Service modularization based on SDL: Application in Catering

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Abstract
The article explores service modularity based on supply chain environment with a mathematical model in catering. Not only we regard downstream clients as the source of value creation, which SDL indicates the co-creation, but also combining activities and customers' resources to achieve the goal of service value innovation.

Keywords: service modularity, value innovation, SDL

INTRODUCTION

With the increasing growth of the sector, services are no longer considered as a peripheral part in markets, in turns to be the most promotion one in company business. This strong competition puts greater pressure on enterprises to provide innovative services. Recent markets show great trends to service variety and in some cases differentiation and special packages of service are needed to be carried out when dealing with high variety demand which from the extension of product. On the one hand, the standardization of service processes are designed to ensure a high efficiency and cut the cost (Böttcher & Klingner, 2011; Tuunanen, 2011). On the other hand, in order to rapidly respond to changing demands, firms need to improve the flexibility of service process(Wang C.S, 2009). However, achieving this balance is increasingly difficult as customer requirements tend to become more heterogeneous and diversified (Rust & Huang, 2012). Linking service efficiency and customization is challenging as they are usually conflictive. To eliminate the contradiction, the modularization of services has been identified as a concept tool to solve the complexity of balancing customized services with efficiency (Geum & Kwak, 2012; Pil&Cohen, 2006).

Although modularity stems from manufacturing industry, studies on modularity in service settings are emerging (Ulkuniemi & Pekkarinen, 2011; Voss & Hsuan ,2009). How to define the service module and how to design it with other related issues, has become a hot spot for a large number of scholars. Therefore, a prominent field of service modularization has been emerging is integration in demand-based sight, where it has been considered as the innovative part in service.

This paper starts from the customer's point of view, to explore the value of service activities, and the mathematic quantitative way of the module division. The rest of paper is organized as follows: Section 2 provides a literature review of service modularity, while Section3 covers the problem description and model formulation .The solution method and proposed algorithm will be discussed in Section 4. Then, the proposed approach is illustrated with a case study of service division. In Section 6, the conclusions and future works discussion are marked.

LITERRATURE SURVEY

The service modularity problem is widely discussed in the literature. The comprehensive reviews has been proposed by Sundbo(1994), Böttcher and Klingner(2011), Bask.(2011), Blok(2010)and Voss and Hsuan(2009). Due to their increasing importance, the service modularity have attained more attentions. Sunbo(1994) is the first researcher who introduces the concept of service. He proposed the feasibility of service modularity. More explicit definition is given for service module by Böttcher and Klingner(2011), including economies of scale caused by standardization of complex services. With driver-based approach and interrelationship-based approach, Geum, Kwak, and Park (2012) propose a method for service modularization by modifying the House of Quality (HoQ). Based on process characteristics, Carlborg (2014) divides service process into two types of rigid and flexible, based on the role of customer in service process ,active or passive, and final forming four types of services in the basis of different types of process and customer. Song（2015）takes the perspective of manufacturing industry product for the background, proposing a service blueprint and fuzzy graph theory of product extension service modular design method, and finally through a case study to verify the validity of this method.

The biggest weakness of service modularity is that the research methods are from an individual enterprise view at conceptual level—the important part of how to modularize services in actual industry has not been dealt with（Geum, Kwak, and Park, 2012）.

This study differs from existing literatures in several parts to explore modular optimization in service process. Firstly, the paper discusses the service modularity from a supply chain perspective, and the research subjects are individual service providers to service integrations model (B to B) instead of individual service firm to end-customers model (B to C), and the service integrations processes are considered as a source of value creation. Secondly, the thought of gathering a cluster of customer demands and activities simultaneously is used to construct the modules. At last, the multiple factors including service activities value, cost, correlation and service capacity are considered in the optimization model, and the sensitivity analysis to service capacity is presented.

PROBLEM DESCRIPTION AND MODEL

Modular construction

The value of the service provider derives from the customer demand which can be analyzed through service process in demands-based sight. Therefore, the method of module division is required to start from the customer process. Suppose a professional service provider has a number of potential customers (service integrator), in which the service process is composed of M service activities, and a_i represents the i service activities in the service process. Make V_i represents the service value of i activity, C_i expresses the service cost of i activity, and e_{ij} represents the degree of association between the activity i and the activity j (The higher degree of two activities is, the more closely related between them, which lead to greater total value), $0 \leq e_{ij} \leq 1$,service activities are constituted by four element array $a_i = \{v_i, c_i, e_{ij}, e_{ji}\}$,in which i or j=1,2,3…M. See in Figure 1.

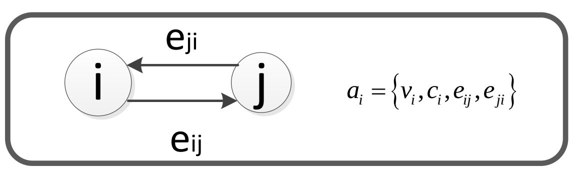

Figure1- Service activity parameter

According to the service activity attribute, the activity can be divided into the standard service activity and the heterogeneous service activity (Voss & Hsuan, 2009). The standard service activities emphasize that the service value is the same, no matter who completed the activity. That is, there is no difference between service providers about the same standard service, such as resource, process and so on; Heterogeneous activities emphasize that the service value created by different service providers is different, which reflects non-replicated in service. Standardized activities can improve the service efficiency, lead to low cost, while the heterogeneous activities can improve the service value, but lead to high cost. Professional service providers can provide the service module with a high value and low cost on the basis of customer's demand. On the one hand, the enterprise has the motivation to design the corresponding process as a modular form. On the other hand, they can order the corresponding service module from professional supplier about non-core activities to improve competitiveness (Rajahonka, 2013). In order to improve the quality of service, the valued service activities should be gathered, so as to customers' demand to reduce cost.

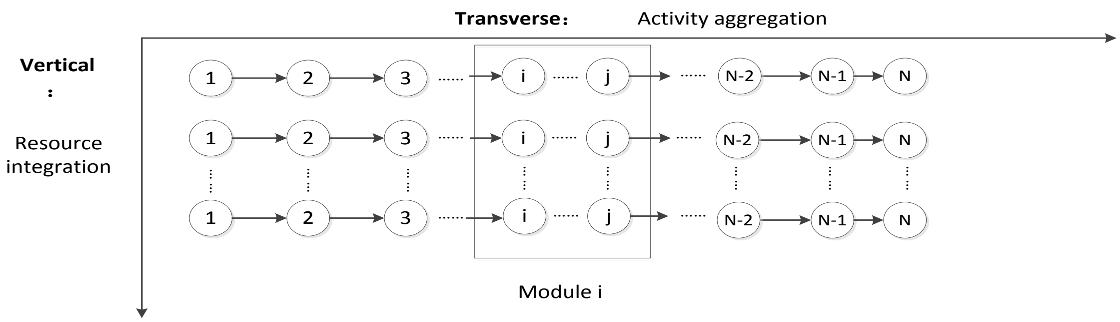

Figure 2-The modularity in integrating customer resources and activities

Therefore, this paper works on how to modularize service, not only considers activities of the aggregation, but also the integration of customers' resources, as shown in Figure 2.

Mathematical modeling

Suppose there are i kinds of customers with different demands, every kind of customers has N_i customers with M_i activities in each kind of service process.

a_i : service activity i, $a_i \in \{a_1, a_2, ... a_M\}$

q_i : the times that activity i has appeared in the whole service process

V_i : the value of activity i

C_i : the cost of activity i

e_{ij} : the correlation between activity i and activity j

Through the Design Structure Matrix (DSM) method, we construct a $\mathrm{M} \times \mathrm{M}$ matrix $\mathrm{A} = [\mathrm{e}_{ij}]_{M \times M}$. And e_{ij} and e_{ji} show different meaning. For instance, when $e_{ij} = 0 = e_{ji}$, it shows activity I and j are independent; when $e_{ij} > 0, and\ e_{ij} = 0,$ it shows activity i and j are in the order of dependence; when $e_{ij} > 0\ and e_{ji} > 0,$ it shows activity i and j are conjugate dependent.

The value of the service module depends on the composition of service activities, the degree of correlation and the size of resource integration. These parameters and indices of model will be as following.

Definition 1: As the Voss and Hsuan (2009) defines the heterogeneity of service activities are specific and non-reproducible activities. Suppose the more species and quantity of resource in heterogeneity are needed, the greater the value of the activity is. Set, $Z_i = \begin{Bmatrix} 0; & Activity\ i\ is\ standard. \\ 1; & Activity\ i\ is\ heterogeneous. \end{Bmatrix}$

Definition 2: If there are just activity $a_i\ and\ a_j$ in the k service module, the modular basic value is $V_0^k = v_i + v_j$.

Definition 3: Considering the integration effect of modular activities (Ulkuniemi &Pekkarinen, 2011) the added value of the module K is assumed to form according to the association between the components. The added value is $V_1^k = v_i e_{ji} + v_j e_{ij}$, the total value of service module is $V_k = V_0^k + V_1^k$.

Definition 4: Considering the integration effect of customer resources and demands, we assume that when we integrate the heterogeneous activities,it can enhance the value of its activities. Due to integration effect, the increasing part of activities' value is $v_i^n = \begin{cases} v_i; if\,(z_i = 0) \\ v_i . n^{\alpha_i}; else \end{cases}$, of which $0 < \alpha_i < 1$, to ensure that V_i^nchanges in accordance with the law of marginal decline.

Definition 5:. C_0^i is the fixed cost to complete the activity,$C_0^i > 0$; C_1^i is variable cost to complete the activity, $C_1^i > 0$; $c_i = c_0^i + c_1^i$; C_n^i represents the integration cost of forming a service module for the integrating i activity of the n clients together.

Definition 7: y_i^k indicates whether the K service module has I service activity, $y_i^k = \begin{Bmatrix} 0; activity\ i\ is\ not\ in\ the\ K\ module. \\ 1; \quad activity\ i\ is\ in\ the\ K\ module. \end{Bmatrix}$;$y_s^k$ indicates whether the K module has s customer, $y_s^k = \begin{Bmatrix} 0; customer\ s\ is\ not\ in\ the\ K\ module. \\ 1; \quad customer\ s\ is\ in\ the\ K\ module. \end{Bmatrix}$

Definition 8: To simplify the model, the average value of the N client is taken as the module value parameter: $v_i = \frac{\sum_{s=1}^{N} y_s^k v_i^s}{n}$, Where $V_i^s\ represents$ the service value of activity i of customer s. Meanwhile, the average value of all the customer's cost is used as the cost parameter.

Through the optimization of service activities, the objective function is to maximize the ratio of total service value and total cost of the module. The linear optimization models and related constraints can be formulated as follows.

$$\max F = \frac{\sum_{k=1}^{K}\sum_{i=1}^{M} v_i \left[(1+\sum_{j=1}^{M} e_{ji} y_j^k) y_i^k + (n^{\alpha_i} - 1) z_i \right]}{\sum_{k=1}^{K}\sum_{i=1}^{M} (\frac{c_n^i}{n} + c_1^i) y_i^k} \qquad (1)$$

The objective function must satisfy the following constraints:

$$\sum_{i=1}^{M} y_i^k \leq 1 \qquad (2)$$

$$\sum_{s=1}^{N} y_s^k = n \qquad (3)$$

$$F \geq \max\left\{ \sum_{k=1}^{K}\sum_{i=1}^{M} (\frac{v_i^s y_s^k}{c_o^i + c_1^i}) y_i^k \right\}, s = 1, 2 \ldots N \qquad (4)$$

Constraint 2 is to guarantee that every activity appears in any service module at most one time. Constraint 3 is to ensure that modular service capability is consistent with customers. Constraint 4 is to ensure that the target value of the module is higher than the value without modularity.

The solution method and proposed algorithm

The above model is a typical combinatorial optimization. The difficulty will increase with the increasing number of activities and customers in service process. We commonly use heuristic algorithm to solve this large-scale problem instead of analytical method which is not realistic. Genetic algorithm (GA) is a randomized search method evolving from biology evolution: survival of the fittest genetic mechanism. It has characteristics of large scale implicit parallel processing and global optimization, and a lot of practice shows that it is an effective method to solve the problem of NP by using genetic algorithm. So here we give a heuristic algorithm based on genetic algorithm, in the next section we will illustrate the effectiveness of this algorithm by using actual examples.

CASE STUDY

Preparation of data

Select L company as an example to discuss the effectiveness and applicability of the proposed method of service modularity. The company focuses on the supply service in the field of frozen food, and it has provided a series of solutions of frozen ingredients in supply chain service for catering industry. Its customers are diverse, including the chain hotels, restaurants, organ canteen and other catering enterprises. After investigating 50 catering enterprises in Wuhan for one month, the general service activities of catering enterprises are obtained. See in table1. At the same time, we analyze the information of the resources, the degree of complexity and the functional requirements of each service activity, finally we obtain the relevant data: the value and cost of each activity, and correlation degree of each customer.

Table 1-Main service activities of catering industry

Code	Service	Co	Service	Co	Service
a_1	survey customer needs	a_9	Promotion in small	a_{17}	Checking
a_2	Make purchase plans	a_{10}	Tableware preparation	a_{18}	Feedback
a_3	Ingredients purchase	a_{11}	Reservation processing	a_{19}	Farewell
a_4	Publicity and markting	a_{12}	Greeting service	a_{20}	Clean up the table
a_5	Design of new dishes	a_{13}	Pre-meal service	a_{21}	Wash the dishes
a_6	Prepare trial ingredient	a_{14}	Order	a_{22}	Prepared ingredients
a_7	Dish trial	a_{15}	Meal service	a_{23}	Dishes cooking
a_8	Improvement of dishes	a_{16}	Serving	a_{24}	Pre-disposal of food

Note: The sequence of service activity and activity code are irrelevant.

Result analysis and application

Here, input the data of service activities value, cost and activities correlation of from 50 different customers, then we analyze these data to get results. The optimization algorithm is implemented in Matlab 4.0. The basic data for the parameter setting: $value\ V_i$ is the average value of the selected N group data, cost $C_0^i\ and\ C_1^i$ are the average value of the 50 customers, K=1 (to find out an optimal module), M=24.

The parameter setting of this algorithm as follows. Initial population is 30. Iteration is 500. The probability of crossover is 0.8, and the mutation probability is 0.02. Simulation results of data solution are recorded in Figure 2 and table 2.

Table 2- the results of the different service modules

Service capacity	Optimal module	Activity composition	Module value	Module cost	Value cost	The value of	Increase percentage

(customers)					ratio (F)	F before modular	
10	M1	5,6,7,8	0.12	0.0050	2.42	0.51	377.84%
15	M1	5,6,7,8	0.12	0.0046	2.61	0.50	419.86%
20	M1	5,6,7,8	0.12	0.0049	2.45	0.50	387.25%
25	M2	5,6,7,8	0.12	0.0047	2.52	0.50	402.36%
30	M2	22,24	0.0042	0.0035	1.18	0.71	66.41%
35	M2	22,24	0.0042	0.0034	1.23	0.71	73.92%
40	M2	22,24	0.0041	0.0033	1.27	0.70	80.69%
45	M2	22,24	0.0041	0.0031	1.33	0.70	90.28%

Note: The value of F before modularity refers to the value of the corresponding activities that customers complete in the module. Taking the average value of 50 customers as the value of F before modular.

The results show when modular capacity is 10-25, the optimal service module is the M1, including the activities of a_5 , a_6, a_7, a_8, and analysis found that these activities are around the development of new dishes. 3 years ago, L company captured this business opportunities, and launched a corresponding service module named "Chef Club", whose main goal is to integrate customers' resources of high-quality, and provide customers with new dishes and solutions in this new service platform. Knowing that Chef Club's core resource comes from customers, L company uses this modularity to achieve resource integration, so as to the interaction in customer to customer and customer to enterprise. On the one hand, L company can use the service module to tap and get the latest ingredients of the customer needs and in return it provide a better quality of procurement services. On the other hand, catering customers through the service module improve efficiency and quality in the development of new dishes and reduce development costs, thereby enhancing competitiveness in marketing.

When modular capacity increased from 30 to 45, the optimal service module was M2, including the activities of $a_{22}\ and\ a_{24}$, and the activity group became the ingredients prepared and pretreated. Through the analysis and optimization of the service module, L company is about to launch another service module - "Central Kitchen". The purpose of the service is the intensive thought in which enterprises purchase, process and delivery ingredients uniformly to integrate customer demand, form scale effect, so that customers can save cost and improve efficiency. With the increasing demand of food and catering industry, the development of the central kitchen is rapidly emerging, which shows that the idea of modular design has a certain application value in the service industry.

In conclusion, module M1 is to integrate customers' heterogeneous resources, while with the increasing serving customers in module, the integration cost is becoming more and more as well. For example, the more chefs in the club to participate in design of new dishes, the higher costs of the required hardware, time, coordination and organization will be. However, when the number of customers is large, the cost can be reduced greatly by integrating customers' demands, so that the central kitchen service module (M2) which is based on the large scale effect is superior to M1 when serving customers is increasing. Therefore, professional service providers should target at different customer needs and different serving scale when design service modules. At the same time, the optimization effect of the M1 module (which is 400% higher before module) is much higher than that of the module M2 (about 80%). The reason is that the integration of heterogeneous resources can usually achieve better results than standard ones in modularity. These modules which have been introduced so far has attracted more than one thousand members in country and make L company's sales rose from 1 billion to 2 billion.

CONCLUSION

In this paper, the design of service module division in catering industry was discussed. A new approach based on supply chain environment to integrate customers' resource and aggregate service activities was introduced, especially in service industry seem more applicable. Taking the upstream service providers as the decision-making body, the modular strategy design is carried out through the integration of the downstream resources to achieve the value creation. Considering the activity value, cost, correlation degree and the ability of the module as the basis of the design of service module, this paper bases on the idea of intension, and establishes a mathematical model and algorithm to aggregate the discrete service activities into valuable service modules. A heuristic algorithm was introduced to solve the typical combinatorial optimization problem that is based on genetic algorithm and uses evolutionary procedures like heredity, mutation, natural selection and hybridization. Computational experiments were developed for evaluating the effectiveness of this algorithm by using actual examples. The result obtained showed high performance of the service module in gaining high value at low cost and the service modular configuration model is both practical and effective, which provides a new way for the service providers to carry out service modular and service value innovation.

Future works can use the proposed algorithm for other optimization problems in the area dealing with other objectives like identifying more than one module in the service process and combining resources of enterprise itself and customers' process into new service module, not only considering customers' but the enterprises in supply chain, so that we can able to create more valuable and competitive service modules.

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