Formal criteria for the classification of service based on the value-creation model

Nagasaka, Ichiro

Nishino, Nariaki

(Citation)
Procedia CIRP,62:74-77

(Issue Date)
2017

(Resource Type)
conference paper

(Version)
Version of Record

Available online at www.sciencedirect.com

ScienceDirect

Procedia CIRP 62 (2017) 74 – 77

www.elsevier.com/locate/procedia

10th CIRP Conference on Intelligent Computation in Manufacturing Engineering - CIRP ICME '16

Formal criteria for the classification of service based on the value-creation model

Ichiro Nagasaka[a], Nariaki Nishino[b]

[a]Graduate School of Humanities, Kobe University, Kobe, 657-8501, Japan
[b]Department of Technology Management for Innovation, School of Engineering, The University of Tokyo, Tokyo, 113-8656, Japan

* Corresponding author. Tel.: +81-78-803-5579; fax: +81-78-803-5579. *E-mail address:* nagasaka@kobe-u.ac.jp

Abstract

With the aim of providing a scientific methodology for studies of services, the value-creation model, which classifies service models in three classes on the basis of the relationships among service providers, was proposed in the 2000s. However, the model lacks formal criteria for classifying service models in scientific way. Therefore, in this study, we first consider the activity of service design as an activity of designing "service mechanism" in reference to mechanism design, which is an area in economics and game theory. Then, we develop formal criteria for the classification of the service mechanism based on the value-creation model.

Peer-review under responsibility of the scientific committee of the 10th CIRP Conference on Intelligent Computation in Manufacturing Engineering

Keywords: Service mechanism; Value-Creation Model; mechanism design; formal criteria.

1. Introduction

Since most of service studies depend heavily on individual research subject and contain a humane element, there is great difficulty in understanding the structure and complexity of the service and constructing a methodology for the service design.

The value-creation models proposed by Ueda et al. [1, 2] describe the design problem of service as a co-creation decision-making problem that creates an effective solution through mutual interaction among varieties of agents, such as provider (producer), receiver (consumer), environment, and services (products). Depending on the nature of the mutual interaction, the models were classified into three models, Providing Value Model, Adaptive Value Model, and Co-creative Value Model. In the process of the development of this model, Ueda thought that it is essential to consider service not only as an engineering subject but as a scientific subject. However, formal criteria for classifying service models in scientific way have not been given yet.

Therefore, in this study, we first discuss the possibility of considering the activity of service design as an activity of designing "service mechanism" by applying the formal framework of mechanism design, which is a mathematical theory in economics and game theory. Then, we develop a formal criterion for the classification of the service mechanism based on the value-creation model.

2. Mechanism Design

Mechanism design is concerned with rule settings where a social designer faces the problem of aggregating the announced preferences of multiple players into a collective decision when the players exhibit strategic behavior [3]. Each player's objective is to maximize expected value of his/her own payoff measured in some utility scale. Mechanism design can be viewed as reverse engineering of games or equivalently as the art of designing the rules of a game to achieve a specific desired outcome. In this view, the goals of the designer are to design institutions or rules that meet social or designer's own objective. Modeling the problem of service design in the framework of mechanism design is to formulate the design problem of service whether the result of the interaction between varieties of players — provider, receiver and environment — achieves a social or designer's own objective in the designed rule settings.

In this study, we examine how we can formulate the problem of services mechanism using a formal framework of

Peer-review under responsibility of the scientific committee of the 10th CIRP Conference on Intelligent Computation in Manufacturing Engineering
doi:10.1016/j.procir.2016.06.084

mechanism design. Here, we start by explaining the formal setting of mechanisms called indirect mechanisms [4]. A formal description of the elements of indirect mechanism is provided below.
Definition 1.

(a) A set of finite number N of players $I = \{1, 2, \ldots, n\}$ (e.g., a set of consumers or bidders at auction).

(b) Players' type spaces $T_1, \ldots, T_n$, where the parameter T_i is referred to as player i's type, and $t_i \in T_i$ generally contains the preference information on a set of outcomes A shown blow.

(c) Players' action spaces $X_1, \ldots, X_n$. This X_i is a collection of possible actions that i can take (e.g., who to vote or how much to bid).

(d) A set of outcomes A (e.g., a winner of the election or a result of an auction).

(e) Players' valuation functions $v_i: T_i \times A \to \mathbb{R}$, where player i evaluate the "value" of outcome $a \in A$ by referring privately to his/her own type t_i and assigns $v_i(t_i, a)$ to it.

(f) An outcome function $g: X_1 \times \cdots \times X_n \to A$.

(g) Players' payment functions $p_i: X_1 \times \cdots \times X_n \to \mathbb{R}$, where $x_1, \ldots, x_n$ in the payment $p_i(x_1, \ldots, x_n)$ is the action which i takes.

(h) Player i's strategy function $s_i: T_i \to X_i$, where player i have private information about type $t_i \in T_i$ and he/she chose an action from his/her action spaces X_i based on the private information.

(i) Player i's utility function $u_i: T_i \times X_1 \times \cdots \times X_n \to \mathbb{R}$, where $u_i(t_i, x_1, \ldots, x_n)$ is the utility achieved by player i, when his/her type is t_i and the profile of actions taken by all players $(x_1, \ldots, x_n)$.

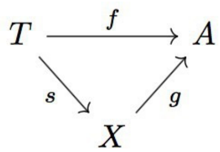

Fig. 1. A diagram of indirect mechanisms.

Using the notions above, the definition of indirect mechanisms is given as followings.
Definition 2. Let outcome function $g: X_1 \times \cdots \times X_n \to A$, player i's utility function $u_i: T_i \times X_1 \times \cdots \times X_n \to \mathbb{R}$, and $u_i(t_i, x_1, \ldots, x_n) = v_i(t_i, g(x_1, \ldots, x_n)) - p_i(x_1, \ldots, x_n)$. Then indirect mechanisms is defined by $\mathcal{M} = (X, g, p)$, where $X = X_1 \times \cdots \times X_n$.

In the above settings, the designer faces a problem called preference aggregation problem, i.e., 'for a given players' type spaces profile $T = (T_1, \ldots, T_n)$, which outcome $a \in A$ should be chosen?'[3] To deal with the preference aggregation problem, mechanism design attempts implementing desired social choices function in a strategic setting.

Definition 3. Function $f: T_1 \times \cdots \times T_n \to A$ is called a social choice function.

Designer tries to aggregate the different preferences of players $t = (t_1, \ldots, t_n) \in T$ toward desired single joint decision $f(t_1, \ldots, t_n) \in A$. To illustrate how mechanism design works, we show a famous example of indirect mechanism: Vickrey's second price auction.

2.1. Vickrey's Second Price Auction

In a Vickrey's second price auction, bidders are asked to submit sealed bids [4].

An auctioneer wants to sell a good among n bidders. Each player i has a private information $w_i > 0$ about the value of the good, that is, he/she is "willing to pay" for it. The bidder i decides the amount w_i by referring privately to his/her actual type t_i. If i wins the good, but has to pay some price $p \neq w_i$, then i's utility is $u_i = w_i - p$. If someone else wins the good, then i's utility is 0. The bids are opened by the auctioneer and the bidder with the highest bid gets the good and pays to the auctioneer an amount equal to the second highest bid. The other bidders pay nothing.

In this auction, mechanism the auctioneer employs is an indirect mechanism $\mathcal{M} = (X, g, p)$, where $w_i \in X_i \subseteq \mathbb{R}^+$ is i's bid, $g: X_1 \times \cdots \times X_n \to A$ is outcome function given by $g(x) = (y_1(x), \ldots, y_n(x), p_1(x), \ldots, p_n(x))$ where $x = (x_1, \ldots, x_n)$. The functions $y_i: X_1 \times \cdots \times X_n \to \{0,1\}$ is known as winner determination rules and the function $p: X_1 \times \cdots \times X_n \to \mathbb{R}$ is payment function.

Let $w^{(k)}$ be the kth highest bid in $(w_1, \ldots, w_n)$ and $(w_{-i})^{(k)}$ be the kth highest bid in $(w_1, \ldots, w_{i-1}, w_{i+1}, \ldots, w_n)$, then the winner determination rule and the payment function will be as followings.

$$\begin{aligned} y_i(w) &= \begin{cases} 1 & \text{if } w_i = w^{(1)} \\ 0 & \text{(otherwise)} \end{cases} \\ p_i(w) &= -(w_{-i})^{(1)} y_i(w). \end{aligned} \quad (1)$$

If we assume that any two bidders do not bid the same bid value in the auction, the following proposition holds [4].
Proposition 4. For every $w_1, \ldots, w_n$ and every w'_i, let u_i be i's utility if i bids w_i and u'_i be i's utility if i bids w'_i. Then,

$$u_i \geq u'_i.$$

Proof. Assume that i wins by bidding w_i and the second highest bit is $p^* = (b_{-i})^{(1)}$, then $w_i = w^{(1)}$ and i's utility $u_i = w_i - p^* \geq 0$.

Now, if i strategically manipulates the auction by changing his/her bid w'_i such that $w_i > w'_i > p^*$, i still wins and have to pay p^*, thus i's utility is still $u'_i = w_i - p^* = u_i$. If i bids w'_i such that $p^* > w'_i$, then i loses the auction, thus $u'_i = 0 \leq u_i$. On the other hand, if i bids w_i and loses, then $u_i = 0$. Assume $j \neq i$ is the winner in above case, then $w_j > w_i$. If i changes his/her bid to w'_i such that $w_j > w'_i$, i still loses the auction, thus $u'_i = 0 = u_i$. When i bids $w'_i > w_j$, i wins and pays w_j, thus i's utility is $u'_i = w_i - w_j \leq 0 = u_i$. □

Note that even the bidders try to maximize their own benefit by referring their private information, the outcome achieves the social welfare.

3. Value Creation Model

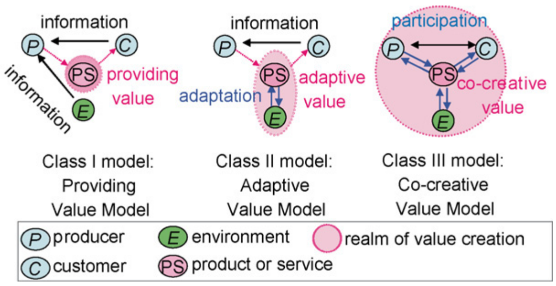

Fig. 2. Classification of value models.

Based on the nature of the value created by the mutual interaction among provider, receiver, services (products), and their environment, Ueda et al. classified the value into three models, namely, Providing Value Model, Adaptive Value Model, and Co-creative Value Model (Fig. 2) [1].

- Class I model (Providing Value Model): Product/Service provider and its receiver are defined independently. Their values (objectives), and environments are clear. Model can be described completely with a closed system. *Optimization strategy* is essential.

- Class II model (Adaptive Value Model): Objective of product/service receiver is defined completely, however, environment is changing and not predictable. Therefore, model is to be an opened system. *Adaptive strategy* is essential.

- Class III model (Co-creative Value Model): Objective of product/service receiver is uncertain even for itself, so that the provider and receiver cannot be separable each other. *Value-Co-creation* by the provider and receiver is essential.

For example, online auction sites like eBay often deal with Class I model value. Since, as a service provider, a seller wants to sell his/her good as high price as possible, and as receivers, bidders want to get the good and pay to the seller an amount lower than their value of the good. In this setting, the seller and the bidders try to maximize their benefit in the closed rule system.

In most cases, restaurant businesses could be seen as an example of the Class II model. Providers of the service want to offer delicious food and to raise as many profits as possible. On the other hand, receivers (customers) want to enjoy delicious food at a handy price. Although these fundamental objectives never change, the customers' behavior changes from time to time due to the change of the seasonal food material or social needs. Therefore, the providers are always required to adopt their service to the change.

Most of social networking services are typically classified in the Class III model. Since the providers of the service do not necessarily know well the needs of receivers in advance, they would explore what receivers want, what they have, and what they are not getting by changing and adjusting their service in accordance with the receivers' reaction. Then, behavior of receivers would also change by reacting to the providers' exploration, and new values could be emerged from these interactions. This would be one of the typical examples of value co-creation.

4. Formal Criteria for the Classification of Service based on the Value-Creation Model

Now, we come to the point where we could consider a formal criterion for the classification of the service mechanism based on the value-creation model.

The main components of the value-creation model as shown above are the provider (P: main body of the service), a set of receivers (R: consumer), a set of products/service (P/S), and the environment (E). It seems natural to consider that provider (P) is the social designer in mechanism design, because the provider of service deals with the problem of aggregating customers' preferences and the goals of the designer are to design institutions or rules of the service that meet social or designer's own objectives. In addition, it is also natural to consider that the set of receivers (R) and the set of products/service (P/S) correspond to the set of players I and the set of outcomes A, respectively.

The environment (E) in the value-creation model needs more careful analysis. Hurwicz [5] called the players' type spaces profile $T = (T_1, \ldots, T_n)$ "environment". On the other hand, in the value-creation model, the concept of the environment is used in a broader sense that includes the mechanism itself. In the following sections, we discuss how the environment in the value-creation model could be interpreted in the formal framework of mechanism design.

Class I

It seems reasonable that social choice function $f: T_1 \times \cdots \times T_n \to A$ represents (P)'s value (goal) and players' type spaces $T_1, \ldots, T_n$ characterize the value of (R). Thus, in Class I model, a designer deal with the problem of aggregating the preferences of receivers into a collective decision in a setting where the characteristic which social choice function f should fulfill and players' type spaces can be fixed in advance. Here, the designer's task is to design f and outcome function g that meet social or designer's own objective, more specifically, maximization of social utility, i.e.,

$$f(t_1, \ldots, t_n) \in \operatorname*{argmax}_{a \in A} \sum_{i \in I} u_i(t_i, a). \quad (2)$$

In addition, all the elements except f and g, namely, I, T, A, X, s, v, u, and p are assumed to be fixed. In this configuration, the designer essentially employs "optimization strategy" to maximize the social utility in the relatively static environment.

Class II

As stated in the definition of Class II model, both the characteristic which f should fulfill and players' type spaces can also be fixed in advance.

Now, the environment would change and (P) attempts to adapt (P/S) to the changing environment. Here, what does the designer attempt to adopt (P/S) to? Generally speaking, it would be "needs of the players." In the mechanism design framework, what represents the "needs"? The short answer is T, because when customer preferences change we say that the environment of market changed. However, in Class II model, objective of receiver can be defined beforehand. To solve this seemingly contradicting situation, we propose to apply the idea of Christopher Alexander [6] who is the pioneer of design theories, that is, replacing the idea of need by an idea "what people are trying to do." In [6], he wrote as followings.

> We shall, in effect, accept something as a need if we can show that the people concerned, when given the opportunity, actively try to satisfy the need. This implies that every need, if valid, is an active force. We call this active force which underlies the need, a tendency.

In the words of mechanism design, the "force" is the tendency of the player, that is, players' strategy function $s_i: T_i \to X_i$. This means that the change in environment is regarded as the alternation of the strategy function — player i chooses an action from action space $X = X_1 \times \cdots \times X_n$ based on the private information about type $t_i \in T_i$. In this way, we can interpret the change of the players' actions as the change of environment.

In summary, the designer's task is to design f and outcome function g that meet social or designer's own objective by adapting f and g to s in the environment where players' strategy function s is changing and not predictable. All the elements except f and g, namely, I, T, A, X, v, u, and p are assumed to be fixed. Objective of the designer is to maximize social utility and to adjust tendency of the player to his/her design objective.

Class III

As stated in the definition of the Class III model, the provider's objective f and the receivers' objective T are interdependent so that they cannot be defined separately. Here, the value of i is $v_i: T_i \times A \to \mathbb{R}$ and social choice function is $f: T \to A$. If these two functions are interdependent, it should be through T. Since if T changes, f and v will change accordingly, so that they cannot be defined separately.

Recall the diagram of indirect mechanisms (Fig. 1). T is the domain of the function f and s so that changes in T leads to the changes in almost all the elements of the mechanism design framework except the set of players I. In this case, what is the job of the provider? In Class III model, it is described that value-co-creation by the provider and receiver is essential. If we take this literally, the task of the provider is to co-create f and v with receivers, that is, the provider and the receiver design f, g, s, A, and p to make following hold for $t'_1 \in T'_1, \ldots, t'_n \in T'_n, a' \in A'$.

$$f(t'_1, \ldots, t'_n) \in \underset{a' \in A'}{\operatorname{argmax}} \sum_{i \in I} u_i(t'_i, a'). \quad (3)$$

5. Conclusion

With the aim of providing a scientific methodology for studies of services, formal criteria for the classification of the service mechanism was proposed. The criteria can be summarized as follows:

Class I: The designer's task is to maximize social utility by designing social choice function f and outcome function g, while the other elements of the framework I, T, A, X, s, v, u, and p are assumed to be fixed.

Class II: The designer's task is to design social choice function f and outcome function g that meet social or designer's own objective by adapting f and g to s in the environment where s is changing and not predictable. The other elements, i.e., I, T, A, X, v, u, and p are assumed to be fixed.

Class III: When T changes. This causes almost all the elements of the mechanism design framework except I to change. The task of the provider is to co-create f and v with receivers.

The further works include: firstly, the meaning of the important notions in mechanism design such as "implementation", "incentive compatible" and "revelation principle" should be considered in the framework of the service mechanism. Secondly, implication of the proposed formal criteria in real world should be discussed by analyzing existing service industries. Thirdly, it is required to discus about what sort of empirical analyses could be conducted based on the criteria.

Acknowledgements

The activity of this work has received funding support from Service Science, Solutions and Foundation Integrated Research Program (S3FIRE), Research Institute of Science and Technology for Society (RISTEX), Japan Science and Technology Agency (JST).

References

[1] K. Ueda, T. Kito, and T. Takenaka, "Modelling of value creation based on Emergent Synthesis," *CIRP Annals - Manufacturing Technology*, vol. 57, no. 1, pp. 473–476, 2008.

[2] K. Ueda, T. Takenaka, J. Vancza, and L. Monostori, "Value creation and decision-making in sustainable society," *CIRP Annals - Manufacturing Technology*, vol. 58, no. 2, pp. 681–700, 2009.

[3] D. Garg, Y. Narahari, and S. Gujar, "Foundations of mechanism design : A tutorial Part 1 – Key concepts and classical results," *Sadhana (Academy Proceedings in Engineering Sciences)*, vol. 33, no. 2, pp. 83–130, 2008.

[4] N. Nisan, "Introduction to mechanism design (for computer scientists)," in *Algorithmic game theory*, Cambridge University Press, 2007, pp. 209–242.

[5] L. Hurwicz and S. Reiter, *Designing Economic Mechanisms*, vol. 8. 2006.

[6] C. Alexander and B. Poyner, "The Atoms of Environmental Structure," Center for Plannning; Development Research, University of Calfornia, Berkeley; Ministry of Public Building; Works, 1966.