IJCSI International Journal of Computer Science Issues, Vol. 10, Issue 1, No 3, January 2013
ISSN (Print): 1694-0784 | ISSN (Online): 1694-0814
www.IJCSI.org

Research and realization of Resource Cloud Encapsulation in Cloud Manufacturing

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Abstract

Resource Cloud Encapsulation (RCE) is one of the key technologies of recourse accessing in Cloud Manufacturing (CM) and the foundation of resource virtualization. Under the analysis of the technologies of resource virtualization in Cloud Manufacturing, a framework of RCE is proposed. With the definition for each layer of the framework, realization of the resource accessing can be achieved. A demonstration with the physical manufacturing resource of stepper motors is enumerated to demonstrate the resource virtual accessing in CM. With the achievement of this article, a prototype of the cloud service platform is developed.

Keywords: *Cloud Manufacturing, resource accessing, Resource Cloud Encapsulation*

1. Introduction

The concept of Cloud Manufacturing (CM) is proposed by LI Bo-Hu who is an academician of Chinese Academy of Engineering. He defines the CM as a new mode of network intelligent manufacturing which is service-oriented, high efficiency and low consumption and knowledge-based, and the development of the concept of Cloud Computing (CC) in manufacturing. CM is becoming the latest network manufacturing mode, with many advantages such as quickly respond to market demand, enhanced competitiveness and collaborative manufacturing[1-3].

Resource Cloud Encapsulation (RCE) which is one of the key technologies of CM based on resource virtualization technology constructs large-scale of virtual manufacturing resource pool, and provides the best service resource meeting the task requirement through service matching. RCE can be used for the interacting and feedback control of manufacturing resources including hardware resources and software resources. It is based on Internet of Things (IoT), computer technology, Computer Virtualization and other technologies. RCE also can reduce the coupling between physical resource and manufacturing application by the transferring from physical resources into logical resources and virtual CM service with high utilization, high agility, high security and high reliability[6].

2. Resource Cloud Encapsulation (RCE)

2.1 A framework of the resource virtualization

A framework of the RCE in CM is proposed as shown in Fig. 1, after analyzing the characteristics of the CM. Resource virtualization and resource service-oriented technology is adopted to specify the forms of manufacturing resource in this framework. Each layer of the framework is relatively independent. Every layer provides services to its upper layer and the upper layer only. Every layer can access to the services of its lower layer through the interface of the lower layer.

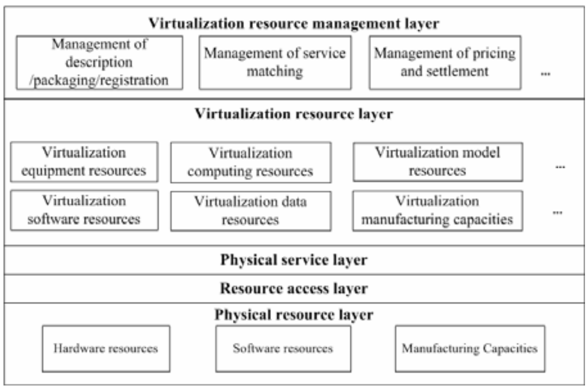

Fig. 1 Framework of the resource virtualization

- Physical resource layer

The bottom layer of RCE framework is a physical resource layer including all kinds of heterogeneous manufacturing resources with various distributions. Each manufacturing resource has its own characteristics

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including heterogeneity, resource autonomy, wide distribution, etc.

Generalized manufacturing resources include hardware resources, software resources and resources with manufacturing capacities, etc. Hardware resources include manufacturing equipments and physical resources, such as all kinds of CNC machine tools, simulation equipments and material resources. Software resources include software, database resources and model resources. Manufacturing capacities include experimental capacities, integration capacities, etc. The CM system ensures the autonomy of scattered manufacturing resources to meet the requirements of costumers by the dynamic integration and the sharing of resources. For this purpose, standard protocol is required for the description and packaging of the manufacturing resources.

- Resource access layer

The main role of the resource access layer is the cloud encapsulation of the physical resources, service packaging, etc. This layer is based on Internet of Things (IoT), embedded technology and other technologies to establish the recognition and connecting between manufacturing resources.

- Physical service layer

The service generated by the description and packaging of the manufacturing resources is called physical service. Physical service is web accessing software components that are physically deployed by mapping the physical manufacturing resources to service. Defined interface which is described in WSDL can be called by the customers to access the physical service. Different management strategies are adopted in different physical service management domain. Physical service can be called by customers, applications and other services.

- Virtualization resource layer

Virtualization resource layer known as virtualization resource cloud pool is defined as resource dispatching and task management. Customers can choose and reorganize virtualization resources to meet their task requirements. Meanwhile, virtualization resource is bound to different physical services to meet the flexible requirements of customers.

- Virtualization resource management layer

The virtualization resource management includes description, packaging, registration management and service matching of virtualization resources, pricing and settlement, etc.

2.2 Resource access of RCE

RCE of software and hardware manufacturing resources and resource sharing are key technologies of the resource virtualization in CM. In the framework of RCE, IoT, Cyber Physical Systems (CPS), embedded technology and other technologies are adopted to achieve the accessing and connecting of manufacturing resources. In RCE, physical manufacturing resources are transferred into logical service to reduce the coupling the physical manufacturing resources and manufacturing applications. Therefore virtualized services with high utilization, high agility, high security and high reliability are published. The manufacturing resource adapter based on WSRF which packaging manufacturing resources into manufacturing services with unified structure and standard calling protocol is presented by Wu Lei in the paper of Research on Resource Virtualization in Manufacturing Grid[7].

To achieve the accessing and controlling of the physical resources in CM system, advanced computer information technologies are adopted in resource accessing. With the development of IoT and CC, reliable technical support is provided for the accessing into the CM system of physical manufacturing resources.

2.3 Demonstration model

For the Manufacturing Resource as a Service (MRaaS) mode, Cloud Service Provider (CSP) provides bottom layer resource to the Cloud Service Customer (CSC). Standard interface is called by CSC for the accessing of resources. In this paper stepper motor of 28BYJ-48 is selected as physical manufacturing resources. In the demonstration system, the control circuit is designed to access the control of physical resources. With a software interface designing of the physical resources, remote accessing by CSC can be done.

To demonstrate resource accessing, stepper motors, S3C2440 development board, and host computers are required in the demonstration. The control signals between host computer and client computer are transferred through Serial Port. This verification system based on embedded system provides Web Service through embedded platform. Control signals from the remote computer client based on UDP protocol is used in the control of stepper motors such as forward rotation, reverse rotation, accelerating and decelerating.

- Resource description

For the MRaaS mode, physical resource is bound to a service which provides the creation and maintenance of the resource through the interface of the physical resource. In this paper, stepper motors are described in XML schemas and its attributes is presented in XML.

```
<?xml version="1.0"?>
< ManufacturingResource>
<ResourceID>00001</ ResourceID >
<Name>28BYJ-48 Stepper Motor </Name>
<Type>Stepper Motor</Type>
<MinTorque>300.00</MinTorque>
<MinFrequency>150.00</MinFrequency>
…
</ ManufacturingResource >
```

- Resource registration

Resource registration is performed on the web page of the CM service resource node to package resource information into XML schemas. The steps of registration are listed as : (1) Administrator of the physical resources input detail information of the resources such as names, attributes and parameters in the web page which will call the application named as “AddProductLine” to submit the information. (2) The submitting process will call the “Add” method of the “MgResourceManager” service which is assigned to manage the CM service resources. (3) “Add” method creates a service resource of “MgResource” with its attributes in XML.

- Service resource matching

After resources are registered in the CM system by the resource provider, the resource will be indexed and recognized by the system. When CSC submits a manufacturing task on the CM system website, the task will be analyzed into manufacturing parameters such as maximum processing size, accuracy and so on by the JavaBeans of the system. Matching calculation is the procedure of searching for the manufacturing resource matching those parameters. After that, the task will be assigned to the task list of the best resource by adding the index number of the task into the task list of the resource.

- Resource packaging

(1) The definition of service interface

The service interface is also called PortType which describes the Web service in Web Services Description Language (WSDL). In the WSDL, “wsrp: ResourceProperties” attribute is used to describe the resource attributes in the PortType element. Resource attributes must be defined in the type attributes of the WSDL, which is listed as follows.

```
<portType name="mgcommandPortType"
wsdlpp:extends="wsrpw:GetResourceProperty"
wsrp:ResourceProperties=
"tns:CommandResourceProperties">
<operation name="command">
<input message="tns:CommandInputMessage"/>
<output message="tns:CommandOutputMessage"/>
</operation>
<operation name="add">
<input message="tns:AddInputMessage"/>
<output message="tns:AddOutputMessage"/>
</operation>
<operation name="getValueRP">
<input message="tns:GetValueRPInputMessage"/>
<output message="tns:GetValueRPOutputMessage"/>
</operation>
</portType>
```

(2) Web service programming in Java

The Web service is designed to create a resource in the system resource node and modify the attributes of the resource such as resource status (working, repairing, scrapped, etc.). The method named as “CreateResource” is called to create a resource through the URI of the Web service with the return of Endpoint Reference (EPR) through which the modification of the resource can be made. With the EPR of the resource, attributes and methods of the resource can be accessed without creating the resource.

(3) WSDD Configuration

The Web Service will be published with the file called publishing description file for the accessing to the CM service. The publishing description file with Web Service Deployment Descriptor (WSDD) format is listed as

ISSN (Print): 1694-0784 | ISSN (Online): 1694-0814
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follows.

```
<?xml version="1.0" encoding="UTF-8" ?>
<deployment name="defaultServerConfig"
xmlns=http://xml.apache.org/axis/wsdd/
xmlns:java="http://xml.apache.org/axis/wsdd/providers/ja
va xmlns:xsd="http://www.w3.org/2001/XMLSChema">
<service name="mgrid/mgcommand" provider=
"Handler" use="literal" style="document">
<parameter name="className" value=
"mgrid.mgcommand.impl.commandService" />
<wsdlFile>share/SChema/mgrid/mgcommand/mgcomm
and_service.wsdl</wsdlFile>
<parameter name="allowedMethods" value="*" />
<parameter name="handlerClass" value=
"org.globus.axis.providers.RPCProvider" />
<parameter name="SCope" value="Application" />
<parameter name="providers" value="GetRPProvider"
/>
<parameter name="loadOnStartup" value="true" />
</service>
</deployment>
```

3. The CM prototype system

The prototype system includes three roles of users: CM resource providers, CM customers, CM service providers.

(1) CM resource providers

The modules designed for this role include the installation of the system, deployment and configuration, resource designing template, resource virtualization, resource packaging and registration, service deploying, servicing strategy designing and modifying, Portal developing, accessing controlling, etc. The CM resource provider can achieve the missions such as resource rent providing, registration, declaring and monitoring as shown in Fig.2 and Fig. 3.

Fig. 2 Interface of rental reservation

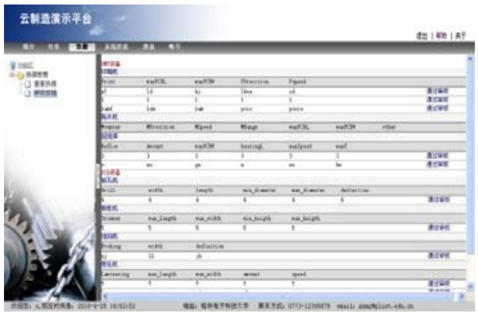

Fig. 3 Confirming interfaces of the resource provider

(2) CM customers

The modules designed for this role include user registration and canceling, Portal, task description, resource search, resource dispatching, task monitoring, service level negotiation (client side), service reserving (client side), notification mechanisms, etc. CM customers can achieve the missions such as task submitting, service level negotiation, task monitoring, resource overview as shown in Fig. 4 and Fig. 5.

Fig. 4 Interface of new task submitting

Fig. 5 Interface of resource listing

(3) CM service providers

The modules designed for this role include renting negotiation, resource registration and canceling, Portal, resource description and description templates, service level negotiation (server side), service reserving (server side) and security management as shown Fig. 6 and Fig. 7.

4. Conclusions and future work

CM is the latest network manufacturing and revolution

Fig. 6 Interface of resource reservation

Fig. 7 Interface of resource template

of manufacturing mode. RCE provides access technology for physical resource into CM system, which is one of the key technologies of CM. After proposing a framework of the RCE, the realization is demonstrated. With our achievements, the prototype system of CM has been constructed. In the future, the virtualization standard of manufacturing resources will be studied.

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