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An Application of Product-Service System Development Methodology in Development of Smart Home Appliances

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An Application of Product-Service System Development Methodology in Development of Smart Home Appliances

A thesis
submitted to the School of Integrated Industrial Design
and the Graduate School of UNIST
in partial fulfillment of the
requirements for the degree of
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2. 5. 2014
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An Application of Product-Service System Development Methodology in Development of Smart Home Appliances

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ABSTRACT

With the diffusion of smartphones, smart products are taking deep root within our lives. Considering the high-end smart home appliances displayed at international electronics shows, smartness is being regarded as one of the most critical criteria to judge the competitiveness of manufacturing companies not only for IT devices but also for home appliances. Reflecting this tendency, many global home appliance manufacturers are devoting effort to Smart Home Appliance (SHA) development. In many cases, however, smart functions cannot provide users with significant added values because of technology-oriented approaches. Without a clear understanding on the notion of smartness, developmental strategy, and relevant methodologies, it is hard to develop genuine SHAs which effectively address users' needs by providing differentiated values.

Defined as marketable systems of products and services capable of fulfilling a user's demand, Product-Service System (PSS) can provide SHAs manufacturers with an innovative approach to develop solution that address users' needs in more effective ways and raise market competitiveness through offering both products and services. By shifting from sales-oriented business model to PSS, companies can perform better in terms of environmental, social and economic sustainability. Nonetheless, switching the business model based on manufacturing into a PSS model is a challenging approach for manufacturing companies because of differences between offering products and services.

Underlying hypothesis of this research is that PSS development methodology can contribute to SHA development. As the first step to prove this hypothesis, the developmental direction of SHA and various PSS development methodologies were explored through literature reviews. A unified PSS methodology was proposed and the relevance of its application to SHA development inquired through expert interviews. In the expert interview the stages of existing SHA development processes which need to be reinforced with PSS development methodology were identified. Based on the findings from diagnosis, a set of tools to reinforce the SHA development processes were selected and their effectiveness identified through the workshop with practitioners. Through the entire process, the potential of PSS development methodology for SHA development was recognized and the points to be improved to support SHA development better were suggested.

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1. INTRODUCTION

1.1 Background

Initiated by smartphones, smartness is emerging as one of the essential attributes of IT products and home appliances. The global market for Smart Home Appliance (SHA) is expected to grow from 3.06 billion USD in 2011 to 15.12 billion USD in 2015 (Figure 1) (Zpryme, 2010). This indicates that SHA business can be an opportunity for home appliance manufacturing companies to revitalize their stagnant market. In fact, many international home appliance manufacturers such as GE, Siemens, Whirlpool, Samsung and LG are introducing the state-of-the-art technologies and products related to SHAs. This trend is evident at the international electronics fairs where the latest trendy SHAs are exhibited (윤명현 & 장동현, 2012). For example, in 2011 Samsung introduced a smart home solution named 'SMART HomeNet' consisting of 6 elements (smart touch, smart control, smart save, smart manager, smart shopping and smart apps) by combining home appliances with smartphones, wireless internet and cloud computing technologies (나민수). LG also proposed a total smart solution 'Smart ThinQ' in 2011, to help consumers use their home appliances more easily and conveniently by connecting them and applying 5 technologies: smart grid, smart diagnosis, smart access, smart adapt and smart manager (LG Electronics).

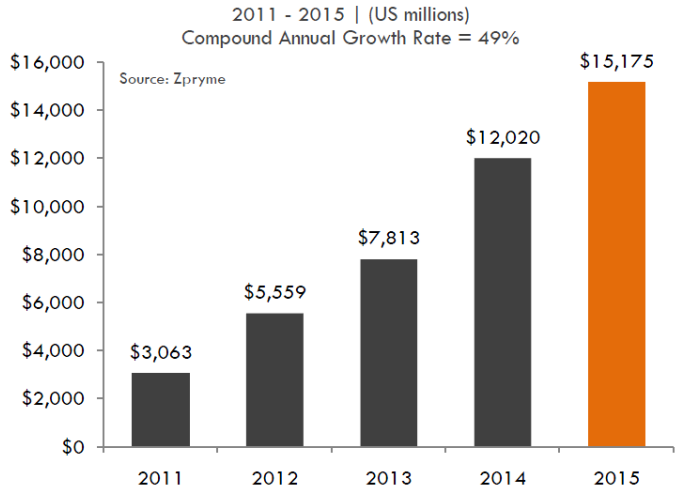


Figure 1 Projected Global Smart Appliance Market Value (Zpyme 2010)

While Samsung and LG possess advanced technologies and many things became possible (e.g. users can turn on an air conditioner out of the house or shop for groceries using a smart refrigerator) it is doubtful whether their smart solutions are indeed beneficial in users' daily life. Sciacca (2013) argues that some features of SHAs are beneficial and attractive, but many functions are not desirable. Using the food management function of a smart refrigerator, for example, users can input name, amount and expiration date of food by touchscreen; the food inventory list helps users avoid unnecessary purchase of food, and therefore it contributes to reducing food wastes; and notification of expiration date will lead the users to consume their foods while they are fresh. If the food management function is fully utilized, it can contribute to the efficient use of food. In reality, however, as refrigerators are often used by multiple users and contain different types of food, food management function using touchscreen input system may be an additional annoying task for users. During the interviews for a smart refrigerator development project, smart refrigerator users mentioned that the food management system is attractive but touchscreen operation, especially dragging-and-dropping icons, is inconvenient and complicated to operate. Observation of a selected user group revealed that because of the ineffective input method, most users gave up using the function, utilized the function only for long-term food storage or rarely-used items (정선희, 2012). The case of smart refrigerator suggests that successful SHAs cannot be developed simply by featuring high-end technologies like touchscreen or cloud computing. In order to develop products that provide values to users, the notion of SHAs and a methodology to develop them need to be clarified.

1.2 Research Goal

Recently, Product-Service System (PSS), a system to provide a mix of tangible products and intangible service, is attracting attention with its potential to overcome the limitations of the conventional sales-oriented industry (Kang, 2009). Accordingly, the aim of this research is to propose a methodology dedicated to SHA development by redefining the notion of SHA and adopting PSS

development methodology. Although an array of smart products have been launched in the market and some studies have provided definitions for smart products, neither industry nor academia has a generalized definition (Gutierrez, Garbajosa, Diaz, & Yague, 2013). The absence of a consensus on the definition of smart products implies that the direction of desirable SHAs may be unclear, and it is a significant obstacle to SHA development; a general definition is required for establishing design theory, quality model and assessment standard for SHA. Meanwhile, PSS is regarded as an innovative business modeling method which can offer values in more sustainable and effective ways (Kang, 2009). User-centered, integrated, and cooperative approach of PSS strengthen the interaction between the SHA products and the user, between the SHA products and between the SHA products and stakeholders. In the academic field a number of well-organized PSS development methodologies have been introduced. However, in the SHA industry, market growth is so rapid and market competition is so harsh that practitioners cannot afford to spend much time and effort on changing their development process or adopting new development methods. To provide a guide to the roles of SHAs and to develop them effectually, the identity and attributes of SHAs and the economic and practical way to apply PSS development methodology in the field need to be explored.

1.3 Research Design

This research was designed to test the hypothesis that PSS development methodology can contribute to SHA development. As figure 2 displays, this study consists of 4 major phases: literature review, diagnosis, verification and evaluation.

Initially, the definitions and attributes of SHA and smart home were investigated and analyzed through literature review to suggest how a SHA should be as a component of smart home. In addition, the previous studies on PSS were reviewed to understand the concept of PSS and its advantages.

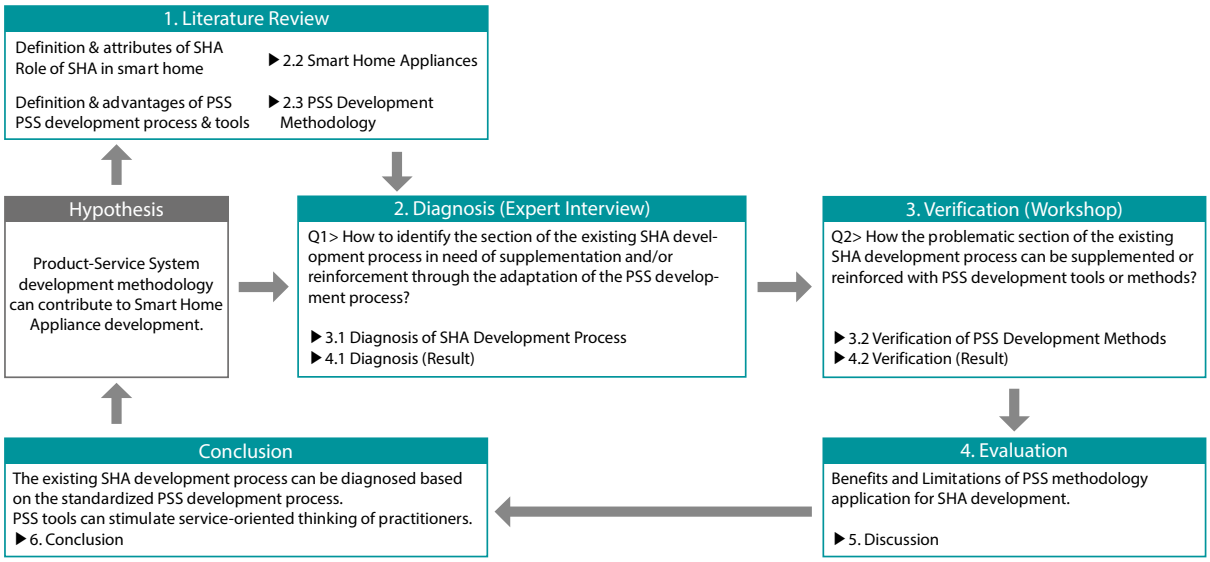


Figure 2 Structure of the Research

Through the fundamental research on SHA and PSS, the potential of the PSS development methodology as an approach to develop SHA was assessed. Considering the difficulty of applying an entire PSS development process to SHA development, however, the development tools and methods need to be simple to understand and easy to use. Accordingly, diverse PSS development processes were analyzed and unified to establish the framework for diagnosis of existing SHA development processes. The diagnosis can help to define the priority of SHA development stages to be improved in a given SHA development process. The development of tools and methods based on the diagnosis result are expected to bring maximum effect with minimum effort. Finally the activities and tools involved in each process were collected and organized to be applied in SHA development practice.

In the diagnosis phase, the potential impact of PSS development methodology on SHA development derived from literature review was confirmed from a pragmatic perspective through expert interviews. In the interviews, SHA developers who work in UX design and product planning departments were asked to diagnose their current SHA development process according to a diagnosis framework. For each activity in the unified PSS development process, they evaluated how it was being undertaken in practice and if it needs to be adopted to their development process. By integrating and analyzing the interview results, the stages and activities which need to be improved were identified.

For the first step of verification phase, the PSS development tools and methods – touchpoints matrix, PSS matrix, priority matrix and strategy matrix – were selected as a prescription for problems on existing SHA development process. Those tools and methods were revised through a pilot workshop with students. They were required to be simplified in consideration of participants without expertise in PSS. Also they were refined for SHA development by reflecting the findings from fundamental research on SHA. Finally, those tools and methods were tested and evaluated in a workshop with practitioners to develop a smart robot cleaner. In the workshop, the practitioners utilized those tools and methods to analyze their current business model, generate PSS ideas for a new robot cleaner and assess their new solutions.

At the end of the workshop, the tools and the workshop were evaluated using a survey. As a result of the workshop, the outcome of using tools and methods and the feedback from participants about the workshop were obtained. Through analyzing the results of diagnosis and verification, and the usefulness and limitations of PSS methodology was evaluated.

1.4 Research Scope

As this research aims to contribute to the SHA development practice, pragmatic verification is inevitable. The participants were recruited from the leading SHA manufacturers in Korea. Also, the data set which was collected from a sample company was analysis to limit the investigation to one existing SHA development process.

In regard to PSS development processes, some of them take the approach to add service elements to existing products and the others take the approach to develop product elements and service elements at the same time. As product design and service design mutually affect each other, product elements and service elements should be developed simultaneously to provide guidelines for SHA development. Thus, the PSS development processes which do not address product development were excluded from PSS process analysis.

The major target audience of this thesis is PSS experts who can arrange existing tools or methods or design new tools or methods depending on the business environment and clients' needs. By using the diagnosis framework, PSS experts can acknowledge the weak points of existing development process and grasp the direction to optimize the development methodology which can be applied to the industrial field with less effort from practitioners. In addition, they can reflect the findings from this research to their PSS tool design in a direction to enhance the strong points and overcome limitations of PSS methodology. Also, this research can offer motivation for SHA developers to adopt the PSS development methodology to their business practice. Although the tools and methods utilized in this research are based on the case of a specific company, practitioners can find opportunities for their business from reviewing the notion of SHAs and potential of PSS approach.

1.5 Research Questions

This research proposes the application of PSS development methodology to SHA development practice and evaluates the effect of application based on the proposition that PSS development methodology can contribute to SHA development. This thesis addresses the following research questions:

• How to identify the section of the existing SHA development process in need of supplementation and/or reinforcement through the adaptation of the PSS development process?

• How the section of the existing SHA development process that need enhancement can be supplemented or reinforced with PSS development tools or methods?

1.6 Outline

This thesis is constructed as follows.

Chapter 1 introduces the background of research, research goal, design of the research, research scope and delimitation, outline and intended audience.

Chapter 2 suggests the desirable developmental direction of SHA through review of literature on SHA and smart home. Moreover, PSS development methodology is proposed as an appropriate approach to develop SHAs through literature review.

Chapter 3 explains about the research methods including expert interviews to diagnose the existing SHA development process and the workshop to verify the effect of PSS development tools on SHA development.

Chapter 4 displays the results of and findings from diagnosis and verification phases.

Chapter 5 discusses the strengths and limitation of PSS development methodology for SHA development.

Chapter 6 summarizes the main findings and lessons of this research and research contribution. Finally, further research is suggested.

2. Literature Review

2.1 Introduction

In this chapter, two streams of literature reviews about Smart Home Appliance (SHA) and Product-Service System (PSS) were conducted to ensure the appropriateness of PSS development methodology for SHA development and establish the theoretical basis for this research. The definitions and characteristics of Smart Home Appliance (SHA), smart products and smart home is explored to understand what SHAs are and how they should be. Furthermore, the concept and advantages of Product-Service System (PSS) are presented to support its relevance as an approach to develop SHAs. Also, PSS development processes and methods are introduced.

2.2 Smart Home Appliances

In the research to find a consensus definition of smart product, Gutierrez et al. (2013) claim that the absence of consensus definition obstructs design theory building, quality model establishment and assessment of product quality, and communication based on common understanding. Their assertion implies that the developmental direction of SHA should be determined based on a full understanding of its identity and roles not only to develop a good SHA but also to provide an appropriate development methodology. In this research, the literatures on SHA, smart products and smart home are explored from a broad perspective to identify the notion of smart home appliances.

2.2.1 Definitions and Characteristics of Smart Home Appliance

In the paper by Schmidt and Van Laerhoven (2001), SHA is described as “devices that are not ignorant about their environment and context.” In this research, authors suggest context-awareness,

which means knowledge about the state of user and device including environment, situation, location and tasks, as an essential property of SHAs. Kango, Moore, and Pu (2002) define a SHA as “an appliance whose data are available to all concerned (all the actors in the appliance life cycle) at all times throughout its life cycle.” Kango et al. regard SHAs as the sources of data required to provide the users and producers with various services, and mention that advanced ICT technologies should be applied to play such a role. They also highlight the role of SHAs to “deliver enhanced or ‘smart’ services within the home.” They state that more and more customer needs will be provided as a bundle of services for more diverse activities at home, and the quality and efficiency of services will be improved. 윤명현 and 장동현 (2012) also mention services defining SHAs as “home appliances which can provide customized contents and smart home service functions with network connections and various service control functions.” The ability of SHAs to automatically adjust to the situation to provide optimized performance is described as well. Reflecting the growth of smart grid markets, Association of Home Appliance Manufacturers (2009) associates SHAs with the smart grid system and defines SHA as “a modernization of the electricity usage system of a home appliance so that it monitors, protects and automatically adjusts its operation to the needs of its owner.” Moreover, they point out some key features of SHAs involving automatic adjustment, communication and customized functions. Meanwhile, Elmenreich and Egarter (2012) provide design guidelines in terms of technical components. That is, “smart appliances consist of a communication interface, a local processing and decision unit and the appliance’s actual function.”

The definitions and characteristics of SHAs introduced above show the roles of SHAs, the attributes and functional structure required to undertake the roles. It is depicted in figure 3. The functional parts of SHAs for communication, data processing and decision making can support SHAs to provide their original functionalities better. Thanks to those additional functional parts, SHAs have attributes like context-awareness, connectivity and automatic adjustment. Through perceiving the state of users and surroundings better and sharing collected data with other SHAs, they can control themselves depending on context and consequently fulfill users’ needs by offering optimized services.

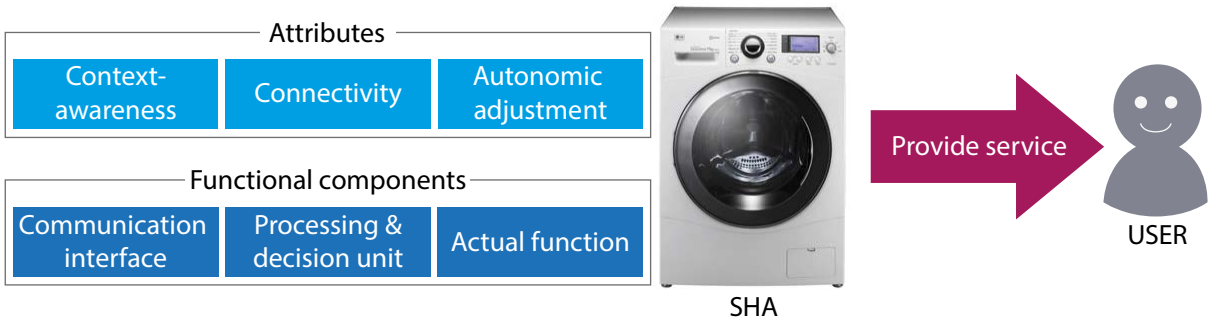


Figure 3 Definition of SHA from Previous Studies

2.2.2 Definitions and Characteristics of Smart Products

For broadening an understanding of the roles and attributes of SHAs, the literature related to smart products were referred to. According to Maass and Varshney (2008), smart products indicate "products with digital representations that enable adaptation to situations and consumers." While the definition offered by Maass and Varshney (2008) focus on the adaptability of smart products, Mühlhäuser (2008) defines a smart product as follows:

> *"A Smart Product is an entity (tangible object, software, or service) designed and made for self-organized embedding into different (smart) environments in the course of its lifecycle, providing improved simplicity and openness through improved product-to user and product-to-product interaction by means of context-awareness, semantic self-description, proactive behavior, multimodal natural interfaces, AI(Artificial Intelligence) planning, and machine learning."*

Based on Muhlhauser's definition, SmartProduct Consortium (Sabou et al., 2009) introduces the abilities of smart products in more detail:

> *"A smart product is an autonomous object which is designed for self-organized embedding into different environments in the course of its life-cycle and which allows for a natural product-to-human interaction. Smart products are able to proactively approach the user by*

using sensing, input, and output capabilities of the environment thus being self-, situational-, and context-aware. The related knowledge and functionality can be shared by and distributed among multiple smart products and emerges over time."

Moreover, Miche, Schreiber, and Hartmann (2009) mention "Smart products assist their users during the whole life-cycle, literally talking to and guiding them to deal with their complexity." With the role of a smart product as an assistant, the authors also note two major challenges: "to support natural interaction with the user and to make use of other smart products and resources available in the environment." In terms of information technology, on the other hand, Rijsdijk and Hultink (2009) identify smart products as "products that contain information technology and therefore able to collect, process and produce information."

In addition to the definitions, the researchers also provide the characteristics of smart products. The characteristics of smart products and the descriptions of them are displayed in table 1. According to the similarity of meanings the characteristics were recategorized into 8 types of characteristics. Table 2 shows the result of recategorization. Because some are defined to broadly and some are identified in too much detail, the meanings of some characteristics were merged, specified or refined in the process of recategorization. For instance, 'support procedural knowledge' of 'connectivity category' is about the interaction with users based on a procedure of activity. To address this role, however, cooperation among SHAs is more important than the way of interaction. Therefore, it was merged with 'self-organized embedding in smart product environment' and assigned to 'connectivity category.' There was also confusion of meaning in 'adaptiveness' and 'adaptability.' Both of them indicate the ability to adjust their behavior, but 'adaptiveness' pay attention to users and 'adaptability' focus on the environment. Consequently, 'adaptiveness' was classed as 'user learning' and 'adaptability' was combined with 'reactivity' reflecting their common concern about the external environment.

Table 1 The Characteristics of Smart Products

Reference	Characteristics	Description
Maass and Varshney (2008)	Situatedness	Recognition of situational and community contexts
	Personalization	Tailoring of products according to buyer's and consumer's needs
	Adaptiveness	Change product behavior according to buyer's and consumer's responses to tasks
	Pro-activity	Anticipation of user's plans and intentions
	Business-awareness	Consideration of business and legal constraints
	Network ability	Ability to communicate and bundle with other products
Mühlhäuser (2008)	Context-awareness	N/A
	Semantic self-description	N/A
	Proactive behavior	N/A
	Multimodal natural interface	N/A
	AI planning	N/A
	Machine learning	N/A
SmartProduct Consortium (Sabou et al., 2009)	Autonomy	Smart products need to be able to operate on their own without relying on a central infrastructure. This is, for example, the case of the smart kitchen devices in our example scenario which interact with each other and the user without the need of central control.
	Situation- and context-aware	Smart products are able to sense physical information (e.g., via a temperature sensor), virtual information (e.g., about the current state in the cooking process maintained by another smart product) and to infer higher level events from this raw data (e.g., the user has finished cooking). These \higher-level events" are often referred to with the term "situation". Situation and context information allow smart products to adapt their interaction with other products and users accordingly, as well as to infer new knowledge.
	Self-organized embedding in smart product environments	A smart product is able to embed itself into an existing smart product environment and to automatically build a smart product environment. For example, a newly acquired smart product such as a rice boiler should be capable of easily embedding itself into the smart kitchen described above.
	Proactively approach the user	The situation information is used to decide when the smart product should proactively approach the user, e.g. for providing additional information or for assisting him in performing a task. Indeed, in our example scenario, when an exceptional situation is detected by a smart product (e.g., it requires some maintenance or cleaning), the smart product can pro-actively interact with the user, potentially through multimodal interaction (see below). Note that proactivity should also characterize the interaction with other products, e.g., the Measuring Scale proactively interacts with the steamer when food is transferred between the two products.

SmartProduct Consortium (continue)	Support the user throughout whole life-cycle	The particular life-cycle stage of a product has a major influence on its behavior. For example, a worker in the production phase needs access to other functionalities (and uses a different terminology) than an end-user during the usage phase. In our example scenario, different smart product features are relevant for different life-cycle stages: the ability to sense the user context is crucial during the usage phase, while providing information about itself and its usage history is needed during the recycling phase.
	Multimodal interaction	Smart products should provide a natural interaction, however most smart products have only limited in- and output resources. For that reason, the smart products are able to make use of the different input and output capabilities in their smart product environment supporting the usage of various modalities (e.g., speech, pointing). Smart products can discover multimodal user interface services in the network and can make use of them as need be. Examples include networked displays, microphones, speakers, etc. This is, for example, the way in which the steamer communicates its status to the user.
	Support procedural knowledge	Many interactions with smart products are based on a procedure, e.g. descaling a coffee machine. Therefore, smart products need to support procedural knowledge, including how the user needs to be involved in the different steps and how implicit interaction (e.g., inferred from context information) can be integrated in the procedure, e.g. recognizing when the user has completed a step in the procedure. The supported procedures are thereby not limited to one single smart product; the procedures can also be dynamically composed of procedures provided by several smart products. For example, in the example scenario, a cooking guide could control the overall cooking process, but parts like boiling water can be outsourced to other smart products which are available in the smart kitchen.
	Emerging knowledge	Smart products learn new knowledge from observing the user, incorporating user feedback and exploring other external knowledge sources like Wikis. They are thus able to gather a more accurate user model and to learn new procedures. Our example scenario illustrates how user preferences are learned and utilized over time, for each individual user (e.g., with the toaster temperature and time when warming the croissant).
	Distributed storage of knowledge	Many smart products have only limited storage resources, thus they need to outsource their knowledge to other smart products in the environment. The user pro le, as an example, is part of the knowledge that needs to be stored in a distributed way. This enables smart products that just enter a smart product environment to benefit from the information that was gathered so far. Another scenario where distributed storage is required is commissioning, i.e., if one product is broken and has to be replaced by another. The distributed storage enables that the new smart product can be initialized with the knowledge of the old smart product and thus does not need to learn everything from scratch.

Miche et al. (2009)	Context sensing	To interact naturally with the user, products must be aware of their current context. We consider two facets of context awareness: Acquiring context and reacting to context … For that purpose, each smart product needs to define its own rules on how to react in a given context … Much smarter behavior can be triggered if higher level context is inferred from this low level context … In almost all cases such higher level context needs input from a variety of different sensors, physical as well as virtual ones. Since equipping each smart product with all the necessary sensors is infeasible, it is important that smart products can gather context information in a distributed way. Therefore, the Context Processor component on each smart product is not only connected to local sensors but can further subscribe to context information provided by other smart products in the environment using the communication middleware.
	User interaction	The main goal of making products smart is to facilitate interaction for the user as much as possible. This comprises (i) automating workflows in order to avoid interaction, (ii) proactively guiding the user through non-automatable workflows, and (iii) providing natural interaction in case no workflow is followed by the user … However, the ability of a smart product to interact naturally is impaired by the limited input and output capabilities of typical smart products. To overcome these limitations, smart products should be able to make use of the interaction capabilities of the environment.
	Distributed storage of data	During their whole life-cycle, smart products require plenty of information … However, due to their resource constraints, smart products are in general not capable of storing all information locally. Also, it would not be reasonable to store all data in a remote storage infrastructure, because of the varying communication capabilities of smart products ranging from WiFi and mobile broadband wireless access technologies to short-range technologies … This functionality is covered by the Ubiquitous Data Store, which facilitates the distribution of information among smart products plus the access to data stored in backend systems.
Rijsdijk and Hultink (2009)	Autonomy	The extent to which a product is able to operate in an independent and goal-directed way without interference of the user
	Adaptability	A product's ability to improve the match between its functioning and its environment
	Reactivity	The ability of a product to react to changes in its environment
	Multifunctionality	The phenomenon that a single product fulfills multiple functions
	Ability to cooperate	Ability to cooperate with other devices to achieve a common goal
	Humanlike interaction	The degree to which the product communicates and interacts with the user in a natural, human way
	Personality	An ability to show the properties of a credible character

Table 2 Recategorization of the Characteristics of Smart Products

Name of category	Maass and Varshney (2008)	Muhlhauser (2008)	SmartProduct Consortium (2009)	Miche et al. (2009)	Rijsdijk and Hultink (2009)
Connectivity	Network ability		Self-organized embedding in smart product environments Support procedural knowledge		Ability to cooperate
Distribution of data			Distributed storage of knowledge	Distributed storage of data	
Context awareness	Situatedness	Context-awareness	Situation- and context-aware	Context sensing	
User Learning	Adaptiveness Personalization	Machine learning	Emerging knowledge		
Autonomy		AI planning	Autonomy		Autonomy
Proactivity	Pro-activity	Proactive behavior	Proactively approach the user		
Natural interaction		Semantic self-description Multimodal natural interface	Multimodal interaction	User interaction	Humanlike interaction Personality
Adaptability					Adaptability Reactivity
Etc.	Business-awareness		Support the user throughout whole life-cycle		Multifunctionality

The meaning of each category is defined as follows.

• Connectivity: A SHA can be connected to other SHAs as a component of SHA system and can communicate and cooperate with other SHAs for their common goal.

• Distribution of data: SHAs can distribute information accumulated during their lifecycle among SHAs and backend system so that overcome limited data storage resources and backup a new SHA

with the knowledge of the old one.

• Context awareness: SHAs can acquire context and situation through sensing physical information and virtual information from local sensors and other SHAs.

• User learning: SHAs can establish a user model through observing the user, analyzing user feedback and gathering knowledge from external sources, and adjust their services to the user.

• Autonomy: SHAs can operate on their own to achieve their goals without control of users and central infrastructure.

• Proactivity: SHAs can proactively approach to the users through anticipating their state and interacting with them.

• Natural interaction: SHAs can interact with their users in more natural, humanlike and emotional way using varied types of user interfaces.

• Adaptability: SHAs can adjust their functioning to changes in their environment through simple reaction to a short-term change and environment model adjustment to a long-term change.

In this research, newly defined 8 types of characteristics are regarded as the attributes of SHA because they can represent the smartness of product well and embrace the attributes of SHAs which were derived from SHA definitions: context-awareness, connectivity and automatic adjustment. The characteristics which are not included in the categories are excluded from the attributes of SHA. ‘Business-awareness’ and ‘support the user throughout whole life-cycle’ also deserve consideration in terms of the entire lifecycle of a SHA, but the main role of SHAs is to provide optimized services for users and they were judged not to be critical from a user perspective. When it comes to ‘multifunctionality’, it is the attribute which is directly related to user benefit. Nonetheless, SHAs having connectivity can share their tasks, so one product does not have to take care of multiple tasks. Considering the case of PDAs and smartphones, both of them have multiple functions but have a difference of smartness, it does not seem to be an influential factor. Figure 4 presents how the

attributes of SHA are revealed in the relationship among environment, user and SHAs.

The descriptions of smart product characteristics also imply that the attributes of SHA are interconnected. According to Miche et al. (2009) and SmartProduct Consortium (Sabou et al., 2009), 'connectivity' among SHAs is essential for high level of 'context awareness' and 'context awareness' supports the cooperation among SHAs. They also reflect that proactive approach and natural interaction can be much improved by 'connectivity'. In addition, the relationship between 'distribution of data' and 'connectivity' is implicitly recognized by Miche et al. The relationship among SHA attributes tells us that connectivity plays a fundamental role in SHA system. In other words, connectivity should be considered prior to other attributes in developing SHAs.

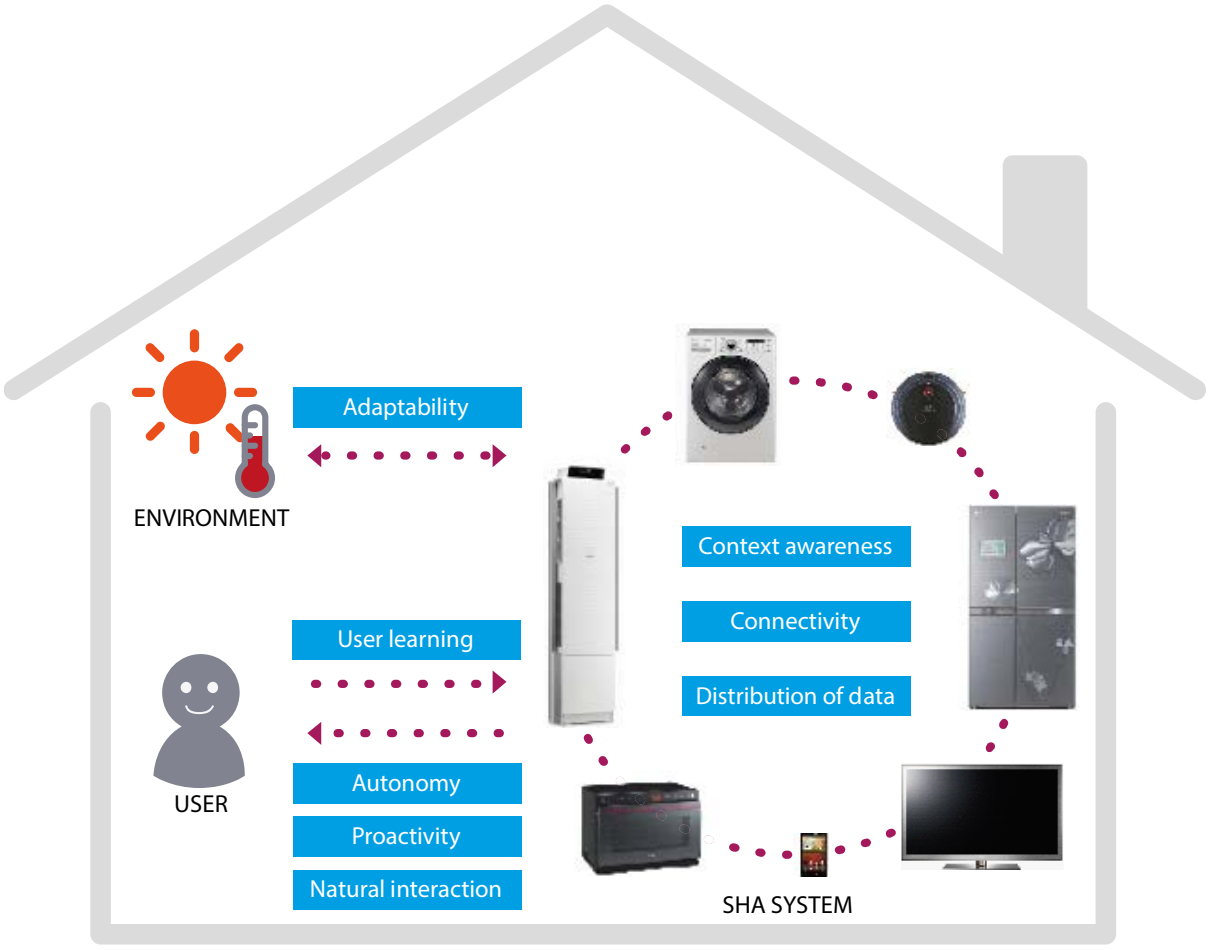


Figure 4 Attributes of SHA

2.2.3 Definitions and Characteristics of Smart Home

The other approach to understanding SHA is the perspective regarding SHAs as "the components of Smart Home." 윤명현 and 장동현 (2012) claim that home appliances in home automation system were developed focusing on function implementation rather than user benefits or usability. However, with the evolution from home automation to Smart Home, the home appliances constructing a Smart Home are also transforming into SHAs suggesting new lifestyle pattern to consumers. Mühlhäuser (2008) also highlights the importance of investigating the notion of smart environment because smart products should be defined based on the consideration of their environmental context. The relationship between SHAs and smart home that was shown in previous research appeals the necessity of studies on smart home.

As the concept of smart home was introduced to popular culture in the 1990s, many researchers have tried to identify Smart homes. Gann, Barlow, and Venables (1999) refer to the definition of Moran (1993) which emphasizes the connectivity, interaction and improvement of controllability: "homes in which ICTs have been installed to help control a variety of functions and to provide communications with the world outside." Aldrich (Harper, 2003) points out the technology for connectivity and interaction as well, but defines a smart home putting more focus on its offering values as below.

> *"A smart home can be defined as a residence equipped with computing and information technology which anticipates and responds to the needs of the occupants, working to promote their comfort, convenience, security and entertainment through the management of technology within the home and connections to the world beyond."*

On the other hand, Jiang, Liu, and Yang (2004) introduce the definition of smart home provided by Intertek. It describes a smart home as "a dwelling incorporating a communications network that connects the key electrical appliances and services, and allows them to be remotely (within the dwelling and from outside the dwelling) controlled, monitored or accessed." They also stated that smart home consist of internal network, intelligent control and home automation. In a paper, Koskela

and Väänänen-Vainio-Mattila (2004) mention that “Smart home environments have evolved to the point where everyday objects and devices at home can be networked to give the inhabitants new means to control them.” In addition, they give a more detailed account: “The smart home adjusts its functions to the inhabitants’ needs according to the information it collects from the inhabitants, the computational system, and the context.”

From these several descriptions of smart home, it is revealed that ICT is the most critical factor for smart homes. The connections and communications among home appliances, devices and stakeholders inside and outside the residence are the key factors which enables smart home to provide the dwellers with beneficial functions and services. It supports the finding from the attributes of SHA that the connectivity act as the basis of other attributes. The other feature discovered from the definitions is controllability. Controlling many elements included in smart home in more convenient and intuitive way is considered as the biggest benefit brought about by the connectivity. 류한석 (2012) also lists ‘smart control’ as one of the values offered by smart home with ‘smart (energy) save’ and ‘smart application’. In connection with the attributes of SHAs, controllability seems to be relevant to adaptability, autonomy, proactivity and natural interaction. Especially, Gann et al. (1999) divide the approach to develop smart homes into 2 directions: traditional concept of home automation involving domestic appliances and informational services related to interactions and communications within and beyond the home. It implies that the natural interaction is relatively new and advanced approach for improving controllability.

According to the levels of communication of information, Aldrich classified the types of smart homes (Harper, 2003). The classification is depicted in Figure 5. Home appliances and devices included in ‘Homes which contain intelligent objects’ may have limited adaptability and autonomy, but ‘Homes which contain intelligent, communication objects’ and ‘connected homes’ with connectivity have improved ability to react. When other attributes like distribution of data, context awareness and learning ability are add to SHAs, smart home can be upgraded to ‘Learning homes’ and has even better reaction ability. Nonetheless, grasping the state of users and objects continuously seems to be

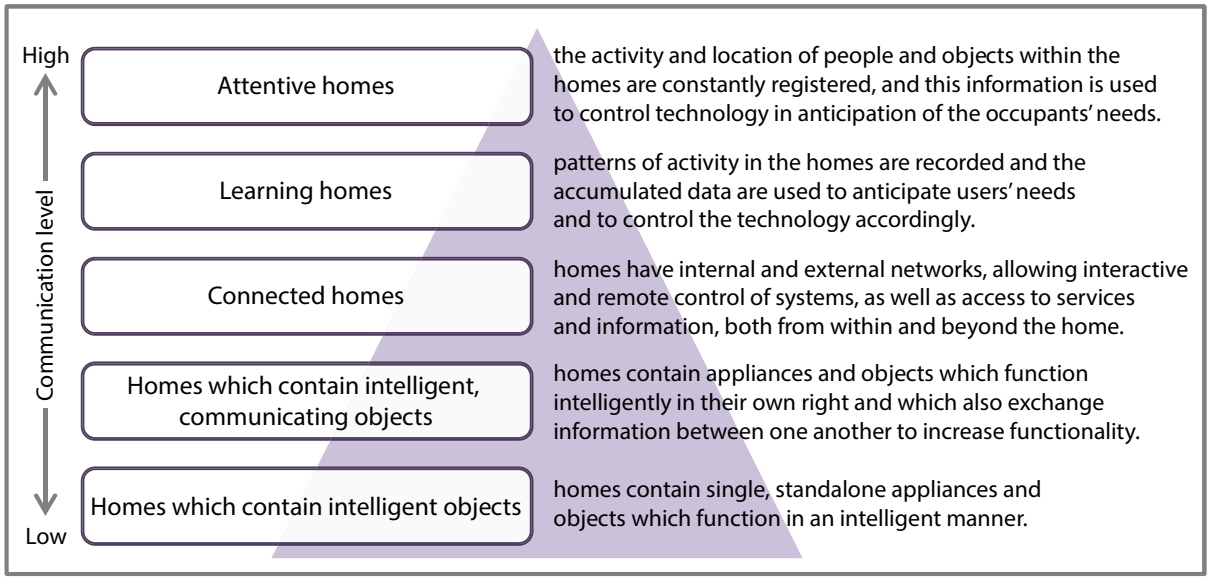


Figure 5 Classification of Smart Home Based on the Level of Communication

difficult for SHAs. In order to realize 'Attentive homes' specialized products to track the occupants or ubiquitous sensors will be required. Considering some smart products like Nest, the thermostat which can learn life pattern and favorite temperature of user and can be controlled using smartphones, the current smart home industry is thought to be between 'Connected home' and 'Learning home.' ICT technologies are matured enough (Eberl, 2002), but the strategy to make smart products learn the users need to be built. That is, what kind of information should be collected and analyzed to fulfill users' needs?

The necessity for user-centered approaches is stressed in the barriers of smart home market vitalization. Gann et al. (1999) identify 5 obstacles for acceptance of smart home technology: high initial investment cost, dependence on old housing, lack of a common protocol, technology push approach with poor consideration on user needs and lack of usability evaluation. About these limitations, Aldrich (Harper, 2003) comments that the equipment for smart home system is being developed to support different protocols, but the issues excepting protocol standardization still need effort to be solved. Meanwhile, Aldrich argues that the role of consumer electronics manufacturers as one of the new main players of smart homes needs to be emphasized (Harper, 2003). Traditionally, electrical equipment suppliers who provide switches, sockets, distribution boards and the rest have

dominated the smart home market, but smartization of dwellings through installing electrical equipment requires high initial investment and takes more effort to be applied to existing homes which were not appropriately-designed for adopting smart technology (Hindus, 1999; Koskela & Väänänen-Vainio-Mattila, 2004). However, SHA manufacturers began to lead the innovations and take a role as a main player in the smart home industry and this tendency is a desirable direction according to the assertion of Rodden and Benford (2003) that smart environment should be developed based on existing homes. Compared to conventional method which involves rebuilding or remodeling of house, retrofitting old housing with SHAs one by one is a more affordable and easier way to set up a smart home (Gann et al., 1999). Consequently, high initial investment cost, dependence on old housing and lack of a common protocol are in the process of being resolved through standardization of protocols and adopting SHAs, but much effort to understand users is still required to solve the other two problems.

Hindus (1999) argues that fulfilling inhabitants by utilizing domestic technology is much more demanding than applying information technology to the workplace because homes are not intended to adopt high technology in consideration of their environment and members of family, dwellers want more customized offerings to fulfill their individual tastes, and their process to make decisions and to set values are more complicated. Thus, transition of advanced technology to domestic everyday use is not simple work so careful research on home environment is required (Koskela & Väänänen-Vainio-Mattila, 2004). Nevertheless, smart homes, especially facilities for housework, are developed by designers and developers who do not have enough interest or knowledge of housework, so suffer from the problems related to the technology push approach (Harper, 2003). Reflecting this tendency, consumers complain that the values offered by smart home are somehow deficient and not that different to the selling points of traditional home automation. They would not pay for additional functions which show the greatness of the state-of-the-art technology but cannot satisfy their needs (류한석, 2012). To stimulate users to invest in smart homes, it is necessary to understand user requirements and satisfy them through their value propositions. As Gann et al. (1999) state, smart home and SHA developers should keep in mind that “customer value-added is the benefit of the

system, not its smartness or intelligence."

About the conditions and needs smart homes should fulfill, Gann et al. (1999) suggest that the general conditions described in table 3 must be satisfied in generic, context specific and user specific levels. In detail, generic level indicates "common devices and communication protocol" which are designed for use in general housing situation, context specific level includes "scale dependent devices and transmission medium" for specific housing types, and user specific level contains "interfaces and specific devices" to fulfill individual user need. The authors also list dwellers' needs for smart homes which were derived from focus group discussion as follows.

• Safety, security and convenience in the control of household appliances

• Energy and environmental management

• Improved internal and external communications, including access control in and out of the home

• Assistance and medical care for older people and those with disabilities

• New forms of entertainment and business applications

Table 3 General Conditions of Smart Home

Conditions	Description
Functionality	The system must have clear and unambiguous functions.
Ease of use	The system must be capable of supporting use by a wide range of different types of occupants, visitors and where necessary their carers. It must be safe and easy to use, assisting independent activities within the home.
Affordability	The system must be inexpensive, with demonstrable benefits for individuals and housing providers
Replicability and ease of installation	The system needs to be available as a standard, reproducible product which has a low-installation impact and is easy to install in refurbishment and new build projects. Suppliers must be prepared to train for necessary installation skills required.
Reliability and maintainability	Manufacturers must indicate data on reliability, provide a full back-up and maintenance service, and where required train maintenance and operations staff.
Flexibility and adaptability	The system must be programmable, accept add-ons and interface with other suppliers' equipment. Systems need to be capable of development as user needs change.
Upgradability	The basic infrastructure must have a long shelf-life, it must be upgradable at low cost and effort.
Interactivity	The system must offer wide interconnectivity and comply with recognized standards.

As SHAs are the components of smart home, these conditions and users' needs are also applicable to SHAs.

In addition to understanding users better, smart home manufacturers and suppliers have the other challenge: providing services. According to Gann et al. (1999) the competitiveness in provision of service for supporting products and systems is critical for market success. As the importance of offering services are emphasized, manufacturers try harder to combine service elements with their business (Ulaga & Reinartz, 2011). From the smart home strategy of Siemens dealing with not only product-related benefits but also service-related values, it can be inferred that service is being perceived as necessity for competitive smart home solutions from industrial perspective as well as academic viewpoints (Gärtner, 2006). ECHONET also introduces several types of services which can be provided through smart home systems: energy management services, comfortable living support services, home security services, home healthcare services, remote appliance maintenance services and mobile services. Nevertheless, manufacturing business and services are fundamentally different; business production phase and delivery phase is separated in manufacturing but services are produced and delivered simultaneously. Brezet et al. (2001) also mention about the differences between product design and service design (Table 4). Because of these differences, manufacturing companies, of which

Table 4 Differences between Product Design and Service Design (Brezet et al., 2001)

Product design	Service design
Long lead time	Short lead time
Is conducted by product developers and technicians	Is conducted by marketers, business administrators and service providers
Hard to adjust to a changing environment	Easy to adjust to a changing environment
Hard technical variables (material, dimensions, etc.)	Soft variables (time, place, etc.)
Secondary products are unimportant for the environmental impact.	Secondary products are essential for the environmental impact.

corporate structure and process are optimized to develop and produce products, can barely design and develop fine services (Burger et al., 2011). The value and benefits of service provision cannot be shared across entire organization of manufacturing company so supports and cooperation for improve services are deficient. Also field service providers fail to bring communication with and cooperation of customers. Consequently, conventional manufacturers face many challenges in the process of offering services in marketing, production, delivery, product-design, communication and relationship (Brax, 2005).

To overcome these challenges, Brax (2005) claims that manufacturers should take radical approach instead of adding service elements to their product-centered offerings. However, changing operation policy drastically is difficult and risky for a company especially when the scale of the company is large. As an alternative to a drastic strategy, manufacturers can cooperate with service suppliers. Besides home appliance manufacturers, Aldrich (Harper, 2003) nominated service providers as another new main player of smart home markets. Few suppliers can provide products and services in an integrated way, so in order to provide diverse services various stakeholders need to be involved in the smart home business: social services providers, healthcare experts, telecommunication companies and others. To support the cooperation of various stakeholders and to let them offer better services, smart home systems and their functions inside and outside of the home should be integrated and it can be possible by smart technologies related to communication and control (Gann et al., 1999).

2.2.4 The Role of Smart Home Appliances in Smart Home

According to the review of literature on SHA, smart products and smart home, a SHA can be defined as a home appliance product which can fulfill users' needs better by providing optimized services through improved product-to-product and product-to-user interaction based on their attributes: connectivity, distribution of data, context awareness, user learning, autonomy, proactivity, natural interaction and adaptability. In a smart home which is connected to the world outside, SHAs serve as

mediator between users and external service providers as well. Consequently, the role of a SHA is to provide value to both users and relevant stakeholders in smart home system through its own function and services from outside on interactions with users, other SHAs and external stakeholders.

2.2.5 Product-Service System Approach to Smart Home Appliance development

Studies of SHAs, smart products and smart homes suggest that developing SHAs is not just about manufacturing electronic products, but designing and implementing a system that consist of products and services. Therefore developing SHAs or smart homes through traditional product development processes or methods have several limitations, and instead, an approach to designing a coordinated product service mixes is needed. The industry life-cycle stage of home appliance also supports this assertion. On the industry life-cycle (Figure 6), home appliance market can be positioned between maturity and decline (Tukker & Tischner, 2006). For instance, lately refrigerator manufacturers are competing mainly on capacity or design rather than the functions or performances of products, and this phenomenon implies that there is little room for improvement through innovation in product or process. In this context, the home appliance industry requires strategic innovation that enables

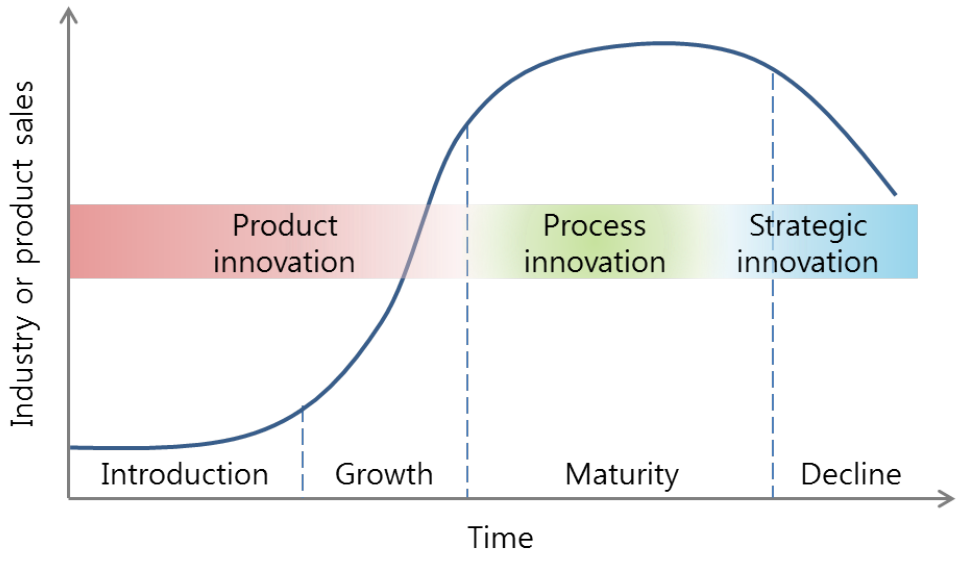


Figure 6 Industry Life-cycle and Innovation per Stage (Tukker & Tischner, 2006)

companies to explore new sources of additional value and extend the life-cycle of home appliance market, and adding products and services is a form of strategic innovation (Tukker & Tischner, 2006). For this reason, Product-Service System (PSS) development methodology is suggested as an alternative solution for SHA development. PSS development methodology can contribute to SHA development at three levels: enhancing the relationships a) between the SHA products and the user, b) between the SHA products and c) between the SHA products and stakeholders (Figure 7).

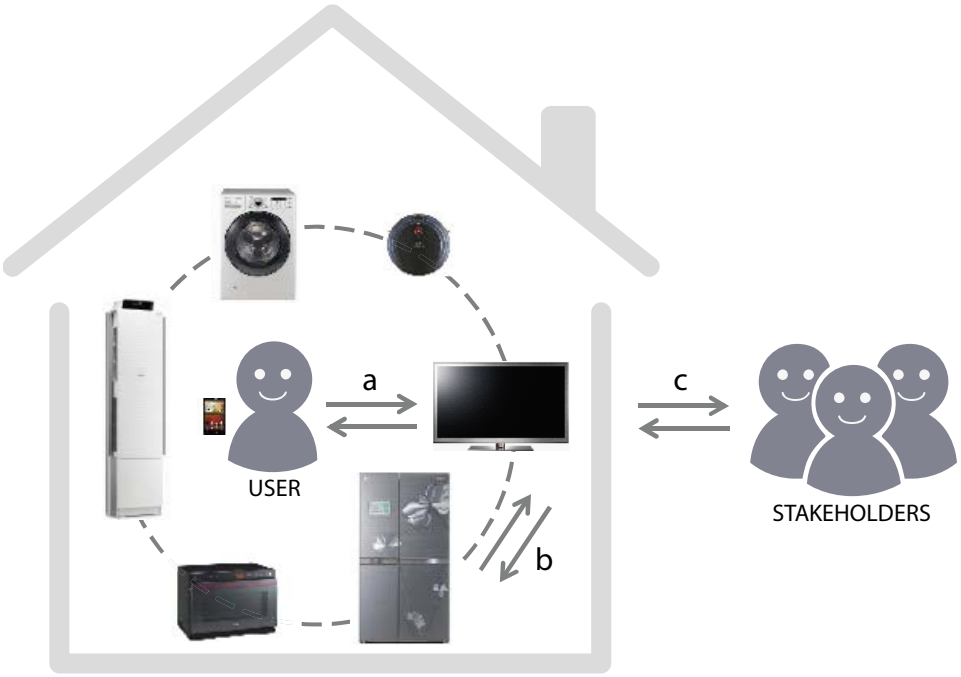


Figure 7 Relationships among Products, User and Stakeholders in Smart Home

a) Between a product and user

Based on the definitions of SHAs focusing on their ability to sense and communicate, SHAs can be categorized as an "ICT product or system that processes, stores or communicates information". Although the development of ICT generally brings about convenience systems for users, it can easily be technology-driven rather than needs-driven because little time to recognize customers' needs and demands is allowed for technology or product developers (Tukker & Tischner, 2006). From the perspective of user needs, PSS is thought to be an effective approach because it can lead providers

toward a novel solution to satisfy users' demands and needs through a combination of efficient products and effective services (Kang, 2009). Moreover, providers of products or services can have longer interactions with customers in PSS so that they can co-create values with their customers and increase customer loyalty.

b) Between products

The capability of processing, storing and communicating information of SHAs can enhance the satisfaction of consumer needs (Tukker & Tischner, 2006). Smart products share the information about users through communication and cooperate for the same purpose to offer better services and values to users (Rijsdijk & Hultink, 2009). In order to design and develop a cooperative ecosystem of SHAs, a systematic approach is required (Brezet et al., 2001; Burger, Ganz, Pezzotta, Rapaccini, & Saccani; Tukker & Van Halen, 2003). The systematic approach of PSS, which enables developers to integrate products and services in a smart way and contribute to providing users with coherent experiences and values, will thus promote the cooperation among SHAs.

c) Between a product and stakeholders

Smart home scenarios (Eberl, 2002) suggest that service elements are important for fulfilling user needs and offering values. As developing the high technology for SHAs and providing various services are realized through partnership, synergies among stakeholders from diverse areas are required. In this context, PSS development methodology can encourage cooperation among various stakeholders. Constructing multi-dimensional partnership allows stakeholders to take advantage of professional knowledge, advanced technology and high quality products or services of other companies and lower system costs at the same time (Kang, 2009; Tukker & Tischner, 2006). PSS development tools or methods to analyze stakeholders' needs and to help their communication and involvement can contribute to SHA development involving a variety of stakeholders.

2.3 Product-Service System Development Methodology

In order to build a strategy of how to apply PSS development methodology, the basic concept of PSS and its advantages and limitations were explored and the precedent studies which are suggesting PSS development process and tools were reviewed.

2.3.1 Definitions and Characteristics of Product-Service System

In the background of severe competition among product manufacturers and the improvement of digital ICT, service sectors has grown beyond other industry sectors. Furthermore, consumers began to pursue quality of life than quantity of material and their demands are getting more diversified. These situations and trends have triggered the improvement of PSS (Kang, 2009).

According to the centrality of product content and service content in business, PSS can be categorized into 3 types: product-oriented PSS, use-oriented PSS and result-oriented PSS (Figure 8). The business model of product-oriented PSS is still dominantly geared towards sales of products, but some extra services are added. Smartphone and applications and media contents offer service are the representative examples of product-oriented PSS. In use-oriented PSS, the traditional products still plays a central role, but the business model is no longer geared towards selling products. The product stays in the ownership of the provider, and is made available in a different form, and sometimes shared by a number of users. Common examples of this PSS type are car sharing/pooling services. On

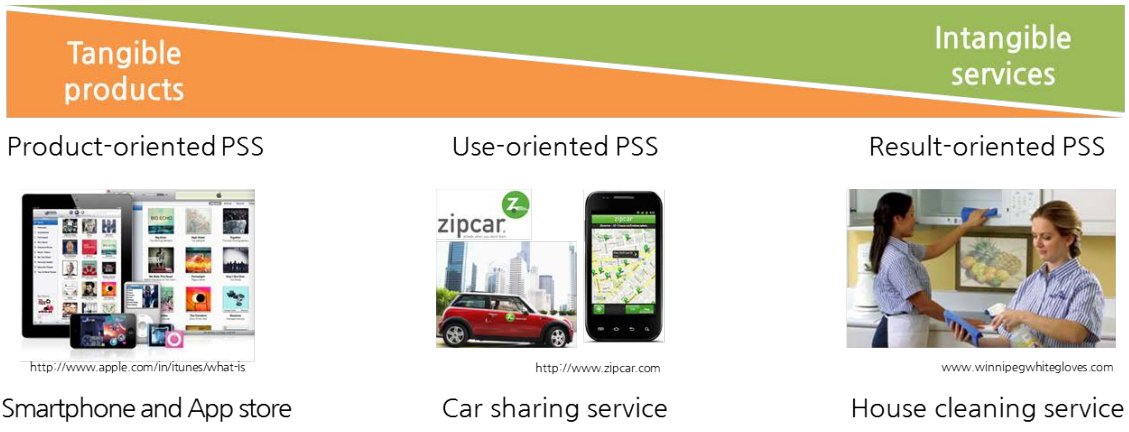


Figure 8 Categories of Product-Services

the other hand, for provision of result-oriented PSS, the client and provider in principle agree on a result, and there is no predetermined product involved, like house cleaning service (Tukker & Tischner, 2006).

About the definition of PSS, Brezet et al. (2001) describe as “marketable systems of products and services capable of fulfilling a user’s demand.” Reflecting the definitions by Brezet et al. and other researchers, Tukker and Tischner (2006) identify product-service and PSS more specifically as below.

- Product-Service: a value proposition that consists of a mix of tangible products and intangible service designed and combined so that they jointly are capable of fulfilling final customer needs

- Product-Service System: the product-service including the (value) network, (technological) infrastructure and governance structure (or revenue model) that 'produces' a product-service

While these definitions are focusing on the ability of PSS to satisfy users’ needs, Burger et al. (2011) introduces PSS as “a market proposition that extends the traditional functionality of a product by incorporating additional services, often embracing sustainability aspects”. From these definitions, it can be inferred that the combination of products and services in PSS can bring advantages from two perspectives: market competitiveness through fulfilling user need and sustainability.

According to Tukker and Tischner (2006), PSS have strength in co-creating user value, minimizing system cost, improving bargaining power and innovating offerings. Besides, manufacturers try to provide services more to “facilitate the sales of their goods, lengthen customer relationships, create growth opportunities in matured markets, balance the effects of economic cycles with different cash-flows, and respond to demand” (Brax, 2005). These advantages in terms of business can be depicted in the relationship among stakeholders of business (Figure 9). In the interaction with customers, providers can understand their needs and problems better and it can enhance the innovation power of the company. Thus, they can provide customized and tailored offerings which can fulfill users' needs better. In the process of delivering services, providers can establish prolonged and intimate

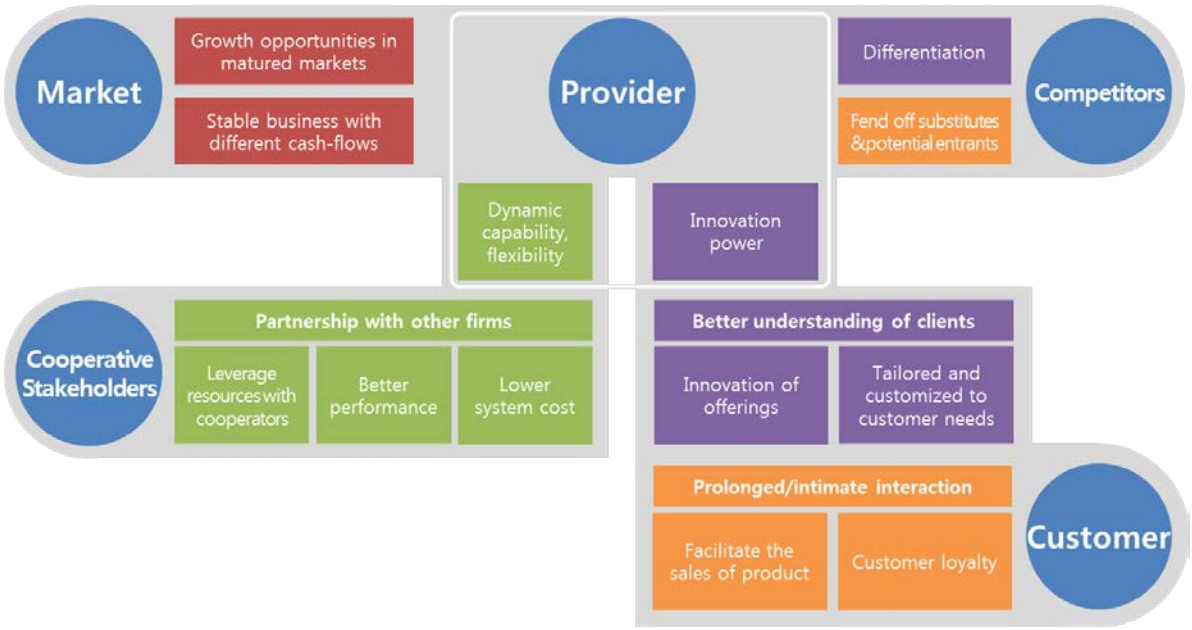


Figure 9 Advantages of PSS

relationships with customers which can facilitate the sales of product and prevent customer churn. In this way, companies can differentiate their offerings from those of competitors and avoid the threats of substitutes and potential entrants. Also, the companies taking the PSS approach have strong bond with partnering companies. In partnership with external stakeholders, they can leverage human and material resources by working with coalition. Also, they can achieve better performance through specializing and outsourcing their works. In this relationship, the providers in PSS can lower system cost and improve dynamic capability and flexibility. As a result, PSS approach enables involved stakeholders to achieve stable management with different cash-flows and to take growth opportunities in matured markets.

Furthermore, PSS is considered to be an effective solution for sustainable development. From an environmental point of view, PSS contribute to reduce environmental burden by improving productivity of resource and managing environmental efficiency through entire life cycle of products. Besides, system-level solutions which were obtained from PSS strategy can lead the business to comply with environmental regulations proactively. In terms of social sustainability, PSS create more employment in industry because services are mainly delivered through human resources. Increased job opportunity can improve the quality of community life. In economic aspect, PSS suggests new

way of profit generation. PSS approach can bring greater profit through added values of offerings and immaterial sources for value creation. Not only financial profits from value proposition but also environment cost saving can be counted as economic benefit from PSS (Kang, 2009). However, sustainable aspects are not natural consequences of PSS so it should be designed with intention to enhance the sustainability performance of PSS solution (Kang, 2009; Tukker & Tischner, 2006).

2.3.2 Product-Service System Development Processes and Tools

In order to apply PSS development methodology to SHA development practice, a unified PSS development process which can be employed as a representative of diverse processes is required. For the first step, existent PSS development processes and activities on each phase were collected and analyzed. The criteria for selecting the methodologies are: 1) PSS development processes of which the division and description of the stages are clear and specific enough to understand the activities undertaken on each phase were selected for analysis and 2) the processes which add service elements on complete product were excluded because product elements and service elements can influence each other in development process so simultaneous development of products and services is important for a holistic approach (Brezet et al., 2001; Meier, 2013). Finally 7 processes were selected to be analyzed. Table 5 displays the selected processes.

Table 5 Selected PSS Development Processes

Process ID	Reference
DES	Brezet et al, 2001
Innovation Scan	Tukker et al, 2003
MEPSS	Halen et al, 2005
IPSE	Lindahl et al, 2007
Kang	Kang, 2009
NSD	Burger et al, 2011
IPSS	Meier, 2013

a) Designing Eco-efficient Services (DES)

DES methodology was developed as a more systematic approach to design eco-efficient services. The authors claim that their ultimate aim is not proposing a 'manual' which provides a fixed developmental direction but suggesting a 'toolbox' which can evolve and adapt to depending on dynamic environment. As a first step to develop a toolbox, they offer a systematic methodology not only for immediate successful eco-efficient service development but also further improvement of development methodology by collecting feedback from cases.

As figure 10 displays, DES process consist of 6 stages from exploration to evaluation. This process introduces tasks to be performed on each stage in specific compared to other processes, especially for realization and evaluation after market release. Monitoring and evaluation of project process as well as environmental and financial performance seems to aim at collecting feedback for refinement of development methodology. Besides, consideration and evaluation on environmental value is emphasized in this process because its purpose to develop eco-efficient services. With regard to product elements, developing a vision of new product in future context is involved on exploration stages, and it is specified by considering the balance of products and services on policy formulation phase. Table 6 indicates the activities included in DES process.

Reflecting the importance of environmental aspect in this methodology, developmental tools related to eco-design e.g. EVR (Vogtländer, Bijma, & Brezet, 2002), LiDS-wheel (Norwegian University of Science and Technology) and Meta-matrix were utilized actively. However, as evaluation tools usually do, these tools require detailed data about environmental influences, business concept need to be specified to use these tools.

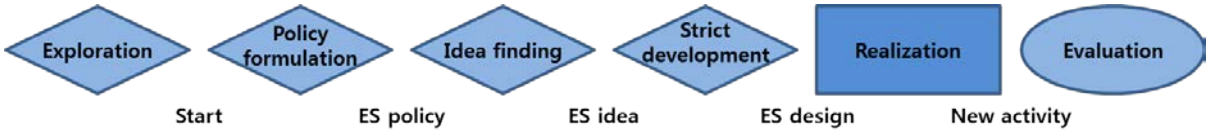


Figure 10 Development Process of DES Methodology (Brezet, Bijma, Ehrenfeld, & Silvester, 2001)

Table 6 Activities Included in DES Process

Stage	Activity
Exploration	· Form a project team · Appoint a project manager. · Formulate a vision and goals. · Determine the system that will be the 'playing field' of the project team. · Make an analysis of the current situation. · Assess the environmental load and the economical value of the system · Identify future users.
Policy formulation	· Set more specific goals than the global ones formulated in Step 1. Indicate the direction of the innovation. · Determine the roles of the partners and external groups. · Create an atmosphere of trust and openness between the partners. · Specify budget and tasks. · Make a time schedule with milestones. · Refine the project plan with the ES policy in it. · Determine what knowledge is needed and if this knowledge should be involved in the form of participating partners or should be purchased. · Develop a first list of requirements.
Idea finding	· Define accurate problem definition. · Refine the list of requirements. · Generate ideas with the project team. · Select one or more ideas to be further developed. · If necessary, start sub-processes with participants or future suppliers.
Strict development	· Define every variable. For the involved products their specifications and for the services their protocols of executions. · Make an assessment of the prototype. · Check if the ES complies with the list of requirements. · Before one starts with the next phase, it is recommended to test the design, so when necessary, adjustments can be made before the ES is being marketed. · Have regular meetings with all people involved in designing the different parts of the system.
Realization	· Communicate the new ES to the market. · Produce or purchase the necessary products. · Hire staff. · Maintain the service. (manage time, place and people) · Sell the ES
Evaluation	· Monitor market response. · Measure the environmental impact of the new system and compare with the old system. · Measure financial effects for the involved companies. · Evaluate project process. · Write final report.

b) Innovation Scan

Innovation Scan is a step-by-step plan for the practitioners who want to confirm the effectiveness of PSS in terms of market performance and environmental impact. According to the checklist of innovation scan process, practitioners are asked if they are fulfilling the requirements which should be achieved on each stage. If their companies are doing the tasks well, they can go on to the next stage. If the requirements are not being appropriately addressed, they can take the help of activities included on each stage to solve their problems. For people in companies without background knowledge of PSS, introductory stages were spent more than other processes to give them a deep understanding of innovation scan and the basic concept of PSS. The flow of process and description of each stage are provided in figure 11 and table 7 respectively.

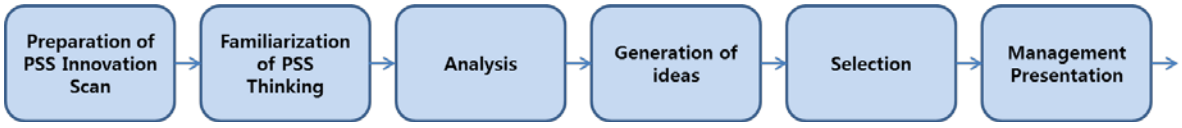


Figure 11 Development Process of Innovation Scan (Tukker & Van Halen, 2003)

Table 7 Activities Included in Innovation Scan Process

Stage	Activity
Preparation of PSS Innovation Scan	· Generate support for carrying out a PSS Innovation Scan in your organization and draw up an action plan
Familiarization of PSS Thinking	· Introduce all team members to the concept of PSC and translates it to your own organization
Analysis	· Analyze your customers and their wishes/needs · Think in terms of the function your product performs · Analyze business context of your company (chain, developments)
Generation of ideas	· Brainstorm to identify possible PSS strategies for your organization
Selection	· Select and shortlist the most promising PSSs · Elaborate the short-listed PSSs more systematically
Management Presentation	· Prepare the management presentation

In regard to tools, ideation tools like brainstorming and Bono's 6 hats which are frequently used in ordinary design sessions are introduced in the idea generation stage. Those tools can be applied to design practice in a familiar way even though the participants are not experts on PSS design and development. Moreover, many tools involved in this methodology are in the form of matrix, so developers can see their works from a systematic point of view and visualize the position of ideas conveniently.

c) Methodology for Product-Service Systems (MEPSS)

MEPSS takes the systematic PSS approach for business innovation. This methodology consists of actions included in 5 stages (table 8, figure 12), tools to support those actions and the outcomes obtained through the actions using tools. An array of tools are systematically connected to activities, so the modules of methodology can be used in order of stages or selectively according to demand. From PSS idea development and PSS development stages both including evaluation and elaboration of PSS ideas, it can be inferred that MEPSS have stronger competitiveness on developing PSS ideas to implementable level.

On the other hand, the authors stress the importance of tools to realize complex PSS innovation. Indeed the tools are optimized for PSS developments and embrace wide range of perspectives: "dynamic system analysis, PSS design, sustainability assessment and market acceptance." However, systemicity and inclusiveness of the tools can make tool users feel difficult and complicated.

Table 8 Activities Included in MEPSS

Stage	Activity
Strategic analysis	· build a thorough and systematic understanding of the company's markets, organization and production and value chain. 1. preparatory phase - getting prepared - management meeting - project planning 2. stakeholder identification - definition of stakeholders - prioritization of stakeholders and planning their involvement 3. evaluation strategy

	- discussion of visions - definition of assessment strategy 4. system analysis workshop - preparing system analysis workshop - performing system analysis workshop 5. elaboration of results for phase 1 - system analysis results - preparing the decision
Exploring opportunities	· look at possible PSS innovation routes for the future 1. preparing scenario workshop - stakeholders' involvement planning - update sustainability aspects - exploring customers' needs - strategic options for scenarios - prioritize sustainability guidelines 2. performing scenario workshop - building PSS scenarios 3. elaboration of results: formalizing and pre-assessing - elaborate scenarios' format - pre-assessing scenario's for consumer needs - scenario preliminary sustainability assessment - visualize sustainability aspects of PSS scenario
PSS idea development	· Develop selected PSS idea into more precise version, evaluate and select the most promising one 1. preparatory phase - prioritize sustainability guidelines 2. PSS idea design - idea development - stakeholders' input generation 3. elaboration of result - PSS idea sustainability assessment - visualize sustainability aspects of PSS idea - selection of best PSS version
PSS development	· Detailed design of each PSS dimension and elaboration of the specs for PSS implementation 1. preparation - attuning to customer preferences - stakeholders' input integration 2. PSS design - PSS dimensions design - customizing to target groups 3. elaboration of result - PSS specifications - PSS sustainability evaluation - visualize sustainability aspects of developed PSS
Preparing for implementation	· Implement PSS using PRINCE project management method · Commercialization of selected PSS - starting a new venture - strategic alliance - joint venture

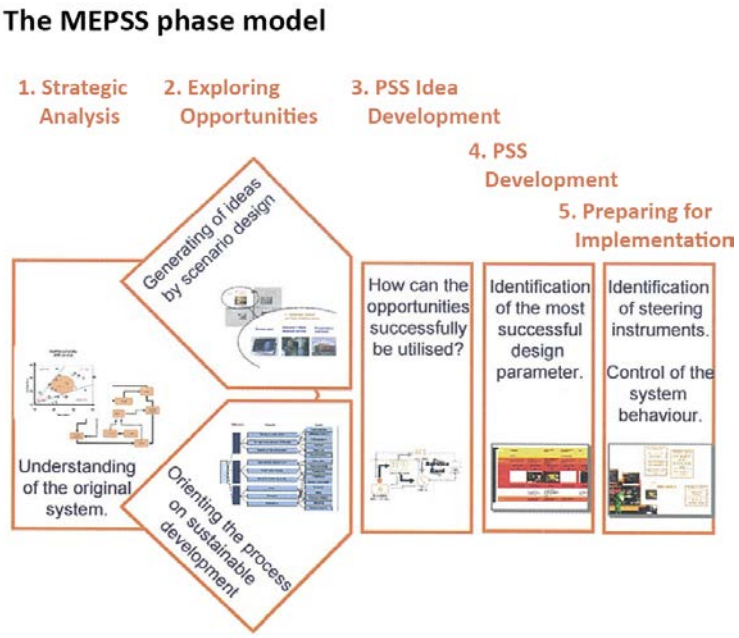


Figure 12 Development Process of MEPSS (Van Halen, Vezzoli, & Wimmer, 2005)

d) Integrated Product and Service Engineering (IPSE)

In the paper introducing IPSE methodology, the limitations of existing PSS development tools were pointed out that they cannot see issues from integrative perspective. As the tools are designed focus on a single problem, it cannot be used harmoniously with the existing work methods of companies which usually need to consider multiple issues at the same time to deal with tangled problems. In contrast with existing methodology, IPSE attempt to develop offerings from lifecycle perspective so that it can increase both competitiveness and environmental effect. With this intention, this process also puts effort on end-of-life stages (5^{th} and 6^{th} stages of table 9) by communicating with customer and collecting played out products for recycling. The double-headed arrows in figure 13 indicate the significance of communication with external stakeholders in lifecycle activities.

Service explorer (Arai & Shimomura, 2004), an ISPE tool, depicts how the state of receiver change depending on contents delivered by channel. It enables PSS developers to gain a holistic understanding of the relationship among providers, receivers and intermediate agents, but has complicated structure so it seems to be useful for idea refinement rather than idea generation.

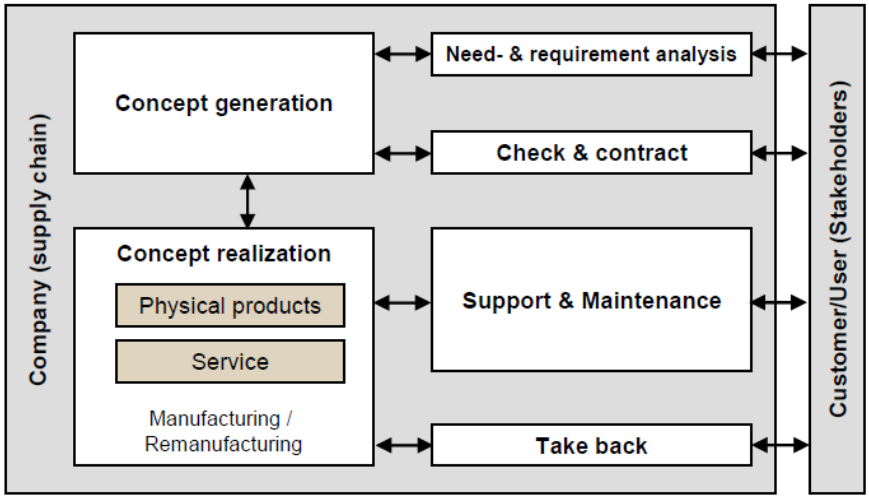


Figure 13 Development Process of IPSE(Lindahl, Sundin, Sakao, & Shimomura, 2007)

Table 9 Activities Included in IPSE

Stage	Activity
Need and requirement analysis	· Determine needs and requirements for all stakeholders (The identified requirements should primarily be seen as requirements on the requested function and not as product or service-related) · Environmental related requirements are stated by different stakeholders
Concept generation	· Generate concepts in an integrated way (concepts: combination of products and services based on the validation of the different requirements stated for the requested function)
Check and contract	· Verify that customers understand what they will gain from the offering, verify that the customer is satisfied with the offering · need and requirement analysis → compare the values from the use of the offering with the original values (activity-identified parameters)
Concept realization	· Realization of the offering (producing services and products needed for the offering)
Support and maintenance	· Service and maintenance is delivered · Active communication with the customer helps the company learn about customers' needs and how to better identify/fulfill customer requirements
Take-back	· Take back the products if the user no longer needs the offering →can be integrated with a remanufacturing system

e) Kang

Although many methodologies and tools have been developed so far, the application cases of those methodology and tools to practical PSS solution development has not been widely known. From this perspective, Kang suggests refined processes and tools through the study of successful PSS development cases. Basically, her methodology was developed based on MEPSS methodology; MEPSS tools were utilized in case studies and refined through reflecting the findings from the workshops. To increase the usability of the methodology for practitioners who are generally novice of PSS development, the process and tools were simplified. Some of tools were refined from existing ones and the others were newly developed. Figure 14 shows which activities and tools are involved and which results are obtained in each stage, and table 10 summarize the activities of process.

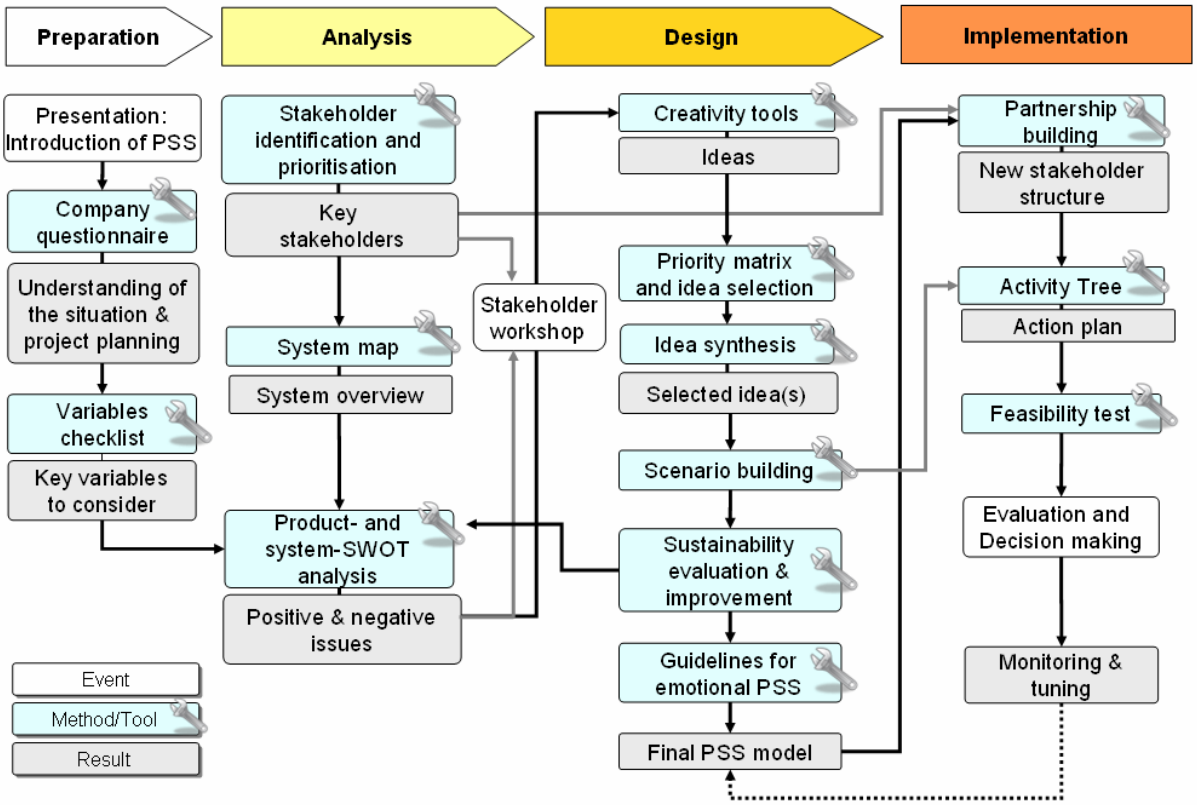


Figure 14 Development Process of Kang (Kang, 2009)

Table 10 Activities Included in Kang's Process

Stage	Activity
Preparation	· Introduction of PSS
Strategic System Analysis	· Understand your organization and current business model as well as market strength and weaknesses
PSS Design	· Find new service opportunities and build up a concrete idea
PSS Implementation	· Know what factors are critical to lead the idea to a success at the same time avoiding the pitfalls

f) New Service Development (NSD)

NSD process (figure 15) was suggested as a systemized service development approach to guide manufacturing-oriented companies which still could not establish matured service design process. This process aims to overcome the limitation of existing service development models through applying knowledge which has been accumulated in product and service development field. Even though service design is more highlighted in this process, the issues related to product elements are also handled in the service design stage. NSD does not introduce specific tools, but gives some instances of service test: usability test, prototyping & simulation, observation & feedback and pilot market test. Activities and tasks related to each stage were stated in table 11.

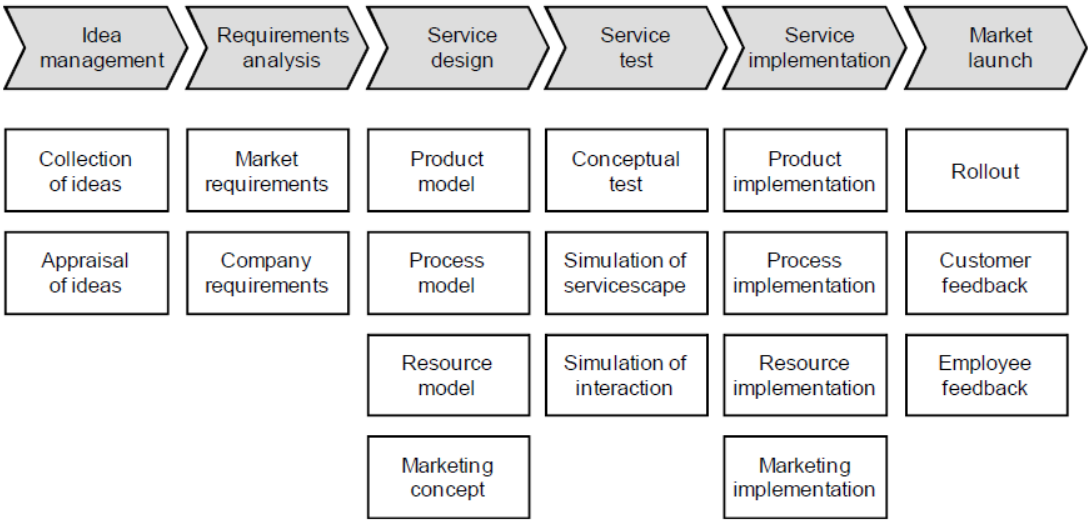


Figure 15 Development Process of NSD (Burger, Ganz, Pezzotta, Rapaccini, & Saccani, 2011)

Table 11 Activities Included in NSD

Stage	Activity
Idea management	· Brainstorming and appraisal of the ideas (collect, filter and crystallize ideas for new services) · Elaborate preliminary concepts
Requirements analysis	· Record and compare requirements from various stakeholders' view point · Detailed planning of new service
Service design	· Concept development -Service definition (scope of service, technical description) -Organizational concept (Processes, roles and resources, training concept) -Marketing concept (Product policy, price policy, place policy, promotion policy) · Describe the service in detail → define organizational parameters, plan the deployment of resources · Elaborate a marketing concept (take market and customer aspects into account)
Service test	· Verify the consistency and plausibility of the service documentation (e.g. business plans, process models, training material)
Service implementation	· Definition of organizational rules (e.g. the creation of procedures), training for affected employees and the procurement of necessary operating resources are necessary · Operative implementation of market concept
Market launch	· Internal and external communication and information measures monitor the start-up period and review the efficiency of the service → (final adaptation, improvement process) · Collect, evaluate, take into account possible change requests from customers · Decide when services should be removed or replaced

g) Industrial Product-Service Systems (IPSS)

IPSS pays more attention to IT support for PSS system. The authors introduce "IPSS assistance system" which help planning and developing IPSS, and it was designed based on the IPSS development process displayed in figure 16. As the scope of this system is determined as planning and developing, realization stage is not included. Instead, it shows its ability in developing ideas by dealing with product-service modules. Table 12 describes the activities involved in each stage.

Various IPSS models are available in this process, but they are relatively intricate so substantial time and efforts are required to understand how to use them.

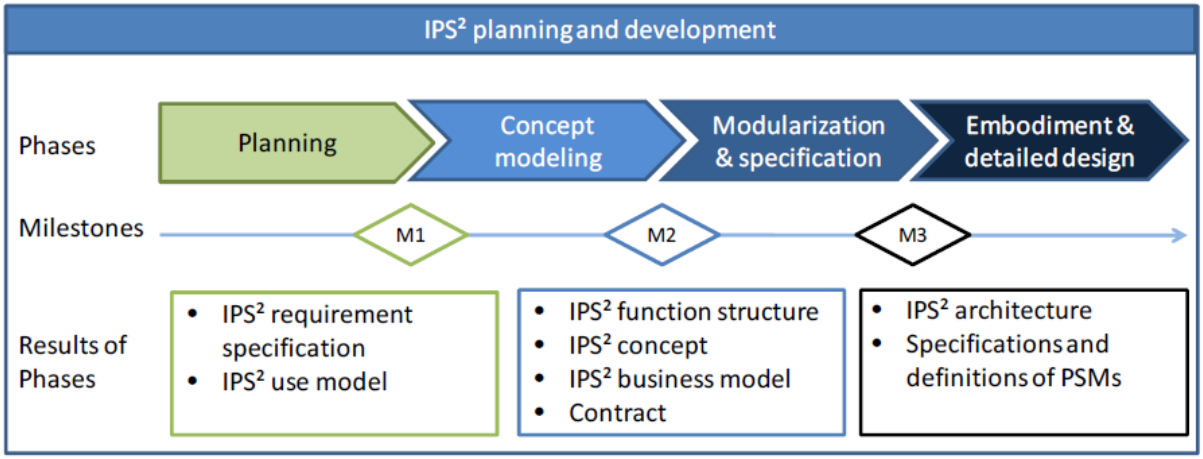


Figure 16 Development Process of IPSS (Meier, 2013)

Table 12 Activities Included in IPSS

Stage	Activity
Planning	· Acquisition of customer needs and values · Customer specific factors (e.g. competences, business strategies, production processes) & external factors (legislation, infrastructure, market, competitors, etc.) should be considered
Concept modeling	· Function model - representation of the intended behavior (the functions) of an IPS² and its modules without specifying an IPS² module · Concept model - structural interaction between function model and principle solutions and their logical functionality. · Business model - business relationship between provider and customer as well as any third parties over the lifecycle of an IPS²
Modularization and specification	· Define and specify Product-Service Modules (PSM) · Subdivide IPSS into PSMs (both product and service elements, product or service elements only) · Develop important aspects of integration of PSMs into IPSS
Embodiment and detailed design	· Variants and possible solutions are generated and evaluated · Assess PSMs · Draft and design product and service elements (embodiment and detailed design of PSMs is discipline-specific, but interdependencies between IPSS elements must be considered for integrated development)

After selecting the processes, the stages of PSS development process were segmented, grouped and rearranged (Figure 17) to the following process: Exploration, Concept Generation, Idea Development, Preparation for Realization and Realization. The name of each phase came from the most representative name of the grouped stages. Then the activities performed during each phase were analyzed based on the keywords and tasks. Figure 18 depicts the entire stages of the unified PSS development process.

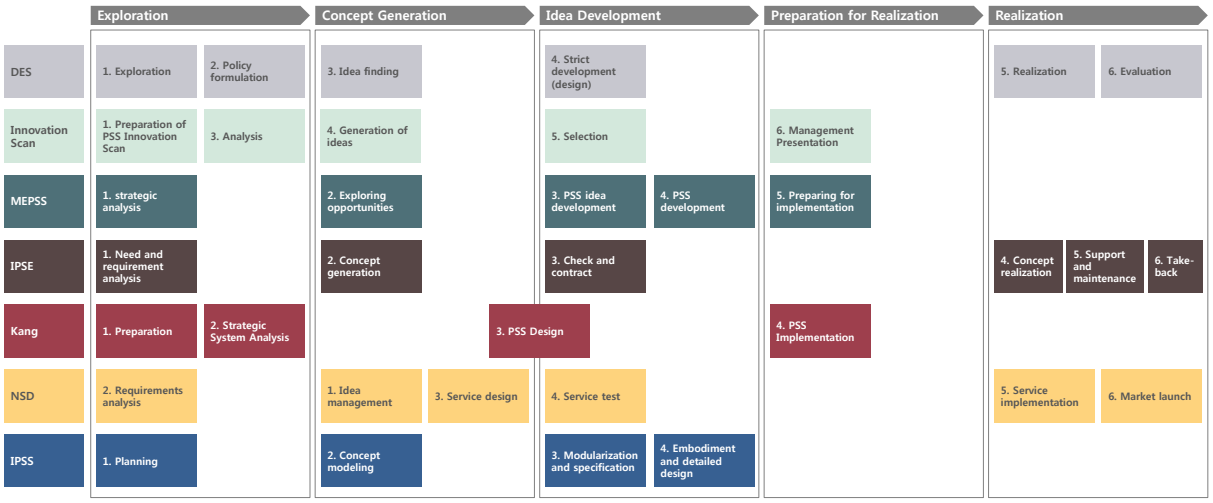


Figure 17 Rearrangement of Process Segment

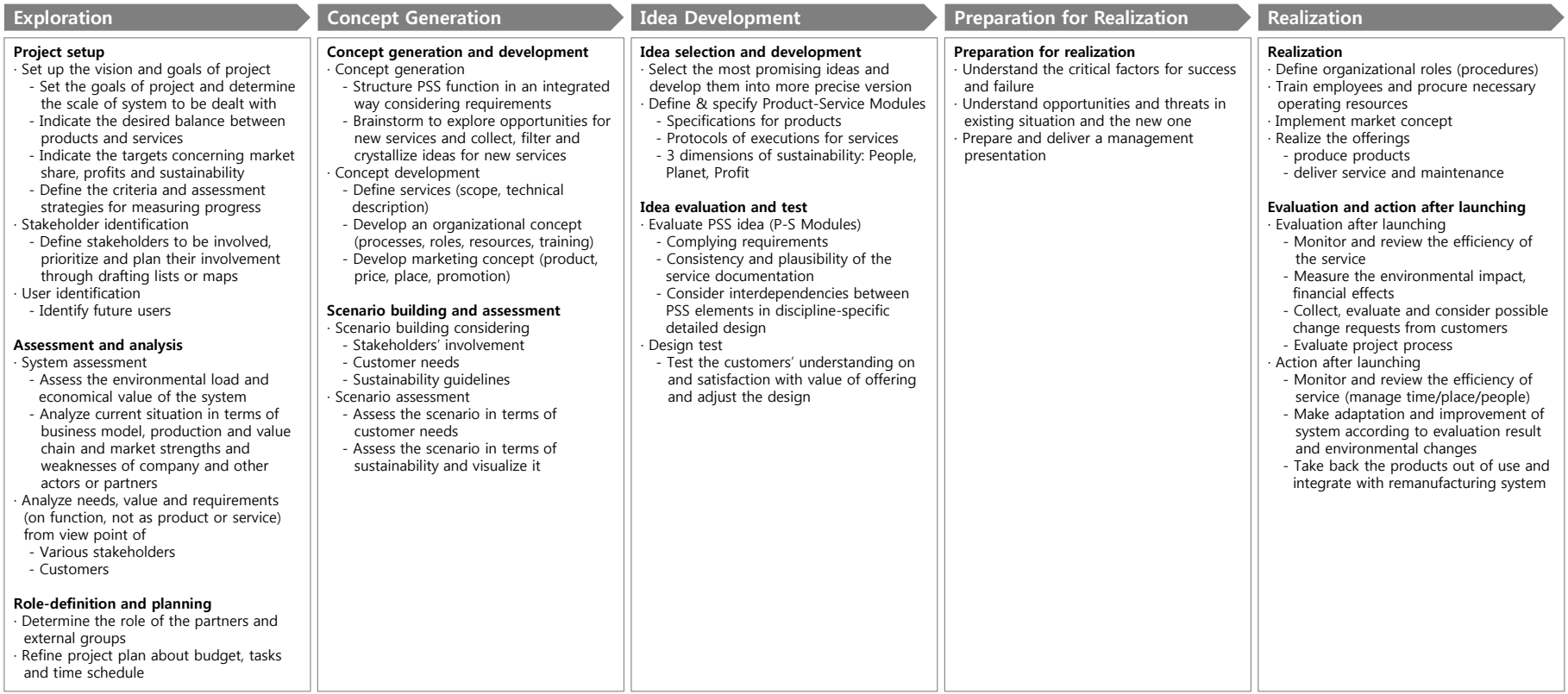


Figure 18 Unified PSS Development Process

3. METHODOLOGY

3.1 Diagnosis of SHA Development Process

To address the first research question of 'how to identify the section of the existing SHA development process in need of supplementation and/or reinforcement through the adaptation of the PSS development process,' a diagnosis framework was developed based on existing PSS development processes and applied to a case of SHA development process.

The diagnosis method was inspired by Innovation scan (Tukker & Van Halen, 2003) and 'MEPSS' (Van Halen et al., 2005) which can provide a remedy to make up for the weakness of process. Both of those methodologies were designed with great care to practical application, and their modular approach can reduce the burden of practitioners from adopting unfamiliar methodology and encourage use of PSS development methodology. For this approach, Innovation scan uses a checklist to scan if the company is fulfilling the requirements suggested at each stage, and MEPSS provides a list of frequently asked questions together with tools which can help to answer the question. In this study, checklist type was thought to be more appropriate because FAQ type is more effective for the developers who have basic knowledge of PSS and recognize their own problems for PSS development. For detailed diagnosis, checklist items were arranged for every activities involved in stages.

Based on the unified PSS development process (figure 18), interviews were designed to diagnose the current SHA development process. In the interview, the interviewees were asked to answer the following questions for each activity included in process stages:

1. Is this activity conducted in current SHA development process?

2. Is this activity necessary for your SHA development?

3. Through this activity, how do you expect your SHA development process to be improved?

The question 1 and 2 were answered as 3-point likert scales: to a great extent (2), somewhat (1) and

hardly (0). From the answers to questions 1 and 2, the activities which presented a strong demand for improvement were identified. Question 3 addressed the pain points of the current development process and expectations on a new method in depth.

The requests for interviews were made to 20 SHA experts, and 5 of them responded. Interviews were conducted for 1 to 1.5 hours and every interview was recorded and transcribed. As one interviewee belonged to a different company from the others, his interview data were excluded in this analysis. The information of 4 interviewees is summarized in table 13.

Table 13 Interviewee Information

		Interviewee 1	Interviewee 2	Interviewee 3	Interviewee 4
Department		UX design	UX design	Product planning	Product planning
Position		Assistant manager	Assistant manager	Senior manager	manager
Years of service		3	2	13	6
Involving stages					
Exploration	Project setup	○	○	○	○
	Assessment and analysis	○	○	○	○
	Role-definition and planning	-	○	○	○
Concept Generation	Concept generation and development	○	○	○	○
	Scenario building and assessment	○	○	○	○
Idea Development	Idea selection and development	○	○	○	○
	Idea evaluation and test	○	○	○	○
Preparation for Realization	Preparation for realization	-	-	○	○
Realization	Realization	-	-	-	-
	Evaluation and action after launching	-	-	○	○

After conducting the interviews, the transcripts of interviews were organized according to related activities and interviewees and categorized based on thematic coding as depicted in figure 19 (Galleta, 2013). Although the main purpose of checklist was to explore the entire PSS process and elicit the answers about the problems on their own process, the answers to the question 1 and 2 were also analyzed through quantitative analysis: the average of scores of the 4 interviewees on each activity were calculated and plotted on the chart (figure 20).

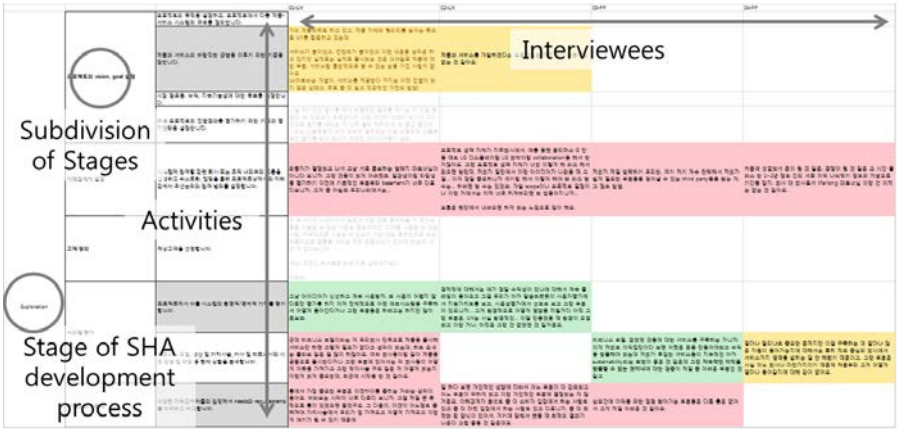


Figure 19 Analysis of Transcripts

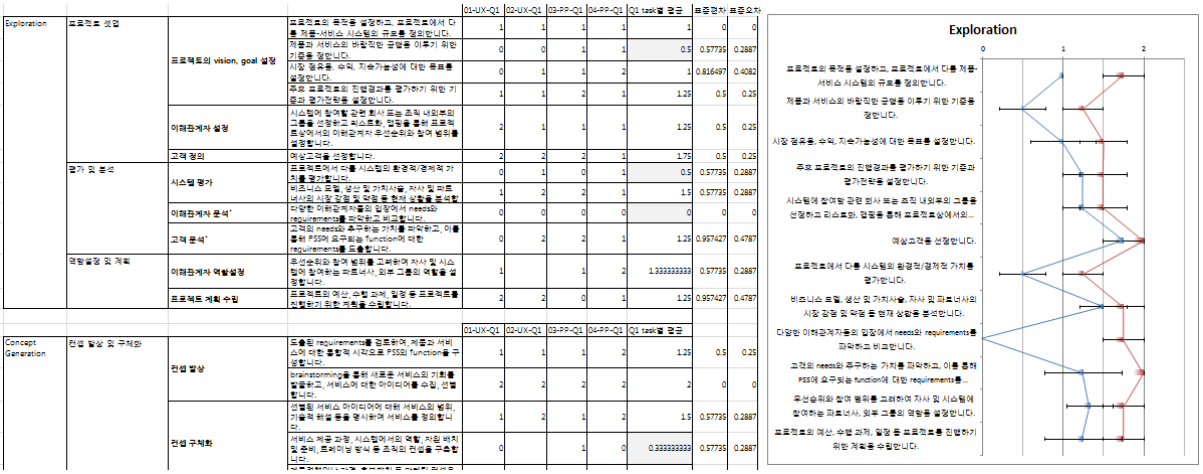


Figure 20 Analysis of Response of Question 1 and Question 2

3.2 Verification of PSS Development Methods

After diagnosing the current SHA development process, a workshop with SHA development practitioners was planned as the attempt to answer the second research question, 'how the section of the existing SHA development process that need enhancement can be supplemented or reinforced with PSS development tools or methods.' At the request of participants, the theme for the workshop was decided as the finding of new service for a smart robot cleaner. The workshop was held at the meeting room of the company building and run for 4 hours with 7 SHA development practitioners from product planning, UI design, engineering and service planning departments working for same company. 3 participants could not go through the entire process of the workshop due to their business schedule. Table 14 provides the participant information. With the consideration of these conditions for the workshop, 18 tools were selected from 36 PSS development tools which were collected through the literature review. In this research, basically the development tools were collected from 7 literatures which were used to construct the unified development process because the activities they support are already identified in the literature. To select the tools which are applicable the actual workshop, the tools which take long time to get required preexisting knowledge and to be trained to use the tool , require the participation of stakeholders, require information – related to social and environmental

Table 14 Participant information

Participants	Department	Position	Years of service	Participated session
Participant 1	Interaction design	Researcher	2	Entire process
Participant 2	Advanced control	Assistant engineer	3	Entire process
Participant 3	Product planning	Manager	11	Entire process
Participant 4	Convergence service	Staff	5	Entire process
Participant 5	Product planning	Assistant researcher	7	System analysis
Participant 6	Product planning	Assistant researcher	7	System analysis ~ Idea generation
Participant 7	Advanced control	Assistant engineer	7	System analysis ~ Idea generation

sustainability – which cannot be provided by participants were excepted. Also, the tools which are not supporting problem-oriented approach and too complicated so not appropriate for novice PSS tool users were refused (Appendix 1). Considering the fact that environmental experts who can provide the information which is required for sustainability assessment and external stakeholders are not supposed to participate in the workshop, among 3 issues from the interviews the workshop was designed focusing on supporting the adoption of service. Therefore, the scope of the workshop was set as problem identification, idea generation, development and evaluation.

In addition, the tools were filtered depending on degree of current implementation and the necessity of PSS methodology application to SHA development. Through selecting tools which can support the activities with low scores on question 1 and high scores on question 2, the tools supporting the activity 14, 19, 20 and 21 were remained (Appendix 2). For idea generation, PSS matrix was considered to be appropriate because it provides the framework for ideation – 3 types of PSS – which can help participants to generate ideas with consideration of different combination types of products and services. Among the tools involved in activity 21, synthesis of ideas was selected for idea development. Through arranging ideas on the matrix the promising ideas can be recognized and participants can develop the PSS solution by combining the ideas around the promising ideas. In addition, strategy matrix and score table were employed for evaluating PSS ideas. Score table provide a list of criteria to evaluate attractiveness of the PSS and business fit of PSS ideas and the evaluation result can be visualized on strategy matrix so that participants can make decision on investment to further develop the ideas.

Meanwhile, a tool to identify the problems could not be found from the activities with high necessity, so system-SWOT analysis, which is the only applicable tool included in the exploration stage, was adopted. Through using this tool, participants can identify the opportunities and problems in the existing business model and then the service ideas can be generated and developed based on those findings. Also, story board format was borrowed from scenario building tool to visualize the PSS solutions.

Before the actual workshop, the applicability of the tools and the workshop procedure were verified through a pilot workshop. As it is very hard for the practitioners to devote time to the tasks other than business, the pilot workshop was carried out with 5 design students who were taking the course on PSS. The main theme of the PSS classes was bottled water industry, so the pilot workshop also was conducted with the topic of new business model for bottled water so that students can deal with the familiar topic based on abundant background knowledge. Although the characteristics of robot cleaners could not be reflected to the revision, the pilot workshop with the design students was sufficiently beneficial because they had experience of participating in workshops, so could give enough feedback about the workshop and tools. Initially the workshop was composed of system analysis, idea generation, visualization and evaluation sessions in 4 hours, and (a) system SWOT analysis (Kang, 2009), (b) PSS Matrix (Tukker & Van Halen, 2003), (c) priority matrix (Kang, 2009), (d) story board (Kang, 2009) and (e) strategy matrix (Tukker & Van Halen, 2003) were employed as the supporting tools (figure 21).

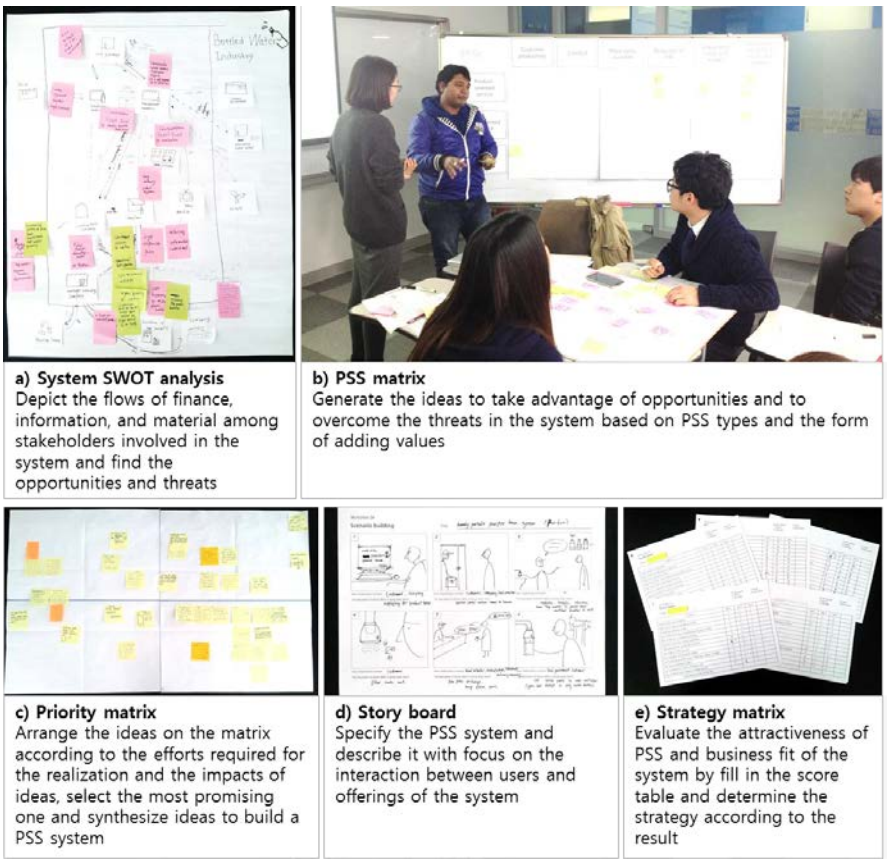


Figure 21 Pilot Workshop

According to the result from the pilot workshop and the scope of the actual workshop, some tools were exchanged and methods and time distribution were revised. In detail, system SWOT analysis was replaced with touchpoints matrix. As external stakeholders will not participate in the actual workshop, system SWOT analysis, which is based on system maps and indicate the relationship among involved stakeholders, was considered inappropriate for this workshop. Instead, the tool for exploration of service opportunities to provide customers with benefits was desired. As there was no appropriate tool for the exploration phase in the PSS tool list from literature review, touchpoints matrix was newly adopted. Although this tool is introduces as a service design tool, it focused on the connections among products which act as touchpoints and support the services in the user's journey (Brugnoli, 2009). In terms of consideration on product-service system and the relationship among products, this tool was regarded to be effective in SHA development. Meanwhile, PSS matrix with rows of PSS types and columns of added value types was so strict and complicated that the students felt this activity was more like for organizing ideas rather than for generating ideas. Also the forms of added value are too general for SHA development, so the idea sources were provided in the shape of cards instead of matrix and the format and the contents of cards were tailored for SHA development. Because of the time constraints on the workshop, the idea visualization session was omitted. The program of the actual workshop is described in table 15.

Table 15 Workshop Program

Activity	Time	Used Tool	Reference
An introduction to the basic concept of PSS	30 min		
System analysis	60 min	Touchpoints matrix	(Brugnoli, 2009)
Idea generation	90 min	Ideation card game	(Tukker & Van Halen, 2003)
Idea synthesis	30 min	Priority matrix	(Kang, 2009)
Idea evaluation	15 min	Strategy matrix	(Tukker & Van Halen, 2003)
Survey	15 min		

The PSS development tools which were utilized in the actual workshop were introduced in table 16. In system analysis session of the actual workshop, 2 participants were asked to describe their routines using touchpoints matrix and then all participants explored the problems and opportunities in interaction with touchpoints– products or services encountered in user journey– based on the journey of 2 participants. The findings from this activity were utilized as the idea sources in the idea generation session. The participants generated ideas to solve the problems or take advantage of the opportunities found in previous session using cards containing the information about PSS types, the attributes of SHAs, possible interaction objects and base technology. They got some hints for solutions from the cards and described their ideas on Post-it notes. The idea generation and arrangement of the ideas on the priority matrix were proceeded at the same time. When a new idea came out the participants discussed about the impact of the idea and the efforts required to realize it and attached the Post-it on the priority matrix. After the idea generation session, the most promising ideas were selected and with focus on those ideas the ideas were synthesized to build PSS solutions. Finally the PSS solutions were evaluated in terms of the attractiveness of the PSS and business fit. The participants wrote down the weighting factors to indicate the importance of each criterion and the evaluation scores on the score tables and evaluation result was visualized through strategy matrix.

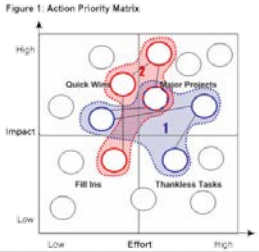
After the workshop is over, the survey to evaluate the workshop from the participants' perspective was conducted. In the survey, the participants responded how much the workshop was helpful in terms of a) exploring business opportunities and business models and b) defining and assessing services were in 5-likert scale. Moreover, the tool which made them think so was asked. Also, the survey includes following questions:

· Which tool was the most helpful to SHA development? Why?

· Which tool was the most unhelpful to SHA development? Why?

· Which tool was the most difficult to utilize? Why?

Table 16 PSS Tools Used in the Actual Workshop

Tool name (Reference)	Image	Related activity in the PSS process	How to use
Touchpoints matrix (Brugnoli, 2009)		Exploration- Analyze needs, value and requirements on function from view point of customers	1) Set the phase of activities (columns) and touchpoints (rows) to be explored 2) Mark the touchpoints used on each activity phase 3) Describe the journey of users by connecting the marks 4) Write down the opportunities and problems which are found in the interactions between users and touchpoints on Post-it notes and attach them on the matrix
Ideation card game (revision of PSS matrix from Tukker & Van Halen, 2003)		Concept Generation- Brainstorm to explore opportunities for new services and collect, filter and crystallize ideas	1) Remind the opportunities and problems from system analysis and scan the contents of ideation cards 2) Generate ideas to utilize the opportunities, to solve the problems and to improve other people's ideas through combining the cards 3) Describe the ideas on Post-it notes, share them with other participants and attach them on the priority matrix
Priority matrix (Kang, 2009)		Idea Development- Select the most promising ideas and develop them into more precise version	1) Understand the structure of the matrix. (horizontal axis: difficulty, required effort, vertical axis: impact) 2) Arrange the ideas on the priority matrix 3) Construct the PSS solutions based on the promising ideas with high impact
Strategy matrix (Tukker & Van Halen, 2003)		Idea Development- Select the most promising ideas and develop them into more precise version	1) Assign 10 points to the evaluation criteria to determine their importance (max. 3 points for an item, sum of points become weighting factor) 2) Evaluate each PSS solution using score tables in 5 points likert scale 3) Make total of evaluation scores and arrange the solutions on the strategy matrix to set up strategy

· Compared to the ordinary tools, what are the strong and weak points of the PSS tools used in this workshop?

To evaluate the effect of the workshop and involved tools, the output of the workshop and survey responses were analyzed. ABC analysis method (Rebernik & Bradač, 2008) was adjusted for evaluation of generated ideas in terms of requirements for SHA development process that were suggested in the diagnosis phase. According to the reflection degree of requirements, ideas were categorized. The categorization was repeated by 2 coders until inter-rater agreement is obtained. In addition, survey scores were totaled and compared among tools and requirements. Also the comments about the tools and the whole workshop from the survey were reviewed. The survey was carried out with 4 participants who carried through the entire workshop process.

4. RESULTS

4.1 Diagnosis

Figure 22 shows the summary of the response data to the question 1 and 2. In this graph, blue points and red points indicate the answers to question 1 and 2 respectively. According to the response of question 1, the activities with circle marks which scored lower than 1 can be regarded as the activities which are not being undertaken sufficiently. As described in figure 22, they are concentrated on the earlier phases of entire process. Meanwhile, the activities framed rectangle shows the high necessity of adoption of PSS development activities. The activities which got high scores on both question 1 and 2 imply that these activities are so important that they are still in need for improvement although they are currently being conducted well.

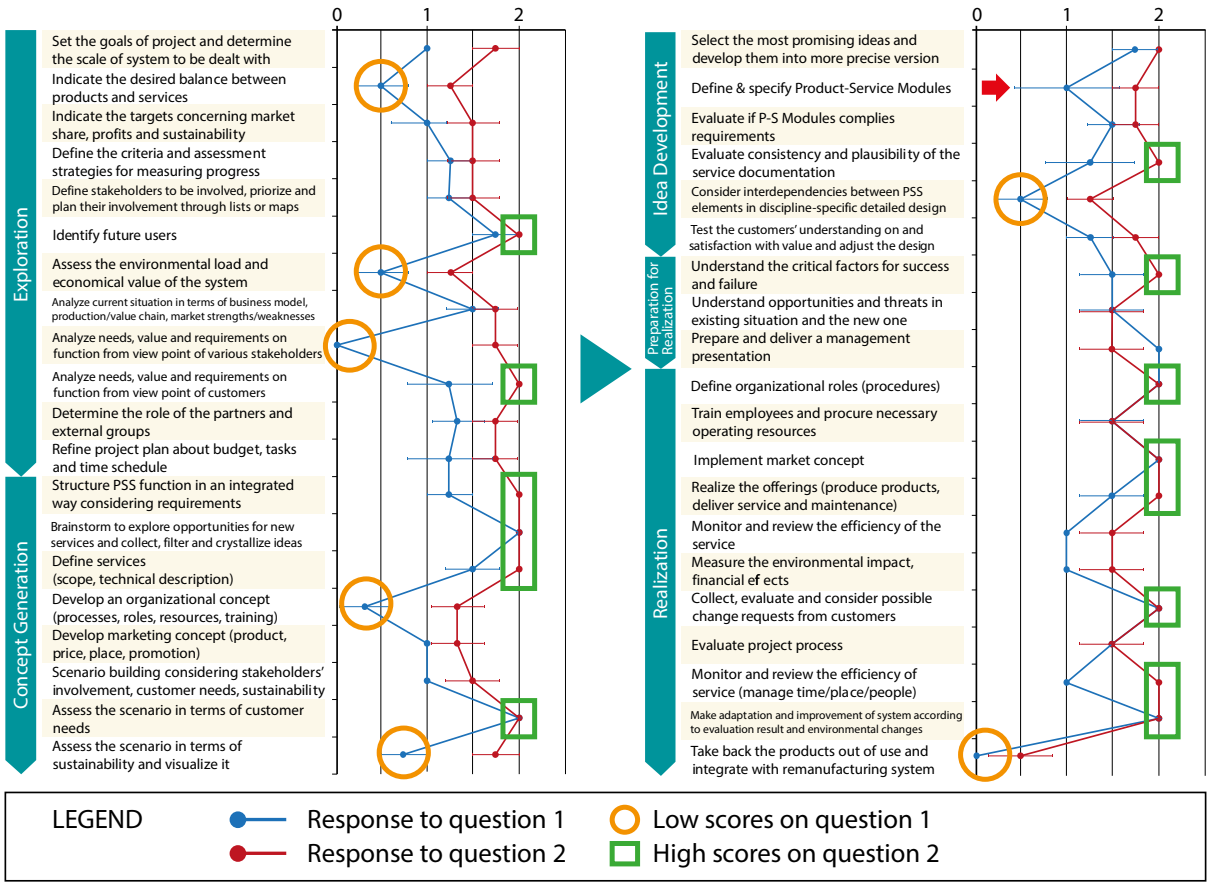


Figure 22 Response of Question 1 and Question 2

With respect to the standard error described by error bars, the second activity of the idea development stage ‘defining and specifying product-service modules’, which was marked with a red arrow, displays outstandingly large value. For this activity, UX designers gave 0 as the answer while product planners gave 2 points. This difference seems to be caused by the different perspectives of UX designers and product planners on services. UX designers claimed that the projects were principally prone to be focused on product improvement from the stage for investigating needs and requirements, so the service modules were not developed as well as product modules were. On the contrary, product planners were recognizing service modules as the modules which were utilized to contact customers like software, applications and infra servers and they thought that it is natural to develop product modules and service modules separately for parallel development.

The interview analysis revealed 3 main pain points in the current SHA development process.

a) The difficulty of handling service

The most evident problem was that the practitioners were not familiar with developing, evaluating or managing services. As the corporate culture is manufacturing-oriented, the company has had few projects on integrated products and services. Therefore, practitioners hardly had opportunities to learn how to develop services. Interviewee 1 said “Although we think about combining products with services and contents, what have been launched on the markets is usually product-oriented. There is no one who has an integrative perspective on both products and services in our team.” Without an integrative perspective, it is hard to achieve a balance between products and service. As a result, services for SHA are usually developed through product-oriented approach to improve the quality of products such as providing or managing media contents. About developing an organizational concept, interviewee 3 mentioned “As the company is manufacturing-centered, we are not used to defining services. To define how to use a product, for instance, which button the users should push, is easy, but specifying services, especially building or training service organization is challenging.”

The interviewees assessing service elements also had difficulty. Interviewee 4 told us that the criteria

to evaluate services were obscure and therefore absolute evaluation of services was difficult. Under the condition that how the services for SHA should be is not clearly defined, setting the criteria is not easy. Interviewee 3 also noted “We are currently establishing a service development process. Evaluating the degree of service completion and acceptance to the market is very difficult.” He emphasized the need for evaluation tools prior to the stage of assessing interdependencies between products and services.

b) Lack of consideration for sustainability

Another problem is that sustainability is not taken into account in the development process. In PSS development process the sustainability of a system is evaluated from 3 different perspectives: social, economic and environmental aspects. According to the interviews, however, the sustainability considered by SHA companies is mainly about economic feasibility and usability. Interviewee 2 commented on assessment of environmental load and economical value that they investigated profitability of new ideas continuously through user evaluation to ask willingness to pay or preference, but they did not consider how the SHA would affect the environment yet. When it comes to scenario assessment, interviewee 1 said “To tell the truth, some functions of smart refrigerators are more annoying than convenient. A refrigerator itself is nothing but an icebox. When smart functions are added to it, users only try them a few times and stop using them in the end.” Interviewee 3 also admitted that the products after use were undermined. The tendency to underestimate social and environmental issues in development process may have been established due to product-centered business model; as their major profit comes from selling products, they naturally focus on how to deliver by selling more products.

c) Weak relationship with stakeholders

The interview revealed a low level of involvement of stakeholders in the development process. In the current process, the concepts or ideas for SHA are generated and developed internally, and only after they have been specified enough, shared with external stakeholders. As the stakeholders do not

participate in the early phases of development process, understanding their needs or requirements is not necessary, either. Regarding this aspect, interviewee 3 stated “We look for the most appropriate third party which are advantageous for us to cooperate with or which can fulfill our needs easily. The most difficult thing is producing an agreement to create a mutually profitable relationship.” As saying by interviewees, cooperation with external stakeholders from the initial phase is usually avoided because of security issues and tricky distribution of profit. Unless the cooperative project is set by top-down decision-making or based on MOU relationship, those problems become a powerful barrier to idea development that requires the involvement of external stakeholders.

4.2 Verification

Workshop Outcomes

With touchpoints matrix, daily lives of 2 participants passing through 20 touchpoints were explored and 20 problems and 12 opportunities were derived from their daily experiences. In ideation card game, a total of 26 ideas were generated and these ideas were categorized according to the reflection degree of service perspective and systematic perspective as described in figure 23.

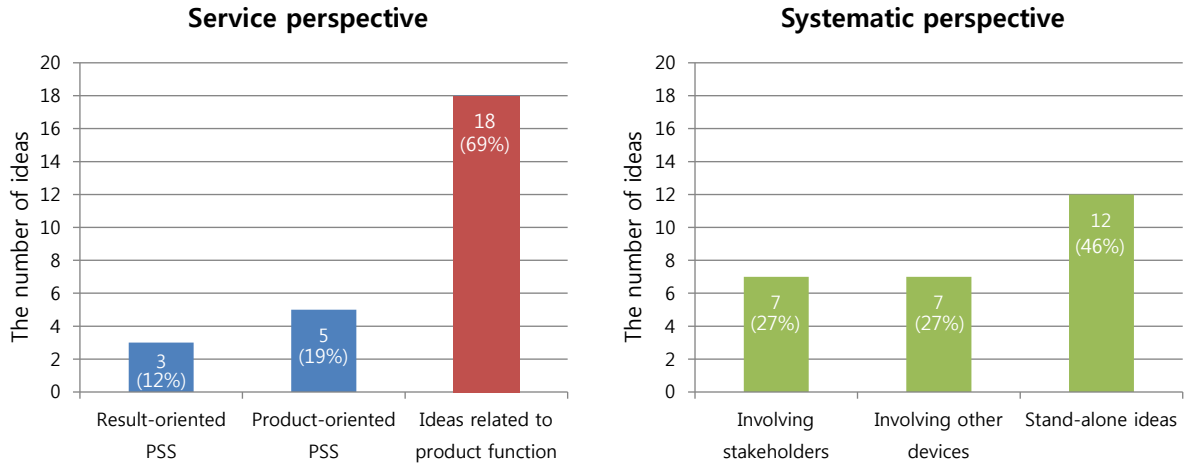


Figure 23 Idea Categorization Result

As the blue bars show in figure 23, about a third of ideas include service elements. In terms of the types of PSS (Tukker & Tischner, 2006), 5 ideas for product-oriented PSS, 3 ideas for result-oriented PSS and no idea for use-oriented PSS were obtained. Moreover, even 3 result-oriented PSS ideas were suggested on the premise that the users possess the products: a robot cleaner is purchased for its major function – vacuuming the house – and take additional role in a PSS as an assistive device utilizing its minor function. This result implies that although the cards containing the 3 types of PSS stimulated the ideation of participants, it was hard to change their manufacturing-centered and sales-oriented perspectives. Also, this tendency may be caused by the touchpoints matrix. As the idea sources were derived from routine life, the problems or opportunities on the purchase process could not be taken into account.

In terms of systematic approach, more than half of ideas involve the cooperation with external stakeholders or other home appliances. Note that 7 of 8 ideas involving service elements are classified as ‘involving stakeholders’ and the other idea belongs to ‘involving other devices’ (Figure 24). From this result it can be inferred that consideration on the cooperation with external stakeholders, especially existing service providers, can be a good stimulus for service-based idea generation. The systematic approach could be induced through exploring a wide range of life journey with touchpoints matrix and making reference to the cards presenting possible interaction objects and the attributes of SHA in idea generation phase.

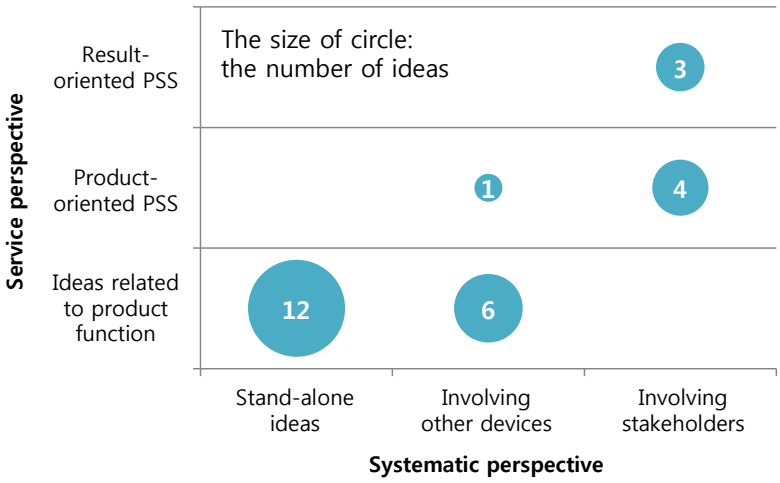


Figure 24 Distribution of Ideas by Systematic and Service Perspectives

Survey Results

In the survey, all respondents said that the whole workshop was 'somewhat helpful' for exploring business opportunities and business models and 2 of them selected priority matrix and the others chose strategy matrix as the beneficial tools for business opportunity exploration. With regard to defining and assessing services, 2 respondents evaluated the workshop as 'very helpful' and the others evaluated as 'somewhat helpful.' The most useful tool for handle service was priority matrix which was chosen by 2 participants, and the other 2 people selected ideation card game and strategy matrix respectively.

Although the survey included the questions about the most helpful, unhelpful and difficult tools, the meaningful quantitative analysis result could not be obtained because the number of the respondents was too small. Instead, the comments on each tool were displayed in table 17.

Table 17 Comments on Each PSS Development Tools

Tool name	Positive comments	Negative comments
Touchpoints matrix	"It was helpful for understanding and having a perspective on external environments of products." "A tool considering lifecycle seems to be effective for home appliance development." "It was beneficial in terms of organizing ideas depending on the scenario…"	"Selection of touchpoints from limited items." "Abstract painpoints disturbed to grasp core problem." "The standard to set activity phases and to organize touchpoints was ambiguous."
Ideation card game	"The concept could be developed naturally by improving each other's ideas."	"It has the limitation in terms of conventional method and technological approach."
Priority matrix	"Effects for efforts were visualized."	"The evaluation of value with experts from various department was difficult."
Strategy matrix		"The criteria and understanding of each participant on various axes were different." "It seems to make no difference from Priority matrix."

In regard to touchpoints matrix, the participants commented that consideration on routine life was effective for home appliance development and it broaden their perspective to understand the environment around the product. However, it was also the most difficult tool to use because setting

the phase of activities and touchpoints was an ambiguous task. When it comes to ideation card game, participants were satisfied with the advantage that they could naturally develop the concept by adding own ideas to those from other people. However, it felt to be similar to usual ideation method and focused on technology-centric approach. Meanwhile, priority matrix was a useful tool to visualize the value creation by effort for realization of ideas, but to achieve general agreement on the value of ideas among the participants from different departments was challenging. For strategy matrix, understanding difference of participants on the criteria was recognized as a problem. Also, a participant said that using both strategy matrix and priority matrix seemed to be redundant.

As the overall evaluations, scenario-centered approach, immediate evaluation on ideas, consideration on various view points and systematic construction of tools were described as the advantages of PSS tools. On the contrary, the limitations of PSS tools were also discussed: blurred distinction from general analysis methods, difficulty in verification of customer value and trickiness of establishing clear standards for each tool.

5. DISCUSSION

5.1 Diagnosis

Returning to the research question 1, ‘how to identify the section of the existing SHA development process in need of supplementation and/or reinforcement through the adaptation of the PSS development process’, it was verified that the unified PSS development process can be used as a diagnosis framework to find out weak points of the SHA development process which can be overcome by applying PSS development methodology through the expert interviews. Through comparing existing SHA development process and PSS development process, and answering to the questions about current conditions of operation, necessity of and expectations on activities involved in PSS development process, the limitations of current SHA development process and the stages which need to be enhanced were identified.

Based on the result of diagnosis, the expected benefits of improving SHA development process are elaborated as below.

Cooperation with external stakeholders

Through exploring and understanding the needs of stakeholders in an SHA ecosystem, greater values can be generated through a business model as such a model addresses their demands more effectively and thus satisfy them better. In such a model, participation and cooperation of the stakeholders are encouraged and greater social values are generated.

Moreover, user information shared by various stakeholders can act as a good stimulus for idea generation. The problem scope of conventional SHA development has been limited the usage of home appliances. However, the manufacturer can discover hidden needs of users and generate innovative solutions by sharing the view points and experiences with other stakeholders. Unexpected needs or problems introduced by other stakeholders can be a source of inspiration for SHA developers, or the user needs failed to be addressed by them could be fulfilled by the solutions from other stakeholders.

Support for the service approach

Most activities related to defining services are not going well and it is caused by the practitioners' lack experience in dealing with service in a manufacturing-centered company. When we consider the alternative, getting help from service-specialized companies is easier and more effective way to develop service elements. In addition, developing organizational concepts and marketing concepts together with other stakeholders will contribute to maintaining consistency of their offerings. However, collaborating with external stakeholders from the early phases is almost impossible in reality because of security issues and profit distribution. Before suggesting collaboration, manufacturing companies can utilize PSS development methods to explore business opportunities and conceive business models which can fulfill users' needs better by combination of product and service elements. Being assured about their business model, they would be able to make decision to work with others with confidence.

Proactive stance on sustainability

While the SHA manufacturer has a team dedicated dealing with environmental regulations and corporate social responsibility (CSR), collaboration between the sustainability team and developers does not occur. In other words, sustainability is not at the core of business model but exists at the peripheral as CSR. However, a more positive approach to social and environmental sustainability can give a new perspective on their business and lead to product and service innovations. Adopting PSS methodology, companies can consider sustainability issues from earlier phases of the development process and find out solutions for both their own business and sustainability.

5.2 Verification

Addressing the research question 2, ‘how the section of the existing SHA development process that need enhancement can be supplemented or reinforced with PSS development tools or methods,’ according to the survey result, the participants felt that the workshop was helpful for dealing with the issues related to services on the whole. In this research, the effectiveness of PSS development tools to improve two activities with high demand of PSS development approach was verified.

Activity 14: Brainstorm to explore opportunities for new services and collect, filter and crystallize ideas

The responses to the survey revealed that touchpoints matrix and ideation card game worked effectively. Although touchpoints matrix was adopted for ‘analyzing needs, value and requirements on function from view point of customer’ on exploration stage, its Scenario-centered approach helped participants to find the problems and opportunities from the product and the interaction between the product and users. Also, the journey of users’ daily lives helped the understanding of ecosystem around the products so that participants can see through the possibility of connection with other products or services. Based on the findings from touchpoints matrix and the information provided by cards, they could generate ideas and improve other people’s ideas in a natural way.

The analysis of ideation outcome also implies that the ideas involving the collaboration with other devices or stakeholders are more likely to include service elements than the ideas for stand-alone products. To stimulate the service-oriented thinking, not only the idea sources and the framework of tools to lead participants to take service approach but also those to make them consider the cooperation with other products and external stakeholders can be beneficial.

Activity 21: Select the most promising ideas and develop them into more precise version

In this activity, priority matrix and strategy matrix were utilized. These tools seem to be influenced a lot by the various backgrounds of participants. As the participants from a variety of departments work

together, the pursuit of value and criteria to evaluate ideas may be different depending on their departments. Such diverse perspectives can not only bring a wide range of considerations and raise the quality of ideas but also cause conflict or confusion on idea evaluation. Respondents satisfied with priority matrix in terms of immediate evaluation on ideas, and visualization of effects for efforts. However they claimed that reaching general agreement on the values and criteria among the participants was difficult.

In order to set PSS goal and evaluate ideas in the appropriate way, the values and standards should be set carefully considering both products and services elements involved in PSS and shared enough among participants.

6. CONCLUSION

This paper aims at improving the development process of smart home appliances whose core competence lies in offering customized services through an integrated solution connecting users, products and stakeholders. It argues that the conventional process can be improved by adapting product-service system methodology. As the first step, literature studies were conducted to identify the characteristics of SHA, and to develop a unified PSS development process. Based on the interviews with practitioners, activities of development process practiced in the field and in need of improvement were identified. The earlier stages of development process need to be supplemented by PSS development methodology, especially in terms of dealing with services, communication and collaboration with other stakeholders and consideration on social and environmental sustainability. Furthermore the PSS development tools were evaluated in a workshop for SHA development practitioners with focus on handling services. According to the analysis of the workshop outputs and survey results, PSS development tools could support 'brainstorming to explore opportunities for new services and collect, filter and crystallize ideas' and 'selecting the most promising ideas and develop them into more precise version.'

As this research aims the practical application of PSS methodology and should be conducted with practitioners, there are many constraints which make the study difficult. In order to develop the optimized tools and methods for SHA development, data from various application cases need to be accumulated and a variety of PSS development tools should be tested and revised according to the feedback from practitioners. Nonetheless, running experiments involving practitioners is challenging especially in SHA manufacturing field because of limited time, complicated organizational structure and develop process, company policy, security issues and harsh competition in industry. For example, sustainability assessment is usually a time consuming task and requires data related to environmental burden and social impact involved in the lifecycle of product, so practitioners would not welcome these studies unless they have strong motivation. Moreover, the SHA manufacturers are mostly big

global companies whose security policies tend to be stricter than medium enterprises and they are so cautious about working with external stakeholders that getting an opportunity to test the tools related to collaboration among stakeholders is almost impossible.

However, the research at practical level is essential to encourage the application of PSS development methodology in practice. As developmental process and methods are critical issues in SHA industry, the tools and methods should be fit into the needs of companies and the effect of them need to be ensured to be accepted in practical field.

To stimulate the application of PSS development methodology to the manufacturing-centered field like SHA industry, a standardized process and tools to support each activity involved in the process need to be developed based on the cooperation of PSS experts and practitioners. Existing PSS tools need to be revised with consideration for conditions and constraints of practice and industry characteristics: they need to be tailored to SHA development conditions and simplified so that practitioners who are not familiar with PSS can use them in effective and intuitive way. Also, additional practical case studies should be conducted to provide PSS researchers with up-to-date tendency and condition of industry to be reflected to the revision of PSS development methodology.

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APPENDIX

1. Tool Selection Table

No.	Tool name	Reference	Required time	Requirements	Selection criteria	Related activity
1	EVR(eco-cost/value ratio)	1. DES	3~4h	lifecycle 각 단계에서 창출되는 가치와 eco-cost (prevention cost at the norm) 파악	time constraint	7, 22
2	VIP-approach (Vision in Product development)	1. DES	1~2h		not appropriate for problem definition	14
3	LiDS-wheel (lifecycle design strategies)	1. DES	3~4h		time constraint	14, 22
4	Meta-matrix	1. DES	2~3h	서비스 실행에 필요한 media/channel 리스트 및 각각의 단위사용당 소요되는 에너지량	detailed information required	22
5	Blueprinting	1. DES	1~2h	서비스 컨셉	**applicable**	22
6	Mindmap	2. Innovation Scan	0.5~1h		for warming up	1
7	Forms of adding value	2. Innovation Scan	0.5h	현 system 에 대한 분석	included in PSS matrix need to be tailored to SHA development	13
8	Creativity session	2. Innovation Scan	1~2h		**applicable**	14
9	Classical brainstorm	2. Innovation Scan	ideation: 0.25h weeding/ highlighting ideas: 0.25h		**applicable**	14
10	Brainwriting	2. Innovation Scan	0.5~1h		**applicable**	14
11	Progressive abstraction tool	2. Innovation Scan	0.5~1h		not appropriate for problem definition	14
12	Bono's 6 hats	2. Innovation Scan	1~2h		**applicable**	14
13	PSS matrix	2. Innovation Scan	1~2h		**applicable**	14
14	Ansoff matrix	2. Innovation Scan	0.5~1h		**applicable**	21
15	Strategy matrix	2. Innovation Scan	0.5~1h	Score table 을 통한 multi-criteria analysis 결과	**applicable**	21
16	Score table	2. Innovation Scan	1~2h	심도 있는 평가가 필요한 항목에 대해서는, quick analysis with four-axes model 사용	**applicable**	21
17	Pragmatic differential	2. Innovation Scan	0.5~1h		**applicable**	21
18	Quick analysis with four-axes model	2. Innovation Scan	1~2h		**applicable**	21
19	Ecodesign portfolio	2. Innovation Scan	0.5~1h	아이디어 대안에 대한 배경지식	**applicable**	20,21
20	Variables' checklist	3. MEPSS	1~2h	시스템에 대해 파악하고 있는 다양한 참가자의 시각	(use before 'cross impact analysis and/or 'system's feedback diagram') time constraint participation of stakeholders is required	7 8

21	Cross impact analysis	3. MEPSS	워크샵 자체: 0.5~1day	variables' checklist (완성된 뒤, scenario building 에 활용 가능)	(use after 'variables' checklist) time constraint participation of stakeholders is required	7 8
22	System's feedback diagram	3. MEPSS	시스템분석: 1~3 달	variables, system analysis 앞단계의 자료	(use after 'variables' checklist') time constraint participation of stakeholders is required	7 8
23	Inventory sustainability indicators	3. MEPSS	2~3h		complicated detailed information required for PSS experts	3, 4, 5, 7, 18, 19, 21, 22
24	Property rights analysis	3. MEPSS	2~3h	어느정도 구체화 된 PSS idea	participation of stakeholders is required	4, 8, 18, 19, 21, 22
25	Exploring customer needs	3. MEPSS	0.5day	고객에 대한 지식, 어느정도 구체화 된 PSS idea	time constraint complicated	10
26	Assessment of customer acceptance	3. MEPSS	2~3h	고객에 대한 지식, 니즈 이해능력	**applicable**	21, 26
27	Sustainability design-orientating	3. MEPSS	3~5h	앞서 이루어진 정량적 평가 결과	time constraint	3, 18, 20, 21, 22
28	System map	3. MEPSS	system map: 0.5h each phase: 2/3h	구체화된 아이디어, 이하관계자 조직에 대한 설명과 그 사이의 흐름 (완성된 후, 전략논의나 PSS 개선에 활용)	**applicable**	18, 19, 21, 22
29	Service explorer	4. IPSE	3~4h	이해관계자가 참여하지 않을 경우, 고객의 상태변화에 영향을 주는 다양한 요인에 대한 파악 필요	time constraint complicated for PSS experts	21, 22, 23
30	System-SWOT analysis	5. Kang	2~3h	system map (완성된 뒤, sustainability assessment 를 통해 지속가능성 분석 가능)	**applicable**	8
31	Synthesis of ideas (Priority matrix)	5. Kang	1~2h	sub-ideas related to products, services, production processes, service arrangements, marketing	**applicable**	21
32	Sustainability assessment	5. Kang	2~3h		detailed information required	23
33	Guidelines for emotional PSS design	5. Kang	1~2h		**applicable**	22 23
34	Stakeholder identification and prioritization	5. Kang (3. MEPSS)	2h		participation of stakeholders is required	5
35	Scenario building	5. Kang (3. MEPSS)	(MEPSS) preparation time: 2~3h brainstorming: 4h homework: 3h	actor 들에 관한 information (motivation, context, strength and weakness or current situation) 있다면, 현상태의 SWOT 분석 결과	**applicable (Kang's simplified tool)**	18
36	Concept model	7. IPSS	3~4h		time constraint complicated for PSs experts	22, 23

2. Activity Number Table

(*SV: Service, ST: Stakeholder, SU: Sustainability)

(**LS: Low Score on question 1, HS: High Score on question 2)

Stages	No.	Activities	Related perspectives*	Interview Result**	Supported by applicable tools
Exploration	1	Set the goals of project and determine the scale of system to be dealt with	-		
	2	Indicate the desired balance between products and services	SV	LS	
	3	Indicate the targets concerning market share, profits and sustainability	SU		
	4	Define the criteria and assessment strategies for measuring progress	-		
	5	Define stakeholders to be involved, priorize and plan their involvement through lists or maps	ST		
	6	Identify future users	-	HS	
	7	Assess the environmental load and economical value of the system	SU	LS	
	8	Analyze current situation in terms of business model, production/value chain, market strengths/weaknesses	-		O
	9	Analyze needs, value and requirements on function from view point of various stakeholders	ST	LS	
	10	Analyze needs, value and requirements on function from view point of customers	-	HS	
	11	Determine the role of the partners and external groups	ST		
	12	Refine project plan about budget, tasks and time schedule	-		
Concept Generation	13	Structure PSS function in an integrated way considering requirements	-	HS	
	14	Brainstorm to explore opportunities for new services and collect, filter and crystallize ideas	SV	**HS**	**O**
	15	Define services (scope, technical description)	SV	HS	
	16	Develop an organizational concept (processes, roles, resources, training)	SV	LS	
	17	Develop marketing concept (product, price, place, promotion)	-		
	18	Scenario building considering stakeholders' involvement, customer needs, sustainability	SV, ST, SU		O
	19	Assess the scenario in terms of customer needs	-	**HS**	**O**
	20	Assess the scenario in terms of sustainability and visualize it	SU	LS	O

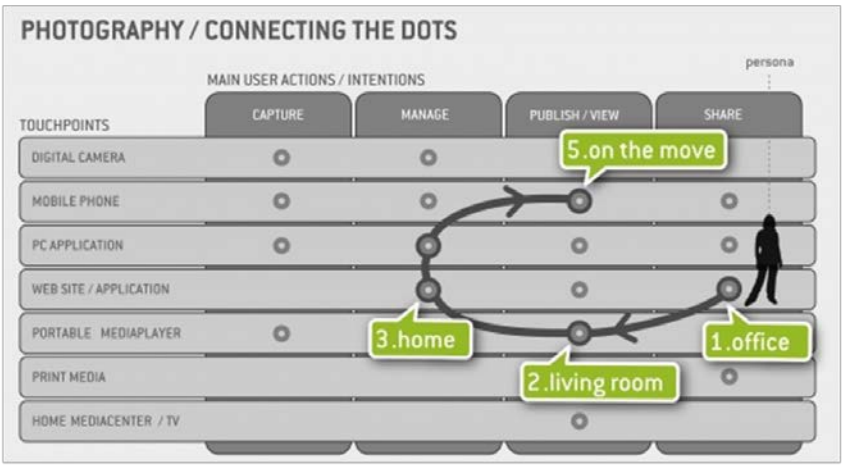
Idea Development	21	Select the most promising ideas and develop them into more precise version	-	**HS**	**O**
	22	Define & specify Product-Service Modules	SV		O
	23	Evaluate if P-S Modules complies requirements			O
	24	Evaluate consistency and plausibility of the service documentation	SV	HS	
	25	Consider interdependencies between PSS elements in discipline-specific detailed design	-	LS	
	26	Test the customers' understanding on and satisfaction with value and adjust the design	-		O
Preparation for Realization	27	Understand the critical factors for success and failure	-	HS	
	28	Understand opportunities and threats in existing situation and the new one	-		
	29	Prepare and deliver a management presentation	-		
Realization	30	Define organizational roles (procedures)	-	HS	
	31	Train employees and procure necessary operating resources	SV		
	32	Implement market concept	-	HS	
	33	Realize the offerings (produce products, deliver service and maintenance)	SV	HS	
	34	Monitor and review the efficiency of the service	SV		
	35	Measure the environmental impact, financial effects	SU		
	36	Collect, evaluate and consider possible change requests from customers	-	HS	
	37	Evaluate project process	-		
	38	Monitor and review the efficiency of service (manage time/place/people)	SV	HS	
	39	Make adaptation and improvement of system according to evaluation result and environmental changes	SU	HS	
	40	Take back the products out of use and integrate with remanufacturing system	SU	LS	

3. Workshop Protocol

현 시스템 분석하기

터치포인트 맵

- '터치포인트 맵'을 이용하여 현재의 시스템 속 사용자의 활동 흐름과 그 과정에서 접하게 되는 다양한 이해관계자 및 터치포인트를 시각화하고 그 속에서 발견되는 문제점과 기회들을 발굴합니다.

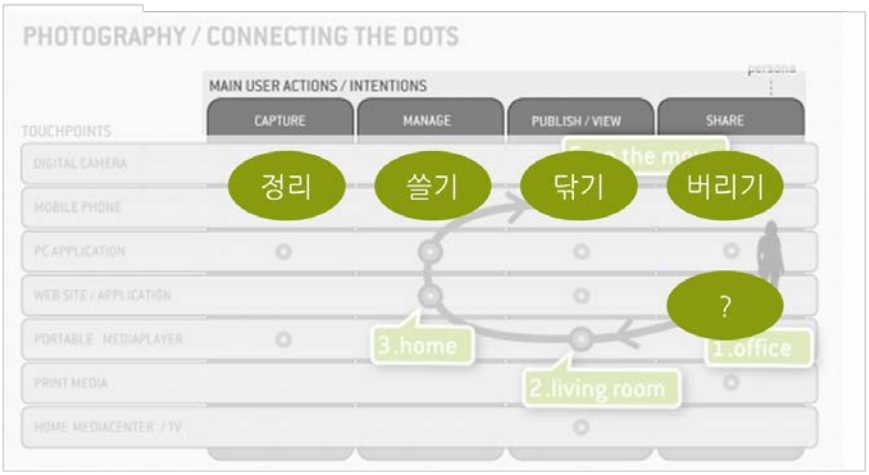


현 시스템 분석하기

터치포인트 맵

- 활동 순서

1) 사용자의 활동단계 정의하기
"주거공간을 청결하게 유지"하기 위한 사용자들의 활동

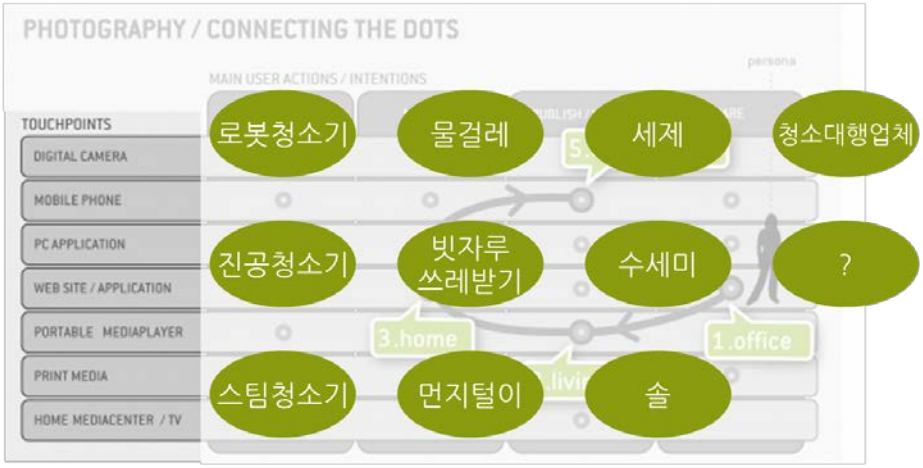


현 시스템 분석하기

터치포인트 맵

- 활동 순서

2) 이해관계자 및 터치포인트(제품) 정의하기
"주거공간을 청결하게 유지"하기 위해 사용되는 제품/업체
단계별로 사용되는 터치포인트에 O표시 해주세요

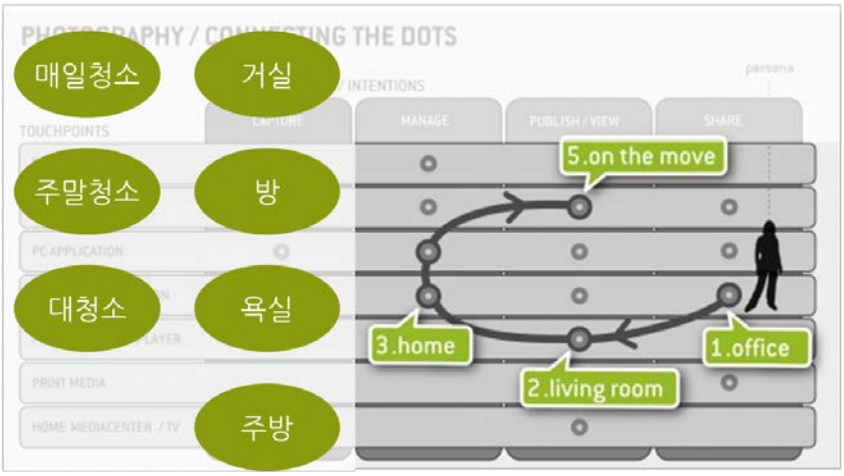


현 시스템 분석하기

터치포인트 맵

- 활동 순서

3) 이해관계자/터치포인트를 연결하여 사용자의 여정 표현하기
상황 별, 공간별 활동 여정

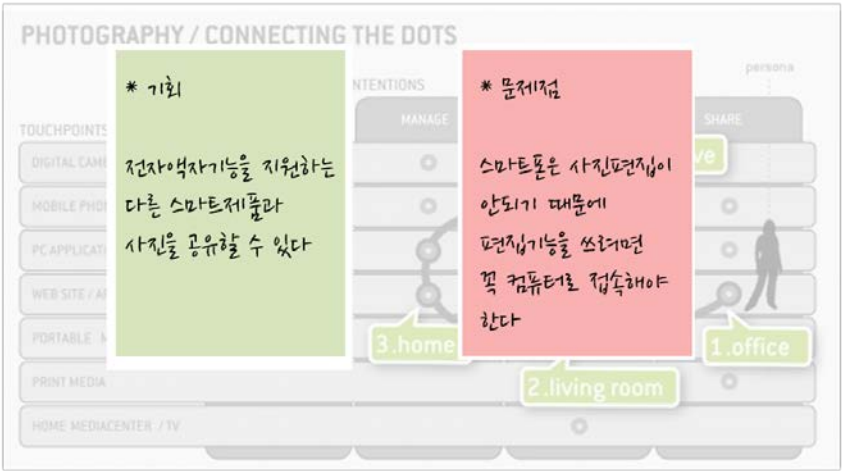


현 시스템 분석하기

터치포인트 맵

- 활동 순서

4) 기회 & 문제점 발견하기
제품/업체와의 인터랙션에서 발견되는 기회(충족되지 못한 니즈) & 문제점



아이디어 발굴하기

Ideation 카드게임

- 터치포인트 맵에서 발굴된 기회와 문제점을 바탕으로, PSS 유형과 스마트가전의 속성, 기술 요소를 고려하여 PSS 아이디어를 발굴합니다.

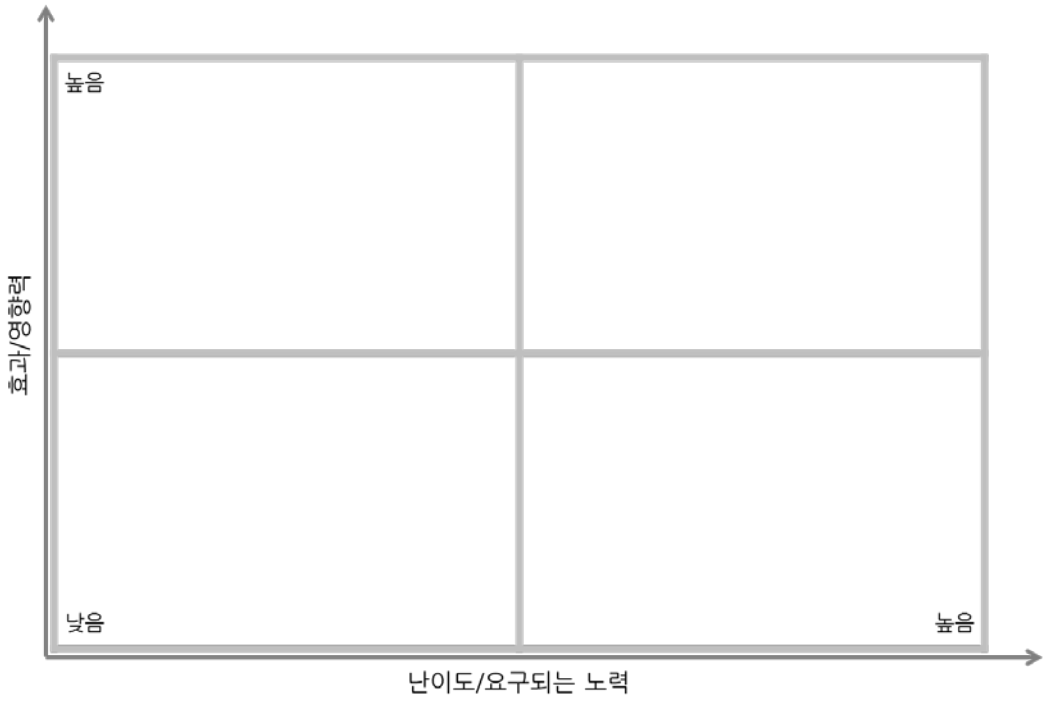
아이디어 발굴하기

Ideation 카드게임

1) 기회와 문제점, PSS 유형, 스마트가전의 속성, 기술요소 내용을 다시 한번 확인합니다.
2) 우선순위 매트릭스에 대해 소개합니다.
(가로: 난이도/요구되는 노력, 세로: 효과/영향력)
3) 한 사람씩 돌아가면서 PSS유형 카드와 스마트가전 속성카드를 조합하여 각 문제를 해결할 수 있는 아이디어, 또는 기회를 활용할 수 있는 아이디어를 간단한 그림과 글로 표현합니다.
4) 자신의 차례에 포스트잇에 기록한 아이디어를 소개하고 우선순위 매트릭스에 붙이면 아이디어를 등록할 수 있습니다.
5) 다른 사람의 아이디어를 보고 바로 다른 카드를 더하여 아이디어를 업그레이드 시키는 경우도 아이디어를 등록할 수 있습니다.

아이디어 표현 예시

우선순위 매트릭스

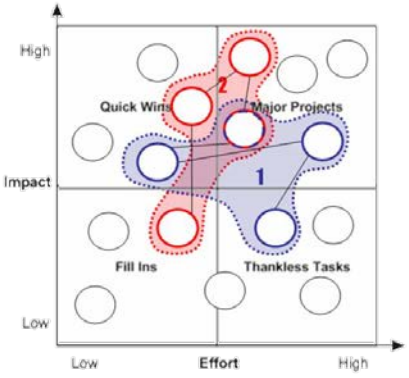


아이디어 합성하기

우선순위 매트릭스

- 발굴된 아이디어 모듈을 연결하여 PSS 솔루션을 구성합니다.

Figure 1: Action Priority Matrix



아이디어 합성하기

우선순위 매트릭스

1) 우선순위 매트릭스의 각 사분면에 대해 설명합니다.

Quick Wins(작지만 빠른 승리): 가장 매력적인 프로젝트. 적은 노력에 비해 좋은 성과를 얻을 수 있으니 가장 집중해야 할 유형입니다.

Major Projects(주요 프로젝트): Quick Wins가 뭉쳐있는 형태로, 좋은 성과를 거둘 수 있지만 완성에 오랜 시간과 많은 노력이 필요합니다. 착수한다면 최대한 빠르고 효과적으로 완수하도록 합시다.

Fill Ins(자투리용): 시간과 노력에 여유가 있다면 시도해 볼만 합니다.

Hard Slogs(힘든 허드렛일): 효율이 떨어지는 과제이므로 다른 과제를 시도하는 것을 추천합니다.

아이디어 합성하기

우선순위 매트릭스

2) Quick Wins, Major Projects에 포함된 아이디어 중 유망하다고 생각되는 아이디어를 한 사람 당 3개씩 선택합니다. 득표를 많이 받은 메인 아이디어를 2~3개 선정하고, 선정된 아이디어의 제안자는 아이디어당 점수 5포인트를 받습니다.

3) 메인 아이디어들을 중심으로, 함께 실행하면 좋을 아이디어들을 엮어서 PSS 솔루션을 구성합니다.

아이디어 평가

전략 매트릭스

- 도출된 PSS 솔루션을 현재의 제품/서비스와 정성적으로 비교하여 비즈니스모델의 강점을 파악합니다.

1) 채점표를 이용하여 새로운 PSS 솔루션을 평가합니다.
(9=매우 그렇다, 7=그렇다, 5=보통, 3=별로 그렇지 않다, 1=매우 그렇지 않다)

- 채점결과에 따라 전략 매트릭스에 배치해봅니다.

아이디어 평가

전략 매트릭스

PSS 매력도

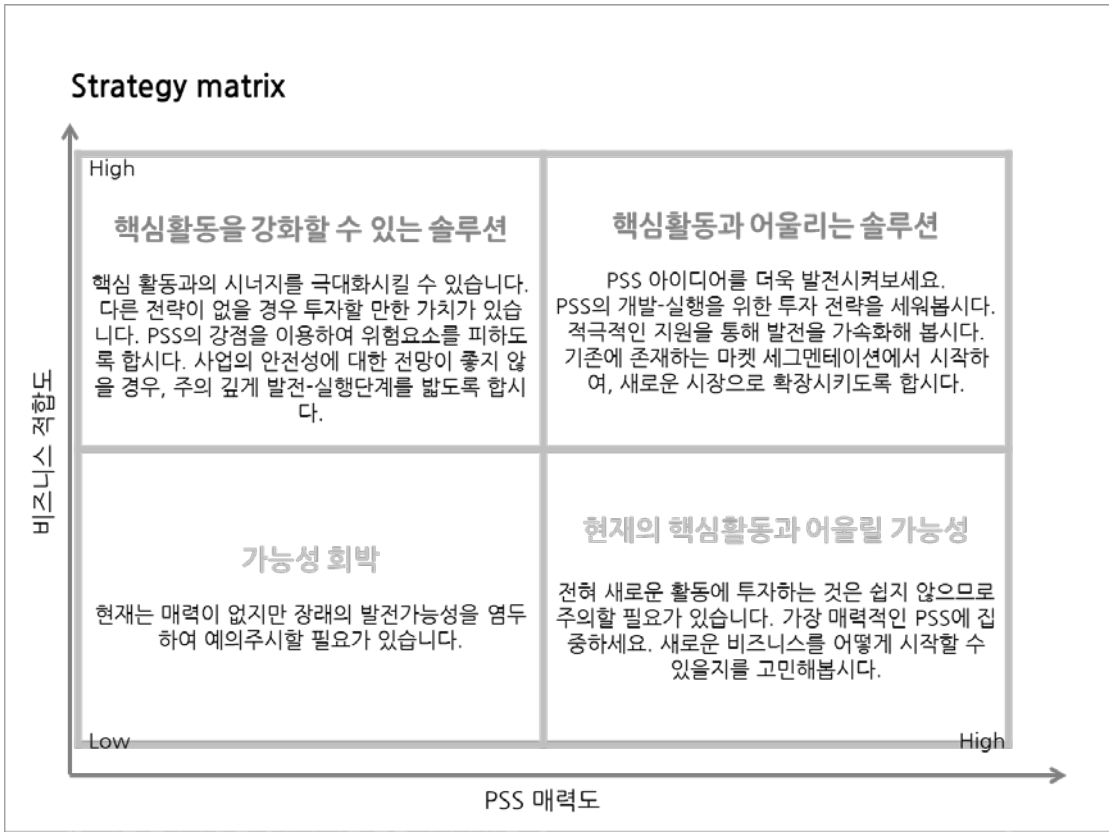
평가기준	점수
시장규모가 크고 잠재력이 있다	
시장 성장률/성장가능성이 크다	
잠재 이익이 크다	
새로운 시장진출에 대한 위협이 적고 진입장벽이 높다	
대체상품에 대한 위협이 적다	
고객의 가격민감도가 낮다	
고객충성도를 확보할 가능성이 크다	
제품의 질이 높다	
이익환수기간이 짧고 이익률이 높다	
금융문제가 적다 (선자금, 정기청구)	
환경적 부담이 적다	
불확실성이 낮다 (비용, 수익측면)	
법적 문제가 적다	

아이디어 평가

전략 매트릭스

비즈니스 적합도

평가기준	점수
현재 시장포지션에 적합하다	
시장에 대한 충분한 지식이 있다	
회사의 이미지에 부합한다	
전략(임무)방향과 일치한다	
현재의 생산 및 판매채널, 직원의 전문지식을 활용하기 적합하다	
회사의 강점을 살리고 약점을 보완할 수 있다	
필요한 변화,전환을 마련할 수 있는 적응력이 있다	
파트너와 좋은 협력관계에 있다	


Strategy matrix
High
핵심활동을 강화할 수 있는 솔루션
핵심 활동과의 시너지를 극대화시킬 수 있습니다. 다른 전략이 없을 경우 투자할 만한 가치가 있습니다. PSS의 강점을 이용하여 위험요소를 피하도록 합시다. 사업의 안전성에 대한 전망이 좋지 않을 경우, 주의 깊게 발전-실행단계를 밟도록 합시다.
핵심활동과 어울리는 솔루션
PSS 아이디어를 더욱 발전시켜보세요.
PSS의 개발-실행을 위한 투자 전략을 세워봅시다.
적극적인 지원을 통해 발전을 가속화해 봅시다.
기존에 존재하는 마켓 세그멘테이션에서 시작하여, 새로운 시장으로 확장시키도록 합시다.
가능성 희박
현재는 매력이 없지만 장래의 발전가능성을 염두하여 예의주시할 필요가 있습니다.
현재의 핵심활동과 어울릴 가능성
전혀 새로운 활동에 투자하는 것은 쉽지 않으므로 주의할 필요가 있습니다. 가장 매력적인 PSS에 집중하세요. 새로운 비즈니스를 어떻게 시작할 수 있을지를 고민해봅시다.
Low
High
비즈니스 적합도
PSS 매력도

THANK YOU

ACKNOWLEDGEMENT

I would like to express the deepest appreciation to my supervisor, Professor Joon Sang Baek for the thoughtful comments, remarks and engagement through the learning process of this master thesis. Thanks to his support, I could enter on a new phase of my master's course as a member of DESIS@UNIST and finish my dissertation. I also acknowledge deep gratitude to my previous supervisor, Professor Seon Hee Jung for leading me to take the first step toward the design field and to start working on this thesis with great care. Furthermore I would like to thank my committee members, Professor James A. Self and Professor Youngshin Kwak, who gave me priceless advices and comments on my dissertation and future work. In addition, I extend thanks to all the Professors, staffs and students in DHE in UNIST.

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I would like to gratefully and sincerely thank K.H. Chung for opening the way for me to study design.

Finally, I wish to express my love and gratitude to my families for their endless love and supports,and thank MOSES families and My Lord for staying together.