# An Architectural Perspective to Service Offerings

Yiyen NIEN
Xinwei JIANG

## Abstract

This article discusses service offerings from an architectural perspective. The purpose of this work is to further the knowledge and declare the importance of an architectural view of services. Firstly, the background of the increasing attention to an architectural perspective of market offerings is presented. Thereafter, the literature related to architectural design principles – modular design, is summarized and applied to modular service design. Finally, remaining issues concerning modular service design are identified.

## 1. Introduction

Why do we have to adopt an architectural perspective to design a product or service offering? Architecture is a kind of design thinking that defines how components interact with each other within the architecture. The architectural approach derives from Herbert Simon's complex system thinking that argues that a complex system could be decomposed hierarchically. The architectural approach has been considered a useful way to investigate innovation from products, production processes and industries (Clark 1985). One of the focuses in the architecture perspective is to decompose complex systems. As a part of design thinking, architectural decisions depend on companies' strategic goals; therefore, a consensus has not yet been reached on the definition of the term modules as constituent of architecture.

*An architectural perspective to deal with market dynamics*

An offering including all marketable products and services, has been considered to occupy a prominent strategic position in several strategic issues. On the surface, a product/service architecture presents a technical base for product development. Essentially, the product architecture is the foundation or frame to define required production resources and organizational capabilities. Therefore, examining the business strategy in a way that takes the "offering" as the basic unit of analysis presents important advantages over existing theories that use the firm as their point of departure (Richard and Ramírez 1989, 112), and decisions on product architecture design have a significant influence on companies' strategy development.

Several researchers have noticed that the architectures of products control the path of product innovations, organizational structures, and even the formation of industries (Sanchez 1995, Abernathy and Utterback 1978, Henderson and Clark 1990). From the viewpoints of effective resource utilization and strategic flexibility, Sanchez (1995) notices that product market competition become more intense and dynamic due to the higher level of uncertainty of the future strategic value of specific resources that are not reducible in the short term. Sanchez (1995) argues that strategic flexibility is a fundamental approach to the management of uncertainty that derives from rapid changing market needs and innovations. Two main challenges that managers face are (1) identifying and acquiring resources in a flexible way and (2) gaining flexibility in coordinating the use of resources. Sanchez (1995) argues that, a new way of product design thinking, modular product design, enable managers to manage uncertainty and achieve flexibility in acquiring and coordinating the use of resources. Therefore, the design rules of offerings are a key variable in several strategic issues (Catel and Monateri 2005), and they might affect the formation of organizational structures and even industries (citation). For example, past studies find that when the higher degree of product modularity leads to a higher degree of organizations modularity.

Similar to the arguments in the operations and strategic management field, in the marketing field, some researchers suggest considering offering architectures as a “frame” of value-creating systems. For instance, Normann and Ramírez (1994) consider that customers want to buy an offering not because of the offering per se but because of the “offering’s leverage value,” which helps them to achieve their goals. Therefore, an offering carries a code for the value-creating activities it makes; that is, it gives users indications about what it allows them to do with it, thereby triggering user activities (Normann and Ramírez 1994, 56-57). On the one hand, Normann and Ramírez (1994) consider that the architecture of each offering defines institutional rules that guide actors’ activities. On the other hand, offerings’ architectures also act as platforms to facilitate new resource configurations if the architecture is open to more actors. Therefore, offerings are not just exchange items; they are more like foundation or boundary definers/makers for more diversified resource configurations and value-creating activities conducted by various actors.

Inspired by Normann and Ramírez’s works of value-creating systems (1994, 1993), researchers started to expand their research focuses to the configurations of value constellations rather than linear value chains. The most representative research group was led by Stephen Vargo and Robert Lusch. The proposed a new concept of service-dominant logic that emphasized value co-creation and value-in-use processes. Within the research trend, some researchers, such as Korkman, Storbacks and Harald (2010), noticed that the configuration of offerings act as a context or institutionalized rules to define or constrain the activities of value creations.

In summary, market offerings have been considered a key variable that related to companies' strategic decisions. Therefore, this article focuses on market offerings, especially services. The next section summarizes the related modular design issues. Thereafter, modular service design, from a modular design perspective, are discussed.

## 2. An architectural approach to market offering design

### 2.1 Modular product design

Against the backdrop of severe competition in the market, companies have to increase the speed of product innovation. The main challenge for most companies is to keep providing innovative, customized offerings without increasing product cost and complexity. To solve the problem, more and more companies have started to adopt modular design thinking to create new product designs in a growing number of markets (Sanchez 1999, Schuh, Rudolf and Vogels 2014). Through adopting the strategy of creating a modular product architecture, companies are able to leverage product variations by substituting various functional modules that represent certain features to customer requirements (Sanchez 1999).

Regarding the modular strategy, several design methods are suggested, such as the design of modular products, product platforms, and product families. The central principle of these ideas is the creation of new products or product varieties based on common modules and capabilities. In other words, adopting a modular product design can be an efficient way to create product variety for different segments of customers via a synergy effect of resource and capability sharing. New products generate from the mixing and matching of existing modules, and the product system can thus be kept in a mass production mode.

The structure of this section is organized as follows. Firstly, the origin, background, and strategic and design issues of modular design thinking are introduced. Afterward, design thinking and related concepts of modular products are introduced.

### *2.1.1 The origin background of modular design thinking - nearly decomposable systems*

The notion of modularity derives from Simon's (1962) discussions of nearly decomposable systems for handling complex systems. The concept of decomposability is also the foundation of modularity thinking. According to Simon, "[a complex system is] made up of a large number of parts that interact in a non-simple way" (1962, 468). By breaking up a complex system into discrete pieces, they can then communicate with one another through standardized interfaces within a standardized architecture (Langlois 2002, 19). Regarding to the structure of a complex system, Simon (1962) claims that a complex system has the properties of hierarchies and near-decomposability. The hierarchal structure implies that decisions can be made at different levels. The nature of decomposability suggests that intra-components' interactions are high and accompanied by strong linkages; however, inter-components' interactions are weak but not negligible. Simon (1962) gives an example of watch making, and the story tells how complexities can be reduced through building a hierarchal and decomposable system:

> *The watches the men made consisted of about 1,000 parts each. Tempus had so constructed his that if he had one partly assembled and had to put it down-to answer the phone say-it immediately fell to pieces and had to be reassembled from the elements. The better the customers liked his watches, the more they phoned him, the more difficult it became for him to find enough uninterrupted time to finish a watch.*
>
> *The watches that Hora made were no less complex than those of Tempus. But he had designed them so that he could put together subassemblies of about ten elements each. Ten of these subassemblies, again, could be put together into a larger subassembly; and a system of ten of the latter subassemblies constituted the whole watch. Hence, when Hora had to put down a partly assembled watch in order to answer the phone, he lost only a small part of his work, and he assembled his watches in only a fraction of the man-hours it took Tempus.*

Although, Simon (1962) does not use the term *modularity*, the case indicates that through decomposing systems according to functions, even if work processes are disrupted, it does not greatly influence work efficiency.

The advancement of new technology makes it possible to solve various problems, and the design thinking of modularity is considered a useful way for managing complexity through system decomposition. The design thinking of modularity has been applied to various fields, from manufacturing to services, such as furniture, software, and syllabus/lecture design.

### *2.1.2 Modular design and strategic issues*

Modularity is a strategy for organizing complex products (Baldwin and Clark 1997). Baldwin and Clark's 1997 article "Managing in an Age of Modularity" may be regarded as an influential article that facilitates the emergence of the research strand of modularity in product, organization, and industry design. Baldwin and Clark (1997) observed the change of the computer industry because of the modular product design. They noticed that companies break up a product into subsystems, or modules, and designers and producers gain enormous flexibility from it, since different companies can design or produce different modules separately. The most well-known case is the first modular computer: IBM's System/360. Components of a computer are interdependent, and one correction in a component will lead to a correction to other components. Designers of System/360 refined the design rule of computers and divided systems into several modules. Visible information defined the interaction between modules, and design rules within modules were invisible. Designers only had to follow visible information to design each module independently. The design principles facilitated various innovations of System/360.

Baldwin and Clark's (1997) article points out several important issues in modular product design, such as modular-based product innovation, design rules of modularity, and companies' strategies. According to Baldwin and Clark (1997), innovations can occur quickly and rapidly through modules within a standardized product architecture. Furthermore, regarding modular design, the most important and difficult task for designers is first specifying the design rules, and it requires designers to understand all working processes to ensure each module can mix and match well.

In addition to the design issue, Baldwin and Clark (1997) point out the strategic issues related to modular design. They suggest that strategic issues change according to the position companies choose:

> *For an architect, advantage comes from attracting module designers to its design rules by convincing them that this architecture will prevail in the marketplace.*
>
> *For the module marker, advantage comes from mastering the hidden information of the design and from superior execution in bringing its module to market. As opportunities emerge, the module marker must move quickly to fill a need and then move elsewhere or reach new levels of performance as the market becomes crowded.*
>
> Baldwin and Clark (1997, 88)

That is to say, companies have to consider carefully to compete as an architect creating visible information, and facilitate innovation by modules, or to compete as a designer of modules that conform to the architect to improve specific modules continuously.

### *2.1.3 Modular innovation*

The emergence of modular innovation implies that there is a widely accepted solution (or offering) for certain customer requirements. This kind of offering is usually defined as a dominant design in a market, which represents a well-established offering architecture. Henderson and Clark (1990) consider modular innovation a kind of architecture-based innovation, and based on two dimensions, they define four types of innovation. The two dimensions are (1) whether core concepts are changed and (2) whether linkages between core concepts and components are changed. Four types of innovation are identified according to the two dimensions: (1) incremental innovation, (2) modular innovation, (3) architectural innovation, and (4) radical innovation. Modular innovation indicates linkages between core components and components are unchanged but core concepts are overturned; architectural innovation indicates the reconfiguration of an established system to link together existing components in a new way (Henderson and Clark 1990).

Modular innovation builds on an existing product architecture or a well-defined architecture in an industry (i.e., dominant design). The term *dominant design* in product design represents a kind of architectural knowledge, and it is defined as a specification consisting of a single design feature or a complement of design features that defines the product category's architecture (Srinivasan, Lilien and Rangaswamy 2006). The emergence of a dominant design of product architecture has a strong and significant effect on firm survival due to, for instance, entry timing (Suàrez and Utterback 1995) and market legitimacy (Meyer and Rowan 1977).

The concept of dominant design was introduced by Abernathy and Utterback (1978) who argue that the emergence of a dominant design implies that product innovation is moving from the fluid phase into the transitional phase. Upon entering the phase, product innovation breaks away from the fluid phase in which product innovation, technological, and market needs are ambiguous, and innovations at this phase are at risk of target uncertainty and technical uncertainty. The existence of a dominant design in a market implies a product architecture at a market is well-defined, the product characteristics are well understood and often standardized, and the production efficiency is greatly improved. In other words, the criteria of product performance are clearly defined, and the production system enters into standardization and mass production (Abernathy and Utterback 1978). Furthermore, innovations of components within a product usually occur; therefore, new component knowledge becomes more valuable to a firm than new architectural knowledge, because competition between designs revolves around refinements in particular components (Henderson and Clark 1990, 14-15).

#### *2.1.4 Benefits of modular product development*

Modular product development could bring several benefits to both the supply side and the demand side (Langlois and Robertson 1992), and the two main issues of (1) creating product variety and (2) achieving mass customization efficiency and product families are considered the main benefits of modular product design. Ulrich (1994) points out that through modular product design, companies can gain several benefits. For instance, modularity allows the same components to be reused across product lines, since companies can reduce resources and production cost through reusing standardized components. Furthermore, modularity makes it easier to change products and create product variety. Through dividing components within a product architecture into independent entities, products can be changed easily to meet market changes or different customer requirements without changing entire product architectures. Moreover, product functions can also be upgraded or extended easily through changing a certain component. Product variety can also be achieved easily through “mixing and matching” different function components. Modular product design also facilitates autonomous innovation, since a standardized interface allows each component to be designed in specialized departments independently (Langlois and Robertson 1992).

In addition to benefits to product design, modular product design also benefits product processes. Contrary to integral product design, which requires frequent and close communication between different departments, modular product design allows different components to be designed separately, and production processes can also be decoupled and conducted in parallel (Sanchez 1995). Furthermore, from a marketing perspective, Sanchez (1999) also proposes several benefits of adopting modular design thinking to create new products. For example, modular product architectures help companies test the best combinations of components on customers, increase speed to market with improved products, reduce uncertainty, and accommodate different rates of technological change.

## 2.2 From products to services – a modular perspective to service design

Due the customers' involvement in service-production processes, the decomposition concept has been applied to the service field to solve the complexity problem derived from customers. The main principle of operations management is productivity (Schmenner and Swink 1998). However, the presence of customers in service processes is considered a main challenge to service operations, since it negates the closed-system perspective taken in manufacturing (Fitzsimmons and Fitzsimmons 1994). Service operations management theory, rooted in the manufacturing context, tends to eliminate variability in the production process (Frei 2006). Therefore, the technique of decomposition for reducing complexity is adopted in the service operations management field. The following sections introduce the evolution of the decomposition concept from production-oriented to market-oriented and the way in which the service modularity research field has emerged.

### 2.2.1 From production-oriented to market-oriented

#### *2.2.1.1 Eliminating variability*

The production-line approach was the focus during the years 1960–1970, advocated by marketing expert Theodore Levitt. His 1976 article "*Production-line approach to service*" suggested that production thinking in manufacturing could also be applied to service production for improving production efficiency and effectiveness, and he proposed the idea of service industrialization (Levitt 1960, 1972). The idea of service industrialization does not mean companies only have to consider production efficiency and ignore customers' requirements. During the initial development period of the service industry, the variable quality of services was the main issue, since services still contained a sort of meaning as a servant. Therefore, Levitt (1972) considered that customers wanted high-quality but low-priced services, and to achieve this, he contended that service companies should adopt rationalized management systems to produce services as well as manufacture goods. For improving the problem of variable quality and production efficiency, Levitt (1972) suggested that services could be industrialized through replacing human power with hard or soft technologies (i.e., a systematized production line established by the division of labor, specialization, or a combination of both) (Levitt 1976). A rationalized service production system, such as MacDonald's, could improve operation efficiency, production cost, and service quality and ultimately lead to customer satisfaction. Levitt applied rational management thinking (i.e., service industrialization) to the service industry, and it indeed provided a useful insight for facilitating the industrialization of services. Furthermore, his idea of service industrialization had a great influence on the field of service operations management and promoted the proposal of several evolved notions of service industrialization, such as just-in-time (JIT) (Bowen and Youngdahl 1998) and lean thinking (Johnston 1999).

However, the descriptive notion did not provide specific criteria to measure the level of efficiency or productivity. In addition, the idea was too general, so it was hard to apply to all service companies, since Levitt only focused on production efficiency and ignored the heterogeneity among service companies derived from the inherent characteristics of service systems. Furthermore, Levitt did not discuss how to deal with external factors, such as customer participation in service systems.

*Potential decoupling points at customer contact points*

The potential decoupling points that could be located at customer contact points are the central notion of the customer contact model proposed by Chase (1978). A customer contact point indicates the physical presence of customers in a service-production process. Chase (1978) considers customers' presence the most distinctive factor differentiating the service operation process from the manufacturing operation process, and it changes the conventional closed-production system. Therefore, Chase (1981) argues that longer customer contact times during a service-production process increase interaction between customers and employees, and it easily leads to high uncertainty in the processes of service production. Uncertainty derives from customer–employee interactions due to individual differences in customers' attitudes and behaviors, and it leads to low operation efficiency.

To ensure maximal production efficiency through reducing the degree of customer-derived variability, Chase (1978, 1981) suggests that service firms could take the customer contact point as a potential decoupling point to decompose a service-production process into high-contact and low-contact systems. The low-contact system could be designed as manufacturing's "technical core" without outside influence. This concept thus became the foundation of the back/front-office design. Chase (1978) further suggests that decisions on decoupling points also depend on companies' strategic decisions. For example, service companies could adopt decoupling thinking to consider whether their strength lies in high contact or low contact in order to strike an optimal balance between the two types of allocation and market emphasis.

*Potential decoupling points defined according to standardizable parts*

Variability also derives from service providers (i.e., employees), and the standardizable parts are potential decoupling points. Besides the issue of customer involvement, labor-intensiveness is considered another important characteristic differentiating service-production processes from manufacturing systems (Nie and Kellogg 1999). Therefore, Thomas (1978) suggests that services could be provided by automated equipment, and he proposes a framework that divides services into equipment-based and people-based services. He believes that some equipment could replace some people-based service delivery systems to improve operational efficiency. Equipment-based service delivery systems, such as self-service systems, are considered an option for not only improving productivity and cost savings but also affecting customers' perceptions of service quality and satisfaction (e.g., Dabholkar 1996, Beatson, Lee and Coote 2007).

*2.2.1.2 Variability accommodation*

Contrary to the argument of the need to remove variability, some researchers argue that service companies also have to proactively meet diversified customer requirements (i.e., variability accommodation). Frei (2006) summaries five types of customer-introduced variability: arrival, request, capability, effort (efforts customers are willing to make), and subjective variability. Moreover, she believes that managing customer-introduced variability does not have to come down to a stark tradeoff between cost and quality. She considers that service companies could deal with customer-introduced variability through methods such as decomposing systems to outsource services and increasing the degree of self-services. Furthermore, some researchers believe that improving employee satisfaction or employing management techniques, such as lean management to services, could achieve a balance between ensuring production efficiency and meeting various customer needs.

Besides customers, employees are considered one of the factors that cause variable quality, and it is also defined as a subject that should be standardized. However, some researchers express a contrary argument and suggest that employee satisfaction is an important factor that leads to customer satisfaction and even service firms' profitability (Heskett et al. 1994). The service profit chain proposed by Heskett et al. (1994) argues that the adoption of production thinking to employee treatment is not the only measure for improving service quality. The service profit chain posits, simply, that profit and growth result from customer loyalty generated by customer satisfaction, which is a function of value delivered to customers. Value for customers, in turn, results from employee loyalty and productivity, a function of employee satisfaction, which is directly related to the internal quality (or value) created for employees (Heskett et al. 1994, Heskett and Sasser 2010). Moreover, internal service quality could be improved through factors such as workplace design, job design, employee development, and reward systems. Hart (1988) also notices the importance of employee focus. He claims that services are delivered by human beings and usually produced at the same time they are consumed. It makes service output more unpredictable than machine output, and it simply cannot be guaranteed. Therefore, training and empowerment for employees to deal with unconventional situations is a way of offering a service guarantee (Hart 1988).

Since the late 1990s, researchers have noticed that low cost and high service are not the only decoupling point strategies for front- and back-office decisions (Metters and Vargas 2000, Chen and Hao 2009, Chen 2011) and that different types of system design thinking do exist. Metters and Vargas (2000) try to explore more decoupling point possibilities rather than just the single objective of cost reduction. They suggest that employees' expertise in selling can change the formation of service packages, especially in the case of high-contact services. In other words, through directing interaction with customers, front-office employees could suggest different assemblages of service packages according to different customer characteristics. Thus, the employees' task is one of the potential decoupling point decisions. They further suggest that service firms could specialize tasks according to employees' skills and orientations. For example, they could make employees who have interpersonal and public relations skills responsible for customer communication to gain service sales. The back-office activities are decoupled primarily to facilitate task focus and ensure consistency of quality (Metters and Vargas 2000). In this situation, the consideration of operation cost is secondary. Zomerdijk and Vries (2007) propose additional coupled/decoupled operational strategies. In addition to enhancing cost efficiency, a coupled process can prevent handovers and idle time while promoting task double-checks, centralization, worker matching, quality control, and operational efficiency. Moreover, companies can utilize various decoupling points to achieve mass customization production (Chen and Hao 2009, Chen 2011).

As kinds of management techniques, JIT and lean service represent the production system of mass customization. The main characteristic of mass customization is the fragmentation of service systems for flexible operation process and resource utilization, such as service outsourcing. One of the representative ways of thinking in mass customization is lean thinking. Bowen and Youngdahl (1998) point to the importance of applying manufacturing thinking to service operation and suggest the application of lean thinking to services. Bowen and Youngdahl (1998) consider that service companies should build flexible processes to efficiently produce customized service costs in standardized production systems. By applying lean thinking to services, companies can eliminate the tradeoff between cost and flexibility. Åhlström and Modig (2012) also suggest that lean thinking is one of the strategies to solve the paradox between resource efficiency (company perspective) and service flow efficiency (customer perspective). Bowen and Youngdahl (1998) identify five lean service characteristics: (1) reduction of performance tradeoffs, (2) flow production and JIT pull, (3) value-chain orientation, (4) increased customer focus and training, and (5) employee empowerment.

The idea of service modularity was formally proposed in the late 2000s, and the first International Seminar on Service Modularity was held at Copenhagen Business School Denmark in 2010 (Brax et al. 2017). The development of the concept of service modularity has received a large amount of attention, especially in the service operations management field. However, there are still many potential areas to be explored. Service modularity is proposed as a more holistic perspective on service systems. Through the modularization of service system architecture, service firms can make their service-production processes more flexible. This permits them to unlock the full value of specialization for themselves and their partners and gain the strategic value of flexibility (Brown et al. 2002). Moreover, modularity allows for the elimination of complexity

(Araujo and Spring 2010). Modularity suggests that profit occurs in part from maintaining and even cultivating pockets of complexity in the total set of business activities and then being better at dealing with that complexity than other firms (Araujo and Spring 2010). By utilizing service modularity strategies, service firms can achieve cost reduction, service customization, increased flexibility, service standardization, and so on. However, although the service modularity concept has received a lot of attention, there are still few research studies on related concepts, such as service platforms, interfaces, and architectures.

## 3. Modular service design

### 3.1 Background & Effects of service modularity

Rapid service innovation has been considered an important capability for service companies for success in service markets. Service companies are able to achieve this kind of capability by leveraging from modular service platforms based on a high level of standardization (Løkkegaard, Mortensen and McAloone 2016). Therefore, in addition to the above-mentioned production-oriented logic, the idea of decomposing service product processes has been applied for the improvement of new service developments and market adaptation. The new emergence of the research approach of service modularity aims at achieving service variety and more customized services without losing the mass production mode. Service modularity is applied to explore how service firms can develop an offering that is flexible and open for tailoring and at the same time achieves efficiency through standardizing processes (Rahikka, Ulkuniemi and Pekkarinen 2011). However, due to the unique characteristics of services, such as customers' presence during service-production processes, some intangible elements in service packages make it difficult to define and reach a consensus on the fundamental terms of service modules, platforms, and interfaces. Therefore, regarding the benefits, there is still not enough evidence to prove that the benefits of modular product design are also applicable to services, and it becomes an issue to be explored. Tuunanen and Cassab (2011) investigate the influence of the reuse of service process modularization on customer trials of service innovations. They find the reuse of service process modularization increases the perceived utility and likelihood of a trial if service extensions are of a combined offering, but the effect is contingent on the perception of task complexity for customers. Furthermore, Rahikka, Ulkuniemi, and Pekkarinen (2011) find that the modular service design contributes to the improvement of flexibility in designing service offering variety, since modularity in service increases the customers' willingness to outsource or buy more services from the chosen service providers. Therefore, service providers could provide various services in a more flexible way.

In contrast, de Blok et al. (2010) find that the reuse of service process modularization does not really lead to production efficiency. In an investigation of elderly care, de Blok et al. (2010) notice that due to the nature of services (i.e., they only occur at the interaction between customers and service providers), the repetitive execution of service modules might not lead to the benefits of efficiency. The main reason is that modules are easily modified and influenced by human behavior, which leads to the adaption of modules rather than constant standardized routines.

This section is organized as follows. Firstly, based on the discussion in the section on services and modular product design, this section investigates how the three design principles of decomposability, reusability, and combinability are connected with the notion of service inseparability in the service modularity literature. Secondly, corresponding with the discussion on modular product design, this section summarizes how terms related to service architecture (i.e., service modularity, modules, platforms, and interfaces) are identified.

Because of the characteristic of inseparability and process-based nature of services, in most studies, the concept of service modularity tends to be investigated from multiple levels (i.e., service offerings, processes, and even organizations) simultaneously. Therefore, modularity in services is composed of three dimensions: service modules, modularity in processes, and modularity organization (Pekkarinen and Ulkuniemi 2008).

De Blok (2013) defines two ways for achieving customized service offerings through the modular approach. In the first one, combinability, variety can be achieved by means of combining predefined menu components that cannot be changed. That is, modularity is achieved through a set of options that service providers or customers are able to arrange and combines to satisfy certain customer requirements. Another way is "changing the dimensions of the service prototypes." Components in the standard design can be modified or unique modules can be created and added to the prototype to provide a service package that meets customer specifications (de Blok, et al. 2010, 17).

### *3.1.1 Principles of service offering design from modular & platform method*

*Decomposability*

The decomposability of service modules at the offering level indicates the decomposability of functional elements in a service package (Voss and Hsuan 2009). A service package thus could be decomposed into a set of modules that describes a bundle of possible services. Service modules could be categorized

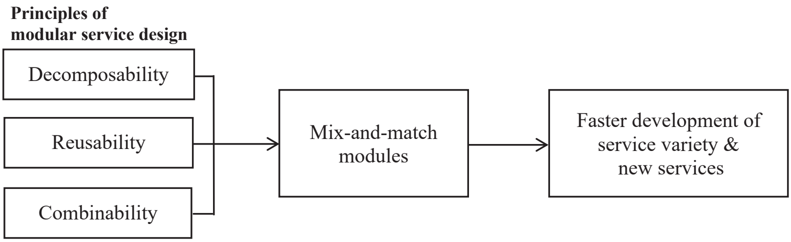


*Figure 1. Mechanism of new service development from modular design principles*

into standard service modules and unique service modules. Standard service modules are utilized across different service packages, and unique service modules are those unique within the firm and difficult to copy in the short term by competitors (Voss and Hsuan 2009). For example, a traveling package contains services such as accommodation, entertainment, and transportation services. de Blok et al. (2010) also define three kinds of modules: basic modules that are common to all services, modules that can be configured to accommodate specific needs, and modules used for the customization of individual services. The decomposability of service modules allows the customization of services to be achieved through the combination of a set of service processes and products to create a unique service or menu, which involves the selection of one or more services from a set of existing services/products to meet customer needs (Voss and Hsuan 2009, 556).

Decomposability at the service offering level also indicates the decomposability of the processes of service encounters. Services are processes. Service process modularization is the systematic combination of service encounter processes known to both the customer and the firm that generates new, customizable service packages of increased utility to the customer (Tuunanen and Cassab 2011). Furthermore, customers are indispensable factors in a service process regardless of whether they are active participants as value co-creators or passive participants as co-producers. Service processes reflect customers' service experiences; therefore, in modular service design, service experience is also an important dimension of service outcome (Tuunanen 2012). From the previous literature, Tuunanen (2012) summarizes four dimensions of the service experience: customers' role perception, personalization, task complexity, and value creation. Li (2010) considers that service process modularization breaks a service experience into discrete episodes.

*Reusability*

Reusability in services is not a new idea. In previous studies, the standardization of the service-production process, service concepts, or management systems has been considered as a way of improving service quality. More precisely, unlike modular product design, at the offering level, reusability indicates the reuse of physical modules or components, which contain bundles of functions or attributes. In the service context, reusability indicates the reuse of mindsets, interaction methods, service settings, and production and management systems for producing a certain service outcome, which could be considered a kind of service script (Grove and Fisk 1983).

Therefore, reusability in modular service design should be identified from three perspectives: functional components, modules, and processes. These factors in service production systems can be applied to different service systems in a modular design service system. For instance, a restaurant and a retail store share the same logistic service. Although Tuunanen and Cassab (2011) do not clearly define the mechanism of reusability of services, they investigate customers' perceived value of reused service processes. They found that when the complexity of service tasks is high, the reuse of service processes could increase the likelihood of trial service extension and perceived utility. de Blok et al. (2010) define common modules as basis modules that can be applied to all care services. The reusability of services also indicates a larger subsystem, called a platform, in a service package (e.g., Pekkarinen and Ulkuniemi 2008).

However, whether the reuse of service modules or processes could improve production efficiency is still under investigation. Due to customers' presence in service-production processes, interactions between customers and service providers can easily lead to adoption. For instance, as noted above, de Blok et al. (2010) find that the reuse of service process modularization does not lead to production efficiency.

*Combinability*

Combinability enables services to be easily combined. Similar to modular product design, the usability of service modules or platforms is highly related to the design of interfaces. The combinability in service design indicates the connection between service outcome modules and processes. Due to the central role of human interactions in service delivery, a higher incidence of loose coupling is probable, which can lead to easier replication of modules across systems (Avlonitis and Hsuan 2017). Ulrich and Eppinger (2015) also state that human interactions can lead an easier combination of service modules.

## 3.2 Glossary of terms and definition for modular and platform design

### *3.2.1 Architectures of service offerings*

A service architecture is defined as the way that the functionalities of the service system are decomposed into individual functional elements to provide the overall service delivered by the system, and a service architecture is composed of service modules, service platforms, and service interfaces (Voss and Hsuan

2009).

### *3.2.2 Service modules*

Due to the process-based nature of service offerings, a service module can be defined from two perspectives: the outcome perspective and the process perspective. The outcome aspect reflects the result of the process, and the process typically takes place before the outcome is realized (Holmlund 2004). A service module from an outcome aspect represents a specific function or attribute that reflects customers' requirements. In other words, services can be split into functions that need to be performed to produce a service that can subsequently be utilized to produce many different services (Tuunanen and Cassab, Service Process Modularization: Reuse Versus Variation in Service Extensions 2011, 358). As noted in the section on modular product design, modules are hierarchically structured. Therefore, a service offering is composed of a set of outcome modules, and each outcome module can be further decomposed into several components that present the smallest unit in a service architecture (Voss and Hsuan 2009). Regarding the types of service modules, de Blok et al. (2010) define three kinds of modules: a basis module that is common to all care services, segment-specific modules to be configured for specific client segments, and person-specific modules that allow for fine-tuning at the individual level (Tuunanen and Cassab, Service Process Modularization: Reuse Versus Variation in Service Extensions 2011). From the outcome perspective, Rahikka, Ulkuniemi, and Pekkarinen (2011) define the service module as the smallest service unit that can be offered to a customer in itself or as a part of a service offering creating the value perceived by the customer. From the process perspective, Rahikka, Ulkuniemi, and Pekkarinen (2011) define a modular process as a process composed of one or more service modules (tasks) that are designed independently but still function as an integrated whole to perform the intended function that the customer requires. Tuunanen and Cassab (2011) define service modularization as the systematic combination of service encounter processes known to both the customer and the firm that generates new, customizable service packages of increased utility to the customer.

Therefore, according to the above discussion, this article defines a service module containing both functional and process aspects. From the outcome aspect, a service module represents a specific function or attribute that reflects customers' desired outcomes. From the process aspect, a service module is a unit of interaction processes between customers and service providers. In other words, a service package can be configured by combining different functional service modules and service processes. Furthermore, a service component in this article is defined as the smallest decomposable unit in service architecture.

### *3.2.3 Service platforms*

For improving service production efficiency and facilitating new service development corresponding to customers' requirements, researchers have recently sought to apply and extend the principles of product platform design to the service field (Moon, Simpson and Kumara 2010). There have been an increasing number of attempts to apply the concept of the product platform to service platform development. The results include new service development, quality control, and mass customization operation system development. Nevertheless, the definition of a service platform remains vague. Comparisons are shown in Figure 1. There is one significant difference among prior researchers' definitions of the service platform. Some define it as a function process (Meyer and DeTore 2001, Bohmer and Lawrence 2005, Hofman and Meijerink 2015), while others refer to it as a set of service offerings, production process, and/or organization of a service package (Pekkarinen and Ulkuniemi

2008, Lin, Luo and Zhou 2010). The latter take a holistic view in defining a service platform as a strategic combination of organization, process, and service offerings, whereas the former only focus on a process structure.

According to a more operational definition from the offering perspective, a service platform is considered to consist of common modules utilized across a service family, and through combining variant modules or unique modules, diversified services can be created (Moon, Simpson and Kumara 2010). Therefore, this article defines service platforms as common modules in a product architecture. Furthermore, due to the process-based nature of services, a service platform also should be considered from a process perspective, and common processes constitute a service platform.

### *3.2.4 Service interfaces*

Interfaces establish the boundaries of modules and develop connections between modules (Peter, Meijboom and de Vries 2018) .  In modular service design, due to the unique characteristics of services, the concept of interfaces in services still needs to be further explored (Peter, Meijboom and de Vries 2018). Voss and Hsuan (2009) argue that since the notion of interface is a set of design parameters describing how two objects mutually interact, this leaves much freedom in terms of the precise definition of the module in different contexts, including services (Voss and Hsuan 2009, 545). According to Voss and Hsuan (2009), customers' presence in the service -production process requires service companies to communicate with customers, and information transfer is a key interface. Therefore, they define interfaces in services as information flow, human flow, and rules governing the flow of information.

Interfaces in services could be considered as "soft" human activities or "hard" technology for connecting different service modules, and the soft interfaces have high potential to make services more customized (Bask, et al. 2010). de Blok et al.'s (2014) work is considered the most compenhsive exploration of service interfaces to date, and they define service interfaces using two dimensions: the level of the service components and the level of the service package. Interfaces on the component level are expected to manage contact interactions and therefore are concerned with the flow of service customers, while interfaces on the service package level are expected to manage service provider interactions and therefore are concerned with the flow of information (de Blok, et al. 2014, 178). In other words, for ensuring customer flow, interfaces between components, such as continuous needs assessments, established communication lines, and customer meetings, are established for connecting customer flow. After defining customer needs, interfaces are product books, pre-combined elements, planning rules for safety, and planning rules for smooth flow for reconfiguring packages and components. Furthermore, for connecting different services from different providers, information flow becomes the main issue, and interfaces between service providers, such as organizational arrangements, work schedules, and care dossiers, are designed for ensuring the information flow (de Blok, et al. 2014). de Blok, et al.'s (2014) further define two functions of interfaces. They find interfaces not only facilitate variety but also enable coherence. Therefore, at the component level, interfaces for facilitating variety to meet different customer requirements are defined as open-customer (OC) interfaces. Furthermore, interfaces at the component level for enabling coherence are defined as closed-customer (C-C) interfaces. The main purpose of these C-C interfaces is to eliminate variability for the achievement of standardization. Interfaces at the service package level can also be defined as open or closed. Open-information (O-I) interfaces are designed for supporting information flow between service providers by increasing information capacity. Closed-information (C-I) interfaces are designed for the purpose of reducing the need for information exchange (de Blok, et al. 2014).

| Descriptions of service interfaces | Sources |
|---|---|
| Information flow<br>Human flow<br>Rules governing the flow of information | Voss & Hsuan (2009) |
| Soft human activities<br>Hard technology | Bask, et al. (2010) |
| Interfaces enable varaibility within a service module<br>– Open-customer interfaces<br>Interfaces enable coherence within a service module<br>– Closed-customer interfaces<br>Interfaces enable variability between service modules<br>– Open-information interfaces<br>Interfaces enable coherence between service modules<br>– Closed-information interfaces | de Blok, et al. (2014) |

In summary, following de Blok et al.'s (2014) definition, interfaces in the service context indicate the customer flows for connecting modules, and interfaces include information for connecting suppliers. Furthermore, interfaces include two functions: enabling variety and coherence.

## 4. Conclusions and future directions

Although several studies have provided several insights into the research field of modular service design, there are still some questions that need to be explored.

The architectural perspective to service offerings states that service providers should turn their partial focuses on the service-production process into more holist viewpoints. Based on a well-established service architecture, new services and service varieties are able to be created in an easier way; that is, according to previous studies, the architectural perspectives on offering design, including modular design, have been adapted to product design and extended to services design in recent years. The three modular design principles of decomposability, reusability, and combinability defined in modular product design also apply to the field of modular service design. Through the three principles, products/services can be mixed and matched easily to create products/services variety and new products/services.

Decomposability indicates that the interdependency between modules is weak. Therefore, each module can be designed and produced separately, and when changes occur in a module, there is no need to change other parts within the same systems. Reusability and combinability are related concepts. Reusability refers to common modules or platforms that are utilized across a product line. The reusability of modules or platforms is achieved through standardized interfaces to make modules combinable. Therefore, defining modules, platforms, and interfaces is a precondition for modular products/services design.

Due to the process-based nature of services, production and consumption occur at the same time. Therefore, customers' engagements are indispensable to a service-production process, and they are also considered to be the main character that make service modules differ from product modules. In modular product design, a product module, platform, and interface could be defined from functional and physical aspects. However, due to the process-based nature of services,  a service module and platform are defined from functional and process aspects. The functional aspect reflects customers' required attributes that are implemented through corresponding service-production processes. The platform aspect to services refers to common modules in a service architecture. Interfaces are design parameters defining how two objects mutually interact.

However, can these three principles of decomposability, reusability, and combinability really directly enable service variety as modular product design? First and foremost, this paper argues that the simplified categorization of service modules is one of the factors hampering discussions of service modularity. From the input-output perspective of services, there are at least four types of functional service modules according to the methods of interaction between customers and service providers. Furthermore, although several previous studies have pointed out that services are complex assemblies of several elements, both tangible and intangible, no research discusses how customers interact with tangible elements or the role of tangible elements based on the modular design principle to create service variety. Therefore, this paper argues that there is a need to adopt a different perspective to re-examine the architecture and composition of service offerings.

## References


Abernathy, William J., and James M. Utterback. 1978. "Patterns of Industrial Innovation." 8 (2): 40–47.

Åhlström, Par, and Niklas Modig. 2012. *This is Lean: Resolving the Efficiency Paradox*. Rheologica Publishing.

Avlonitis, Viktor, and Juliana Hsuan. 2017. "Exploring Modularity in Services: Cases from Tourism." *International Journal of Operations & Production Management* 37 (6): 771–790.

Baldwin, Carliss Y., and Kim B. Clark. 1997. "Managing in An Age of Modularity." *Harvard Business Review* 75 (5): 84–93.

Bask, Anu, Mervi Lipponen, Mervi Rajahonka, Tinnilä, and Markku Tunnilä. 2010. "The Concept of Modularity: Diffusion from Manufacturing to Service Production." *Journal* *of Manfacturing Technology Management* 21 (3): 355–375.

Bohmer, Richard M.J., and David M. Lawrence. 2005. “Care Platforms: A Basic Building Blok for Care Delivery.” *Health Affairs* Vo.27 (No.5): pp.1336–1340.

Bowen, David E., and William E. Youngdahl. 1998. ““Lean” Service: In Defense of a Production-Line Approach.” *International Journal of Service Industry Management* 9 (3): 207–225.

Catel, Florent, and Jean-Charles Monateri. 2005. “Strategic Perspectives on Modularity.” *DRUID Tenth Anniversary Summer Conference 2005, “Dynamics of Industry and Innovation: Organizations, Networks and Systems*”. Copenhagen. 1–32.

Chase, Richard B. 1981. “The Customer Contact Approach to Services: Theoretical Bases and Practical Extensions.” *Operations Research* 29 (4): 698–706.

Chase, Richard B. 1978. “Where does the Customer Fit in a Service Operation.” *Harvard Business Review* November-December: 137–142.

Chen, Jue. 2011. “De-coupling of Front-back Stage in Service Industries Developments from Traditional Operation to Mass Customization.” *African Journal of Business Management* 5 (29): 11727–11735.

Chen, Jue, and Yunhong Hao. 2009. “Service System Decoupling for Mass Customization: A Case Study in Catering Services.” *Journal of Service Science & Management* 2 (4): 255–264.

Clark, Kim B. 1985. “The Interaction of Design Hierarchies and Market Concepts in Technological Evolution.” *Research Policy* 14 (5): 235–251.

de Blok, Carlien, Bert Meijboom, Katrien Luijkx, Jos Schols, and Roger Schroeder. 2014. “Interfaces in Service Modularity: A typology Developed in Modular Health Care Parvision.” *Journal of Operations Managment* 32 (4): 175–189.

de Blok, Carolien, Katerien Luijkx, Bert Meijboom, and Jos Schols. 2010. “Modular Care and Service Packages for Independently Living Elderly.” *International Journal of Operations & Production Management* 30 (1): 75–97.

Fitzsimmons, James A., and Mona J. Fitzsimmons. 1994. *Service Management for Competitive Advantage*. U.S.A: McGraw-Hill.

Frei, Frances X. 2006. “Breaking the Trade-Off between Efficiency and Service.” *Harvard Business Review* November: 1–12.

Grove, Stephen J., and Raymond P. Fisk. 1983. “The Dramaturgy of Service Exchange: An Analytical Framework for Service Marketing.” *Emerging Perspectives on Service Marketing*. 45–49.

Hart, Christopher W. 1988. “The Power of Unconditional Service Guarantees.” *Harvard Business Review* July-Auguest: 54–62.

Henderson, Rebecca, and Kim B. Clark. 1990. “Architectural Innovation: The Reconfiguration of Existing Product Technologies and The Failure of Established Firms.” *Administrative Science Quarterly* 35 (1): 9–30.

Heskett, James L., Thomas O. Jones, Gary W. Loveman, Earl W.JR. Sasser, and Leonard A. Schlesinger. 1994. "Putting the Service-Profit Chain to Work." *Harvard Business Review* March-April: 164–174.

Hofman, Erwin, and Jeroen Meijerink. 2015. "Platform Thinking for Services: The Case of Human Resrouces." 35 (3): 115–132.

Holmlund, Maria. 2004. "Analyzing Business Relationships and Distinguishing Different Interaction Levels." *Industrial Marketing Management* 33 (4): 279–287.

Johnston, Robert. 1999. "Service Operations Management: Return to Roots." *International Journal of Operations & Production Management* 19 (2): 104–124.

Korkman, Oskar, Kaj Storbacka, and Bo Harald. 2010. "Practices as Markets: Value co-creation in e-invoicing." *Australasian Marketing Journal* 40 (2): 236–247.

Langlois, Richard N. 2002. "Modularity in Technology and Organization." *Journal of Economic Behavior & Organization* 49 (1): 19–37.

Langlois, Richard N., and Paul L. Robertson. 1992. "Networks and Innovation in a Modular System: Lessons from the Microcomputer and Stereo Component Industries." *Research Policy* 21 (4): 297–313.

Levitt, Theodore. 1960. "Marketing Myopia." *Harvard Business Review* 38 (4): 45–56.

Levitt, Theodore. 1972. "Production Line Approach to Services." *Harvard Business Review* (Sept-Oct): 41–52.

Levitt, Theodore. 1976. "The Industrialization of Service." 63–74.

Li, Bing-Han. 2010. *Study on Service Modularity and Its Application (Chinese Title 服务模块化的建构与应用研究 )*. Shanghai: Fudan University.

Lin, Yond, Jing Luo, and Li Zhou. 2010. "Modular Logistics Service Platform." *IEEE International Conference*. 200–204.

Løkkegaard, Martin, Niels Henrik Mortensen, and Tim C. McAloone. 2016. "Towards a Framework for Modular Service Design Synthesis." *Research in Engineering Design* 27 (3): 237–249.

Metters, Rihard, and Vicente Vargas. 2000. "A Typology of De-coupling Strategies in Mixed Services." *Journal of Operations Management* (18) 6: 663–682.

Meyer, John W., and Brian Rowan. 1977. "Institutionalized Organizations: Formal Structure as Myth and Ceremony." *American Soiologizal Review* 83 (2): pp.340–363.

Meyer, Marc H., and Arthur DeTore. 2001. "PERSPECTIVE: Creating a Platform-Based Approach for Developing New Services." *The Journal of Product Innovation Management* Vol.18 (No.3): pp.188–204.

Moon, Seung Ki, Timothy W. Simpson, and Soundar R.T. Kumara. 2010. "A Module-Based Service Model for Mass Customization: Service Family Design." *IIE Transactions* 43 (3): 153–163.

Nie, WInter, and Deborah L. Kellogg. 1999. "How Professors of Operations Management View Service Operations?" *Production and Operations Management* 8 (3): 339–355.

Normann, Richard, and Rafael Ramírez . 1994. *Designing Interactive Strategy: From Value Chain to Value Constellation*. England: John Wiley & Sons Ltd.

Normann, Richard, and Rafael Ramírez. 1993. “From Value Chain to Value Constellation: Designing Interactive Strategy.” *Harvard Business Review* 71 (4): 65–77.

Pekkarinen, Saara, and Pauliina Ulkuniemi. 2008. “Modularity in Developing Business Service by Platform Approach.” *The International Journal of Logistics Management* 19 (1): 84–103.

Peter, V. J.T., B. R. Meijboom, and E. de Vries. 2018. “Interfaces in Service Modularity: A Scoping Review.” *International Journal of Production Research* 56 (20): 6591–6606.

Rahikka, Emmi, Pauliina Ulkuniemi, and Saara Pekkarinen. 2011. “Developing the Value Perception of the business Customer through Service Modularity.” *Journal of Business & Industrial Marketing* 26 (5): 357–367.

Richard, Normann, and Rafael Ramírez. 1989. “A Theory of the Offering: Toward a Neo-Industrial Business Strategy.” In *Strategy Organisation Design, and Human Resource Management*, 111–128. Londond: JAI PRES INC.

Sanchez, Ron. 1999. “Modular Architectures in the Marketing Process.” *Journal of Marketing* 63 (Special Issue): 92–111.

Sanchez, Ron. 1995. “Strategic Flexibility in Product Competition.” *Strategic Management Journal* 16 (S1): 135–159.

Schmenner, Roger W., and Morgan L. Swink. 1998. “On Theory in Operations Management.” *Journal of Operations Management* 17 (1): 97-113.

Schuh, G., S. Rudolf, and T. Vogels. 2014. “Development of Modular Product Architecture.” *Procedia CIRP* 20: 120–125.

Simon, Herbert A. 1962. “The Architecture of Complexity.” Proceedings of the American Philosophical Soceity. 467–482.

Srinivasan, Raji, Gary L. Lilien, and Arvind Rangaswamy. 2006. “The Emergence of Dominant Designs.” *Journal of Marketing* 70 (2): 1–17.

Suàrez, Fernando F., and James M. Utterback. 1995. “Dominant Designs and the Survival of Firms.” *Strategic Management Journal* 16 (6): 415–430.

Thomas, Dan R.E. 1978. “Strategy is Different in Service Businesses.” *Harvard Business Review* July-Auguest: pp.158–165.

Tuunanen, Tuure. 2012. "Typology for Modular Service Design: Review of Literature.” *International Journal of Service Scinece, Management, Engineering, and Technology* 3 (3): 99–112.

Tuunanen, Tuure, and Harold Cassab. 2011. “Service Process Modularization: Reuse Versus Variation in Service Extensions.” *Journal of Service Research* 14 (3): 340–354.

Ulrich, Karl. 1994. “Fundmentals of Product Modularity.” In *Management of Design*, 219–231. Dordrecht: Springer.

Ulrich, Karl, and Steven Eppinger. 2015. *Product Design and Development*. 6th. McGraw-Hill

Education.

Voss, Christopher A., and Juliana Hsuan. 2009. “Service Architecture and Modularity.” *Decision Sciences* 40 (3): 541-569.

Zomerdijk, Leonieke G., and Jan de Vries. 2007. “Structuring Front Office and Back Office Work in Service Delivery Systems: An Emprical Study of Three Design Decision.” *International Journal of Operations & Production Management* 27 (1): 108-131.