A Cloud Computing-Based ERP System under The Cloud Manufacturing Environment

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Abstract

As one of the important members of manufacturing enterprise’s informationization technologies, ERP is now facing serious challenges and difficulties under the Networked and global manufacturing. To solve the complex development and application problems of Enterprise Resource Planning (ERP), and explore the evolution of ERP under the new environment, the Cloud computing is involved in. A new ERP system based on cloud computing is put forward and several key technologies are discussed. Firstly, the concept and characteristics of C-ERP are defined and the architecture of Service-oriented ERP based on Cloud Computing is proposed. Then, several key issues such as cloud resources virtual accessing, the construction and inter-operation of cloud services and the management of C-ERP platform are studied. The research in this paper, however, established the theoretical and technological support for helping to construct the dynamic, intelligent C-ERP system.

Keywords: Cloud Computing, C-ERP, Key Technology

1. Introduction

Enterprise Resource Planning (ERP) refers to the developed technologies that assist managers and employees in meeting the demands of reduced product cost and elevated efficiency. ERP plays an important role in the whole life cycle of the product process. With the development of the communication and computer technologies, ERP is facing more difficulties and challenges. For example, the software reusing, the dynamic and complicated transformation, more and more transnational or regional cooperation. There are some figures through the investigation about above: 90% of the traditional ERP implementations are over the limited time; 80% are over the budget; and 60%-70% do not complete system integration [1].

Cloud computing establishes new generation service centers by abstracting the networked resources as the aggregate of virtual resources [2]. It delivers infrastructure, platform and software as services, which are able to be subscription-based services in a use-as-you-need model to users. Cloud computing supports a new solution to the choke points of the networked mechanical industry’s management systems. Research on theories and applications of ERP under the new networked state, especially in the cloud computing situation is meaning and practical.

In section 2, the theory of ERP system based on cloud computing will be proposed and discussed; the characteristics and key technologies of C-ERP (Cloud computing ERP) also will be listed in detail. In section 3 and 4, the key technologies will be studied one by one, including the architecture of the C-ERP, the cloud resources virtual accessing, the construction and inter-operation of cloud services and the management of C-ERP platform. An example of C-ERP will be presented in section 5. Finally opportunities for future research will be pointed out.
2. Theory of Cloud Computing ERP (C-ERP)

2.1 Definition of Cloud Computing ERP

Enterprise Resource Planning aims to bring more benefit and less cost to enterprises. But in the process of the ERP using, the effect of ERP is disquieting. The structure of ERP systems is usually censured as rigid, no scalable and non-portable. In order to solve these problems, the architecture and the ERP operating way have been important embranchments in the field of ERP studies. Cloud computing means to provide services just what customers need. It can be described as an abstraction of the underlying platform which can save customers from the troubles of designing, programming and maintaining, meanwhile, a distinct advantage of cloud computing that can help improve the ERP performance is cloud computing can adjust the services dynamically. The adjustments can be automated from the cloud computing data centers standing by the defined strategies just as the customers’ demands. Thanks to the cloud computing characteristics, Cloud Computing ERP will be the perfect solution to enterprises.

Definition 1: Cloud Computing ERP (C-ERP) is a new, dynamic ERP System that supply custom-made enterprise information management services to customers by organizing appropriate resources in Cloud Service Center (CSC) of the Cloud Computing Platform on the Internet.

The characteristics, also the key points of C-ERP are as follows:

a) Custom-made: The C-ERP system supplies the very management services to customers as they need. This characteristic can configure resources effectively and avoid resources wasting.

b) Dynamic: As one of the most serious choke points, the rigidity of ERP system destroys its due role in enterprises, especially in the case of business process reengineering (BPR). The C-ERP system asks for services from CSC just as what customers need so that the C-ERP system can adjust its function as the actual demand at any time.

2.2 Key factors of C-ERP

There are several important factors that evaluate the performance of C-ERP system:

a) The resources of CSC must be available and can be shared.

b) Cloud resources virtual accessing and the construction of cloud service.

c) Easily integrated and friendly operation.

d) Ensure the system security.

3. C-ERP Architecture

3.1 Traditional ERP Architectures

Along with the development of ERP systems, the ERP architecture has been changing all the time. Through out the ERP’s development process, the traditional ERP architecture can be divided to two phases.

a) The single-chip architecture

In middle 1990s, the concept of ERP extended on the basis of MRP (Material Requirement Planning). The management range of ERP is not only the internal manufacturing resources but also the management resources, pursuing the integration of manufacturing and management resources. In the late 1990s, the rapid development of internet brought new challenge to the manufacturing Industry. The whole industry resources, especially the external resources of enterprises can be used much better and easier than before. In order to meet the requirement of enterprises under the networked manufacturing, ERP system must extend its function from internal departments to external partner, including the suppliers and customers.

In this phase, ERP system pursued the unified management of the value-chain in and out of enterprises, the architecture based on enterprise value-chain began to establish [3]. This architecture usually was the Client/Server (CS) model and the whole system was constituted by several application modules about the enterprise business. The development of ERP system in this phase usually was the
custom-made, because of the enterprise’s complex state and continual changes, the system updating was difficult. The single-chip ERP architecture based on Enterprise Application Bus (EBA) brought out many problems such as long development period, complex deploy, lack of flexibility and the biggest choke point was the ERP system built on the single-chip architecture can’t meet the dynamic requirement when the enterprise business changed.

b) The distributed architecture

To adjust the new challenge of networked and global manufacturing, more cooperation between different enterprises even transnational corporations and the development of e-business, the new architecture must be proposed. The concept of “Service” brings out new challenge, meanwhile, new solution to ERP. The Service-Oriented Architecture (SOA) [4] is the important architecture based on the Browser/Server (BS) model. In SOA, services are wrapped as loosely coupled rather than tight coupling in single-chip architecture. In this phase, ERP systems based on SOA became more and more popular and some new architectures were proposed [3, 5, 6]. Thanks to the characteristics of SOA, the system property improved than before. But problems still exist. For example, the development of networked and global manufacturing makes the cooperation between companies from different areas even countries are common, in this situation, the integration of ERP system is no longer inside the company, it will be across the enterprise boundary. ERP system must adjust to ensure the information transmission and integration. The SOA can’t solve these problems perfectly.

3.2 cloud computing architecture

Everything can be considered as a service under the cloud computing environment. Usually, the cloud computing includes Infrastructure as a Service (IaaS), Platform as a Service (PaaS), and Software as a Service (SaaS) [7]. And corresponding, the typical cloud computing architecture is usually designed as Figure 1.

![Figure 1. Typical Architecture of Cloud Computing](image)

Under the cloud computing mode, packaged services can solve the difficulties perfectly. According to the cloud computing architecture, the ERP system can be a combination of some packaged services that can adjust as the enterprise development.

3.3 C-ERP architecture

After delving into and analyzing cloud computing and traditional ERP architecture, the C-ERP architecture, which is called ERP-CSA, is proposed as the basic research of cloud ERP system. A description of the overall ERP-CSA is presented as shown in Figure 2.
This architecture is a seven layered one, from bottom to top, every layer will be introduced as follows:

- **The physical resource layer**
  This layer is the foundation of the whole system. It provides the hardware such as thousands of servers that cloud resources can run on. This layer supports the other layers by connecting the physical resources to a global network.

- **The virtual resource layer**
  This layer is a collection of virtual resources. It is built on the physical resource layer, and turns the physical resources to the virtual resource. In this layer, the virtual resource is packed as the cloud service resources and published to the data centers. The basis ERP service resources are generated and saved in these distributed data centers.

- **The cloud manage layer**
  This layer is the core part of the whole architecture. In order to organize the clouds belong to different data centers, we need the finding and dispatching work with the virtual Machine Monitor under the standard storage service and programming APIs. The level that cloud service management in this layer determines the success or failure of the ERP System. For example, if we want to receive a service, firstly we should give the service provider exact descriptions of what we want, and then the provider finds, matches and dispatches the service according to the description, lastly the provider delivery the selected service back to us. In this process, service manipulation and transmission are accomplished in this layer.

- **The application cloud service layer**
  The terminal-users apply the requirement of service according to the process of the enterprise, and receive the final service though this layer. This layer provides the interface between the enterprise ERP system and the cloud service. Another important function of this layer is the dispatcher and organization work in the internal system.

- **The application ERP layer**
  In this layer, the cloud service is packaged to achieve separated managements.
• The application workflow layer
  This layer is designed to analyze the workflow of the enterprise. It is the basis of workflow extraction and service definition.
• The user layer
  This layer provides the ERP cloud service requester for the application portal. The users can connect the ERP system through their personal computers or handhelds.

4. The key technologies of C-ERP

In section 3.2, the C-ERP architecture is proposed and introduced in detail. The architecture is built in the basic of cloud computing and SOA, and the key technologies of C-ERP are involved in as well.

4.1 The cloud resources virtual accessing

Virtualization is one of the most important foundation technologies. Resources virtualization can remove the physical resources from distribution and geographic dependence, realize the effective management and unified identifying.

As a general rule, there are two phases in resources virtualization processing: resources perception and virtual resources accessing to the network [8]. In Figure 3, the classification and main content of virtual accessing is given.

![Figure 3. the classification and main content of virtual accessing](image)

According to the characteristics of C-ERP, the C-ERP resources location belongs to soft resources location. Most of the resources in Cloud that related to ERP are data, modules and commonly-used software. Usually, these cloud resources are located in different places or authorized to different companies. In order to make use of these distributed cloud resources, the adapters, including model adapter and software adapter, which can transform the physical resources to virtual resources, are necessary. With the adapters, the dependence of resources and its infrastructure can be weakened by a large margin and the resources sharing can be realized.

4.2 The construction of cloud service

The construction of cloud service can be named servicesation. The virtual resources in CSC must be packaged according to the function and described by the standard language. After servicesation, the CSC provides service to the public by the standard interfaces, and realizes the service calling and sharing. The principle of resources virtualization and servicesation is shown in Figure 4.
During the cloud service constructing and forming, some key technologies are involved in, including the mapping between physical resources and virtual resources, the resources classifying, describing and modeling, and the CSC’s load balancing.

4.3 The inter-operation technologies

After the services in CSC are prepared, the service catalogue will be set up. In the catalogue, the characteristics and key information of services are listed in detail. CSC takes charge of all the service management and monitors their change of state; meanwhile, CSC is the bridge of customers and service suppliers.

According to the different objects, the inter-operation technologies are usually grouped into two layers:

1) Cloud service support layer

Cloud service support layer is the foundation of the whole CSC. A huge deal of services are stored and managed in this layer, including the service registering, updating and canceling.

2) Cloud service employ layer

Cloud service employ is the whole process that meets the cloud-service-need of customers on the basis of the cloud service support layer. Four key steps are significant as follows:

Step1: cloud service asking

Services asking are put forward by the customers, transmitting to CSC by service managers. In this process, customers must list detail information such as service styles and functions.

Step2: cloud service finding

CSC will get the keywords after analyzing the customers’ application. According to keywords, the available services will be listed by service checking and matching. Finally, the best cloud services that meet customers’ requirements will be chosen after service comparing and evaluating.

Step3: cloud service dispatching

According to the service state and customers’ preference, especially the loading balance of CSC and the Qos, the cloud service dispatching management is necessary. Through the cloud service dispatching, the services in CSC will be used in the best way.
Step4: cloud service returning.

4.4 The C-ERP platform management technologies

The C-ERP platform is the medium of customer using the cloud service. The ERP cloud services are used and managed in this platform. In order to make full use of C-ERP services and ensure the system security, the C-ERP platform must have the features as follows:

a) Dynamic: The C-ERP platform must adjust its function according to customers’ requirements promptly, such as the C-ERP service changing and reconfiguring.

b) Integration: The C-ERP platform must hide the heterogeneity of returning services so that these distributed services can process under a unified frame. Therefore, the standard connector must be built to integrate the distributed services.

c) Stability: Because of the dynamic of cloud service, in reality using process, it’s important to control the service updating just at the right time. Continually update must be avoided, if not, the services may not match the customer’s requirements.

d) Security: All the enterprise data, including the data security and integrity in the system updating and use processing, must be protected.

5. An application instance of C-ERP

In order to verify the feasibility and practicality of the theory and method in this paper, the C-ERP platform based on the ERP system in forging enterprise which is developed by the author’s research group has been built and now is running in test in enterprise.

The steps of construction of C-ERP platform are introduced as follows:

Step1: Disassemble the old version ERP system, including the test and online version, to modules, then build the ontology model and describe as the unified standard.

Step2: Package the module and some other systems such as CRM and forging CAPP as service and storage in the CSC.

Step3: Publish the requirement with the purpose of building the C-ERP system to the CSC. Taking the production plan module for example, the process is shown in Figure 5 and 6.

Figure 5. an example of C-ERP platform
Figure 6. process of the production plan module-production plan indexes system

Step4: Combine the backing services and integrate the whole system after all the search process. And then the whole platform building process is finished.

6. Conclusion

The cloud computing provides new solution to help the ERP system change to the service-oriented style. The work in this paper seeks to establish a systematic, collaborative and agile C-ERP system to the manufacturing enterprises. The architecture of C-ERP system has been built, and an initial system has been developed on it. Meanwhile, the key technologies are discussed in this paper. Finally, the application steps of C-ERP are illustrated by an example. In next phase, the construction and description of cloud ERP resources and the management of C-ERP platform will be studied in depth in order to realize the industrialization of C-ERP platform in the future.

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8. References