are directly linked to the loyalty destruction (Miller et al., 2000), customer dissatisfaction (Berry and Parasuraman, 1992; Boshoff, 1997; Michel, 2001), customer defection (Michel, 2001), and negative word of mouth (Michel, 2001; Boshoff, 1997; Michel, 2001), that implies that the prevention of service failures should be treated as the first and foremost issue. With this consideration, suffice it to say that proactive failure management is extremely imperative in a service setting.

The most notable methodology dealing with this issue is the failure mode and effect analysis (FMEA). It is a dominant and systematic process for identifying potential failures before they occur, with the intent to minimize the risk associated with them (Narayanagounder and Gurusami, 2009). It has been widely used in the various manufacturing areas as a solution to many reliability problems (Dale and Shaw, 1990; Vandenbrande, 1998; Rhee and Ishii, 2003). However, the significant body of literature regarding FMEA still place value on manufacturing areas, neglecting the increasing importance of service areas. In line with this necessity, the scope of FMEA has been recently extended to some applications in services (Stamatis, 2003, Chuang 2007), proposing some generic guidelines required to apply for the service setting (Stamatis, 2003) or applying FMEA to the service setting (Chuang 2007).

Despite these attempts, however, FMEA in these studies cannot be directly applied to the service setting for two important reasons. Firstly, from the theoretical perspective, entire corpus of "service" needs be incorporated in order to provide the service-specific analysis. It is found in the literature that service has distinctive characteristics including customer contact (Chase, 1981), customer participation (Fitzsimmons and Fitzsimmons, 1994; Kellogg and Nie, 1995; Edvardsson and Olsson, 1996; Johne and Storey, 1998), process-based characteristics (Edvardsson and Olsson, 1996; Shostack, 1987; Jones, 1989; Van Looy et al., 1998; Syson and Perks, 2004), and employee-process (Johne and Storey, 1998). These characteristics should be well-melted in the methodology to provide the concrete and systematic FMEA for service. However, previous studies in FMEA still remain the same as traditional FMEA, just borrowing the current body of existing methodology using only three dimensions.

In addition, risk prioritization of traditional FMEA does not fit to the service setting where a number of distinctive characteristics should be considered. Traditional risk prioritization of FMEA takes the form of multiplication of severity, occurrence, and detection. However, much debate has been raised regarding the conformity and appropriateness of this calculation (Chang et al., 1999). Especially, doubts have been cast on the appropriateness of multiplication; whether the relation is appropriate or how can deal with the different impacts of factors in the risk implication. This is particularly important in a proposed service setting where the multilateral perspective of service should be considered. Thus, a number of research have been conducted to provide more multilateral consideration for prioritization such as fuzzy logic (Chang et al., 1999; Stewart and Chase, 1999), grey theory (Chang et al., 1999), life cost-based analysis (Rhee and Ishii,, 2003), ANP (Taylor, 1994), and ANOVA (Narayanagounder and Gurusami, 2009). However, these methods are still limited to the manufacturing setting, not focusing on the characteristics of services.

Responding to these necessities, this theme proposes a systematic approach to managing the service failures using a service-specific FMEA and GRA. Addressing the limitation of insufficient consideration of service-specific characteristics, this theme firstly proposes a service-specific FMEA. With the service-specific FMEA, the multilateral service-specific criteria necessary to decide the characteristics of service failure are identified from the existing literature and then reorganized as 3 dimensions and 19 sub-dimensions. It provides the holistic view to manage the service failures by incorporating the notion of customer participation, customer contact, or process-based characteristics that represents the characteristics of service. Following the service-specific FMEA, the risk priorities of each failure modes are evaluated using GRA to highlight the multilateral perspective of service-specific FMEA.

GRA is a method for decision making characterized by incomplete information under the multi-dimensional decision circumstance, providing a flexible approach using different weighting coefficients (Bowles and Peláez , 1995; Pillay and Wang, 2003). It is a simple and data-driven method useful for making decisions by analyzing various relationships (Tay and Lim, 2006). With its flexibility, GRA can relieve the long debate regarding the rigid assessment of traditional risk prioritization. Since the proposed service-specific FMEA consists of many interrelated sub-dimensions compared to the traditional FMEA, GRA is expected to fit to the evaluation of service-specific FMEA, providing a simple and straightforward way.

5.2.2 Service failure

A service failure occurs when customers' expectations are not met (Chuang, 2007) or service performance falls below a customer's expectation (Chang et al., 2001; Chen, 2007). It includes situations when the service fails to live up to the customer's expectations (Michel, 2001). Similar to service quality and satisfaction, it is all about customers' perception that determines whether a service failure occurred even if the company has the best strategic plans and the tightest quality control procedures (Chuang. 2007; Deng, 1989).

The service failure is essentially a flawed outcome that reflects a breakdown in reliability (Shostack, 1985). It generally encompasses any problematic situation during service while service is delivered to a customer, causing significant damages to customer satisfaction (Boshoff and Leong, 1998; Surprenant and Soloman, 1987). What is at the core in terms of discussing service failures is that the service failure is discussed from the customer' perspective because this is what a company needs to recover from, i.e. any dissatisfaction or problem that a customer perceives in relation to a service or a service provider (Lewis and Spyrankopoulos, 2001).

Fließa and Kleinaltenkamp (2004) identified two types of failures: service denial (unavailability), and delay. Both are core failures because the provider has established manifest contracts with the customers. However, the failures differ in terms of severity; denial is considerably more serious than delay because it is a total breach of the basic contract. However, delay can also be a core failure, depending on the circumstances. The representative case is a pre-process wait (Shostack, 1984). If the customer has set an appointment time, arrives at the scheduled time and then waits, a failure has occurred due to the delay. Pre-process waits tend to be viewed as more unpleasant than in-process waits (Fließa and Kleinaltenkamp, 2004). Both in-process waits and pre-process waits result in the dissatisfaction of customer, resulting in lower customer satisfaction of service (Shostack, 1984).

In terms of effect of service failure, literature have discussed regarding many negative effects (Hoffman and Bateson, 1997), mainly including customer dissatisfaction (Berry and Parasuraman, 1992; Boshoff, 1997; Michel, 2001), a decline in customer confidence (Boshoff, 1997), negative word-of-mouth behaviour (Goldstein et al., 2002; Berry and Parasuraman, 1992), and customer defection (Tax and Brown, 1998). With these negative effects, ultimate outcome of a service failure is revealed as customers' behaviors: stay or leave (Smith et al., 1999). A customer may stay after service failure if they are satisfied with the service recovery process. However, a customer may leave if the recovery efforts may be poor, causing the customer to be even more dissatisfied (Smith et al., 1999). Sometimes, regardless of the service recovery performance, customers tend to be dissatisfied with the occurrence of service failure itself, thus decide to leave. This implies that preventing the service failure from happening, in other words, identifying service failure in advance, is a very important work in the service area. However, at the same time, unfortunately, it is said to be a stiff work, having many barriers in it. The greatest barrier to identifying the service failure is the fact that only 5 percent to 10 percent of dissatisfied customers choose to complain following a service failure. Instead, most silently switch provides or attempt to get even with the firm by making negative comments to others (Tax and Brown, 1998). Therefore, it can be said that identifying failures in a service setting should be thoughtfully investigated prior to its emergence.

5.2.3 Proposed approach: Service-specific FMEA

5.2.3.1 Overall Process

First of all, this study defines service failure as the setting that customers' expectations are not met in the service process, as many literatures noted (Chang et al., 2001; Michel, 2001; Chuang, 2007; Chen, 2007). Even if some researchers defined a service failure as a concept of service denial or service delay (Fließe and Kleinaltenkamp, 2004), it can be interpreted as partially linked with customer satisfaction.

The overall process of the proposed approach is shown in Figure 5-5. The proposed approach is composed of two main stages; the first stage is constructing the service-specific FMEA and the second stage aims at evaluating the failure modes under the framework of GRA.

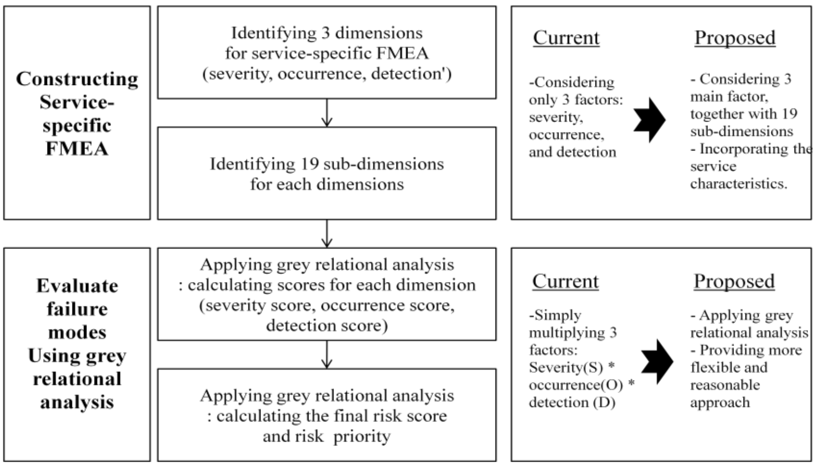


Figure 5- 5 Overall process of the proposed approach

Firstly, the service-specific FMEA is constructed under the three dimensions: severity, occurrence, and detection. Each dimension consists of service-specific elements required to evaluate the service system. This framework encompasses the holistic view of the service system, providing the appropriate decision criteria required to evaluate the failure modes in service. This framework can provide value in terms of not only decision criteria for prioritization, but also failure identification guideline.

Following the service-specific FMEA framework, each failure mode is estimated under the GRA. Since the service-specific FMEA consists of many interrelated different dimensions, the use of GRA fits to the service-specific FMEA by providing the flexible approach. The information of service-specific FMEA seems to be grey in terms of both evaluation criteria and evaluator, GRA is considered to be useful in calculating the risk priority of service-specific FMEA.

5.2.3.2 Preliminaries: Defining the service failure mode

Traditionally, a failure mode is defined as the manner in which an item could potentially fail to meet or deliver the intended function described in the item/function column (Teng et al., 2006), as perceived by engineers. For example, in the case of gear and/or axle shaft thrust button failure mode, leaks are often mistakenly listed as a potential failure mode and loss of lubricant is listed as a potential effect of the failure (Geum et al., 2011d).

In the service industry, compared to the traditional failure modes, service failures generally encompass any problematic situation during service while service is delivered to a customer, causing significant damages to customer satisfaction (Surprenant and Soloman, 1987; Boshoff and Leong, 1998; Bitner et al., 1990). Service failure is, typically, determined by elements such as the nature of the service encounter, the cause of the problem, and the psychographics of the individuals involved (Lewis and Spyrankopoulos, 2001). What is at the core in terms of discussing service failures is that the service failure is discussed from the customer' perspective because this is what a company needs to recover from, i.e. any dissatisfaction or problem that a customer perceives in relation to a service or a service provider (Lewis and Spyrankopoulos, 2001). Therefore, in this theme, a service failure mode is defined as "any situation or event that can cause damages to the customer satisfaction during the service process".

Following on the definition of service failure modes, the types of failure mode can be summarized as shown in Table 5-7. Mainly, the failure modes can be categorized as three parts: service delivery system failures which are caused by the error of service providers, wrong employee actions caused by service employee error and wrong customer actions which can be occurred by customer error. Based on this type of service failure mode, failure modes in a specific domain can be identified systematically.

Table 5- 7 Types of service failure mode

Type of failure mode	Cause	Examples
service delivery system failures	Service provider error	Product defects Slow/ unavailable service Facility problems Unclear policy Out of stock
Wrong employee actions	Service employee error	Unkind behavior Wrong order Lost order Mischarged
Wrong customer actions	Customer error	Mistake prior to use Mistake in use Carelessness

5.2.3.3 Stage 1: Service-specific FMEA as a new tool

In this section, a service-specific FMEA is provided with the appropriate decision criteria representing the service characteristics. The characterizing variable of traditional FMEA consists of three factors: severity, occurrence, and detection. However, in a service setting, risk cannot be measured by a simple judgment due to the intangibility of service.

This theme reorganizes FMEA with 3 dimensions and 19 sub-dimensions, as shown in Table 5-8. Firstly, as the first-level dimensions, 3 dimensions - severity, occurrence, and detection- are selected, accepting the traditional FMEA dimensions. Following the determination of 3 dimensions, sub-dimensions are identified considering the service characteristics.

First and foremost, the dimension 'severity' should be treated from various service-specific perspectives. The severity dimension is divided into three criteria: basic, customer, and process. First, 'basic' criteria deals with evaluation criteria of the traditional FMEA process, dealing with impact, the

Table 5- 8 Key considerations for each constituent for risk priority

Dimension	Criteria	Sub-dimension	Description
Severity	Basic	Impact	How much the impact of failure is
		Core process	How much the customer consider it as a core process
		Typicality	How typical the failure is
		Affected range	How broad the affected range is
	Customer	Customer participation	How much the customer participate in the service process
		Customer contact	How closely the failure process contact to the customer
		Service encounter	How closely the failure process located to the service encounter
	Process	Interdependency	How closely the process is linked with other processes
		Bottleneck possibility	How possible that this process works as a bottleneck
		Hardness of Isolation	How possible that this process can be isolated
		Resource distribution	How much the process occupies the resources
Occurrence	Frequency		How frequent the failure happens
	Repeatability		Does the failure happen repeatedly
	Failure visibility		Is the failure visible to the customer or not
	Single point failure		Does the system fail if a single service failure occurs
Detection	Chance of non-detection		How hard the failure is detected
	Method of systematic detection		Does the periodical and systematic method exist for detection
	Customer / Employee detection		Is the failure detected by employees or customers
	Hardness of proactive inspection		How the failure modes can be inspected proactively

existence of core process, typicality, and affected ranges. Second, the most notable is the customer perspective. First of all, customers exist and participate during the service process, which can be denoted as the customer participation (Fitzsimmons and Fitzsimmons, 1994; Kellogg and Nie, 1995; Edvardsson and Olsson, 1996; Johne and Storey, 1998). Another important issue is "customer contact" (Chase, 1981; Michel, 2001) which denotes the level of contact between employee and customer. It is recognized as an important measure to determine the importance of each service process. In other words, the level of customer contact should be considered in evaluating the failure modes. Finally, the service encounter (Mattila, 2001) should be considered as a constituent for customer perspective. Service encounter is said to be a dyadic interaction between a customer and service provider (Mattila, 2001; Colgate and Norris, 2001). It can be noted as a period of time during which a consumer directly interacts with a service (Puente et al., 2002).

The second perspective is that the service system is a process-based system (Shostack, 1987; Jones, 1989; Edvardsson and Olsson, 1996; Van Looy et al., 1998; Syson and Perks, 2004). Firstly, interdependency exists between service processes since the service is a process-based system. Since a failure of one process can cause the failure of other processes in service, significant consideration regarding interdependency should be paid to determine the severity of each failure mode. Secondly, if a system is process-based, a bottleneck might exist. A bottleneck is the process which makes the overall process caught in a problem. If a sub-process has a high chance to be a bottleneck, its severity should be highly rated considering the expected effects. Therefore, it should be another important sub-dimension considering the process-based characteristics. Another important consideration is the possibility of isolation. Even if the process shows high interdependency or high chance of bottleneck, the severity can be relieved if it can be easily isolated from the system. Therefore, ease of isolation should be also considered as an important criterion. As the final sub-dimension, the resource distribution can be considered. Since many processes shares the limited resources in service, processes which occupy much resource should be treated carefully. In short, from the process perspectives, interdependency, bottleneck possibility, isolation possibility, and resource distribution should be considered as criteria for service.

The second dimension, ‘occurrence’, also consists of several sub-dimensions. Similar to the traditional FMEA, the frequency the failure occurs is the primary consideration (Hoffman and Bateson, 1997) to characterize the occurrence. However, some additional consideration is required due to the service characteristics including the question whether the failure mode is a single point failure or not (Stamatis, 2003), or whether the service failure is visible to the customer, i.e. on which side the failure happens (Shostack, 1987). Since the service system is composed of front stage and back stage which are divided by the visibility to the customer (Shostack, 1987), the side where the failure happens is a very important decision factor to determine the risk. If the failure happens at the front office, it normally causes direct and severe customer dissatisfaction, thus lead to the service failure. Repeatability is also an important factor in terms of occurrence. It is a concept differentiated from the frequency, representing the frequency of occurrence due to the same source within a specified time.

Finally, ‘detection’ is selected as the final constituent of risk priority in service FMEA. The detection also consists of several sub dimensions. Firstly, quite naturally, chance of non-detection is included as a sub-dimension, following the traditional view of detection in FMEA. This measures how easily the service failure can be detected by the predefined control system. If the chance of detection is high, the failure mode can be easily “hidden”, bearing the severe problems in the service system (Chuang et al., 2007; Chang et al., 1999; Chen and Tzeng, 2004). The second dimension is the method of systemic detection. This measures whether the service system is equipped by regular and systemic detection method for service failure (Stamatis, 2003). The third dimension determines whether the service failure is detected by customers or employees. If the service failure is detected by customers, it is directly linked to the decrease of customer satisfaction, thus seems to be serious (Wu et al., 2002). However, if the service failure is detected by employees, it can be fixed without being exposed to the customers. Therefore, detection by customers seems to be more hazardous in terms of service system management. Finally, hardness of proactive inspection is determined as a sub-criterion for detection. This dimension measures how the failure modes can be inspected proactively. This is very important to assess the risk of failure modes. If the proactive action can be possible, the risk of failure modes can be reduced. If the service failure can be inspected and treated prior to the outbreak of failure, in other words, proactively, the risk can be considerably reduced.

The genuine preventive characteristics of FMEA lies in that it identifies all potential failure modes that can cause the system in a system and prioritizes them in a systematic manner, prior to the outbreak of failure. The preventive efforts of FMEA still remain in service-specific FMEA, because the main activities for conducting FMEA are identical to the traditional FMEA: to identify all potential failure modes that can cause the system in a system and prioritize them in a systematic manner, prior to the outbreak of failure.

5.2.3.4 Stage 2: GRA as a tool for risk prioritization

In this section, a new way for risk prioritization is introduced with the help of GRA. GRA is applicable for the calculation of risk priority number due to the following reasons.

First, the concept of grey is considered in terms of evaluation criteria. When considering severity, occurrence, and detection, for example, severity and detection is relatively unknown whereas occurrence is relatively known. When considering sub-dimensions, criteria such as failure visibility, single point failure, and customer participation are known. However, criteria such as impact, affected range, and repeatability are unknown information. Those decision factors of the failure model are compared with the standard series; therefore, the local relationship can be constructed (Chang et al., 1999).

Second, in terms of the evaluator, there has been a lot of research regarding the problem of customer-oriented service evaluation (Mohammed-Salleh and Easingwood, 1993; Edvardsson et al., 1995; Lee et al., 2010). Since it is hard for customers to describe the exact service concept/process and its impact, customers' judgment is not always reliable (Lee et al., 2010). This is especially true in technology-based services that have many complex and difficult-to-follow technical characteristics. In addition, in many cases of service evaluation, part of information is known and part of information is unknown. For example, the level of customer contact is well evaluated by customers, whereas the impact of service failure or frequency of service failure is properly evaluated by service operators. This is in line with service evaluation practice where the information asymmetry exists. In many cases, part of service evaluation is conducted by non-experts such as service employees or customers. For this reason, grey relational analysis fit the purpose of service evaluation.

In addition, contrary to the traditional FMEA which consists of only three dimensions, proposed service-specific FMEA has multiple sub-dimensions describing each dimension, showing the complicated relationships between themselves. Therefore, a GRA characterized by the multiple criteria decision making in a complicated interrelated situation, is proposed as a resolution of this problem. Also, due to its flexibility and utility function-free characteristic, it might be a valuable attempt to the risk prioritization (Chang et al., 1999).

Contrary to the previous studies, application of GRA in this theme consists of two-phase application in order to highlight the multilateral perspective of service-specific FMEA. The first phase deals with the calculation of risk score for each dimension, and the second phase covers the calculation of overall risk priority. At the first phase, risk score for each dimension is calculated and named as severity score, occurrence score, and recovery score. After calculating the grey relational coefficient for each dimension, GRA procedures are repeated for the values of three dimensions. In other words, these calculated scores are then used as the inputs of the second phase, calculating the final risk priority, as shown in Figure 5-6.

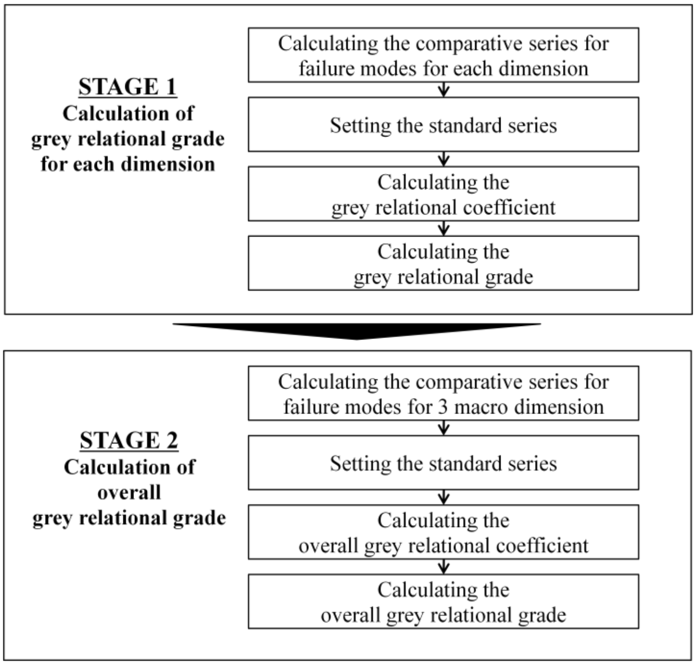


Figure 5- 6 The application procedure of GRA

5.2.4 Case study

5.2.4.1 Case overview

In this section, a case example is presented for illustration of the proposed approach. The proposed approach was applied to the potential failure diagnosis for a hospital located in Seoul, Korea. The hospital service is a typical high-contact service involving significant interaction between customers and employees, including many underlying opportunities of different degrees for potential failure. Recently, service quality in hospital has been discussed as an important issue. The power of customers is gradually increased, which results in the high expectation of qualified service. The target hospital tries to establish the culture of the patient-centric medical service, planning to actively introduce the advanced medical service system.

This case study was conducted for the medical treatment process of outpatients, starting from reservation to the payment in the department of internal medicine. The service for outpatients is likely to have a high level of customer contact than that of inpatients, due to the customer errors as well as employee errors caused by the interaction. Figure 5-7 shows the service blueprint of service tasks for the outpatients of the internal medicine department, providing a basis for understanding the current service. The service blueprint depicts the roles of the consumers, service providers, and supporting services in a two-dimensional plane (Li et al., 2007; Yang and Chen, 2006).

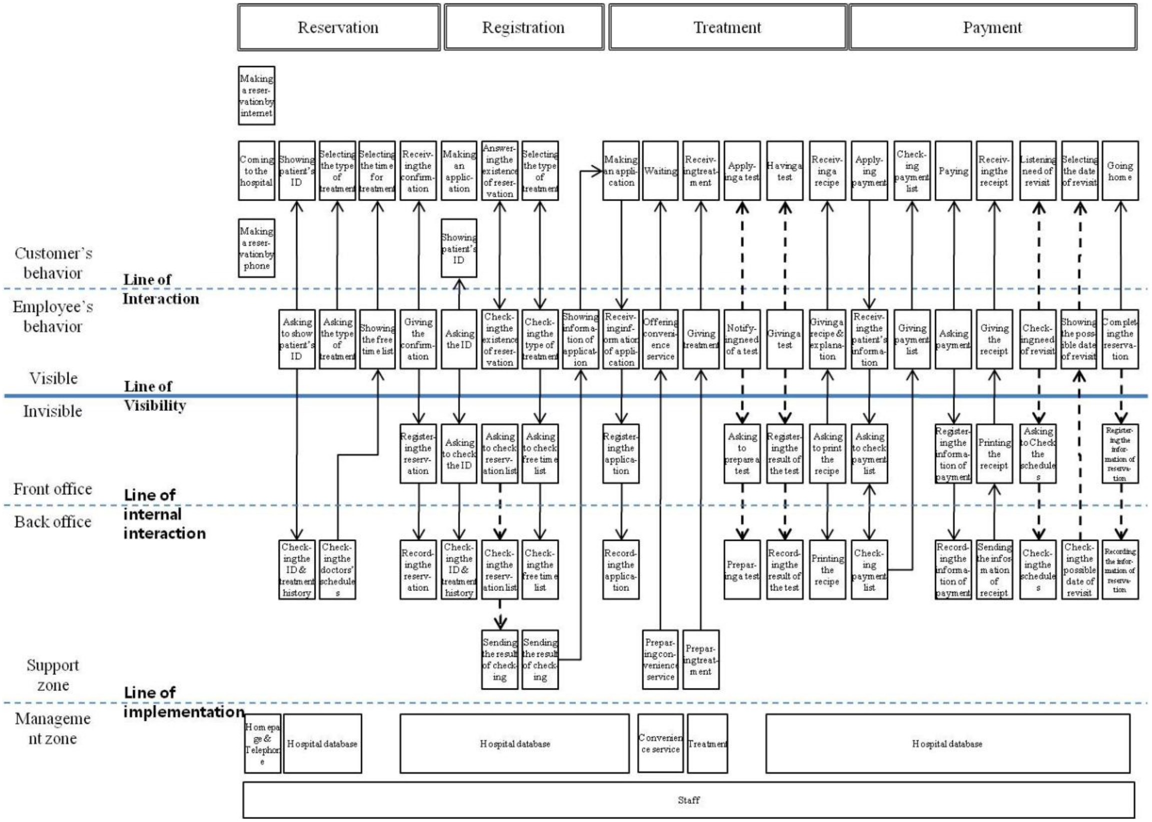


Figure 5- 7 service blueprint of internal medicine department

5.2.4.2 Construction of service-specific FMEA

With consideration of the hospital service, service-specific FMEA is constructed. Firstly, failure modes are identified and listed. Based on the service blueprint in Figure 5-8, we identified 11 failure modes in this hospital case example. The identification of failure mode includes the possible errors which might be occurred during the service delivery process. The list of failure modes is as shown in Table 5-9, explaining the types and characteristics of failure mode in the case hospital.

Based on the identified failure modes and the decision criteria, service-specific FMEA is constructed, as shown in Table 5-10. The value in the parenthesis refers to the weight of each dimension. Each failure mode is evaluated under the predefined criteria, with the 9 point likert scale. The evaluation of failure modes is conducted by the expert who has several-year experiences in the department.

In evaluating the failure modes, two options can exist in terms of subject of evaluation: evaluation by expert and evaluation by customers, as described further in Discussion part. Since the role of case study of this theme is to illustrate how the proposed approach can be applied in a practical setting, this paper employed expert-based evaluation.

Table 5- 9 Failure modes in the hospital industry

No	Failure mode	Type	Description
FM1	Inaccurate check-in	Wrong employee actions	Incorrect reservation, inaccurate prioritization
FM2	No availability of doctor	Service delivery system failures	Long doctor consultation, inaccurate allocation of customers
FM3	Long waiting time	Service delivery system failures	Unexpected arrival of customer, long processing time
FM4	Order forgotten	Wrong employee actions	Inaccurate allocation of customers
FM5	No resources for convenient waiting	Service delivery system failures	No enough resources for customers' convenient waiting in case of long queue
FM6	No availability for medical treatment	Service delivery system failures	Facility broken, lack of service employee (doctor or nurse),
FM7	Wrong prescription	Wrong employee actions	Wrong prescription due to the mistake, wrong communication between doctor and nurse
FM8	Confusion in payment list	Wrong employee actions	Payment information is not relevant to the customers
FM9	Inaccurate payment	Wrong employee actions	The amount of payment is inaccurate
FM10	Payment facility problem	Service delivery system failures	There exists a facility problem (such as credit card machine or automatic payment machine) in payment
FM11	Unkind response to the customer	Wrong employee actions	Employee actions are

Table 5- 10 Sheet of service-specific FMEA for the hospital service

Operation	Characteristics of failure		Rating																		
			Severity											Occurrence				Detection			
Failure modes	Cause of failure	Effect of failure	S1: Impact (5)	S2: Core process (5)	S3: Typicality (1)	S4: Affected range (3)	S5: Customer participation (5)	S6: Customer contact (1)	S7: Service encounter (5)	S8: Interdependency (5)	S9: Bottleneck possibility (3)	S10: Hardness of Isolation (1)	S11: Resource distribution (1)	O1: Frequency (5)	O2: Repeatability (3)	O3: Failure visibility (5)	O4: Single point failure (1)	D1: Chance of undetection (5)	D2:Method of systematic detection (3)	D3: Customer/Employee detection (5)	D4: Hardness of proactive inspection (3)
FM1	Communication error	Giving up the reservation	1	3	7	3	3	5	3	7	1	1	1	5	7	5	9	3	3	3	7
FM2	Not existing free doctor	Giving up the reservation, dissatisfaction	3	5	5	5	1	5	1	3	1	5	1	5	7	1	9	1	7	3	5
FM3	Wrong planning to reservation	Taking long time to check-in	5	3	5	5	7	5	7	1	9	5	1	5	7	7	7	7	9	7	9
FM4	Putting wrong information of reservation	Impossible to check the reservation	7	7	1	7	1	7	1	1	7	5	3	1	1	1	9	5	9	3	3

FM5	No resources for convenient waiting	Dissatisfaction	3	5	7	5	1	5	1	5	1	5	1	5	7	3	9	3	5	5	3
FM6	Error in the medical treatment machine	Impossible to get the medical treatment	9	9	1	9	1	7	3	3	9	7	7	1	1	3	3	1	7	5	7
FM7	Miscommunication between doctor and nurse	Receiving wrong prescription	9	9	1	7	1	3	3	5	5	3	5	1	1	3	1	3	1	3	7
FM8	Putting the wrong patient's information	Checking wrong payment list	9	3	1	5	1	1	1	1	3	3	1	1	1	1	1	3	1	3	3
FM9	Miscalculating the payment list	Receiving wrong payment list	9	9	3	7	7	9	5	9	7	5	3	1	1	7	3	7	5	7	3
FM10	Lack of money/ having problem with credit card	Impossible to pay	5	5	7	5	9	7	9	3	5	9	7	7	3	9	1	7	3	5	3
FM11	Staff education problem	Dissatisfaction	3	1	9	1	9	9	9	1	1	7	1	9	7	9	1	7	3	7	3

5.2.4.3 Application of GRA

In this step, GRA is applied. Table 5-11 shows the comparative series. Working with the reference set, the grey relational coefficients for each dimension are calculated as Table 5-12. In this case, we set $\zeta = 0.5$. After calculating the grey relational coefficients, grey relational grade for each dimension is calculated using the weighted average of each grey relational grade. Table 5-13 shows the weight vector for each dimension. Based on Table 5-12 and Table 5-13, the final grey relational grade is calculated. Similar calculation is conducted for occurrence and detection dimension. Using the result of each dimension, calculation of overall grey relational score is conducted, as shown in Table 5-14.

Table 5- 11 Comparative Series for severity dimension

	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11
FM1	0.000	0.250	0.750	0.250	0.250	0.500	0.250	0.750	0.000	0.000	0.000
FM2	0.250	0.500	0.500	0.500	0.000	0.500	0.000	0.250	0.000	0.500	0.000
FM3	0.500	0.250	0.500	0.500	0.750	0.500	0.750	0.000	1.000	0.500	0.000
FM4	0.750	0.750	0.000	0.750	0.000	0.750	0.000	0.000	0.750	0.500	0.333
FM5	0.250	0.500	0.750	0.500	0.000	0.500	0.000	0.500	0.000	0.500	0.000
FM6	1.000	1.000	0.000	1.000	0.000	0.750	0.250	0.250	1.000	0.750	1.000
FM7	1.000	1.000	0.000	0.750	0.000	0.250	0.250	0.500	0.500	0.250	0.667
FM8	1.000	0.250	0.000	0.500	0.000	0.000	0.000	0.000	0.250	0.250	0.000
FM9	1.000	1.000	0.250	0.750	0.750	1.000	0.500	1.000	0.750	0.500	0.333
FM10	0.500	0.500	0.750	0.500	1.000	0.750	1.000	0.250	0.500	1.000	1.000
FM11	0.250	0.000	1.000	0.000	1.000	1.000	1.000	0.000	0.000	0.750	0.000

Table 5- 12 Grey relational coefficients for severity dimension

	S 1	S 2	S 3	S 4	S 5	S 6	S 7	S 8	S 9	S 10	S 11
FM 1	0.333	0.400	0.667	0.400	0.400	0.500	0.400	0.667	0.333	0.333	0.333
FM 2	0.400	0.500	0.500	0.500	0.333	0.500	0.333	0.400	0.333	0.500	0.333
FM 3	0.500	0.400	0.500	0.500	0.667	0.500	0.667	0.333	1.000	0.500	0.333
FM 4	0.667	0.667	0.333	0.667	0.333	0.667	0.333	0.333	0.667	0.500	0.429
FM 5	0.400	0.500	0.667	0.500	0.333	0.500	0.333	0.500	0.333	0.500	0.333
FM 6	1.000	1.000	0.333	1.000	0.333	0.667	0.400	0.400	1.000	0.667	1.000
FM 7	1.000	1.000	0.333	0.667	0.333	0.400	0.400	0.500	0.500	0.400	0.600
FM 8	1.000	0.400	0.333	0.500	0.333	0.333	0.333	0.333	0.400	0.400	0.333
FM 9	1.000	1.000	0.400	0.667	0.667	1.000	0.500	1.000	0.667	0.500	0.429
FM10	0.500	0.500	0.667	0.500	1.000	0.667	1.000	0.400	0.500	1.000	1.000
FM11	0.400	0.333	1.000	0.333	1.000	1.000	1.000	0.333	0.333	0.667	0.333

Table 5- 13 Weight vector for each sub-dimension in severity dimension

	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11
weight	0.143	0.143	0.029	0.086	0.143	0.029	0.143	0.143	0.086	0.029	0.029

Table 5- 14 Grey relational grades for each dimension

	Severity	Occurrence	Detection	Overall	Ranking
FM1	0.0390	0.1607	0.1064	0.0250	8
FM2	0.0368	0.1458	0.1034	0.0234	10
FM3	0.0498	0.1696	0.2500	0.0362	3
FM4	0.0457	0.0952	0.1354	0.0256	7
FM5	0.0385	0.1518	0.1116	0.0247	9
FM6	0.0632	0.0905	0.1245	0.0303	5
FM7	0.0556	0.0893	0.1033	0.0267	6
FM8	0.0418	0.0833	0.0908	0.0215	11
FM9	0.0706	0.1143	0.1953	0.0373	1
FM10	0.0606	0.1777	0.1516	0.0348	4
FM11	0.0528	0.2381	0.1906	0.0371	2

As a result of simulating the service-specific FMEA and GRA, as shown in Table 5-14, the most important and critical failure mode is FM9. This failure mode happens because of miscalculation of payment. Since the severity of this mode is highly important in terms of customer contact and recovery expectation, this mode is considered as the most important factor despite its lower occurrence. FM10 and FM11 also show high grey relational grade. FM10 can be caused by problem of payment system. FM11 happens due to the staff education problem. As well, FM3, which is related to the long waiting time, is also considered to be an important failure mode which shows high occurrence and high recovery expectation. FM6 also shows high level of grey relational grade. It is caused by the error of medical treatment or lack of medical machine.

Since the weights of customer-participated action are highly-rated in this case example, customer-processed activities are considered as significant failure modes. However, it can be changed according to the firms' strategy, depending on the decision of top management in practice. This flexibility is also considered as a powerful advantage of GRA, compared to the traditional multiplication method.

5.2.5 Discussions

5.2.5.1 Management of failure modes

The identified failure modes should be tightly managed based on the characteristics of each failure mode. Even if the use of GRA can be effectively utilized to provide more reliable result in terms of assessing the risk priority of failure modes, it is still limited to the calculation of the final score to select the most risky failure modes. However, what is required in a practical business situation is to employ appropriate management tool for these failure modes. The problem is that, even if the final RPNs of two processes are identical, the risk implications may be totally different. Rather than selecting the best alternative and discarding the others, management of all failure modes with strategic decision can help the service firm by considering all failure modes for the improvement of service system. In that regard, it is worthwhile to employ the portfolio as a new solution to prioritize the modes. The portfolio approach has the advantage of providing not only the final score, but also for visualizing the value of each key evaluation variable (Geum et al., 2011d).

For example, Geum et al. (2011d) proposed a portfolio for failure modes, constructed on two axes comprising severity and occurrence. In this portfolio, the matrix is divided into four quadrants: highly dangerous, big shot, casual failure, and insignificant. The ‘highly dangerous’ quadrant is characterized by high severity and high occurrence, implying failure modes with frequent occurrence and great destructive power. The ‘big shot’ quadrant is characterized by high severity and low occurrence. The failure modes in this quadrant arise when a failure is not as frequent but causes a huge loss to the total system when it does occur. Contrary to the ‘big shot’ quadrant, the ‘casual failure’ quadrant is characterized by low severity and high occurrence. These failures modes are generated very frequently but have a negligible impact on the system. Finally, failure modes with both low severity and low occurrence belong to the insignificant quadrant and are not critical to overall productivity.

5.2.5.2 Prevention and recovery of service failure mode

The risk of service failure is closely linked to the service recovery. Service recovery includes the actions and activities that the service organization and its employees perform to "rectify, amend, and restore the loss experienced" by customers from deficiencies in service performance (Zeithaml et al., 1993; Chen, 2007). The body of literature has been almost unanimous that service recovery is of utmost importance in case of service failure (Bailey, 1994; Boshoff and Leong 1998; Smith et al., 1999; Michel, 2001), recognized as a significant determinant of customer satisfaction and loyalty (Berry and Parasuraman, 1992; Tax and Brown, 1998). The success or failure in a service system is all about customer perception (Deng, 1989; Chuang, 2007). Therefore, even if the service failure happens, it cannot be directly damage to the customer satisfaction if the corresponding service recovery is followed in a right manner.

Therefore, in an organization where a service recovery is of a great importance, service recovery can be also considered as an important decision criteria for measuring the risk priority. For example, the failure controllability or recovery easiness should be considered as an important criterion. If a service failure is easily recovered, it is expected as an insignificant failure mode than other modes. The question of how the customers are tolerable for the service failure should be taken care of, since the customer tolerance might be different according to the failure modes. Finally, recovery expectation should be also analyzed. Recovery expectation is the customer prediction of how effectively the service provider will resolve service failures when they arise (Kelley et al., 1993; Bailey, 1994; Boshoff and Leong, 1998). If the customer has high expectation for service recovery for a specified failure mode, the importance of that mode should be considered significantly.

5.2.6 Conclusions

The contribution of this theme can be summarized in two-folds. Firstly, this study incorporates the various service characteristics to the service by introducing the service-specific FMEA, incorporating 3 dimension and 19 sub-dimensions to represent the service characteristics, thus modified the traditional FMEA to more concrete and systematic one. The criteria included in this theme, however, are by no means exhaustive or fixed. It can be customized depending on the context according to the firm. The criteria can be selectively used or aggregated according to the judgement of a firm. Using the service-specific dimensions, managers in practice can get the insight to identify the failure modes as well as evaluate the failure modes. It is also expected to be a guideline for managing the service failure in a practice. Secondly, from the methodological perspective, this theme contributes to the field in that it combines FMEA and GRA, addressing the limitation of previous calculation of risk priority which is too simple to apply in a practical setting. In addition, two-phase GRA is applied to reflect the multilateral perspective of service, providing the aggregated risk score of each dimension, together with the overall score. Since the service-specific

FMEA consists of many inter-related different dimensions, the use of GRA fits to the service-specific FMEA by providing a simple, straightforward, but flexible approach.

Despite the contribution of this theme, this theme is still subject to some limitations. Therefore, the refinement of the proposed approach for more sophisticated modelling will be a fruitful area for future research. Further consideration is required to measure the score of qualitative dimensions of service-specific FMEA. For example, the “failure visibility” dimension denotes that “whether the failure is visible or not”. However, it cannot be always said that the failure in a visible area (front office) is more risky than invisible area (back office). Therefore, much consideration should be paid to the determination of risk value for qualitative dimensions. Secondly, the scale of each dimension should be considered carefully. Currently, the scale follows the traditional scale of FMEA. However, appropriate modification of scale which can represent the proposed criteria might provide more concrete framework for service-specific FMEA.

Chapter 6. Conclusions

6.1 Summary and contributions

As Drejer (2004) noted, the vast majority of innovation studies have focused on technological innovation within manufacturing, reflecting the gravity of manufacturing area in the innovation theory. However, recent business trends show a tremendous change towards service innovation. Now firms compete on the basis of services, not on the basis of physical products. Services are no longer considered as a peripheral in the business environment, but are increasingly seen as core customer offerings. Quite naturally, a systematic planning for service innovation became a significant and important issue to the service firms. Unfortunately, the study of service planning is not simply transferring an accumulated body of theories and tools from the manufacturing. Rather, service planning should reflect the innate characteristics of services, such as customer participation, technology interface, and innate service characteristics such as intangibility, heterogeneity, inseparability, and perishability. To reflect these important features to the service planning, traditional planning methods should be modified and adapted.

With this consideration together, the thesis proposed the systematic planning methods for service innovation, at the three different levels of service planning. Each of the six themes represented its usage in the service innovation planning, as shown in Table 6-1.

Table 6- 1 Summary of each theme

Theme	Summary
Theme 1	Employing and adapting FTA to the service process management, suggesting a concept of service tree
Theme 2	Developing a hybrid approach to the new service development using CBR and CD
Theme 3	Suggesting an integrated technology roadmap for product-service integration, with technology as an important interface between products and services
Theme 4	Proposing an ARM-based technology roadmapping process to utilize business data in a big data era
Theme 5	Proposing a way of service modularization using a modified HoQ approach
Theme 6	Suggesting a service-specific FMEA for diagnosing service failures

Theme #1 employed and adapted FTA to the service function identification, suggesting a concept of service tree. In this study, service elements are categorized as core, supporting, and optional services. Theme #2 developed a hybrid approach to the new service development using CBR and modified zigzagging, according to the functional characteristics. For core functions, CBR is employed to find similar functions with existing function. For peripheral functions, modified zigzagging approach in which creativity takes a big seat is employed.

Theme #3 suggested an integrated technology roadmap for product-service integration, with technology as an important interface between products and services. Six types technology roadmap are suggested, with their structures, roadmapping processes, and case study. Theme #4 proposed an ARM-based technology roadmapping process to effectively utilize the business data in a big data era. This study suggested a way of quantifying the inter-layer relationship in technology roadmap.

In Theme #5, a way of service modularization is proposed using a modified HoQ approach. In this research, driver-based approach is employed to SMM modules, whereas relationship-based approach is used to ICCM modules. Module Theme #6 proposed a systematic approach for diagnosing services. In this theme, traditional FMEA is modified and extended to the service-specific FMEA, using three dimensions and 19 sub-dimensions. GRA is also employed to provide the flexibility to the evaluation of service failure modes.

The major contribution of this thesis is to propose the systematic approach to the service planning. Despite the importance of service innovation, previous studies have not addressed this issue with an analytic and quantitative viewpoint, thus, did not provide satisfactory methodologies for service planning. Addressing this problem, this thesis identifies three main service planning situations: ideation, deployment, and design, and suggests a systematic way of service planning for each case. In practice, the proposed approaches are expected to aid managers to plan the service innovation effectively.

To be more specific, each theme has its unique contribution. First, the contribution of theme #1 is to suggest a systematic method to visualize and analyze the service process, with consideration of the important characteristic of service: customer participation. This study suggests a new concept of service tree, with the two way of analysis: qualitative method and quantitative method. Theme #2 deals with the functional heterogeneity of services in new service development, which has been neglected in previous literatures. By suggesting a hybrid approach, it is expected to aid service managers to develop new service in a right way, considering the functional characteristics of service functions.

Theme #3 contributes to the fields in that it firstly suggested a concept, structure, and typology of integrated roadmap for product-service integration. By suggesting six types of technology roadmap, product-service integration is expected to be systematically and flexibly planned according to the firms' circumstances. Theme #4 deals with the data integration issue in technology roadmap. Especially, this theme suggested a way of quantitative measurement of inter-layer relationship, with the consideration of dependency information.

Theme #5 tries to modularize service, which has been a significant but neglected issue in the service design. This study provides a practical way of modularization, by integrating two approaches: driver-based approach and relationship-based approach. Finally, the contribution of Theme #6 is to suggest a service-specific FMEA to diagnose services, reflecting the service characteristics. In addition, the use of GRA is expected to provide the operational flexibility to the evaluation of service failure modes, under the circumstances of interrelated multi-dimensions for service failure modes.

More specifically, each theme has its unique contributions in terms of theoretical perspectives, as stated in the six sub-conclusions and listed in Table 6-2.

Table 6- 2 Theoretical contribution of each theme

Theme	Contribution
Theme 1	- Proposing a systematic way to analyze the service function/process, from the customers' perspective
Theme 2	- Proposing a different approach of new service development, considering functional heterogeneity
Theme 3	- Proposing the structure and typology of technology roadmap for product-service integration according to the technological role - Conducting a practical case study for six type of different integration settings
Theme 4	- Proposing a data-driven technology roadmap for considering layer-dependency
Theme 5	- Proposing a practical approach for service modularization - Considering the innate characteristics of service in terms of modularization
Theme 6	- Proposing a practical tool for the proactive management of services

In addition, each theme has its unique contributions in terms of its methodological usage and methodological extension. Table 6-3 shows the methodological contribution of each theme. Mainly, the methodological contribution of each theme is two-fold. First, each theme extends and modifies the traditional technology planning methods to plan the service innovation. For this purpose, theme 1 modifies the fault tree analysis and suggests a concept of service tree. Theme 3 extends the structure of technology roadmap to accommodate the integration of products and services. Theme 5 also modifies the utility of QFD matrix to support service modularization. The second methodological contribution is related to the suggestion of methodological sufficiency for each setting. Theme 2, 4, and 6 extends the application areas of each method.

Table 6- 3 Methodological contribution of each theme

Theme	Contribution
Theme 1	- Modifying the fault tree analysis and extending it in terms of service process analysis
Theme 2	- Suggesting methodological sufficiency of CBR and zigzagging approach to the new service development
Theme 3	- Suggesting an extended structure of technology roadmap - Proposing different structure and different roadmapping methodologies for each setting
Theme 4	- Employing the application area of ARM to the technology roadmap - Suggesting a new way of calculating the layer relationship, especially calculating the dependency
Theme 5	- Extending the structure of QFD for service modularization - Proposing a methodological sufficiency for modularization for QFD
Theme 6	- Extending the traditional FMEA to the service setting, incorporating service characteristics - Extending the calculation of risk priority number using GRA

6.2 Limitations and future research

Despite the contribution, the thesis is subject to some limitations, which could be a fruitful area for future research. The limitations of each theme are also represented in the section of sub-conclusion in each chapter.

Overall, the role of technology is very imperative in the planning of service innovation. This is especially true of recent service innovation where many cases of service innovation take place with the help of technology. Despite the importance, however, the data-driven approach of this theme is limited to the use of data from application services. Even the application services encompasses the technological characteristics themselves, the use of technical database such as patent database would help firms to plan the service innovation with the in-depth consideration of technological factor.

Second, the role of technology should be extended to the whole modules of service innovation. Currently, the role of technology is reflected to the planning for deployment, as a form of technology interface. Even if the technological factor is slightly covered in other two modules as a form of technology-embodied data and technology-based decision criteria, future research should deeply focus on the technological characteristics of service innovation.

Finally, the six planning problems suggested in the thesis cannot cover all circumstances of service planning. There still exists a wide range of technology planning for service innovation, which deserve systematic methodologies and frameworks. Currently, this thesis includes two subtopics for each module of service planning. However, many different planning problems exist and many different contexts happen in service innovation. Therefore, consideration of full-range of service innovation phenomena will help to understand the service innovation planning. The investigation of real-world practical cases can be a great opportunity to study the full-scale of service innovation phenomena, thus can provide an excellent clue to the service planning literatures.

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Appendix

Appendix A. Deriving the minimal cut set

The simplest way to derive the minimal cut set is explained as follows (Barlow and Lambert, 1975).

In Figure 3-2, since the gate immediately below the top event is an AND gate, construction of minimal cut set is started with listing input G2 and G3 as follows.

G2 G3

Since the gate immediately below G2 is an OR gate, we replace G2 by its input events in separate rows as follows:

E1	G3
G4	G3

Since the gate immediately below G4 is an OR gate, we replace G4 by its input events in separate rows as follows:

E1	G3
E2	G3
E3	G3

As the gate immediately below G3 is an AND gate, we replace G3 by E4 and G5

E1	E4	G5
E2	E4	G5
E3	E4	G5

Since the gate immediately below G5 is an OR gate, we replace G5 by its input events E6 and E6 in separate rows as follows:

E1	E4	E6
E1	E4	E7
E2	E4	E6
E2	E4	E7
E3	E4	E6
E3	E4	E7

Thus, minimal cut sets of fault tree described in Figure 3 are (E1, E4, E6), (E1, E4, E7), (E2, E4, E6), (E2, E4, E7), (E3, E4, E6), and (E3, E4, E7).

Appendix B. The result of association

Appendix B.1 Result of support (P→ P)

	BT	DE	MA	WF	KB	TX	CM	FL	MM	SY	SV	AU	DI	DT	VO	TV	VI	ME	BR	PD	BT	SP	BC	GP	BL	RD	WC
BT	0.080	0.050	0.010	0.000	0.003	0.003	0.017	0.013	0.000	0.017	0.010	0.023	0.000	0.000	0.020	0.003	0.033	0.010	0.023	0.003	0.000	0.010	0.000	0.000	0.037	0.000	0.000
DE	0.050	0.223	0.050	0.023	0.047	0.013	0.037	0.020	0.003	0.020	0.040	0.040	0.000	0.023	0.027	0.007	0.053	0.013	0.017	0.013	0.007	0.013	0.000	0.007	0.030	0.000	0.003
MA	0.010	0.050	0.127	0.033	0.033	0.020	0.057	0.000	0.000	0.023	0.047	0.013	0.000	0.040	0.007	0.003	0.043	0.007	0.003	0.000	0.010	0.000	0.000	0.000	0.000	0.003	0.017
WF	0.000	0.023	0.033	0.070	0.033	0.000	0.030	0.000	0.000	0.010	0.030	0.003	0.000	0.020	0.007	0.003	0.013	0.000	0.000	0.000	0.003	0.000	0.000	0.000	0.000	0.000	0.000
KB	0.003	0.047	0.033	0.033	0.160	0.017	0.027	0.013	0.013	0.013	0.027	0.013	0.013	0.030	0.007	0.000	0.013	0.007	0.000	0.007	0.007	0.000	0.000	0.000	0.003	0.000	0.000
TX	0.003	0.013	0.020	0.000	0.017	0.067	0.013	0.000	0.007	0.003	0.003	0.003	0.000	0.003	0.003	0.003	0.027	0.000	0.003	0.007	0.007	0.007	0.003	0.003	0.000	0.000	0.010
CM	0.017	0.037	0.057	0.030	0.027	0.013	0.117	0.000	0.007	0.013	0.037	0.027	0.000	0.020	0.003	0.003	0.040	0.007	0.000	0.003	0.010	0.000	0.000	0.003	0.010	0.003	0.010
FL	0.013	0.020	0.000	0.000	0.013	0.000	0.000	0.073	0.000	0.003	0.000	0.000	0.000	0.000	0.007	0.000	0.003	0.000	0.027	0.003	0.000	0.000	0.000	0.000	0.007	0.003	0.000
MM	0.000	0.003	0.000	0.000	0.013	0.007	0.007	0.000	0.017	0.000	0.003	0.007	0.000	0.000	0.000	0.000	0.007	0.000	0.000	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SY	0.017	0.020	0.023	0.010	0.013	0.003	0.013	0.003	0.000	0.080	0.010	0.003	0.000	0.010	0.010	0.000	0.013	0.010	0.010	0.003	0.003	0.010	0.000	0.007	0.007	0.000	0.003
SV	0.010	0.040	0.047	0.030	0.027	0.003	0.037	0.000	0.003	0.010	0.093	0.010	0.000	0.027	0.003	0.000	0.023	0.010	0.003	0.000	0.003	0.000	0.000	0.000	0.000	0.000	0.003
AU	0.023	0.040	0.013	0.003	0.013	0.003	0.027	0.000	0.007	0.003	0.010	0.080	0.007	0.010	0.017	0.003	0.040	0.003	0.003	0.000	0.007	0.000	0.000	0.007	0.017	0.000	0.007
DI	0.000	0.000	0.000	0.000	0.013	0.000	0.000	0.000	0.000	0.000	0.000	0.007	0.023	0.000	0.003	0.000	0.000	0.000	0.000	0.000	0.003	0.000	0.000	0.000	0.000	0.000	0.000
DT	0.000	0.023	0.040	0.020	0.030	0.003	0.020	0.000	0.000	0.010	0.027	0.010	0.000	0.063	0.003	0.003	0.017	0.003	0.000	0.000	0.010	0.000	0.000	0.000	0.000	0.003	0.003

VO	0.020	0.027	0.007	0.007	0.007	0.003	0.003	0.007	0.000	0.010	0.003	0.017	0.003	0.003	0.093	0.003	0.010	0.000	0.013	0.003	0.003	0.020	0.000	0.000	0.007	0.000	0.003
TV	0.003	0.007	0.003	0.003	0.000	0.003	0.003	0.000	0.000	0.000	0.000	0.003	0.000	0.003	0.003	0.027	0.007	0.000	0.003	0.000	0.000	0.000	0.000	0.000	0.003	0.000	0.000
VI	0.033	0.053	0.043	0.013	0.013	0.027	0.040	0.003	0.007	0.013	0.023	0.040	0.000	0.017	0.010	0.007	0.130	0.000	0.000	0.003	0.017	0.007	0.000	0.000	0.027	0.000	0.013
ME	0.010	0.013	0.007	0.000	0.007	0.000	0.007	0.000	0.000	0.010	0.010	0.003	0.000	0.003	0.000	0.000	0.000	0.027	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
BR	0.023	0.017	0.003	0.000	0.000	0.003	0.000	0.027	0.000	0.010	0.003	0.003	0.000	0.000	0.013	0.003	0.000	0.000	0.063	0.003	0.000	0.007	0.000	0.000	0.003	0.000	0.000
PD	0.003	0.013	0.000	0.000	0.007	0.007	0.003	0.003	0.003	0.003	0.000	0.000	0.000	0.000	0.003	0.000	0.003	0.000	0.003	0.033	0.000	0.003	0.007	0.003	0.003	0.000	0.000
BT	0.000	0.007	0.010	0.003	0.007	0.007	0.010	0.000	0.000	0.003	0.003	0.007	0.003	0.010	0.003	0.000	0.017	0.000	0.000	0.000	0.033	0.000	0.000	0.000	0.000	0.000	0.000
SP	0.010	0.013	0.000	0.000	0.000	0.007	0.000	0.000	0.000	0.010	0.000	0.000	0.000	0.000	0.020	0.000	0.007	0.000	0.007	0.003	0.000	0.033	0.000	0.000	0.003	0.000	0.000
BC	0.000	0.000	0.000	0.000	0.000	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.007	0.000	0.000	0.013	0.000	0.000	0.000	0.000
GP	0.000	0.007	0.000	0.000	0.000	0.003	0.003	0.000	0.000	0.007	0.000	0.007	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.003	0.000	0.000	0.000	0.037	0.000	0.000	0.000
BL	0.037	0.030	0.000	0.000	0.003	0.000	0.010	0.007	0.000	0.007	0.000	0.017	0.000	0.000	0.007	0.003	0.027	0.000	0.003	0.003	0.000	0.003	0.000	0.000	0.037	0.000	0.000
RD	0.000	0.000	0.003	0.000	0.000	0.000	0.003	0.003	0.000	0.000	0.000	0.000	0.000	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.007	0.000
WC	0.000	0.003	0.017	0.000	0.000	0.010	0.010	0.000	0.000	0.003	0.003	0.007	0.000	0.003	0.003	0.000	0.013	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.017

Appendix B2. Result of support (S → S)

	PT	EM	AT	CV	MU	TH	IF	PW	BW	CT	LC	SF	SM	CC	MV	SW	IT	RT	TM	FB	UC	PB	NT	LG
PT	0.107	0.047	0.017	0.000	0.010	0.003	0.030	0.017	0.013	0.007	0.003	0.013	0.013	0.007	0.000	0.020	0.023	0.007	0.007	0.003	0.003	0.003	0.010	0.007
EM	0.047	0.217	0.037	0.010	0.020	0.013	0.050	0.027	0.027	0.010	0.020	0.043	0.030	0.017	0.010	0.033	0.040	0.000	0.010	0.020	0.010	0.010	0.010	0.007
AT	0.017	0.037	0.133	0.000	0.023	0.030	0.023	0.020	0.013	0.000	0.003	0.020	0.013	0.000	0.003	0.023	0.017	0.003	0.023	0.023	0.000	0.010	0.000	0.003
CV	0.000	0.010	0.000	0.047	0.000	0.000	0.023	0.000	0.000	0.023	0.003	0.000	0.000	0.020	0.000	0.007	0.010	0.000	0.000	0.003	0.020	0.000	0.000	0.000
MU	0.010	0.020	0.023	0.000	0.097	0.017	0.010	0.003	0.003	0.000	0.003	0.010	0.000	0.000	0.010	0.010	0.023	0.010	0.027	0.010	0.000	0.017	0.003	0.007
TH	0.003	0.013	0.030	0.000	0.017	0.050	0.017	0.003	0.003	0.003	0.000	0.007	0.000	0.003	0.003	0.007	0.000	0.000	0.020	0.007	0.003	0.003	0.000	0.000
IF	0.030	0.050	0.023	0.023	0.010	0.017	0.153	0.013	0.020	0.027	0.013	0.020	0.010	0.023	0.010	0.013	0.007	0.007	0.013	0.023	0.013	0.007	0.000	0.010
PW	0.017	0.027	0.020	0.000	0.003	0.003	0.013	0.060	0.010	0.003	0.003	0.020	0.003	0.003	0.003	0.027	0.013	0.000	0.007	0.007	0.003	0.000	0.010	0.003
BW	0.013	0.027	0.013	0.000	0.003	0.003	0.020	0.010	0.060	0.000	0.003	0.033	0.007	0.000	0.000	0.017	0.010	0.000	0.000	0.007	0.000	0.000	0.000	0.000
CT	0.007	0.010	0.000	0.023	0.000	0.003	0.027	0.003	0.000	0.060	0.003	0.003	0.000	0.040	0.000	0.003	0.003	0.000	0.003	0.003	0.033	0.000	0.000	0.000
LC	0.003	0.020	0.003	0.003	0.003	0.000	0.013	0.003	0.003	0.003	0.087	0.003	0.003	0.007	0.007	0.013	0.007	0.000	0.000	0.007	0.000	0.000	0.003	0.000
SF	0.013	0.043	0.020	0.000	0.010	0.007	0.020	0.020	0.033	0.003	0.003	0.083	0.007	0.003	0.003	0.010	0.023	0.000	0.000	0.010	0.003	0.000	0.003	0.007
SM	0.013	0.030	0.013	0.000	0.000	0.000	0.010	0.003	0.007	0.000	0.003	0.007	0.057	0.000	0.000	0.013	0.003	0.000	0.000	0.000	0.000	0.003	0.000	0.003

CC	0.007	0.017	0.000	0.020	0.000	0.003	0.023	0.003	0.000	0.040	0.007	0.003	0.000	0.077	0.003	0.003	0.010	0.000	0.003	0.000	0.020	0.000	0.000	0.000
MV	0.000	0.010	0.003	0.000	0.010	0.003	0.010	0.003	0.000	0.000	0.007	0.003	0.000	0.003	0.037	0.007	0.000	0.000	0.000	0.003	0.000	0.013	0.000	0.000
SW	0.020	0.033	0.023	0.007	0.010	0.007	0.013	0.027	0.017	0.003	0.013	0.010	0.013	0.003	0.007	0.107	0.030	0.000	0.013	0.010	0.003	0.007	0.010	0.007
IT	0.023	0.040	0.017	0.010	0.023	0.000	0.007	0.013	0.010	0.003	0.007	0.023	0.003	0.010	0.000	0.030	0.097	0.007	0.007	0.010	0.003	0.003	0.007	0.010
RT	0.007	0.000	0.003	0.000	0.010	0.000	0.007	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.007	0.020	0.003	0.000	0.000	0.000	0.000	0.003
TM	0.007	0.010	0.023	0.000	0.027	0.020	0.013	0.007	0.000	0.003	0.000	0.000	0.000	0.003	0.000	0.013	0.007	0.003	0.067	0.013	0.003	0.003	0.000	0.003
FB	0.003	0.020	0.023	0.003	0.010	0.007	0.023	0.007	0.007	0.003	0.007	0.010	0.000	0.000	0.003	0.010	0.010	0.000	0.013	0.090	0.000	0.007	0.000	0.000
UC	0.003	0.010	0.000	0.020	0.000	0.003	0.013	0.003	0.000	0.033	0.000	0.003	0.000	0.020	0.000	0.003	0.003	0.000	0.003	0.000	0.033	0.000	0.000	0.000
PB	0.003	0.010	0.010	0.000	0.017	0.003	0.007	0.000	0.000	0.000	0.000	0.000	0.003	0.000	0.013	0.007	0.003	0.000	0.003	0.007	0.000	0.043	0.000	0.003
NT	0.010	0.010	0.000	0.000	0.003	0.000	0.000	0.010	0.000	0.000	0.003	0.003	0.000	0.000	0.000	0.010	0.007	0.000	0.000	0.000	0.000	0.000	0.017	0.003
LG	0.007	0.007	0.003	0.000	0.007	0.000	0.010	0.003	0.000	0.000	0.000	0.007	0.003	0.000	0.000	0.007	0.010	0.003	0.003	0.000	0.000	0.003	0.003	0.030

Appendix B3. Result of confidence (P→ S)

	BT	DE	MA	WF	KB	TX	CM	FL	MM	SY	SV	AU	DI	DT	VO	TV	VI	ME	BR	PD	BT	SP	BC	GP	BL	RD	WC
PT	0.042	0.119	0.158	0.048	0.250	0.500	0.200	0.045	0.800	0.083	0.143	0.125	0.429	0.211	0.071	0.000	0.282	0.125	0.053	0.200	0.500	0.100	0.000	0.000	0.000	0.000	0.400
EM	0.250	0.313	0.368	0.381	0.438	0.400	0.229	0.182	0.400	0.250	0.357	0.417	0.714	0.474	0.321	0.125	0.282	0.125	0.211	0.300	0.600	0.100	0.500	0.273	0.182	0.500	0.400
AT	0.167	0.149	0.211	0.095	0.125	0.300	0.057	0.227	0.000	0.208	0.214	0.167	0.286	0.211	0.179	0.125	0.128	0.125	0.263	0.000	0.200	0.300	0.000	0.091	0.000	0.000	0.400
CV	0.000	0.060	0.053	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.179	0.000	0.000	0.000	0.250	0.000	0.051	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MU	0.500	0.149	0.105	0.095	0.021	0.050	0.086	0.136	0.000	0.250	0.143	0.167	0.000	0.000	0.250	0.000	0.179	0.375	0.421	0.200	0.100	0.400	0.250	0.000	0.455	0.000	0.000
TH	0.250	0.090	0.000	0.000	0.063	0.050	0.000	0.273	0.000	0.083	0.000	0.042	0.143	0.053	0.143	0.250	0.026	0.000	0.368	0.000	0.000	0.200	0.000	0.000	0.091	0.000	0.000
IF	0.083	0.164	0.132	0.238	0.188	0.250	0.114	0.000	0.000	0.125	0.107	0.208	0.286	0.316	0.429	0.375	0.154	0.250	0.000	0.100	0.300	0.300	0.000	0.000	0.000	0.000	0.000
PW	0.042	0.060	0.211	0.143	0.146	0.200	0.114	0.045	0.600	0.167	0.143	0.083	0.000	0.211	0.000	0.000	0.179	0.000	0.053	0.200	0.300	0.000	0.000	0.000	0.091	0.000	0.200
BW	0.000	0.090	0.184	0.143	0.125	0.200	0.114	0.000	0.000	0.000	0.036	0.042	0.000	0.211	0.036	0.000	0.077	0.250	0.000	0.100	0.200	0.000	0.250	0.000	0.000	0.000	0.400
CT	0.042	0.015	0.000	0.000	0.042	0.000	0.000	0.136	0.000	0.083	0.036	0.000	0.000	0.000	0.357	0.000	0.026	0.125	0.053	0.000	0.000	0.000	0.000	0.000	0.091	0.000	0.000
LC	0.000	0.045	0.105	0.000	0.021	0.100	0.143	0.045	0.000	0.125	0.036	0.167	0.000	0.105	0.071	0.000	0.051	0.000	0.000	0.200	0.100	0.100	0.250	0.545	0.000	0.000	0.200
SF	0.083	0.134	0.237	0.381	0.208	0.100	0.114	0.045	0.000	0.208	0.214	0.000	0.000	0.368	0.000	0.125	0.077	0.500	0.053	0.100	0.200	0.000	0.250	0.000	0.091	0.000	0.000
SM	0.000	0.045	0.026	0.238	0.167	0.100	0.057	0.000	0.200	0.042	0.036	0.042	0.429	0.000	0.036	0.000	0.026	0.000	0.000	0.100	0.100	0.000	0.000	0.000	0.000	0.000	0.000

CC	0.042	0.045	0.026	0.000	0.063	0.000	0.057	0.136	0.000	0.125	0.071	0.000	0.000	0.000	0.214	0.000	0.051	0.125	0.053	0.000	0.000	0.000	0.000	0.000	0.091	0.000	0.000
MV	0.250	0.075	0.053	0.000	0.042	0.050	0.114	0.000	0.000	0.000	0.071	0.208	0.000	0.053	0.071	0.125	0.179	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.545	0.000	0.000
SW	0.167	0.179	0.395	0.333	0.167	0.200	0.286	0.136	0.200	0.167	0.214	0.292	0.000	0.368	0.071	0.125	0.333	0.125	0.105	0.000	0.300	0.000	0.000	0.000	0.182	0.000	0.800
IT	0.042	0.164	0.316	0.238	0.125	0.250	0.171	0.045	0.000	0.167	0.250	0.167	0.000	0.263	0.071	0.125	0.231	0.125	0.053	0.100	0.300	0.000	0.250	0.182	0.000	0.000	0.200
RT	0.000	0.000	0.000	0.000	0.000	0.050	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.100	0.000	0.000	0.000	0.000	0.000
TM	0.250	0.090	0.026	0.000	0.000	0.050	0.000	0.091	0.000	0.167	0.000	0.042	0.000	0.053	0.250	0.125	0.077	0.000	0.263	0.100	0.000	0.600	0.000	0.000	0.091	0.000	0.000
FB	0.125	0.134	0.053	0.048	0.104	0.050	0.057	0.045	0.000	0.083	0.036	0.208	0.000	0.105	0.071	0.000	0.077	0.250	0.105	0.000	0.000	0.000	0.000	0.273	0.091	0.000	0.000
UC	0.042	0.015	0.000	0.000	0.021	0.000	0.000	0.136	0.000	0.042	0.036	0.000	0.000	0.000	0.214	0.000	0.026	0.000	0.053	0.000	0.000	0.000	0.000	0.000	0.091	0.000	0.000
PB	0.250	0.060	0.026	0.000	0.021	0.050	0.143	0.000	0.000	0.042	0.036	0.375	0.143	0.000	0.107	0.000	0.179	0.125	0.105	0.100	0.100	0.000	0.000	0.000	0.455	0.000	0.200
NT	0.000	0.030	0.079	0.048	0.063	0.000	0.057	0.000	0.400	0.083	0.107	0.083	0.000	0.105	0.036	0.000	0.077	0.000	0.000	0.000	0.100	0.000	0.000	0.000	0.000	0.000	0.200
LG	0.000	0.015	0.053	0.095	0.021	0.000	0.029	0.045	0.000	0.125	0.036	0.042	0.000	0.000	0.071	0.000	0.026	0.000	0.053	0.000	0.100	0.000	0.000	0.000	0.000	0.500	0.000

Appendix B4. Result of confidence (S→ P)

	PT	EM	AT	CV	MU	TH	IF	PW	BW	CT	LC	SF	SM	CC	MV	SW	IT	RT	TM	FB	UC	PB	NT	LG
BT	0.031	0.092	0.100	0.000	0.414	0.400	0.043	0.056	0.000	0.056	0.000	0.080	0.000	0.043	0.545	0.125	0.034	0.000	0.300	0.111	0.100	0.462	0.000	0.000
DE	0.250	0.323	0.250	0.286	0.345	0.400	0.239	0.222	0.333	0.056	0.115	0.360	0.176	0.130	0.455	0.375	0.379	0.000	0.300	0.333	0.100	0.308	0.400	0.111
MA	0.188	0.215	0.200	0.143	0.138	0.000	0.109	0.444	0.389	0.000	0.154	0.360	0.059	0.043	0.182	0.469	0.414	0.000	0.050	0.074	0.000	0.077	0.600	0.222
WF	0.031	0.123	0.050	0.000	0.069	0.000	0.109	0.167	0.167	0.000	0.000	0.320	0.294	0.000	0.000	0.219	0.172	0.000	0.000	0.037	0.000	0.000	0.200	0.222
KB	0.375	0.323	0.150	0.000	0.034	0.200	0.196	0.389	0.333	0.111	0.038	0.400	0.471	0.130	0.182	0.250	0.207	0.000	0.000	0.185	0.100	0.077	0.600	0.111
TX	0.313	0.123	0.150	0.000	0.034	0.067	0.109	0.222	0.222	0.000	0.077	0.080	0.118	0.000	0.091	0.125	0.172	0.167	0.050	0.037	0.000	0.077	0.000	0.000
CM	0.219	0.123	0.050	0.000	0.103	0.000	0.087	0.222	0.222	0.000	0.192	0.160	0.118	0.087	0.364	0.313	0.207	0.000	0.000	0.074	0.000	0.385	0.400	0.111
FL	0.031	0.062	0.125	0.000	0.103	0.400	0.000	0.056	0.000	0.167	0.038	0.040	0.000	0.130	0.000	0.094	0.034	0.000	0.100	0.037	0.300	0.000	0.000	0.111
MM	0.125	0.031	0.000	0.000	0.000	0.000	0.000	0.167	0.000	0.000	0.000	0.000	0.059	0.000	0.000	0.031	0.000	0.000	0.000	0.000	0.000	0.000	0.400	0.000
SY	0.063	0.092	0.125	0.000	0.207	0.133	0.065	0.222	0.000	0.111	0.115	0.200	0.059	0.130	0.000	0.125	0.138	0.000	0.200	0.074	0.100	0.077	0.400	0.333
SV	0.125	0.154	0.150	0.357	0.138	0.000	0.065	0.222	0.056	0.056	0.038	0.240	0.059	0.087	0.182	0.188	0.241	0.000	0.000	0.037	0.100	0.077	0.600	0.111
AU	0.094	0.154	0.100	0.000	0.138	0.067	0.109	0.111	0.056	0.000	0.154	0.000	0.059	0.000	0.455	0.219	0.138	0.000	0.050	0.185	0.000	0.692	0.400	0.111
DI	0.094	0.077	0.050	0.000	0.000	0.067	0.043	0.000	0.000	0.000	0.000	0.000	0.176	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.077	0.000	0.000

DT	0.125	0.138	0.100	0.000	0.000	0.067	0.130	0.222	0.222	0.000	0.077	0.280	0.000	0.000	0.091	0.219	0.172	0.000	0.050	0.074	0.000	0.000	0.400	0.000
VO	0.063	0.138	0.125	0.500	0.241	0.267	0.261	0.000	0.056	0.556	0.077	0.000	0.059	0.261	0.182	0.063	0.069	0.000	0.350	0.074	0.600	0.231	0.200	0.222
TV	0.000	0.015	0.025	0.000	0.000	0.133	0.065	0.000	0.000	0.000	0.000	0.040	0.000	0.000	0.091	0.031	0.034	0.000	0.050	0.000	0.000	0.000	0.000	0.000
VI	0.344	0.169	0.125	0.143	0.241	0.067	0.130	0.389	0.167	0.056	0.077	0.120	0.059	0.087	0.636	0.406	0.310	0.000	0.150	0.111	0.100	0.538	0.600	0.111
ME	0.031	0.015	0.025	0.000	0.103	0.000	0.043	0.000	0.111	0.056	0.000	0.160	0.000	0.043	0.000	0.031	0.034	0.000	0.000	0.074	0.000	0.077	0.000	0.000
BR	0.031	0.062	0.125	0.000	0.276	0.467	0.000	0.056	0.000	0.056	0.000	0.040	0.000	0.043	0.000	0.063	0.034	0.000	0.250	0.074	0.100	0.154	0.000	0.111
PD	0.063	0.046	0.000	0.000	0.069	0.000	0.022	0.111	0.056	0.000	0.077	0.040	0.059	0.000	0.000	0.000	0.034	0.000	0.050	0.000	0.000	0.077	0.000	0.000
BT	0.156	0.092	0.050	0.000	0.034	0.000	0.065	0.167	0.111	0.000	0.038	0.080	0.059	0.000	0.000	0.094	0.103	0.000	0.000	0.000	0.000	0.077	0.200	0.111
SP	0.031	0.015	0.075	0.000	0.138	0.133	0.065	0.000	0.000	0.000	0.038	0.000	0.000	0.000	0.000	0.000	0.000	0.167	0.300	0.000	0.000	0.000	0.000	0.000
BC	0.000	0.031	0.000	0.000	0.034	0.000	0.000	0.000	0.056	0.000	0.038	0.040	0.000	0.000	0.000	0.000	0.034	0.000	0.000	0.000	0.000	0.000	0.000	0.000
GP	0.000	0.046	0.025	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.231	0.000	0.000	0.000	0.000	0.000	0.069	0.000	0.000	0.111	0.000	0.000	0.000	0.000
BL	0.000	0.031	0.000	0.000	0.172	0.067	0.000	0.056	0.000	0.056	0.000	0.040	0.000	0.043	0.545	0.063	0.000	0.000	0.050	0.037	0.100	0.385	0.000	0.000
RD	0.000	0.015	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.111
WC	0.063	0.031	0.050	0.000	0.000	0.000	0.000	0.056	0.111	0.000	0.038	0.000	0.000	0.000	0.000	0.125	0.034	0.000	0.000	0.000	0.000	0.077	0.200	0.000

초 록

서비스 혁신은 최근 몇 년간 기업 환경의 중요한 화두 중 하나로 고려되어 왔다. 새로운 제품을 만들고 판매하는 것으로부터, 즉 제품의 혁신으로부터 기업 가치를 창출하던 시대에서 이제는 서비스 혁신 역시 기업 성공을 좌우하는 중요한 요소로 고려되기 시작한 것이다. 자연스럽게 기업은 서비스 혁신을 어떻게 하면 잘 할 것인가 라는 질문에 맞닥뜨리게 되고, 그 답은 모든 경영 활동이 그러하듯, 체계적인 기획에 있다.

본 학위논문은 이러한 서비스 혁신을 효과적으로 기획하기 위한 3가지의 서비스 기획 유형을 다루고 있으며 각 유형별로 두 가지씩 6가지 주요 의사결정 문제를 다루는 6개의 논문으로 구성된다. 서비스 혁신의 기획 유형은 서비스 혁신의 단계에 따라 서비스 컨셉 개발 (ideation), 서비스 컨셉 전개 (deployment), 서비스 컨셉 디자인 (design) 의 세 가지로 구분될 수 있으며, 본 논문에서는 각 유형별로 두 개의 기획 문제를 포함한다. 각 논문에서는 다양한 방법론을 활용하여 각 기획 문제에 대한 방법론적 적합성을 제시하고 해당 방법론의 구체적 활용 방법을 제시한다.

연구#1은 서비스 트리 (service tree)를 통한 서비스 시스템의 가시화 및 운영에 관한 것이다. 본 연구에서는 제조 시스템에서 실패 분석에 주로 활용되어 왔던 FTA를 서비스 시스템에 수정 적용하여 서비스 트리를 작성하고, 서비스 시스템을 구성하는 각 서비스 요소들을 유형화한다. 또한 각 서비스 요소들이 전체 서비스 시스템의 만족도에 어떤 영향을 미치는지 정량적으로 분석한다. 본 연구는 복잡한 서비스의 효과적인 가시화를 촉진하고, 서비스 요소들의 핵심성을 판단함으로써 향후 서비스 운영관리에 효과적 도구로 활용될 수 있다.

연구#2는 서비스 기능간 이질성 (heterogeneity)을 고려한 신서비스 개발 (new service development: NSD) 에 관한 것으로, 본 연구에서는 서비스 기능이 핵심적인 기능인지 부가적인 기능인지에 따라, 핵심적 기능인 경우 사례기반추론 (case-based reasoning, CBR) 기법을, 부가적 기능인 경우 지그재깅 (zigzagging) 기법을 적용하여 신서비스 개발을 수행한다. 제시된 접근법은 서비스 기능의 이질성을 고려함으로써 효과적으로 서비스 아이디어를 창출할 수 있을 것으로 기대된다.

연구#3은 제품, 서비스의 통합 (product-service integration)을 기획하기 위한 새로운 형태의 기술로드맵 (technology roadmap)을 제안하는 연구에 관한 것이다. 기술로드맵에 관한 기존 연구 대부분이 단일 제품 또는 단일 서비스를 기획하기 위한 목적으로 활용되어 왔으나, 본 연구에서는 제품과 서비스를 동일한 선상에서 기획의 대상으로 고려하고, 이 과정에서의 기술의 역할을 6가지로 유형화한다. 이러한 기술의 역할 유형에 따라 6가지의 기술로드맵 유형을 제시하여 차별화된 로드매핑 프로세스를 제시하였다.

연구#4는 기술로드맵의 계층간 인과관계를 효과적으로 반영하기 위한 연관성 분석 (association rule mining, ARM) 기반의 기술로드맵이 제시된다. 본 연구에서는 동일 계층간 관계는 키워드 유사성에 기반하고, 타 계층간 관계는 키워드 의존성에 기반해 키워드 벡터를 구성하고, 이를 네트워크 형태로 시각화하여 키워드 수준의 기술로드맵을 작성한다. 본 연구는 기술로드맵 작성에 있어 대량의 데이터를 효과적으로 로드매핑 과정에 활용할 뿐 아니라 계층간 인과관계를 정량적으로 분석하였다는 점에서 의의를 가진다.

연구#5는 서비스 모듈화 (service modularization) 에 관련된 것으로, 효과적인 서비스 운영관리를 위해 품질기능전개 (quality function deployment, QFD)를 수정 적용한 서비스 모듈화 프로세스가 제시된다. 이를 위해 우선 서비스를 서비스 산출물

(service outcome), 서비스 프로세스 (service process), 서비스 자원 (prerequisite for services)의 세 가지 관점에서 분해하고, 모듈화 평가 기준을 공통 모듈 동인 (common module driver)과 서비스 특화 모듈 동인(service-specific module driver)으로 나누어 제시한다. 본 연구는 서비스 시스템의 특징을 고려한 모듈화의 실질적 방법을 제시함으로써 효과적 서비스 운영관리를 촉진할 것으로 기대된다.

연구#6은 고장모드 영향분석 (failure mode and effect analysis, FMEA)과 그레이 관계 분석(grey relational analysis, GRA) 을 통한 서비스 시스템의 진단 및 평가에 관한 것이다. 본 연구에서는 기존 고장모드 영향분석의 각 차원을 서비스 시스템의 특성에 맞게 수정 확대하여 3개의 차원과 19개의 하위 차원으로 구분하고, 각 서비스 실패 모드의 평가에 있어 그레이 관계 분석을 활용하여 유연한 평가 기법을 제시한다. 본 연구는 서비스 실패 모드를 판단하기 위하여 서비스 시스템의 특성에 맞는 평가 프레임워크를 제시하였다는 데 그 의의가 있다.

주요어: 서비스 혁신, 기술기획, 기술로드맵, 기술 경영, 의사결정

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감사의 글

감사의 글을 쓰기 위해 앉으니 참으로 많은 장면들이 뇌리를 스칩니다. 그 중 가장 먼저 떠오르는 장면은, 처음으로 국제저널에 논문을 제출했던 순간입니다. 그 때 느꼈던 설레임과 떨림을 저는 아직도 생생히 기억하고 있습니다. 그 느낌을 평생 기억하면서, 미진하지만 노력하는 연구자로 앞으로 살아가고자 합니다. 지금까지의 길에 묵묵히 큰 도움을 주신, 그리고 앞으로 큰 도움을 주실 분들께 이 자리를 빌어 감사의 인사를 올립니다.

먼저 지도교수님인 박용태 교수님께 깊은 감사의 말씀을 드립니다. 교수님의 가르침이 없었더라면 제가 이 자리에 절대 서 있지 못할 것입니다. 교수님께서는 학문을 대하는 진지한 자세를 가르쳐 주시고 연구자로서의 길을 밝혀주셨을 뿐만 아니라 인격적으로도 크게 성장할 수 있도록 많은 도움을 주셨습니다. 끊임없이 현장과 학문의 변화에 귀 기울이시고 이를 선도하고자 하는 모습에서 연구자로서 갖추어야 할 많은 덕목을 배웠습니다. 진심으로 감사드립니다. 또한 부족한 논문을 지도해주시고 심사해주신 오형식 교수님, 박우진 교수님, 최후곤 교수님, 이학연 교수님께 진심으로 감사의 말씀을 드립니다. 또한 산업공학과의 모든 교수님들께도 진심으로 감사드립니다. 교수님들의 가르침이 있었기에 지금의 제가 있을 수 있었다고 생각합니다.

6년 반이라는 긴 대학원 재학 기간을 함께 울고 웃었던 기술경영연구실 가족들께도 진심으로 감사의 인사를 전합니다. 연구자로서, 그리고 인생 선배로서 훌륭한 귀감이 되어 주신 박광만, 김문수, 설현주, 김철현, 강인태, 윤병운, 신준석, 김선우 박사님을 비롯한 여러 선배님들께 감사의 인사를 드립니다. 부족한 후배와 짧게나마 연구실 생활을 함께 하며 학문적, 인간적으로 많은 가르침을 주신 정환오빠, 창우오빠, 성주언니, 낙환오빠, 창호오빠,

학연오빠, 승겸오빠, 윤미언니, 창용, 수환, 현명에게 진심으로 감사의 마음을 전합니다. 함께 했던 시간을 가슴 속에 넣어두고 좋은 추억으로 간직하겠습니다. 그리고 연구실의 많은 대소사를 함께 하며 정을 나누었던 용윤, 보미, 란, 양래, 상훈, 지은, 대국, 효진, 성수, 유진, 지영, 은지, 우석, 현정, 윤정, 해진에게도 고마움을 전합니다. 이들과 함께 한 연구실의 많은 일상들이 졸업하고도 늘 마음에 남을 것입니다. 그리고 무엇보다 6년간 모든 희로애락을 함께 하고 든든한 버팀목이 되어 준 소중한 나의 동기, 소라언니와 우리에게 더할 나위 없는 고마움을 전합니다.

제 삶을 더욱 행복하게 만들어주며, 늘 큰 위로와 도움을 주는 친구들에게도 감사의 인사를 전합니다. 열 일곱살의 고등학생으로 만나 십 수년을 함께 하고 있는 사랑하는 친구 은화, 경하, 주연, 가람에게 감사를 전합니다. 늘 서로의 버팀목이 되며 오랜 시간을 함께 지내온 희진, 경연, 은아, 경윤, 분홍에게도 감사의 마음을 전합니다. 수많은 즐거움과 고민을 함께 했던 주리, 윤혜, 세리나, 문정언니에게도 감사의 마음을 전합니다. 꿈 많던 어린 시절을 함께 했던 여고초등학교, 거제여자중학교, 부산과학고등학교의 친구들, 불타는 젊음을 함께 했던 KAIST 산업공학과의 선후배와 동기들에게도 모두 감사의 인사를 전합니다.

그리고 무엇보다, 저의 가장 큰 버팀목이었던 사랑하는 가족들께 무한한 사랑과 감사의 인사를 전합니다. 늦은 나이까지 공부하는 자식을 묵묵히 지켜봐 주시고 사랑으로 감싸주신 부모님, 부모님의 믿음과 사랑이 저를 지금 이 자리에 설 수 있게 했다는 것을 믿어 의심치 않습니다. 그저 오래 행복하고 건강하십시오. 두 분이 걸어오신 인내의 세월에 이 작은 논문을 바칩니다. 삼십년이 넘도록 늘 부족한 동생의 든든한 울타리가 되어 주는 사랑하는 언니에게도 정말 고맙다는 인사를 전합니다. 제게 또 하나의 가족인 시부모님과 형님 내외분께도 큰 감사의 인사를 드립니다. 늘 부족한 며느리를 과분할 정도로 예뻐해 주시고 사랑해 주시는 시부모님,

저의 일을 존중해 주시고 늘 든든한 지원군이 되어 주셔서 아무 걱정 없이 박사과정을 무사히 마칠 수 있었습니다. 감사하고 사랑합니다. 늘 따뜻한 웃음과 배려로 부족한 저를 감싸주시고, 물심양면 많은 것을 지원해 주시는 큰형님, 작은형님 내외분께도 큰 감사의 인사를 전합니다.

마지막으로, 사랑하면서 사는 것이 무엇인가를 알게 해 준, 나의 사랑하는 남편 이호준 씨에게 무한한 사랑과 감사를 전합니다. 대학원 생활을 무사히 마친 것은 남편의 사랑과 지원이 있어서 가능했습니다. 고맙고 사랑합니다. 그리고, 예쁜 딸 수현이. 부족한 엄마임에도 불구하고 늘 웃어주고 행복해하며 무럭무럭 크고 있는 우리 아기. 지금껏 한 번도 경험하지 못한 세상을 경험하게 해 준 남편과 수현이에게 세상의 모든 사랑을 전합니다.

앞으로도 모든 분들의 기대에 어긋나지 않는 사람이 되도록 노력하겠습니다.

2013년 8월

관악에서

금영정 올림