

An Object-Oriented Design Framework for Developing Product-Service Systems

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제품-서비스 시스템 개발을 위한 객체 지향 설계 프레임워크 개발

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Trends of integrating products and services lead to the emergence of Product-Service System (PSS). To implement and embody a PSS solution in new product development, a comprehensive design framework is allowed designers to facilitate the design factors of the PSS in complex business environments. A physical product, containing functionalities for services, is the role of medium between customers and a manufactures. Customers can access those metaphysical interfaces to utilize the product fully or expand its performances. The PSS is aiming to prolong its lifecycle while maintaining its expected quality. Since the quality can be represented as a measure which belongs to user's perspective, guaranteeing certain level of quality can be interpreted to sustaining customer satisfaction. The objective of this paper is to propose a PSS design framework to identify design factors for developing products and services by integrating object-oriented concepts and blueprinting in context of a business ecosystem. The proposed model is developed based on relationship products and services matching with their design factors. The products and the services are then brought together to form a PSS. Functions and processes can be categorized to identify the design factors in different levels using the object-oriented concepts. Objected-oriented concepts provide PSS analysis tools for describing a business process or a workflow process in the PSS. The blueprint is used to identify the relationships between the products functions and the service processes that are offered as part of a job. To demonstrate of the effectiveness of the proposed model, we use a case study involving a smart phone.

Keywords : Product-Service System, Product-Service Platform, Design Factors, Objected-Oriented Concept, Blueprint

1. Introduction

The emergence of Product/Service System (PSS) is led

by widespread of smart products. PSS was first introduced from Goedkoop et al. [5] as a business model to meet diverse customer needs with integration of products and services. Compared to conventional products, a PSS consists of products and services integrated into one set to satisfy user's needs cooperatively. Since the PSS has a characteristic of

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the smart products expanding its services with embedded microprocessors and control systems to meet a variety of needs, the PSS is often realized as smart products. Trends of integrating products and services lead to the emergence of Product/Service system [11]. To implement and embody a PSS solution in new product development, a comprehensive design framework is allowed designers to facilitate the design factors of the PSS in complex business environments.

In the context of a complex network in business world, Moore [14] introduced the concept of a business ecosystem, which is concentrated on behaviors and tendencies of organizations and individuals. While individuals are interacting each other through goods and services, other organisms (e.g., suppliers, competitors, and other stakeholders) also participate and form a huge business network. The network is called as an ecosystem because the individuals and the organizations co-evolve their capabilities and roles over time through value chains among them. One characteristic of a PSS is that the mass interactions related to the PSS take place in physical or metaphysical interfaces among customers and manufacturers. A physical product, containing functionalities for services, is the role of a medium between customers and a manufacturer. Customers can access those metaphysical interfaces (e.g., online application stores) to utilize the product fully or expand its performances. In this process, content (embodies service itself) providers may or may not be the manufacturer itself—there are lots of open chances anonymous contents suppliers participate in. Therefore, the PSS is represented as a business ecosystem and requires the interrelationships between entities that act for its own profit.

In the era of mass production, creating the value of products comes from exchanges between the customers and the companies—more selling brings more profit. In the network of a PSS, however, the value is produced by supporting customer's activities related to use of a physical product. It is attained by guaranteeing customized use of the product with enhanced service availabilities through a PS platform. While providing physical products is a core business of manufacturing industries in times past, the core business of the PSS in these times is now customer's interaction with the products [19].

PSS concept was started from Europe and its background was to change a sales-oriented approach to a service-oriented approach for meeting dynamic needs of customers timely and effectively [11]. Because the conventional design methods of a product or service are only for the product or service itself, a new design framework for developing the PSS is

needed to consider products and services simultaneously.

Tan et al. [19, 20] described problems when a conventional product development model is used to create a PSS. In traditional manufacturing industries, the value of products is filled in the manufactured goods processed by technology. The value is referred to the customer's reaction toward cost, quality, and time. Under this circumstance, demands from customers are converted to functionalities of the products. However, in case of the PSS, the demands are related to customer's activity with product use. It infers that specific functions and features of a product cannot be the design factors of the PSS. Instead, the design factors are needed to represent customer's motivation of purchasing related to services that can be performed through the product.

By switching of view from product-centered to service-centered, a PSS is also described as functional products effectively [20]. As business perspective, integrating services to product features requires redefine of core business market segment. Simultaneously, a proper business strategy has to be set to increase company's competitive edge in the market segment. It can be acquired through managing product lifecycle by supporting diversity of services to user groups.

Although a PSS is usually realized as a smart product, the PSS does not only stay in the form of it. The PSS is to support sustainability of both the consumption of its services and the production of the product [3]. Therefore, the PSS is aiming to prolong its lifecycle while maintaining its expected quality. Since the quality can be represented as a measure which belongs to user's perspective, guaranteeing certain level of the quality can be interpreted to sustaining customer satisfaction.

The objective of this paper is to propose a PSS design framework to identify design factors for developing products and services by integrating object-oriented concepts and blueprinting in context of a business ecosystem [1]. The proposed design framework is developed based on relationship between products and services. Based on extending the concepts from object-oriented concepts, this paper introduces a methodology to identify design factors in developing a PSS. Object-oriented concepts provide PSS analysis tools for describing a business process or a workflow process in the PSS. The blueprint is used to identify the relationships between the products functions and the service processes that are offered as part of a job. Functions and processes can be categorized to identify the design factors in different levels using the object-oriented concepts. Interaction between

products and services lies on a PSS platform to form Product/Service system in the blueprint.

The remainder of this paper is organized as follows. Section 2 describes the proposed PSS framework to identify design factors for developing a PSS using object-oriented concepts and blueprints. Section 3 gives a case study using a smart phone. Closing remarks and future work are presented in Section 4.

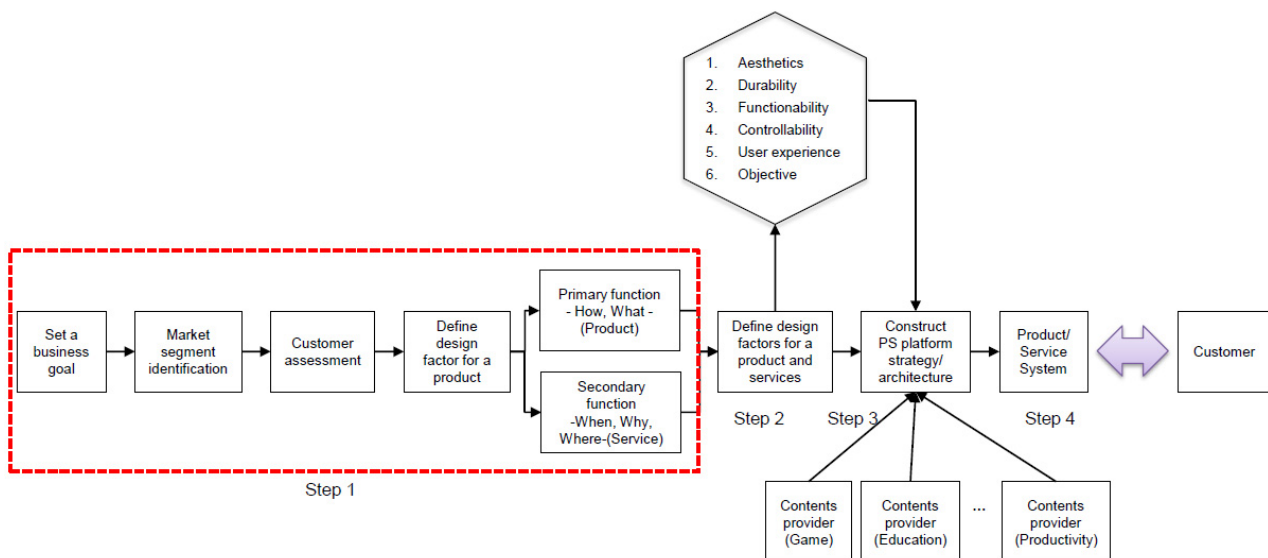
2. The Proposed PSS Design Framework

<Figure 1> describes the proposed PSS development process based on a PSS design framework by identifying PSS design factors. The proposed process consists of four phases: (1) determine a job and PSS functions, (2) identify PSS design factors, (3) define a PS platform, and (4) develop a PSS. In the initial phase, a company sets a business goal to gain more profit by making a new product. The business goal can be established by assessing target market segment and customer population. The analyzed customer needs are converted to a job and functions for identifying the new design factors using object-oriented concepts. At this step, technological capability of the company determines functions that the PSS can contain. From the first step, the whole development process sequence may depend on a business strategy that the company selects based on technology-push or market-pull [7]. In contrast to conventional product development process, consideration for PS platform architecture is re-

quired in the proposed process. A PS platform is defined to form Product/Service system based on interaction between products and services in a blueprint. During product development procedure, the PS platform can be varying based on company's business strategy. Depends on its strategic position in a market segment and technological capability, the business strategy to form and lead an ecosystem is various [4]. Finally, a PSS is developed based on the business strategy and the PS platform.

2.1 A PSS Design Framework

In a business ecosystem, a PSS is the role of an interface between users and manufacturer. For example, the users can purchase or download additional contents or services through the PSS from on/off-line sources and improve capability of the PSS to any shape they want. With this regard, the PSS certainly requires having accessibility to those optional sources, like a physical product in a PSS, the 'source' is the role of an interface, but in this case, the interface locates between the users and the contents providers (or the manufacturer). By grouping the capability of accessing the source and the source itself, we introduce a new concept of Product/Service platform (PS platform) in <Figure 2>. In order to meet customer needs exactly by PSS products, it is needed to interconnect tangible products and intangible services to fulfill jobs required by customers. In this research, we define a medium as a PS platform that connects products and services in the proposed PSS design framework as shown in



<Figure 1> The Proposed PSS Development Process

<Figure 3> shows the proposed PSS design factors comprising of a hexagon being segmented in various regions. The design factors are consisted of six main sections; (1) aesthetics, (2) durability, (3) functionality, (4) controllability, (5) user experience, and (6) objective.

The aesthetics refer to the physical outlook of the particular product or services, comprising of shape, color, and size. The appearance of a product can directly alter the user's preference whether to buy or not to buy that particular product. The durability suggests whether the product or services is long lasting or not, further divided into flexibility, sustainability, and toughness. The flexibility concerns with materials that are made up of the product (or services) regarding its properties. Sustainability can classify as the go-green element of the design whether the product can be recycled, reused or remarked or not. Toughness refers to product's values as the time goes by. The functionality is categorized into core, expected, augmented and potential functions. The controllability represents functional effectiveness, efficiency, and sensitivity for products or services. This part of factor examined product's (or services) input and output such as power, time spent, responsiveness, energy used, etc. The user experience is focused on the end user's emotion or feeling when using the product or services. This includes the customizability of the product, sense experienced during the use of product (or services), and finally satisfaction and preferences of the users. The objective describes the purpose of the product or services being created to fit the needs or criterion such as reason, location, person and time. Generally, the proposed design factors model is still very vulnerable and is flexible to change its element from time to time whenever necessary. Different sub elements could be included as well to fit different types of product and services.

2.3 Product-Service Platform

Platforming strategy is widely applied to various industries such as automotive and electric consumer products to reduce costs of product and service development as well as manufacturing process [12, 18]. In product development process, a platform is defined as a set of common features, components or subsystems that remain constant from product to product, within a given product family [17]. In IT, a platform is depicted as a set of tools or components that provide building blocks for application providers [9]. Although the definition of the platform varies based on industries, it can be

notified the platform indicates common components used across set of products.

Dissimilar to the conventional meaning of the platform, a PS platform is not just pointing out a set of physical components, yet it may be shared across product families from the same centered manufacturer in an ecosystem. The PS platform is rather a metaphysical or physical place where users, contents providers, and manufacturers interacts each other. Through the PS platform entities in an ecosystem create and facilitate unlimited addable options to mitigate unsatisfied needs. For example, customers can utilize a PSS in wider way by adding services through a PS platform. More participating outsourced content providers in open environment can make the ecosystem get more powerful so customers want to remain. A good example would be a Kindle Fire application store developed by Amazon.¹⁾ Through the PS platform each organism in a PSS business ecosystem co-evolve and obtain more contents, which enhance overall competitive power of the ecosystem [9]. In other words, the PS platform determines the level of values of an ecosystem, thus fulfills a critical role.

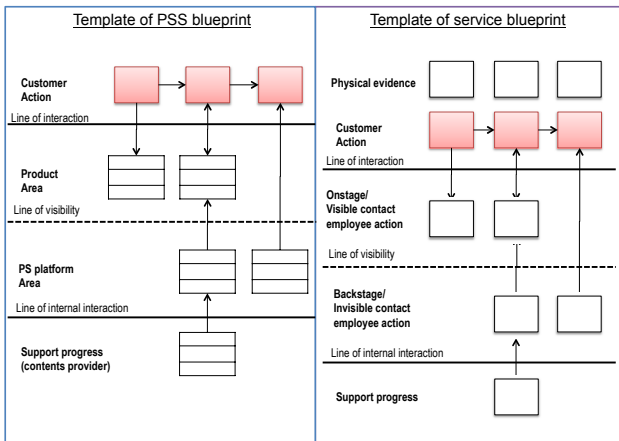
2.4 Extended Object-Oriented Concepts and a Blueprint to a PSS

In service design, we should consider service characteristics that can be defined by a set of processes, operations, people, objects, and/or features. We apply object-oriented concepts to describe services using these service characteristics [13] Object-oriented design and analysis methodologies are used to develop information systems by modeling a system as a set of objects in the area of software engineering and business [15]. In this paper, since Object-oriented concepts can include the process names, detailed contents under process, and main department to carry out the process-unlike conventional service blueprint, object-oriented concepts will be used to support service analysis and representation by combining a blueprint. For applying the blueprint, we use the definitions of characteristics in object-oriented concepts [1, 8]. The objects are described by their identity, behaviors, and states through behavioral structural modeling. The unified modeling language (UML) can be used to develop a behavior model and a structural model for services, since UML provides an appropriate modeling setting [1].

1) <http://www.amazon.com>.

A blueprint, which is the basic frame of PSS blueprint, provides managers with information to support process control and management in product and service development [16]. In the process of designing a blueprint, we need to consider the several issues : identifying processes, isolating fail points, establishing time frame, and analyzing profitability. Among the issues, identifying processes indicates how the service influences customer’s wants and product functions. For any service, a blueprint can trace processing steps and information flows between a customer and a provider [2, 6]. We can identify service processes in the service through designing a blueprint.

In this paper, we propose a PSS blueprint which is combined with object-oriented concepts and a blueprint method to identify processes based on a PS platform in PSS design. <Figure 4> shows the comparison of the proposed PSS blueprint and a service blueprint. PSS blueprint and service blueprint share some common features such as structure, the same lines which divide each area, and a similar developing procedure. We applied an objected-oriented concept which includes rectangles divided into thirds from product area to support progress area. Areas of PSS blueprint are modified to express Product/Service system. PSS blueprinting that contains object-oriented concepts is a significant difference.



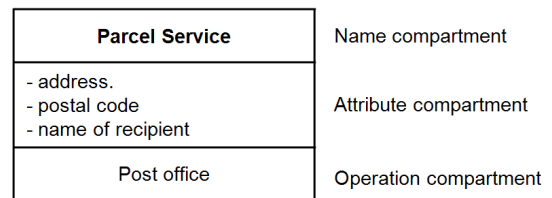
<Figure 4> The Comparison of the Proposed PSS Blueprint and a Service Blueprint

The process of developing the PSS blueprint is consisted of five steps as follows :

1. Identify product functions and service processes to be blueprinted
2. Define all elements of the blueprint based on customer actions
3. Draw the lines of interaction in product area
4. Draw the lines of internal interaction and support progress
5. Determine the line of visibility and Product/Service platform area

3. Draw the lines of interaction in product area
4. Draw the lines of internal interaction and support progress
5. Determine the line of visibility and Product/Service platform area

Before establishing product and service area, designers have to know how fill in each class and express the relationship between classes. A class consists of three rectangles horizontally. The higher section is for class name; the middle section is the information attribute in class; and the lower section is a department or system related with class. By using this class as process component in service blueprint, this whole process can describe more specific information of Product/Service system than service blueprint and we can realize what kind of attributes each process have and which department or system is involved in class. For example, if we develop class for parcel service, simplified class concept is shown as <Figure 5> for Product/Service system. For name compartment, class name is used; for attribute compartment, attribute name (address, postal code, and name of recipient); for operation compartment, a main department (Post office) related parcel delivery service is used. This concept is easier to learn and remember for PSS designer than conventional class diagram in UML.

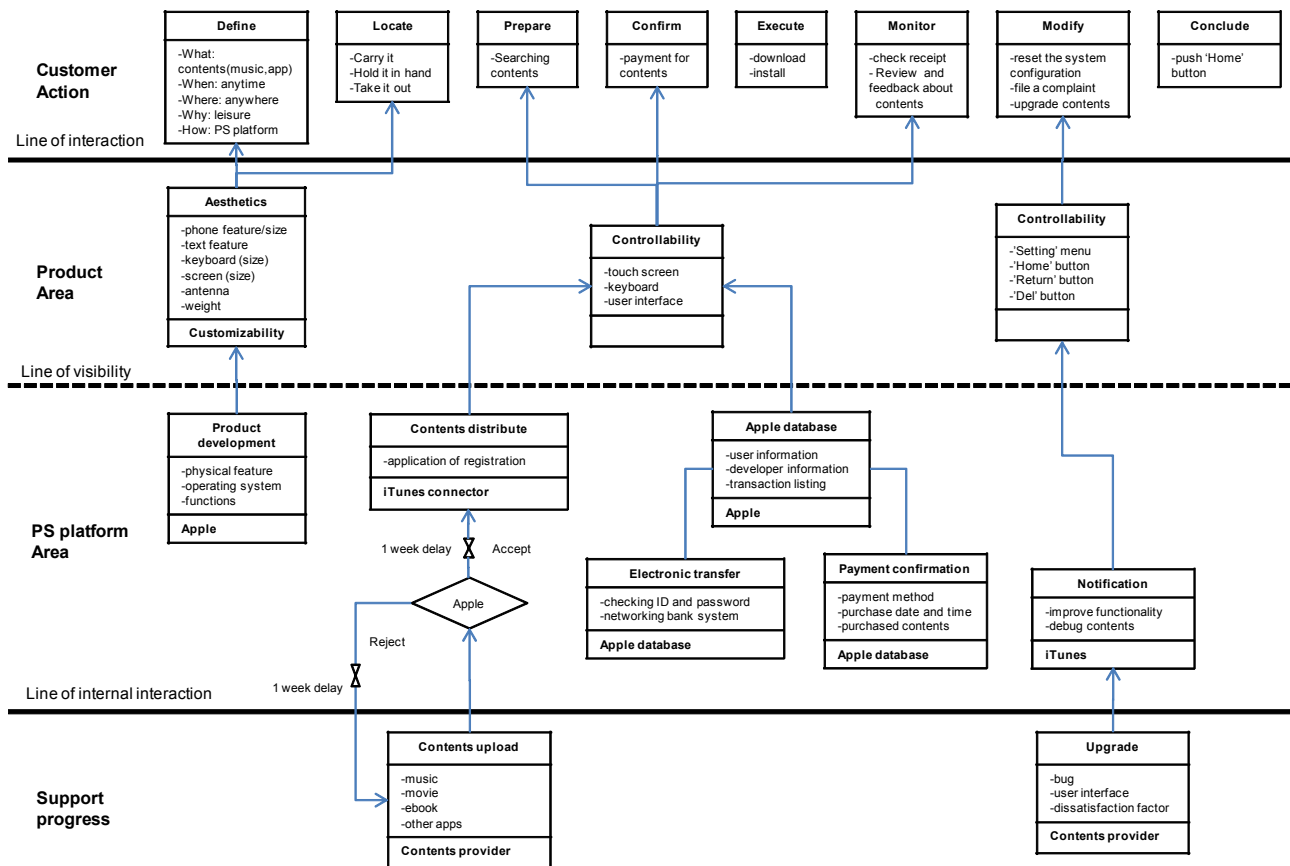


<Figure 5> The Simplified Class Concept

After building class, the relationships are expressed to visualize the semantic connections between classes and understand the flow of information on the blueprint as shown in <Table 2>.

<Table 2> The Expression and Meaning of Arrows in the PSS Blueprint

Expression	Meaning
	<i>A to B is navigable/B to A is not navigable</i>
	<i>A to B navigable/B to A is navigable</i>



<Figure 7> A PSS Blueprint for iPhone and iTunes

The proposed design factors and PSS design framework can be utilized for evaluating existing PSS products and developing new products. Future research efforts need to focus on enhancing objectivity of proposed design factors by applying various products and industries. Especially, studies on PSS products considering with society, economy and environment have to be along with it. Further research for a PS Platform will be conducted in terms of specific design methods through optimization, diverse utilization and interconnecting products and services. We will also examine the roles of the primary and secondary functions during competitions of PSSs in market segments by applying data mining methods.

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