RESEARCH AND IMPLEMENTATION OF CERAMIC PRODUCT CLOUD DESIGN SERVICE PLATFORM

Hua Huang[1,2], Yi-lai Zhang[1] , Zaiwen Feng[2]
[1]Jingdezhen Ceramic Institute, 333001, Jingdezhen, Jiangxi, China
[2]State Key Laboratory of Software Engineering, School of Computer, Wuhan University, 430072,Wuhan,China
jdz_hh@qq.com,jdzzyl@qq.com, zwfeng@whu.edu.cn

Abstract

To develop the ceramic industry cluster and satisfy the public technology service requirements of ceramic enterprise product innovation design, it is important to study the open integration mode of various ceramic product design resources and abilities and to build ceramic product cloud design service platform. Therefore, based on the analysis of product design service requirements of the ceramic industry cluster and the current state of the existing ceramic product design service platform, the architecture and service model of the ceramic product cloud design service platform is proposed. To build this platform, this paper presents the cloud design resource model and investigates the key realization technologies, such as the resource aggregation and organization, virtualization and encapsulation technology, the design cloud service management technology and the support technology of interaction design according to users' requirements. Combining the emerging advanced technologies (such as internet of things, and service-oriented technologies) with the existing ceramic cloud platform, the ceramic product cloud design service platform is implemented. At last, the application effect of this platform is discussed.

Keywords: cloud computing; cloud design; internet of things; ceramic product design;

1. INTRODUCTION

During the traditional process of ceramic product production, the ceramic product design (including product material formula design, product shape design and product pattern design) is an important step. According to the recent statistics, the number of professional ceramic design staff in China is no more than 30,000, which is less than three percent of the ceramic industry practitioners. Due to the lack of product designers and the limit of the scale, capital and other factors of ceramic enterprises, many small and medium-sized ceramic enterprises do not employ professional product design staff. Therefore, the product design ability of these enterprises is poor. Meantime, with the rapid development of information technology, a series of new way of product design are emerging. Especially the application and popularity of the web technology provides a new way for ceramic product design service. In these web-based product design service platforms, many ceramic product design resources provided by platform operators are collected into to a WEB server. In these platforms, product design resources can be uploaded and used to meet the enterprises' product design requirements (Celesti *et al*., 2010, Wang *et al*., 2013). Unfortunately, all the product design resources in these platforms are only from the platform operators, thus the amount and category of design resources is limited. It means that these platforms cannot aggregate enough professional design resources from the ceramic industry cluster.

With the development of cloud computing, how to aggregate ceramic product design resources and abilities into the cloud computing architecture to conduct ceramic product online design based on cloud computing is the problem that need to be addressed. Therefore, this paper focuses on the research and realization ceramic product design service platform based on cloud computing (namely the ceramic product cloud design service platform, CPCD for short). This platform can aggregate mass ceramic product design resources and abilities to build a product design resource cloud for the enterprises in the ceramic industry cluster. With the support of Internet of things (IoT) technology, the communication between enterprises and designers can be achieved to meet enterprises' personalized design requirements. In addition, small and medium enterprises can accelerate the upgrading speed of their products and enhance their competitive ability by obtaining the design services and resources from the CPCD.

In summary, the paper has the following contributions:

- Present the whole architecture of the CPCD based on the theory and architecture of cloud computing.
- Propose the cloud design service model and the cloud design resource model.
- Investigate the key technologies for implementing the CPCD and discuss the application of the CPCD.

The rest of this paper is as follows. Section 2 analyzes the product design service requirements of the ceramic industry cluster and the current state of the existing product design service platforms. Section 3 introduces the overall architecture of the CPCD. Section 4 proposes the service

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model of the CPCD and the cloud design resource model. Then the key realization technologies of the CPCD is investigated in Section 5 and the application effect of the CPCD is discussed in Section 6. At last, Section 7 draws out the conclusion.

2. REQUIREMENT ANALYSIS AND RELATED PLATFORMS

2.1 The product design service requirements of the ceramic industry cluster

In china, there are nearly 20,000 ceramic production enterprises in the ceramic industry cluster. The number of small and medium-sized enterprise accounts for more than 98 percent of the total ceramic production enterprises. For the ceramic industry cluster, there are the following intrinsic deficiencies.

1)Extremely uneven technical force causes the shortage of technology innovation ability in some small and medium-sized enterprises.

Developing new ceramic product requires a lot of time, manpower and material resources. Unfortunately, for the small and medium-sized enterprises, due to the insufficient funds and the lack of high-quality professional and technical personnel and management personnel, they have to imitate large-sized enterprises' products to produce. Therefore, the phenomenon of product infringement is serious, and the whole ceramic industry lacks the technical support and motivation of product innovation.

2)In the ceramic industry cluster, the degree of labor division and specialization is not high, and the industrial chain is imperfect. For most of enterprises, they need more common resources, such as product design resources.

According to the above description, To shorten the product design cycle, improve the product design quality, and reduce the product infringement, it is urgently necessary to provide an effective way to centralize excellent design personnel or organizations, build design resource cloud, and provide product design services for the ceramic industry clusters (Rimal *et al*., 2011, Marinescu *et al*., 2013).

2.2 Related product design service platforms

Currently, there exist some product design service platform. For example, in apparel industry there are AIKE technology service platform (http://www.iechosoft.com), 3 Fnet textile apparel online service platform (http://www.3fnet.com). In automobile industry, there is an automobile mould design service platform (http://www.emouldchina.com), which is a creative design service platform dominated by governments. The above platforms provide many product design services and resources. However, they are not suitable for ceramic product design.

Recently, some ceramic service platforms and portal sites are emerging, such as China ceramic net (http://www.chinaciqi.com), HuaXia ceramic net (http://www.chinachina.net) and so on. These platforms can improve the communication of ceramic professional technology and information, and change the means of ceramic product trading, but they only focus on the ceramic information service and the ceramic e-commerce service (Lackermair, 2011).

According to the above description, although there have been some product design service platforms, but these platforms are not professional ceramic product design service platforms. They do not provide ceramic product design services by adopting the cloud computing architecture. Therefore, it is of great significance to build the ceramic product cloud design service platform.

3. THE ARCHITECTURE OF THE CPCD

To realize the full sharing and circulation, high utilization, and on-demand use of various ceramic product design resources, we combine cloud computing with the internet of things technology to build the ceramic product cloud design service platform (CPCD). Based on the theory and architecture of cloud computing (Tao *et al*., 2011, Wang *et al*., 2013), we propose the whole architecture of the CPCD, which is a hierarchical structure as illustrated in Figure 1. It consists of nine layers as below.

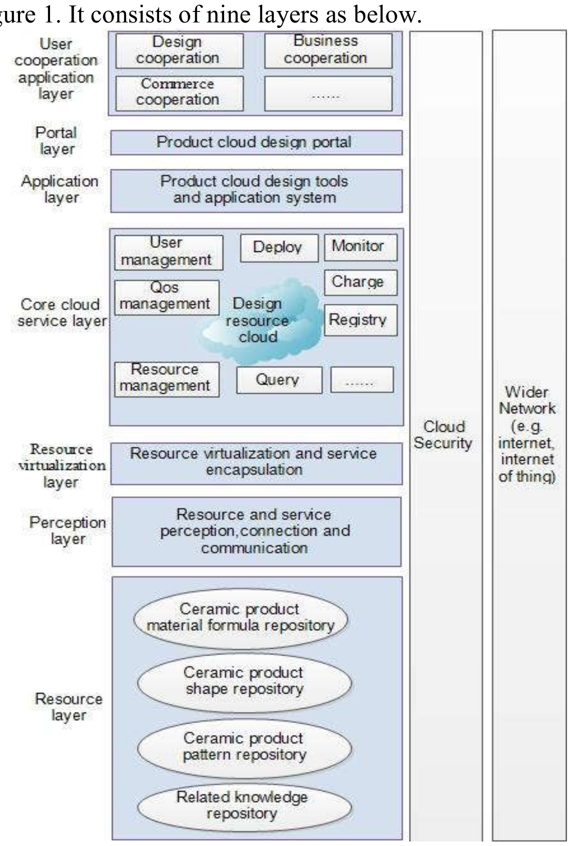

Figure 1. The architecture of the CPCD

Resource layer: It is composed of three ceramic product design resource repositories (including ceramic product material formula repository, ceramic product shape repository and ceramic product pattern repository) and a related knowledge repository that can provide various knowledge used in the ceramic product design process (Huang *et al*., 2016), e.g., process knowledge, domain knowledge, model knowledge, etc.

Perception layer: It is responsible for sensing the physical ceramic product design resources and devices, enabling them to be connected into the wider network, and processing the related data and information.

Resource virtualization layer: It is used for the virtualization of ceramic product design resources and abilities, and encapsulating them into the design cloud services.

Cloud service layer: It primarily includes two kinds of service: the design cloud service (DCS) and the platform core service (PCS). DCS is the service encapsulation of ceramic product design sources and abilities, which can be invoked by platform users. PCS is the main service for the three types of platform users (i.e. the provider, operator, and consumer) to invoke and manage DCSs, including registry, deploy, query, charge and monitor, etc (Zhang *et al*.,2016,Wang *et al*., 2016, Anisetti *et al*., 2016).

Application layer: Except for the existing 3D model and pattern design tools, the application layer also provides a special ceramic online interaction design support tool.

Portal layer: It provides various man–machine interaction interfaces for platform users to query and invoke DCSs.

User cooperation application layer: With the support of the DCSs and the PCSs, different kinds of cooperation applications can be realized, including design cooperation, business cooperation, commerce cooperation, and so forth.

Cloud security layer: It provides different security architecture, mechanisms, and strategies for the CPCD.

Wider network layer: It uses the internet and internet of things technologies to provide the base communication environment to all the resources, devices, services, users, and operations in the CPCD.

4. THE CLOUD DESIGN SERVICE MODEL AND CLOUD DESIGN RESOURCE MODEL

4.1 The cloud design service model

According to the above description, in the CPCD, a large number of ceramic product design resources and abilities can be intelligently sensed and collected into the wider network, and automatically managed and controlled using IoT technologies (e.g. embedded system, wired and wireless senor network). Then the ceramic product design resources and abilities are virtualized and encapsulated into different design cloud services (DCSs). The users that have the requirements of ceramic product design can query, invoke, deploy and use the DCSs. To understand the running mechanism of the CPCD, the cloud design service model is proposed as illustrated in Figure 2.

As shown in Figure 2, there are three types of platform users. The description of them is given below.

Providers: They provide the design resources and abilities involved the design process of ceramic product. The provider may be a person, an organization, an enterprise, or a third party in the ceramic industry cluster.

Consumers: They are the subscribers of the DCSs available in the CPCD. They can use the DCSs after purchasing them according to their requirements.

Operators: They operate the CPCD to deliver services and functions to the providers and consumers. Meantime, they provide, update, and maintain the technologies, resources, and services involved in the CPCD.

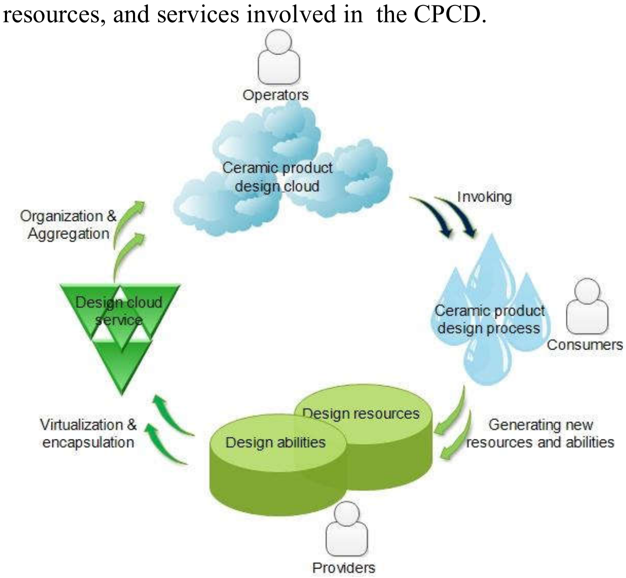

Figure 2. The cloud design service model

4.2 The cloud design resource model

In the CPCD, there are various ceramic product design resources, such as ceramic material formula, ceramic product shape, ceramic product pattern and ceramic product design proposal, etc. These resources and abilities located in different places are owned and controlled by different providers. To virtualize and encapsulate these ceramic design resources into different design cloud services, they should be classified and organized beforehand. Therefore, we propose a cloud design resource model (CDRM) to specify them. The formal definition of the CDRM is given below.

Definition 1 (Cloud Design Resource Model)

The cloud design resource model (CDRM) is a 9-tuple: CDRM =(UID, RID, RName, RType, RLevel, RCategory, RUrl, RData, RDes), where:

- UID specifies the provider ID of a ceramic product design resource;
- RID specifies the unique identifier of a ceramic product design resource;
- RName specifies the name of a ceramic product design resource;
- RType∈RT specifies the type of a ceramic product design resource, where RT is the set of the types of the product design resource supported by the CPCD, RT={ceramic material formula, ceramic product shape, ceramic product pattern, ceramic product design proposal };
- RLevel ∈ RL specifies the level of a ceramic product design resource, where RL is the set of the level of the product design resource supported by the CPCD, RL={public, protected, payed};
- RCategory∈RC specifies the category of the corresponding ceramic product of a design resource, where RC is the set of the categories of the ceramic product supported by the CPCD, RC={tea sets, cutlery, cups,...};
- RUrl specifies the URL of accessing a ceramic product design resource;
- RData specifies the actual data of a ceramic product design resource;
- RDes specifies the detail description of a ceramic product design resource.

According to Definition 1, the cloud design resource model can be used to classify and aggregate various ceramic product design resources by the specific rules and algorithms provided by the CPCD. Then these ceramic product design resources can be virtualized and encapsulated into different design cloud services by using the virtualization technology and the service-oriented technology.

5. THE KEY REALIZATION TECHNOLOGIES AND PROTOTYPE SYSTEM OF THE CPCD

5.1 The key realization technologies of the CPCD

To implement the CPCD, there are some key technologies that need to be researched as follows.

1)Ceramic product design resource aggregation and organization technology.

To rapidly aggregate mass ceramic product design resources (including ceramic material formula, ceramic product shape, ceramic product pattern and ceramic product design proposal) provided by the providers in the ceramic industry cluster, we adopt the technologies and related services of internet of things, which can provide the support for the realization of intelligent perception and effective connection among different things (including man-man, machine-to-machine, and man-to-machine), to intelligently collect the related data of these design resources. Then, based on the CDRM, these design resources can be classified and organized.

2)Ceramic product design resource virtualization and encapsulation technology.

After aggregating and organizing the ceramic product design resources, we use the virtualization of cloud computing to hide the physical characteristics of these resources and abilities from the providers. Then the service-oriented technologies (e.g., semantic web, web service,etc) are adopted to intelligently construct a virtual design cloud service environment (Shafieibavani *et al*., 2016, Zhang *et al*., 2016).

3) Design cloud service management technology.

In the CPCD, there are a large number of DCSs that are queried and invoked by different consumers. Therefore, it is necessary to realize the classification, cost management, QoS management, composition, trust and reliability management and optimal allocation of the cloud services provided by the CPCD.

4)The support technology of interaction design according to users' requirements.

Ceramic product design includes three steps: ceramic material formula design, product shape design and product pattern design. Thus, the interaction design tool provided by the CPCD also includes three kinds of interaction design support technologies for the three steps. The ceramic material formula can be online obtained by the design system of ceramic material formula that can be accessed by http://pd.pasp.cn. The ceramic product shape can be designed by the special application software (e.g. 3D Max, AutoCAD, etc). The ceramic product pattern design is usually done by Photoshop or other graphic design software, e.g., the online design tool of ceramic pattern provided by the CPCD. Therefore, the main functions of the interactive design support tool is to realize the real-time interactive communication between the product designers (providers) and the product users (consumers). With the interactive design support tool, the product designers and users can synchronously view the design results, conduct the real-time interaction of design information, and even join the design process of ceramic products. The interaction design support tool is realized by using P2P technology, remote controlling technology, the design data real-time synchronizing technology.

5.2 The implemented system of the CPCD

Combining the above proposed key realization technologies with the existing ceramic cloud platform that can be accessed by http://www.pasp.cn, the system of the CPCD is implemented. The accessing URL of the system is http://design.ccmall.cn. It's homepage is shown in Figure 3.

Figure 3. The homepage of the CPCD

6. THE APPLICATION EFFECT OF THE CPCD

The wide application of the CPCD can greatly speed up updating new products of small and medium-sized ceramic enterprises with low cost of product development and promote their market competitiveness. In summary, the contributions of the CPCD for the ceramic industry cluster includes the following three aspects.

- It can provide product design resources and services according to ceramic enterprises' product design requirements to support developing new products for the ceramic enterprises in the ceramic industry cluster. In the CPCD, a large number of ceramic product design resources, such as ceramic material formula, ceramic product shape, ceramic product pattern, and ceramic product design proposal, are aggregated and organized. These resources are virtualized and encapsulated into various cloud services, which can be accessed and invoked by the consumers of the CPCD (e.g., small and medium-sized ceramic enterprises). Therefore, the CPCD provides a new way of obtaining product design resources, and improve the design and developing capability of new products for the ceramic enterprises in the ceramic industry cluster.
- It can improve the efficiency of product design for the designers and enhance the satisfactory degree of new ceramic products. In the CPCD, the product designers can obtain the ceramic design resources that they need, and quickly complete the product design by using the services and tools from the CPCD. During the process of product design, the real-time interactive communication between the product designers and the product users can be achieved by the interaction design support tool provided by the CPCD. Therefore, the speed of designing new ceramic product is enhanced, and the satisfactory degree of new product is also promoted.
- It can reduce the cost of developing new products for the small and medium-sized enterprises in the ceramic industry cluster. During the process of developing new products, the CPCD can lead to reduced infrastructure and administrative cost, upgrading and maintaining cost, energy saving for the small and medium-sized enterprises in the ceramic industry cluster.

7. CONCLUSIONS

To promote the development of the ceramic industry cluster and improve the design and developing capability of new products for the enterprises in the ceramic industry cluster, this paper studies and implements a ceramic product cloud design service platform (CPCD) by using the emerging advanced technologies (such as cloud computing, internet of things, virtualization, and service-oriented technologies). Based on the analysis of product design service requirements of the ceramic industry cluster, the architecture and service model of the CPCD is firstly proposed. To aggregate and organize the ceramic product design resources and abilities, we present a cloud design resource model (CDRM) to specify them. To implement the CPCD, we investigate the related key realization technologies: ceramic product design resource aggregation and organization technology, virtualization and encapsulation technology, design cloud service management technology and the support technology of interaction design according to users' requirements. Lastly, we discuss the application effect of the CPCD.

In summary, the CPCD can enhance the design resource utilization and reduce resource and energy consumption of the ceramic industry cluster by realizing the sharing and cooperation, and on-demand use of ceramic design resources and abilities. Therefore, with the wide application of the CPCD, the design level of the ceramic industry in our country will be promoted, and the market competition capabilities of the enterprises in the ceramic industry cluster will be strengthened.

8. ACKNOWLEDGMENT

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Authors

Hua Huang received Ph.D in Computer Software from Wuhan University. Now he is an associate professor in School of Information Engineering in Jingdezhen Ceramic Institute, China. His research focuses on cloud computing and business process model management.

Yi-lai Zhang is the corresponding author. He is an professor in School of Information Engineering in Jingdezhen Ceramic Institute, China. His research focuses on enterprise information technology.

Zaiwen Feng received Ph.D in Computer Software from Wuhan University. He is now a lecturer at the School of Computer, Wuhan University, China. His research focuses on business process management, service computing and so on.