



## Knowledge Sharing of Products and Services Design Based on Design Knowledge Management

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### Abstract

Product-Service System (PSS), which highly integrates products and services, and offers high-value-added to customers, is attracting great attention in manufacturing industry. When designing PSS, it is important to design products and service collaborative and simultaneously referring to various design knowledge. In this paper, we propose a knowledge management framework to support designers to search for PSS case knowledge from the aspect of compatibility among products and services. The proposed method is based on the framework of ontology that represents and manages design knowledge of both product and service. The effectiveness of the proposed method is demonstrated by application to an example case.

**Keywords**-component; product-service system(PSS);Products design; services design; knowledge sharing

### I. INTRODUCTION

In recent years, due to the rapid development of the globalization of the economy, the competition will be more intense between the manufacturing sector in the international market. To this end, as a means to enhance industrial competitiveness, a high degree of unity of products and services, to provide users with high-value-added products, (Product-Service System, PSS)[1][2], has become the focus of concern in manufacturing.

PSS has emerged as a concept to maintain the functionality of product for customers throughout the whole product lifecycle, which is supported by physical product together with corresponding service[1]. The product here refers to the industry product. PSS will integrate product design, production and services together completely, for example: in the product service systems, very complex, and not easy to deal with product design and service design, can be completed by learning from the previous experience in the product's design and service. Whether the Knowledge of product design and service design is match should be the focus of the study.

As mentioned above, it's very necessary for the designers to consider the uniformity of the product design and service design in the preliminary design stage. Therefore, we should consider the following questions in the design process of PSS: (1) knowledge sharing of the product design and service design. That is how to provide possible service knowledge to designers, or provide product design knowledge in service design phase. (2) The set up of product and service design platform for most people to participate in based on the collaborative environment.

In this paper, based on the computer intelligent management method will establish a reasonable framework between the knowledge needed in product design and service design by the excavation of the above problems and based on this framework, to provide designers product design and service design knowledge management system with collaborative sharing design platform is the purpose of our study, so next is the detailed description.

### II. THE RELATED RESEARCH INTRODUCTION AND THE LEVEL

#### A. Performance practices of PSS design knowledge

The scholar Shimomura once had some proposals about the performance practices of knowledge in PSS design, especially the performance of knowledge in service design[3]. The methods he proposed is that knowledge performance of the "Service design" in the PSS could on the basic concepts of service requirements、service functions、entities、actors viewpoint. "Service requirement", that is customer requirement. "Service function" means what do the design objects do? Design objects are Functional and can be described by semantics. "Entities", that is the needs to achieve a specific kind of function, but also indicates the necessary resources where PSS to provide. About entities, not only refers to the product or auxiliary product in a physical sense (such as: information systems、infrastructure sectors and so on), but also information contains elements of personnel and organizations. "The actors" refers to provider of design entities, just like enterprises, organizations and individuals.

The knowledge performance is order to have better accesses to effective knowledge. In order to have better access to get the useful and needed knowledge during the service design process, the concepts about service's "requirements" and "functional" will be classified, reference to these classifications, collected a variety of standard knowledge terms that can be expressed from the case to compose category axis and forming a glossary as shown in Table 1.

TABLE I. GLOSSARY USED IN CATEGORY AXIS

<i>Target</i>	<i>Class</i>	<i>Term</i>
<b>Demand</b>	Life cycle stage (ten terms)	Raw materials, manufacture, distribution, sale, import the use (Pre), use (During), using the (Post), conservative, abandoned
	Realized value (seven terms)	Good performance (performance), reduce the raw material (cost), reduce the risk (risk), comfortable to use, easy to use, sparking user feelings, reduction of environmental hazards
<b>Function</b>	input/output element (three terms)	Information, material, energy
	Input/output relation (twenty-one terms)	Separation ,dispersion, income, take-out, transport, lead, combine ,mix ,handling, inducing, combined, mixed, braking, suppression,stop, transform, savings, supply, cognitive, said, handling, stability, fixed , fixed position.

#### B. Maintaining the Integrity of the Specifications

Like Chapter 1 expressed, the PSS here in order to make the collaborative design of service and product to be possible, first, we need to provide share information about product design and service design in production service systems; second, we need to show to the designs about the knowledge of service design which is matched to product design.

However, the existing knowledge presentation described in Section 2.1, almost no information about the product design is mentioned, furthermore, product design and service design's relationship is not clear, a far cry from the goals of the above first & second. To solve this problem, we need to use information theory to build a knowledge management framework and sharing knowledge platform for the product design and service design.

### III. APPROACH OF THE PROPOSAL

#### A. The cutting approaches of the study

In order to solve the above problems, knowledge of product design and service design need to use the same frame structure and exist in the same platform, and using the ontology's manifestation for the frame design and management of knowledge in this study. In the field of computer science, Ontology is a specification of a conceptualization or a description of concepts and relationships that can exist as an agent or a community of agents[4] [5] [6].

Ontology technology is paid to attention in sharing knowledge on the web[4]. The essence of ontology is to cut out the fundamental concepts from the object world, to define the relation of the concepts, enable inference processing. The next-generation web can be updated further from information sharing to knowledge sharing by constructing ontology.

The concrete method is: use elements of ontology, the description ontology individuals (instances) 、 classes (concepts) 、 attributes、 and relations methods, to the formation of the knowledge concept module of product design and service design, based on these modules to determine the relationship between knowledge and knowledge, and form a unified knowledge representation and management framework. Concrete knowledge of PSS examples can be indicated by ontology instance, and meanwhile build a collaborative design platform that most people can simultaneously share.

In addition, in the design of the PSS, we found the product design and service design have proximities and similar characteristics, in order to obtain beneficial service design knowledge, this study will leading-in the taxonomy about product design, and in this category manage specific case knowledge, we can effectively obtain the necessary services design knowledge from existing PSS case when doing product design.

The following will detail the knowledge management methods of product design and service design on the purposes of knowledge retrieval.

#### B. The definition of conceptual model based on knowledge representation

##### • Conceptual Model

This study is based on the theory of ontology, extract knowledge concept from product design and service design and compose the corresponding knowledge model. Refer to Figure 1 for the product design usually divided into these three processes: conceptual design、 basic design and detailed design[7]. This paper based on these three processes to determine the required knowledge of the product design. Specifically, the basic knowledge of "design requirements" and "product features" in the conceptual design stage, "spare parts" and "product structure" in the basic design stage, "product size" and "part material" in the detailed design stage can be extraction. And use ontology theory to describe the structural relationship of these knowledge. In service design, such as described in the 2.1 sections, you can extract the service "requirements"、 "functions"、 "entities"、 "actors" to describe service knowledge. Services "requirements", in Table two's expression, "product life cycle stage" and "realized value" is defined as the sub concept of "service requirements". In addition, the concept of "entity", in order to consider the distinction between entities associated with product design and other entities, the entities use to express service design will be constitute by the sub concept of "core parts" and ancillary products (such as staff) etc.



## B. The management and utilization of PSS examples knowledge

Concrete case knowledge of the six classifications is saved as a concept instance. In this paper, through this arrangement, we can store and manage the case knowledge about product design and service design. In this framework, what Represented in Table 1 indicates the glossary definition for the concept, and set the corresponding properties for the concept. So that we can retrieve stored PSS knowledge from all angles, can also function knowledge retrieval based on the service requirements or product function's classification.

## V. VERIFICATION

In this paper, we collect 15 PSS cases, about sixty-four examples knowledge, and store as knowledge representation of the instance. Then, use this knowledge, and take agricultural machinery for example, do validation analysis.

Agricultural machinery belonging to the general machine classification 's category, according to Protégé's search function, can extract sixteen related service design in function of obtain use information, after judgment and confirmation, service design can be combined with agricultural machinery. The "service function" prompted by the above result and "product features" are described by the common form, so it's convenient to be shared in the same design platform that the design of product and service which could be participate by majority people. As shown in Figure 5.

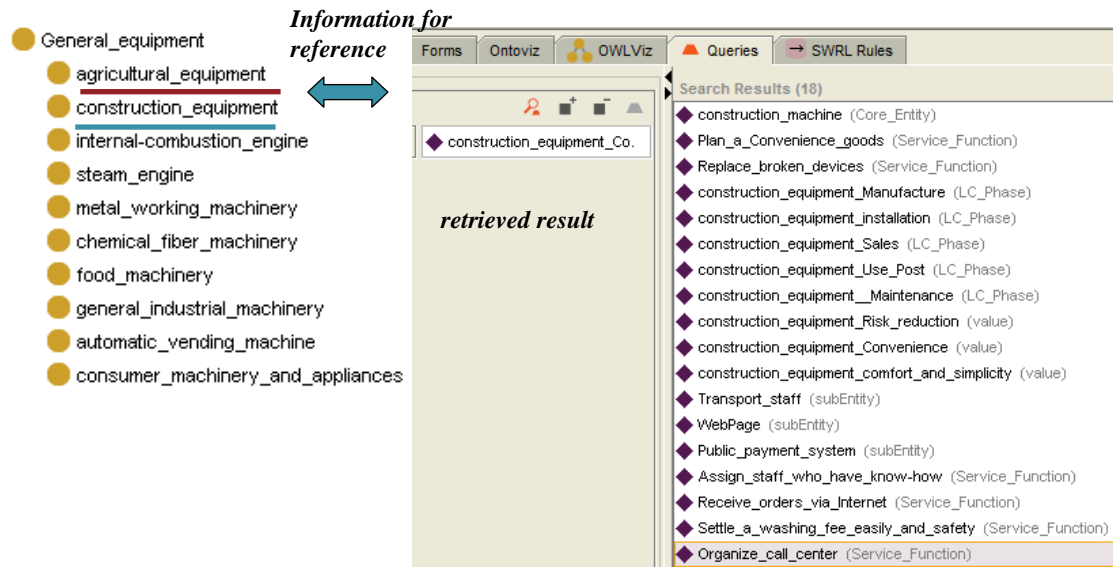


Figure 5. Example of PSS knowledge management and utilization

## VI. CONCLUSIONS AND PROSPECTS

In this paper we have started from the point of view of the co-design of products and services, researched the framework of knowledge management and means to realize effective retrieval of knowledge, and also verified the effectiveness of this approach. In future, we will continue to collect and accumulate PSS case knowledge, for the target of raise better co-design methodology between products and services and build a more concrete and feasible knowledge model to do deeper research explore.

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## REFERENCES

- [1] Y. Shimomura and T. Tomiyama: Service Modeling for Service Engineering. In IFIP International Federation for Information Processing, Vol. 167, (ISSN 1571-5736 (Paper) 1861-2288 (Online)), pp. 31-38, Springer Boston, 2005.
- [2] Aurich et al: Life cycle oriented design of technical Product-Service Systems, Journal of Cleaner Production, Vol. 14, No.17, pp. 1480-1494, 2006.
- [3] Y. Nemoto, F. Akasaka, R. Chiba and Y. Shimomura: Establishment of a Function Embodiment Knowledge Base for Supporting Service Design, Science China Information Sciences, Special Focus on: Geometry Computing and Digital Media Processing, Vol. 55, No. 5, pp.1008-1018, (ISSN:1674-733X CN:11-5847/TP), doi: 10.1007/s11432-012-4561-3, Springer-Verlag, 2012.
- [4] Gruber, T. R., A Translation Approach to Portable Ontology Specifications. Knowledge Acquisition, 5(2):199-220, 1993. See also What is an Ontology? <http://www-ksl.stanford.edu/kst/what-is-anontology.html> l.
- [5] Gruber, T. R., Toward Principles for the Design of Ontologies Used for Knowledge Sharing. International Journal Human-Computer Studies, 43(5-6):907-928, 1995.
- [6] Guarino, N. and P. Giaretta: Ontologies and knowledge bases towards a terminological clarification, Proc. of KB&KS'95, pp.25-32, 1995.
- [7] G. Pahl, W. Beitz, J. Feldhusen, K.-H. Grote, Engineering Design A Systematic Approach, (1995), 427.
- [8] Rodenacker. W. Methodisches Konstruieren. Springer—VeLag, Berlin, 1971.
- [9] The Protégé Ontology Editor and Knowledge Acquisition System, <http://protege.stanford.edu/>.