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Research on industrial product–service configuration driven by value demands based on ontology modeling

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ABSTRACT

It has become an important trend in the manufacturing industry that service is used to enhance the competitiveness of businesses as well as an important source of values. Aiming to extend the achievements of product configuration in manufacturing industry to service industry, an ontology-based product–service configuration approach is presented in this paper. Firstly, value attributes of product–service are defined based on the analysis of customer demands. And the demand cluster method is proposed to identify value demands of customers. Secondly, the modular system of product–service is established which is the basis of building product–service ontology. Thirdly, the product–service configuration method based on ontology modeling is put forward. Finally, the proposed approach to product–service configuration is demonstrated by an example of configuring service packages of civil aircraft materials.

1. Introduction

With the rapid development of producer services, the human society is moving toward service economy era step by step. In the context of service economy, service is becoming the driving force of the global economy [1]. And service proportion of output and profits in manufacturing enterprises are increasing [2,3]. Manufacturing enterprises have realized that there will be no great development opportunities in the traditional manufacturing sector any more [4]. So many manufacturers try to transfer into service-oriented enterprises [5,6]. For example, IBM (International Business Machines) experienced the way of transition from a hardware supplier, to a software supplier, and finally a service supplier; Rolls Royce offers 'Total Care Package' and 'power by the hour' rather than transferring ownership of the gas turbine engine [7,8]; Boeing and Airbus as the representative of the civil aircraft manufacturing industry are transforming to be service provider through continuously integrating service capabilities and packages. In this paper, 'product–service' is defined as service portfolio provided for satisfying customer's value demands based on sale of industrial product. The industrial product of the definition has a long lifecycle and a high price. And it integrates many important parts and advanced technologies.

The service-oriented enterprise provides product–service value instead of single product for customers [9–11]. The product–service value should be quantified according to customer perceived value which depends on the subjective evaluation of customers. In order to maximize customer perceived value, product–service value should be defined according to accurate service demands from customers.

However, the preliminary service demands are unclear and even contradictive because customers are lack of knowledge on service attributes and performances. Besides, with the changes of environment and updates of concepts, service demands are changing and expanding continuously. However, the value demand is intrinsic which means it doesn't changes frequently. So how to identify value demands is a tough issue for researching product–service.

The mass customization paradigm has been widely applied to manufacturing industry and many achievements have been made in product configuration. However the study on product–service configuration is rare. Current research is only suitable for specific industry and cannot reflect the own characteristics and value attributes of generic service.

2. Literature review

2.1. Demands identification

Delivering superior value to customers is an ongoing concern of management in many business markets today. There are already a

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Table 1
The expression methods of demand.

Methods	Manifestation	Advantages	Disadvantages
Topology	Chart	Clearly express the demands hierarchy	Poor operability
Template	Forms	Simplify the process of customer demand capturing	Difficult to build and maintain template
Rules	Chart/tree	Clearly express the constraint relationship among demands	Difficult to define rules of complex product/service
Structured modeling	Chart/tree	Beneficial to clarify design object	Modeling process is complex; difficult to subdivide demands
Ontology	Semantic network	Conducive to sharing, reusing, and reasoning of knowledge	Demands hierarchy is not clear

lot of researches on the concept of customer value among business managers and academia. Michael E. Porter points out that the value of service depends on the recognition and perception of customers [12]. Customer perceived value is composed of perceived benefits and loss. Slater has observed that 'the creation of customer value must be the reason for the firm's existence and certainly for its success' [13]. Ulaga argues that customer value analysis is more than just a pricing technique or a market research method. It is a strategic marketing tool for auditing customers' needs [14]. The expression methods of demands are summarized in Table 1 [15–17]. The main expression methods of value demands include topology, template rules, structured modeling and ontology. In these methods, ontology modeling is conducive to sharing, reusing, and reasoning of configuration knowledge with the manifestation tool of semantic network.

The accurate expression of value demands is the premise and foundation of successful service implementation. Most of literatures on identification of value demands put focus on the research of service profit chain. Drucker believes that the target of manufacturers is not production and manufacture, but service that could create great value for customers [18]. From the perspective of product–service, the value demands changed from tangible products (product-oriented) to intangible services (service-oriented).

2.2. Service scheme

At present, the study on service scheme is rare, especially on the product–service of manufacturing industry [19,20]. Most of researches on scheme configuration focus on physical products. For example, Ni et al. presented a configuration strategy with the arithmetic of tree preorder traversal method in search of the configuration structure model to achieve the product configuration based on product family [21]. Yang et al. presented a way of representing product configuration knowledge using semantic web technology, namely OWL and SWRL, and developing actual configuration engines based on derived configuration knowledge [22].

Current research of service scheme is only suitable for specific industry. For example, Shen et al. proposed a configuration method of Product Extension Services (PESs) for the building service [23]. And Dong et al. present service product modeling and configuration approach for mobile communication industry. However, various service businesses have different characteristics [24]. These service businesses need different design focuses and configuration methods.

Parts of existing literatures study the product–service scheme from the perspective of PSS (Product Service Systems) [25,26]. For example, the MEPSS (Methodology for Product Service Systems) Handbook proposes 4 groups of methods and tools [27]: Dynamic system analysis, service design (Selection, design and development of service business model), Sustainability assessment, Market acceptance. This project is funded by European Commission between 2001 and 2004.

Aurich et al. introduce life cycle oriented method for systematic design of technical services based on its modularization and integrate it with existing product design process to design and realize a technical PSS in the extended value creation network [28]. Technical Product-Service Systems is a kind of PSS which emphasizes the content of technical services such as maintenance, retrofitting, refurbishing and user training. In light of the potential impact of technical services on the entire product life cycle, life cycle engineering techniques should be applied to service design. Aurich et al. [29] point out that the process definition and standardization are very important for service design because the quality of technical services depends on the quality of the underlying service processes.

2.3. Service modularity

Modularity arises from the increasing of individualized requirements of products in the last part of 20th century [30]. Most of popular definitions of modularity show the common characteristics: combinability, changeability and substitutability, and standardization of modules. However, most of existing researches on modularity focus on product rather than service [31,32]. The concept of modularity in services production was first introduced by Sundbo [33]. Modularity allows firms to combine rationality and cost saving with focusing on the customer needs.

In the realm of service, enterprises are facing ever increasing challenges of shorter product–service lifecycle, increased outsourcing, longer customer lifecycle, mass customization demands, and rapid fulfillment needs. In order to cope with the mass customization of product–service and other problems, such as diverse geographical or cultural backgrounds of customers and service partners, there should be different collocations of products and services. At present, most of service development models have at least one of four key weaknesses: insufficient detailing, non-configurability, lack of field tests or lack of information and communication technology support [34,35]. Modularity has been recognized as a way to overcome these weaknesses which could provide the ability for businesses to offer quick, customized product & service without totally destroying old designs [36]. Modularity can be seen as a means to standardize product–service production, provide customized services and, thus, achieve better customer value and profitability [37].

3. Value demands of customers

3.1. Product–service demands

Woodruff divides customer demands into three layers [19]: target layer, result layer, and attribute layer as shown in Fig. 1. The target layer is the final goal of customers; the result layer is the service result of product–service; the attribute layer contains the attributes of product–service. The service demands could be obtained through the identifying steps from bottom to top and the forecasting steps from top to bottom.

3.1.1. Identify

There are many methods for the identifying steps, such as the interactive identification and inductive identification [38,39].