Study on the scheme-design framework and service-business case of product service system oriented by customer value

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Abstract: As the market competition is becoming fierce, to obtain long-term profits for manufacturing enterprises, under the high-frequency dynamic customer needs (CNs), commercial competition has become increasingly fierce. At present, the global economy is transitioning from a product economy to a service economy. The State Council stated in ‘several opinions on accelerating the development of the service industry’, increase the proportion of the service industry in the three industrial structures, make the service industry the leading industry of the national economy as soon as possible, and promote the adjustment of the economic structure and accelerate the transformation of economic growth. The only way of the method is to effectively alleviate the bottleneck constraints of energy resources shortage and improve the critical use of resources. It is an effective way to adapt to the new situation of opening up to the outside world and realise the overall leap in overall national strength. With the increase in the proportion of service industries, the deepening of the social division of labour, the interdependence and integration between manufacturing and service industries, the boundaries between the two are becoming increasingly blurred.

Under the influence of rising raw material and labour costs, competition in the second-hand market, and increasing global environmental protection calls, factors such as increased competition and shrinking profit margins in the manufacturing industry worldwide are changing. Manufacturing companies must seek a path to survival in the higher direction of the value chain and provide knowledge-intensive products and services [1]. For example, Dell is no longer just engaged in a traditional computer manufacturing business and has realised huge profits from service operations. The proportion of IBM’s service-business revenue in total revenue rose from 23% in 1992 to 52% in 2005. The successful transition to the service industry has enabled IBM to withstand the 2008 international financial crisis.

A critical marketing method in the manufacturing industry is package sales, that is, providing customers with two or more products and services to meet their needs, and using this strategy to increase product sales. With the deepening of the significance of the combination of products and services, services have begun to cease to be an additional element of products [2]. The integration of products and services has been the focus of both manufacturers and service providers [3]. The product–service system (PSS) was created in this context. The PSS was proposed at the end of the 20th century as a functional-oriented business model that integrates products, services, stakeholders, and infrastructure [4]. The PSS is mainly composed of three parts: products, services, and systems. First, products refer to the tangible products that are sold to meet specific needs of customers; second, services refer to activities that have economic value to other business activities; and finally, the system links products and services as a whole. Concepts similar to PSS include functional products, functional sales [5], technical PSS (t-PSS) [6, 7], industrial PSS (i-PSS) [8] etc. Sun et al. and Li et al. proposed the concept of service-oriented manufacturing [9, 10]. Service-oriented manufacturing is a new form of manufacturing that integrates manufacturing and service industries. It has the characteristics of integration, value-added, and innovation. Several concepts, similar to PSSs, have a different emphasis. Aurich et al. [11] proposed a PSS based on the product life cycle. Through the integration of the product design process and the service design process, the construction of a PSS oriented to the product life cycle was finally achieved. Torney et al. [12] proposed an activity-based service design framework, including service development, implementation methods and tools. Stormi et al. [13] analysed the RFM customer analysis for product service and service business development with the intervention of two manufacturers.

Although the above research has made significant progress in the concept and connotation of the PSS, there are still many problems that need to be broken through. Because of the complexity and dynamics of PSS scheme design, we lack a clear and complete framework and model, namely, customer-oriented PSS framework scheme design and architecture modelling.
The key technology of the PSS scheme design is not transparent, and even the business service model of the PSS is not thoroughly analysed. This paper is based on the above issues, and oriented customer value-oriented PSS solution design is researched. The remaining of the paper is organised as follows. Section 2 mainly reviews the overall architecture and modelling of PSS solution design. In Section 3, the customer value-oriented PSS solution design framework is established, and the PSS solution design architecture is modelled. In Section 4, we analyse the critical technologies of the PSS scheme design. Section 5 discusses the implementation model of the PSS scheme design and analyses various implementation models by applying a large number of service-business cases. It is summarised in Section 6.

2 Literature review

2.1 Overview of ‘business strategy’ on PSS

In terms of PSS modelling, Lee [14] proposed an integrated manufacturing framework for electronic product manufacturing and recycling. Qu et al. [15] proposed a PSS configuration platform based on Analytical Target Cascading (ATC). Duncgo and Tiwari [16] used a function-oriented information flow model to the design of PSS. Information flow as a function-oriented method can clearly distinguish the input and output of the system. Hara et al. [17] analysed the functional factors, customer factors, and service activity factors in the service process and proposed a brand-new PSS design method. To provide and expand manufacturing and processing capabilities, Zhu et al. [18] proposed a PSS enabling structure system from the perspective of software and hardware. Doultsinou et al. [19] proposed a service knowledge reuse framework to realise the reuse of service knowledge in the PSS design phase. Gao et al. studied the service-based manufacturing network and realised the integration of service and product manufacturing [20]. However, whether it is a PSS or other service-oriented concepts (such as service-oriented manufacturing), ultimately, it is necessary to rely on physical product integration or a series of services to meet CNs [21]. In other words, product service is the underlying foundation for implementing concepts or strategies such as PSS. Because product services can directly enhance the functions of industrial products, and ensure their working ability and performance, it is an essential part of the PSS and the foothold for implementing a service-oriented strategy. It can be seen that product service is the basis of various product–service solution strategies, and the solution design of PSS would be the focus of future research.

2.2 Overview scheme design of PSS

Some experts and scholars have researched the design of product–service solutions. By analysing the service process, Yang and Shan [22] used a functional relationship matrix to measure the relationship between service elements to identify service modules. Gao et al. [20] thoroughly considered customer value and service function and developed a value-oriented integrated PSS (IPSS). The extended product–service blueprint is derived from the service blueprint, which is used to describe product behaviour, service delivery process, stakeholder activities, and support activities. An ontology-based design support system is proposed to improve design efficiency and help designers make more informed decisions.

At present, the uncertainty of customer's individual needs makes the customer's needs appear high-frequency dynamic. Therefore, an effective method for quickly customising product and service solutions is needed. The study of product and service configuration has attracted widespread attention from academia and industry. In the field of service design, there is still relatively little research on optimal allocation. Considering life favourable impact of industrial services on product environmental performance and product use cost, Aurich et al. [23] established a service configuration model oriented to the product life cycle, which includes two sub-models: product model and service model. Among them, the product model is described using a hierarchical structure, and the service model is further subdivided into a resource model, a process model, and a result model. Based on the analysis of product after-sales service types, Legnani et al. [24] established a service configuration model and proposed an expression framework for service process activities. Long et al. [25] proposed a multi-class support vector machine model to achieve a customer-oriented product–service configuration. Meier and Massberg [26] built a service configurator but did not give detailed steps on how to implement service configuration.

3 Overall framework and modelling of scheme design of PSS

3.1 Overall framework of scheme design of PSS

In terms of PSS design, traditional design methods are mainly two types of general design methodologies, namely serial design and concurrent engineering. The main difference in their design process is the order or method of product and service activities. Serial design is a design method in which products and their processes are developed in order. Concurrent engineering is a systematic method for the concurrent design of products and their related processes (such as manufacturing). The primary purpose is to reduce the design time and reduce the waiting time for subsequent design activities by conducting part of the design activities simultaneously. The PSS solution design is the integrated design of products and services, which can ensure the reasonable matching and coordination of products and services, and jointly meet CNs. The above two traditional design patterns may not achieve any compromise and coordination between products and services due to the context between product design and service design. At the same time, the increase of interaction in the early stage can avoid possible changes or rework processing in the later stage. The positioning, matching, and interaction of products and services are challenging to handle with traditional serial design or concurrent engineering, and the overall performance of the solution cannot be optimised during its life cycle.

However, due to the rapid development of intelligent information collection technologies such as the Internet of Things and Big Data, it has provided an excellent technical implementation foundation for the identification and analysis of CNs for industrial products and services. Although the demand for product services is affected by different life cycle stages and different stakeholders, due to the development of the Internet, Internet of Things, wireless mobile communication technology and product intelligent identification technology, CNs (such as product use and maintenance in the product life cycle: repair, overhaul, recycling, disassembly etc.) would be better satisfied. For example, some industrial equipment is equipped with automatic data collection units (such as sensors, radio-frequency identification etc.) that can transmit their operating status information to service providers of industrial products in real-time. So service providers can obtain various customer service needs promptly to make a real-time response.

Based on the characteristics of the product–service plan and its design, based on the literature research and CNs analysis, a complete customer value-oriented PSS plan design framework is presented, as shown in Fig. 1. The overall design framework is divided into four layers:

(i) Data and knowledge support layer: The application of scheme-design technology is inseparable from the support of relevant data, information and knowledge, including product life cycle information (such as equipment health status monitoring information, customer feedback etc.), technical characteristics mapping knowledge of design experts, service processes and resource data, services conflict resolution rules and configuration constraints of service plan optimisation.

(ii) The critical technical layer of scheme design. This layer involves implementation methods and technologies. It mainly includes demand identification technology for the entire product life cycle, CNs importance analysis technology, service technology feature extraction and conflict resolution technology, PSS program...
implementation planning technology, and PSS program optimisation configuration technology.

(iii) The design process layer of the scheme. The starting point is the identification and analysis of requirements and the determination of their importance, followed by requirements transformation and optimisation of product and service system solutions, and finally, ending with solution evaluation and core business decisions. Each part progresses layer by layer according to time, and the design information is transmitted through interactive mapping.

(iv) Application layer. Under the support of the data and knowledge layer of the PSS, the critical technology of the scheme design, and the process level of the scheme-design process, manufacturing companies comprehensively consider factors such as industry characteristics, CNs, their comprehensive strength, and the status of the industry chain, and choose different implementation modes of the PSS. Regarding the three implementation models of the PSS, there are specific model analyses and case references in Section 5.

3.2 Modelling of the framework of scheme design of PSS

When purchasing products and services, on the one hand, customers should consider the functions and attributes of products and services. On the other hand, customers need to realise these functions to generate expectations and preferences for the expected results, and then further form expectations for the goals based on the expected results. Finally, these constitute the customer value hierarchy. Kim et al. [27] proposed a set of criteria encompasses both provider and customer perspectives, all of the 3P (profitability, planet, and people) values and various PSS lifecycle phases. He pointed out that customer value is divided into three levels: the purpose layer, the result layer, and the attribute layer. In the three value levels, the specific product attributes are only the means to achieve the customer's expectations of the results, and whether the customer can achieve the purchase purpose depends on the result of using the product. The customer value hierarchy model reveals the process of customer satisfaction formation, and also the process of CNs for products or services. Wei et al. [28] based on the customer value theory, the purpose of constructing mobile communication services-expectation axiomatic design theory is a structured design method that can improve the design activities by establishing indicators for evaluating the design and implementing tools for these indicators. The axiomatic design structure divides the design process into domains, and expresses the objects within the domain as a hierarchical structure, and maps between domains. The domain structure can reflect the basic structure of the analysis and solution of design problems.

Researchers use domain structure division in axiomatic design; the PSS solution design process is expressed as a process consisting of a value domain, a functional domain, a solution domain, and a mapping mechanism between the three domains, as shown in Fig. 2.

In the process of PSS solution design, to begin with, after analysing CNs information, we can obtain customer expected value elements, extract customer value characteristics, and then convert them into product function characteristics and service function characteristics. The relationship matrix is expressed as CNs product functional characteristics and CNs service functional characteristics. The autocorrelation matrix is correspondingly divided into product functional characteristics, functional service characteristics, and four autocorrelation matrices between them.

Then, function planning and design are carried out through the transmission and distribution of customer value characteristics. Finally, the program features are determined based on the functional features to design products and services. These functional characteristics are converted into product and service scheme characteristics, corresponding to the attribute values of each module. In this conversion process, a transition analysis is added, i.e. a reasonable service strategy is selected according to the functional service characteristics.

For this reason, a selection matrix is established for service policy selection. The characteristics of the service plan are determined according to the functional relationship with the service function characteristics and subject to the selected service strategy. We take the maintenance service as an example; the maintenance scheme characteristics, functional service characteristics, and four autocorrelation matrices between them.

On the one hand, we can analyse it from looking from right to left. Firstly, when a customer buys and uses, he would consider the specific attributes of the product or service. Then he would form expectations and preferences for the ability of these attributes to achieve the expected results. Finally, under the expected effect, customers form the ability to achieve their goals.

On the contrary, satisfaction based on attributes, satisfaction based on results, and satisfaction based on goals is formed. Customers would judge whether they would choose or continue to choose such products or services. On the other hand, looking from left to right of the value hierarchy model, the customer would determine the importance of the results of the product or service in the usage scenario according to his purpose, and the importance of
Therefore, enterprises should make full use of the theory of customer value hierarchy to guide CNs acquisition and drive product or service solution design. From the deeper motivation of customers’ purchasing behaviour, manufacturing enterprises should try their utmost to develop a much more competitive product or service solutions to meet the customers’ dynamic needs.

3.2.2 Value modelling of scheme design of PSS: The description of the customer’s purpose or goal in the customer value hierarchy model is usually expressed in a paragraph. The customer’s goal of using the PSS is closely related to the customer’s necessary information, such as type of customer, construction site, capital level, management level etc. The necessary information about the customer can replace the text description of the customer’s use target. It is used to analyse the system usage result that the customer expects.

Therefore, there are two levels in the value model of the PSS solution design includes the result layer and the attribute layer. The task is an essential concept in a customer-centric design approach, especially in the field of software design. A task can define how a customer achieves the usage goals in a specific application context. Based on the customer’s necessary information, the designer determines the customer’s desired usage results through customer surveys and expert decisions. Customers are more inclined to express the phases of tasks they expect the system to complete than to use the results. Therefore, the system task that the customer expects is adopted instead of the result layer that the customer expects to use the result to express the value model. The value model attribute layer expresses the attributes required by the customer’s desired system tasks, and the customer expectation value elements are used to express the attribute model of the value model. The customer information model and value model are shown in Fig. 4.

After the value model is established, the designers can plan the function of the PSS to establish a functional model. Then they can design a PSS scheme and establish a solution model. The process of establishing the PSS solution design data model is shown in Fig. 5.

3.2.3 Functional modelling of scheme design of PSS: In terms of the functional model of the PSS solution design, it expresses the functional principle structure planned by the designer. The model is a tree-like decomposition structure that is built for the system tasks that customers expect in the value model. Some customers expect that the system tasks are wholly implemented by services, and the total functions, sub-functions, and functional elements in the corresponding function model are service function models.

Functional black box representation is used to describe the model functions. The traditional functional black-box model uses a block diagram to represent the input and output of matter, energy, and information. Researchers want to use a unified modelling language in the functional model, and a functional black-box model is used to establish a product–service functional model. According to the service information, because the realisation of the service function is realised by the service personnel through some equipment or tools. Therefore, the input and output streams of the service function black box involve matter, people, information, and energy. When the total function is decomposed into sub-functions that can be determined by-products or services, the sub-functions would be expressed using the product function black-box model or service function black-box model, as shown in Fig. 6. The properties of functions in the functional model are described using engineering characteristics.

3.2.4 Scheme model of scheme design of PSS: The solution model should not only describe the product structure and service activities but express the design knowledge contained in the solution, especially the interaction and integration relationship between products and services, to facilitate the subsequent design activities. Existing PSS solution modelling methods: improved service blueprints [30], extended service blueprints [31], and product–service blueprints express service activity processes and
product names in the solution model. The research object in this paper is about the PSS in the industry. The product is a crucial part of this kind of system. The product structure scheme influences the formulation of the service scheme, and the service scheme also affects the choice of the product structure scheme [32]. Therefore, the product solution in the PSS solution model still needs to be expressed using the traditional product structure tree model. The description method of the service scheme is usually the service-blueprint method. The service-blueprint method can reflect the connection between customers, service employees, and back-end equipment, and mainly expresses the service execution process. In the PSS, the service activity process also needs information from the product or its accessories, such as product status monitoring information, product component plan information etc. Service activities also have an impact on the product, such as determining product component plans, whether to install sensors and condition monitoring equipment. The content of service scheme modelling includes service results, service processes, and service resources [23]. The service process needs to express the support role of other devices to the service, so the service process and service resources can be expressed in the way of service blueprints. The service result reflects the characteristics of the service plan. It is expressed by parameters because it needs to be established to express the service activities and the information interaction relationship with the products by the input and output information of the service activities. The service information blueprint is used to express the service plan, as shown in Fig. 7. The solution modelling is expressed by a tree diagram that reflects the product module structure, and the product solution characteristics are the parameters corresponding to the modules. There is an interactive relationship between the input and output information of service activities and the design and status information of the product structure.

4 Leading vital technologies of scheme design of PSS

According to the problems faced by the manufacturing enterprise in implementing the PSS scheme design and the above research, the key technologies related to the customer service-oriented PSS scheme design are proposed, including the following four key technologies.

4.1 Identification of customer value and determination of its importance

In the field of engineering design, CNs are the most important influencing factor for the success of a product development project and meeting the needs of customers, enterprises. Their related stakeholders is an essential factor in ensuring the successful implementation of PSSs. Requirements identification is the first step in design activities and the basis for CNs analysis and processing. Vague and inaccurate CNs would affect the smooth development of subsequent design activities, so customer value identification technology is fundamental.

Compared with product requirements, service requirements are more implicit value requirements. Therefore, unlike identifying product needs, the focus of identifying service needs is a too in-depth exploration of customer value needs. Often in the whole life cycle of a product, it is mainly the identification of customer service needs in product planning, research, and development, design, manufacturing, assembly, sales, tuning operation, and recycling. In the past, many types of research on customer demand mainly focused on product demand, and there were few related kinds of research in the field of service demand. The impact of the interaction between products and services was not considered in the demand analysis.

The implementation of the PSS scheme design is an industrial system engineering centring on customer activities, focusing on customer experience, and emphasising the cooperation between products and services. During this period, the impact of the interaction of different product–service combinations must be considered.

CNs analysis can help manufacturing companies understand CNs information correctly to meet the demand orientation of subsequent designs. The analysis of the importance of CNs is the most critical and painful part of demand analysis. It is directly related to the ability to find out the essential requirements and to allocate resources for subsequent program design reasonably.

4.2 Customer value mapping and conflict resolution techniques

After obtaining the needs of customers, manufacturing companies need to further transform them into technical characteristics that can be easily identified and used [33]. It is because the demand information expressed in the customer’s language is often vague, emotional, and non-standard, and cannot be directly applied to the product–service planning and configuration. Among many demand transformation methods, quality function deployment (QFD) is a standard tool for demand transformation. The key to QFD is to use the house of quality to establish a relationship matrix between CNs and technical characteristics, and transform CNs into technical product characteristics through matrix transformation. Although the QFD has the advantages of being intuitive, easy to understand, and easy to operate, the information in the QFD is mostly reflected in human experience judgment and evaluation. There is a certain degree of ambiguity and subjectivity. If it is not handled correctly, it will affect the accuracy of the description of technical characteristics.

Technical characteristic conflicts mean that the introduction or improvement of one technical characteristic would cause the deterioration or change of other technical characteristics [34, 35]. Technical property conflicts often occur between technical properties that are negatively related. For example, the technical characteristics of ‘service response time’ and ‘service cost’. If the service response time is reduced, the manufacturing enterprise needs to allocate more service resources, but at the same time, the service cost would increase accordingly. At present, there are few systematic studies on the design conflict resolution, and they are mainly focused on the field of product design, such as conflict resolution in collaborative design and concurrent design. Inferential conflict resolution [36], conflicts are adjusted by adjusting design goals [37], traditional product TRIZ theory is used to resolve conflicts [38], and transition bridge models in extensions are used to resolve conflicts [39].

Conflicts in the design of PSSs involve the entire product life cycle, multiple stakeholders, and knowledge in multiple related fields, and due to the impact of service characteristics and product–service interactions, the analysis and resolution of personal conflicts are relatively complex.

4.3 Implementation plan of scheme design of PSS

From the long-term planning of enterprise development, service-oriented would help manufacturing enterprises to get rid of the current competition model of price wars, while seeking new profit margins while forming differentiated competitive advantages, and provide manufacturing enterprises with increasingly fierce market competition. The new sustainable development direction is a
necessary choice for the strategic transformation of manufacturing enterprises.

However, while service-oriented brings many advantages to the enterprise, it will also increase the cost and investment of the enterprise and bring risks to the development of the enterprise. Therefore, before carrying out the strategic planning of the PSS scheme design and implementation, manufacturing enterprises must first consider from the perspective of enterprise development strategy, comprehensively consider their development conditions, industry characteristics, characteristics of consumer demand, and status of the industrial chain. A comprehensive quantitative assessment of the development status is provided to formulate a clear, reasonable, and accurate development plan.

In the planning process of the PSS implementation plan, the manufacturing enterprise needs to solve two critical problems: (i) determining the implementation model of the PSS plan design; and (ii) making the core business decisions of the PSS. These two kinds of problems are also the focus and core of the PSS implementation plan. According to the development status of the manufacturing industry in different countries and regions and its comprehensive strength, different manufacturing enterprises have different strategic choices. For great manufacturing companies in developed countries such as Europe and the United States, their products have high technological content and strong market competitiveness, and they are located at crucial links in the industrial chain. These companies have sufficient advantages due to their brand and technological advantages, strong sales, and service capabilities. They can maximise user satisfaction and user experience by applying the use-oriented PSS and the results-oriented PSS. However, for the weaker manufacturing companies in many developing countries and regions, they are mostly engaged in simple production and processing. They are located at the low end of the industrial chain. Although the advent of the service economy era has brought them great development opportunities, however, due to the lack of strength and the low level of CNs, it is impossible to implement a more advanced PSS service model. Therefore, product-oriented PSSs are ideal strategic choices for these manufacturing enterprises.

### 4.4 Optimal configuration of scheme design of PSS

Product configuration is an effective way to achieve rapid customisation. Generally, configuration problems are reasoned about all feasible solutions based on configuration rules, related constraints, and requirements. If the size of the configuration problem is too large, the constraints are insufficient, the CNs are vague, or the number is small, it would lead to too many feasible solutions inferred. In this case, it would be difficult to find a better solution among many feasible solutions. The PSS scheme involves a large number of products and services, and the relationship between the two is more complicated than before. Using traditional scheme configuration methods to configure the PSS scheme would cause the above problems [40].

To quickly obtain a configuration plan that meets one or more goals and constraints, many scholars have explored different configuration optimisation models and methods. Chakravarty and Balakrishnan [41] took product diversification and profit maximisation as the module's configuration optimisation goals and established an optimisation model when the module supply was uncertain. From the perspective of concurrent engineering, Huang [42] provided a modular configuration method based on the network platform to achieve the coordination and optimisation of the various modules.

The traditional configuration research mostly focuses on product design. Due to the influence of solution transformation, insufficient constraint relationship analysis, and neglect of CNs, it is not suitable for PSS solution configuration. First of all, when using the previous configuration method to solve the configuration optimisation model, the multi-objective combinatorial optimisation problem is often converted into a single-objective combinatorial optimisation problem to solve. The subjective factors in the conversion process would have an individual impact on the configuration result. Secondly, in the analysis of configuration optimisation problems, constraints such as compatibility and exclusion between products and products, products and services, and services and services are ignored, resulting in insufficient accuracy of the final configuration plan. Finally, manufacturing companies must fully consider CNs when deploying PSS solutions. Traditional configuration research and in-depth discussions on whether the configuration results meet CNs factors.

### 5 Implementation model and service business case of scheme design of PSS

When manufacturing companies implement PSS program design, they need to solve two key issues, that is to say, the determination of the implementation mode of PSS program design and the core business decision of PSS. According to the different items purchased by customers, the PSS is divided into three categories: product-oriented PSS, use-oriented PSS, and results-oriented PSS because different PSS implementation models have different customer groups, service businesses, and customer experiences. The section analyses service business, customer experience, and product characteristics under the three types of PSS implementation models.

#### 5.1 Product-oriented PSS and service-business case

In this type of PSS, manufacturing companies produce and sell products in the traditional way. The customer has the right to occupy, use, gain, and dispose of the product. While maintaining the ownership of the tangible product, the maintenance, repair, monitoring, recycling, and final disposal of the product are left to the manufacturing enterprise. Customers change from purchasing products to purchasing products and related services such as product maintenance and repair, as shown in Fig. 8. From the perspective of the product's full life cycle, manufacturing companies provide customers with services before, during, and after the purchase. In this type of PSS, enterprises still mainly provide products, and services depend on the existence of products. Enterprises win customers through products and gain value-added benefits through services. Products and services are equally important in competitive strategies.

Product-centric development of a series of related services, on the one hand, provides manufacturing companies with an effective way to add value to the industry, on the other hand, the product maintenance, repair, and other services are provided to specialise talents to improve the work efficiency of customers reduced customer maintenance costs. Table 1 shows the industry characteristics and successful service-business cases for implementing a product-oriented PSS.

#### 5.2 Use-oriented PSS and service-business case

For some products with timeliness, regionality, high technology, and high investment, such as large medical equipment, containers etc., the capital cost for customers to purchase products is relatively high. Due to the financial pressure and risks brought by the purchase of products, customers may be reluctant to adopt the traditional purchasing model, which leads to transaction methods such as renting and sharing. It is a use-oriented PSS. In this model, the ownership of the product is owned by the service provider. The service company is responsible for the care, maintenance, and disposal of the product at the end of its life cycle. It provides the
customer with a combination of products or services, not the tangible product itself, and the pattern is shown in Fig. 9.

This type of PSS implementation mode effectively combines tangible products and their functions, reduces customer purchase costs, helps manufacturing companies to achieve differentiated operations, improve customer satisfaction and dependence, and thus obtains long-term cooperation with customers. To a certain extent, we have achieved a win-win situation for service companies and customers. Table 2 shows the industry characteristics and successful cases of the use-oriented service system.

5.3 Result-oriented PSS and service-business case

After experiencing the accumulation of technology and experience in the first two stages, manufacturing companies can choose a more advanced service model based on providing products and functions to customers, i.e. directly providing results to customers, and providing customers with overall solutions. In the result-oriented PSS, the manufacturing company integrates multiple services or organic combination of products, services, technologies, and other system solutions. The customer does not need to purchase the products, nor does it need to consider product design, use, maintenance, and other related issues. The final result and utility of the product are purchased directly, as shown in Fig. 10.

Compared with the two service modes of purchasing and using products, obtaining the overall solution is the ultimate goal of the customer. If the customer can directly obtain the results without using the product, then corresponding time and energy can be saved, thereby improving productivity. The result-oriented PSS

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**Table 1** Product characteristics and service-business case of product-oriented PSS

| Industry category | Basic services | Value-added services | Typical case |
|-------------------|----------------|---------------------|--------------|
| Central air conditioning | On-site repair services | Remote diagnostic services | Carrier launched the ‘room temperature control service’. By cooperating with other companies, the design of the building is more efficient, the demand for air conditioning is greatly reduced, or no air conditioning is needed at all, but it can produce the same level of comfort. |
| Installation and commissioning | Home appliance package services | Interior design services | |
| ‘Three-guarantees service’ | Renovation of old houses | |
| Delivery | |

**Table 2** Product characteristics and service-business case of use-oriented PSS

| Industry category | Basic services | Value-added services | Typical case |
|-------------------|----------------|---------------------|--------------|
| Carpet | Product consult | Interior design | The carpet service launched by Interface Carpet Company in Atlanta, USA, through long-term lease contracts with customers, monthly inspections, and charges, only the damaged carpet blocks are replaced, and the carpet vendor is transformed into a service provider. |
| | 'Three-guarantees service' | \(\text{Recycling} \) services | |
| Mobile communication | 'Three-guarantees service' | Information security | Guangzhou Information Technology Co., Ltd. launched a confident and safe rental service. While ensuring the safe operation of the enterprise computer information system, it reduces the construction cost of the enterprise and provides more professional services for the enterprise. |
| | | Leasing services | |
| | | Overall solution | |
| | | Professional maintenance | |
| Lubricating oil | 'Three-guarantees Service' | Custom services | A medium-sized company producing lubricants in the Midwestern United States provides equipment support services to ensure that the contractor’s equipment can be stopped for a certain period due to lubricant problems. |
| | Equipment assurance services | | |

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**Fig. 9** Service model of use-oriented PSS
products to the use or results of selling products, use-oriented PSS, extension. In terms of marketing model, it extends from selling mainly in the two aspects of marketing mode and responsibility

Table 4 provide products, supplemented by related services. Finally, the concept of the PSS is continuously changing, and its change is

Table 3 For high-value customers (an enterprise that can bring substantial long-term profits) of an enterprise, the enterprise can mainly

| Industry category       | Available service categories                  | Value-added services                     | Typical case                                                                 |
|------------------------|-----------------------------------------------|------------------------------------------|-------------------------------------------------------------------------------|
| Mobile phone           | Shipment service                              | Equipment repair                         | MediaTek is characterised by providing ‘one-stop service’, bundling key components of mobile phones, and providing ‘one-stop solutions’ to mobile phone manufacturers, which greatly reduces the difficulty of mobile phone product development and enables terminal manufacturers to save costs and speed up product launch cycles. |
| Intelligent monitoring system | Product consultation                          | Custom services                          | Ningbo Dehong Intelligent System Engineering Co., Ltd. abandons the original business philosophy of selling products regardless of subsequent services, and provides intelligent monitoring systems for more than 20 streets and towns under Cixi City and provides regular operation cooperation for a 5-year after-sales service guarantee system. The method changed from one-time payment to installment payment, which effectively reduced the burden on customers. |
| Energy management      | Energy-saving services                        | Contract energy management system solution | Schneider’s newly launched an energy efficiency management platform (EcoStruxure) which combines Schneider Electric’s unique technology and professional experience in five areas: power, industry, construction, data centre, and security, and can develop and deploy integration that integrates five key technical features to make energy safe, reliable, efficient, economical and environmentally friendly. |

frees customers from the dilemma of how to use complex products, and it is conducive to increasing efficiency, improving quality, and saving time. Table 3 shows the product characteristics and successful business cases of the result-oriented PSS.

Table 4 shows the comparisons on cases of product-oriented, use-oriented and result-oriented PSSs. It can be seen that the concept of the PSS is continuously changing, and its change is mainly in the two aspects of marketing mode and responsibility extension. In terms of marketing model, it extends from selling products to the use or results of selling products, use-oriented PSS, such as car rental services, carpet services etc., and result-oriented PSS, such as mobile phone R&D services, energy management services etc. The transformation of the enterprise marketing model is also reflected from selling products to selling products + services, such as Apple’s iPad + iTunes, iPhone + Appstore. In terms of the extension of corporate responsibility, it is manifested in providing customers with remanufacturing and recycling services and providing customers with product use guarantees, such as product recycling services and other closed-loop services. From the above research content, we can draw inspiration from it. For high-value customers (an enterprise that can bring substantial long-term profits) of an enterprise, the enterprise can mainly provide products, supplemented by related services. Finally, the enterprise wins customers through products and gains value-added income through services. For customers with insufficient funds, they can provide services for product use by leasing, sharing, and other transaction methods to obtain market share and profits. For customers who do not care about products and product use methods, but only care about the final results and effectiveness after purchasing products, enterprises can provide total solution services, similar to contractors’ services in contractors, to obtain customers and revenue.

6 Concluding discussion
The overall architecture of the customer value-oriented PSS scheme proposed in this paper is conducive to manufacturing companies by analysing customer value information to find out the customer’s value needs, and through product, service substitution, complementarity, and collaboration, so that products and service can be coordinated together and optimisation to maximise meet the diverse needs of customers. The research in this paper has three significant contributions. The first contribution is based on the data and knowledge-support layer, the main technology-layer, the process-layer of solution design, and the application layer. It establishes an overall framework, a four-layer customer-oriented value-oriented PSS architecture. The architecture provides theoretical support for studying how to plan PSS solutions under highly dynamic customers’ needs. The second contribution is to
build a customer-value hierarchy model based on customer value theory; a functional model for PSS solution design based on functional black-box representation; and a product and service solution for PSS solution design based on the product structure tree and service-blueprint method. The model provides a theoretical reference for studying how to optimise and configure PSS solutions for dynamic and complex customers’ needs. The third contribution is a comprehensive analysis of the primary vital technologies required for PSS solution design. For different solution design implementation models, it offers the typical service-business cases and also provides useful references and experiences for the practical application of PSS solution design.

Although the above research contents are discussed in this research, there are some limitations, because the current PSS has been transforming from traditional PSS to smart PSS [43–45]. Moreover, the PSS business strategy is moving forward to value co-creation [46]. Therefore, the future research work of based on this study, this paper will combine the latest research on PSS, introduce value co-creation to create CSN, improve the core competitiveness of enterprises, reduce the impact of products and services on the environment at the same time, and expand the network externality of business model. In addition, under the smart PSS, the smart connected product would be used as the media and tool to produce various electronic services in a bundling way, to achieve the personalized customer satisfaction with less impact on the environment. The smart PSS would be discussed in combination with advanced ideas such as adaptive sustainability, advanced IT infrastructure, people-centred perspective, and cycle life management.

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