2013 International Conference on Mechatronic Sciences, Electric Engineering and Computer (MEC)
Dec 20-22, 2013, Shenyang, China

A Strategy of Building Cloud Manufacturing Service Platform Based on CloudAnalyst*

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***Abstract*—Cloud Manufacturing Services Platform is the product of Cloud Manufacturing model, it aims to promote the development of Cloud Manufacturing model. In the process of building cloud manufacturing service platform, how simple and convenient to find the best allocation of resources scheme and minimal hardware construction costs is a challenging problem to be solved. In order to simplify this process, we propose a method of constructing Cloud Manufacturing Service Platform by using CloudAnalyst in this paper. This method not only describes how to get the best allocation of resources program using CloudAnalyst, but also joined the Cost Function which used to determine the best hardware building program of Cloud Manufacturing Service Platform. Finally, we explained this strategy in detail through a case.**

***Keywords*—Cloud Manufacturing; Cloud Manufacturing Service Platform; CloudAnalyst; Cost Function**

I. INTRODUCTION

Cloud manufacturing is a networked intelligent manufacturing new model, which is intelligent, networked, service-oriented, efficient, low-cost and knowledge-based. It extends to the existing network of manufacturing and service technologies, making a variety of manufacturing resources and manufacturing capabilities be virtualized and service-oriented. It accomplishes a intelligent, multi-win-win situation, universal and efficient sharing and collaboration by using a unified, centralized and intelligent management and operation. And it provides readily accessible, on-demand use, safe and reliable, high-quality and low-cost services for the entire life cycle of manufacturing process through the network at the same time[1]. The Cloud manufacturing system consists mainly of three kinds of users who are manufacturing resource providers, manufacturing cloud operators and manufacturing resource users [2].

With the continuous development of the cloud manufacturing model, the construction of Cloud Manufacturing Service Platform which aimed at the manufacturing cloud operators and supported cloud manufacturing model is becoming increasingly important. Therefore, this paper proposes a common approach of constructing Cloud Manufacturing Service Platform based on the CloudAnalyst. The strategy includes analyzing respectively the cloud resource agent service policy, the virtual machine load balancing policy and the cost of platform hardware construction. In addition, we exampled a case of Cloud Manufacturing Service Platform for SME to demonstrate this building strategy in detail.

II. THE OVERALL BUILDING STRATEGY OF CLOUD MANUFACTURING SERVICE PLATFORM

A. Cloud Manufacturing Service Platform

Cloud Manufacturing Service Platform is a product of cloud manufacturing model, it connects huge social manufacture resource pools together to provide a variety of manufacturing services to achieve open collaboration of manufacturing resources and services, high degree of social resources sharing. Recently, cloud manufacturing service platform has the following five main orientations : service platform of researching and designing for large conglomerates, sharing service platform of regional processing resource, supporting platform of service-oriented manufacturing, public service platform for SMEs and logistics-led modern manufacturing service platform. Cloud Manufacturing Service Platform is actually a cloud computing service platform for manufacturing. The virtualization of manufacturing resources and the support of online software (Cloud Manufacturing Service Platform mainly provides services on the SaaS level) are its main features that are different from ordinary cloud computing platform [3].

B. CloudAnalyst

CloudAnalyst is a graphical cloud simulation software on the basis of CloudSim [4]. CloudAnalyst can simulate the cloud computing system model, the three levels of cloud computing, and also support systemic and behavioral modeling of cloud computing components, such as data centers, virtual machines and resource allocation policies. Compared with CloudSim, CloudAnalyst has many advantages: a better graphical user interface, many parameter settings, standardized output and easy expansion. Meanwhile, CloudAnalyst has a powerful virtualization engine on the basis of CloudSim toolkit [5]. It has many good features: supporting many distributed environments and simulate performance evaluation for networks of dedicated link; modeling and simulation of heterogeneous grid resources is available; allowing multiple users to use their own scheduling policy to schedule

Project supported by the Guizhou Provincial Department of Education (Grant No. 2010006)

applications [6]. CloudAnalyst can not only simulate the agent service strategy and load balancing, but can also evaluate the cost of renting service spent by cloud services platform builders.

So, CloudAnalyst can help researchers evaluate the performance of cloud-based applications in the cloud simulating environment [7]. Researchers use the request processing and response time of data center as the parameters of performance evaluation, by which they can find the best simulation configuration service agent policy and provide the simulation results of load balancing strategy in high-quality services by controllable and repeatable experiments. Thus enables researchers to deploy their applications on a real cloud platform with minimal cost and high server utilization.

C. Platform hardware construction costs

Hardware devices are the foundation of Cloud Manufacturing Service Platform. The platform operators need to select hardware facilities construction program based the business strategy. Hardware facilities construction programs are mainly two: the first one is self-purchase hardware facilities, called self-built model; the other one is to facilities lease from a device service provider, called hiring mode.

In self-built model, we can use the Gartner Group's TOC (Total Cost of Ownership) to evaluate the visible and cloud manufacturing service platform operators. And the cost includes the overall costs of platform hardware facilities life cycle from purchase to final disposition [9], such as the equipment operating costs. In hiring model, the operators of Cloud Service Platform use cloud resources ISP service by paying the rental fee. Meanwhile, the quality of service and breach of contract are defined by cloud resource providers and users with service-level agreements (Service Level Agreement, SLA). In the SLA agreement quality control, the Cloud Manufacturing Service Platform service quality would be guaranteed.

In self-built model, C_B represents the overall cost of self-built model, C_S represents the investment of the underlying hardware, δ represents the breakage ratio of hardware N years later, C_Γ represents the service system construction cost, W represents the costs of equipment maintenance and management labor, Y represents the cost of managing and maintaining hardware. Since equipment maintenance costs increased year by year, so the α_K represents the device in the first years of hardware devices tube k-dimensional factor [8][9]. Thus, the self-built mode Cost Function is as follow:

$$C_B = C_S\delta + C_\Gamma + \sum_{K=1}^{N}(W + \alpha_K Y)$$

In Hiring model, C_A represents the overall cost of hiring model, C_I represents the construction cost of service system which is based on SaaS, R_V, R_T are respectively rental charges of the virtual machine and data traffic charges for SaaS services, k is the service usage time. As the annual rental rate is constant, so the hiring model Cost Function is as follow:

$$C_A = C_I + \sum_{K=1}^{N}(R_V + R_T)$$

Put the cost difference between the two models with C_C, we can get the difference function which is as follow in N years useful life by the two models Cost Function:

$$C_C = C_A - C_B$$

So, with the same quality of service as the basis, we can get the best solution to build platform by comparing the cost of the two models.

D. Construction of cloud manufacturing service platform

To construct a cloud manufacturing Service Platform, we need first of all to analyze the user group, including the geographical distribution of users, the number of users of each user group and the peak user online time. Secondly, using cloud simulation software to analyze after defining the user's basic information. We can repeat simulating experiments using different configuration parameters in CloudAnalyst to get the experimental data under the premise of meeting the user requirements for the quality of service. Thirdly, according to the results of experimental data and the quality of service, we would get a configuration and hardware building programs with most efficient and lowest cost by using of cost function to process cost analysis. Finally, we can repeat the above steps once again to get the improved program, upgrade and improve the platform to enhance the user experience with the development and adjustment of the platform business.

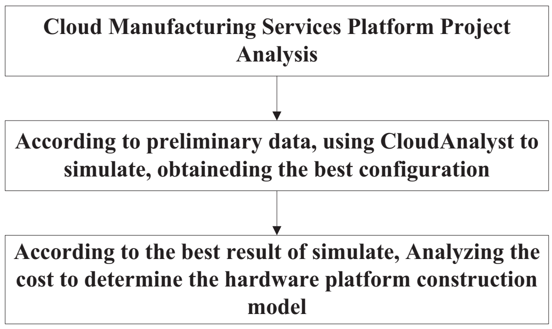

Fig. 1. Cloud manufacturing service platform construction process

The whole process of the building strategy shown in Figure 1, in the next section, we will use an example to illustrate the entire process of building strategy in detail.

III. CASE STUDIES OF SME CLOUD MANUFACTURING PUBLIC SERVICE PLATFORM

According to the website information at Taiwan Research Institute, the SMEs is accounted for 98 % or more in the global enterprise. Asia, North America , South America, Europe , Oceania and Africa has 27 million , 25 million , 10 million , 30 million , 1.5 million , 1.2 million small and medium enterprises respectively. Besides, the manufacturing SMEs accounts for about 10% of all small and medium enterprises [10]. Thus, we take the case of the manufacture public cloud service platform for SMEs to do research. It not only can elaborate the building strategy of the service platform for cloud manufacturing we propose, it also has practical significance.

A. Experimental parameters

Based on the above information, we set for the number of users each user group was approximately 10% of all users during peak hours, the number of users accounting for non-peak hours to 10% of peak time users. The detailed settings is showed in Table 1. And we assume the Americas, Europe, Oceania user requests once every five minutes; Asia users request once every three minutes;

TABLE I. USER BASES USED IN THE EXPERIMENT

User base	Region	Time Zone	Peak Hours (Local time)	Peak Hours (GMT)	Online Users During Peak Hrs	Online Users During Off-peak Hrs
UB1	N.America	GMT-6.00	9:00am~5:00pm	3:00~11:00	250000	25000
UB2	S.America	GMT-4.00	9:00am~5:00pm	5:00~13:00	100000	10000
UB3	Europe	GMT+1.00	9:00am~5:00pm	10:00~18:00	300000	30000
UB4	Asia	GMT+6.00	9:00am~5:00pm	15:00~23:00	270000	27000
UB5	Africa	GMT+2.00	9:00am~5:00pm	11:00~19:00	15000	1500
UB6	Oceania	GMT+7.00	9:00am~5:00pm	16:00~24:00	12000	1200

TABLE II. SIMULATION SETTINGS AND EXPERIMENT RESULTS

	Configuration	Load balancing policy across VM	Overall average response time (ms)	Average Data Center processing time (ms)	VM Cost ($/day)	Data Transfer Cost ($/day)	Total Cost ($/day)
1	1 data center with 40 VMs（N.America）	Round Robin	423.78	77.99	96.04	1854.14	1950.18
2	2 data centers with 20 VMs each(N.America,Europe)	Round Robin	388.61	233.73	96.04	1854.14	1950.18
3	2 data centers with 40 VMs each(N.America,Europe)	Round Robin	257.57	101.19	192.08	1854.14	2046.22
4	2 data centers with 40 VMs each (N.America,Europe)	Equally spread current execution load	257.68	101.27	192.08	1854.14	2046.22
5	2 data centers with 40 VMs each (N.America,Europe)	Throttled	207.29	51.63	192.08	1854.14	2046.22
6	3 data centers with 40 VMs each (N.America,Europe,Asia)	Throttled	136.15	57.87	288.12	1854.14	2142.26
7	3 data centers with 60,40,20VMs(N.America ,Europe,Asia)	Throttled	148.54	69.47	288.12	1854.14	2142.26

TABLE III. SIMULATION SETTINGS AND EXPERIMENT RESULTS

	Configuration	Load balancing policy across VM	Overall average response time (ms)	Average Data Center processing time (ms)	VM Cost ($/day)	Data Transfer Cost ($/day)	Total Cost ($/day)
1	1 data center with 120 VMs (N.America)	Throttled	363.79	10.75	288.12	1854.14	2142.26
2	2 data centers with 60 VMs each (N.America,Europe)	Throttled	187.95	30.20	288.12	1854.14	2142.26
3	3 data centers with 40 VMs each (N.America,Europe,Asia)	Throttled	136.15	57.87	288.12	1854.14	2142.26

TABLE IV. SIMULATION SETTINGS AND EXPERIMENT RESULTS

	Configuration	Overall average response time（ms）	Average Data Center processing time（ms）	VM Cost ($/day)	Data Transfer Cost ($/day)	Total Cost ($/day)	User scale
1	3 data centers with 40 VMs each with peak load sharing and queuing(N.America,Europe,Asia)	136.15	57.87	288.12	1854.14	2142.26	3377000
2	3 data centers with 4 VMs each with peak load sharing and queuing(N.America,Europe,Asia)	130.30	59.24	288.12	189.13	217.94	337700

Africa once the user requests every 10 minutes. The user requests data size is 150b each time [4]. Cloud resource services agency policy is the closed data center policies.

Data center contains 150 identically configured servers, each with the x86 architecture, Linux operating system, 2G memory, 100G storage space, four processors. And the processor speed is 10000MIPS; Bandwidth is 1000Mbps; Virtual machine resource scheduling policy is the time-sharing. Applications in the experiments virtual local storage size is 100MB, the virtual machine has 1GB of RAM and 10MB of available bandwidth. Users are grouped by a factor of 1000, and requests are grouped by a factor of 100. Each user request requires 250 instructions to be executed. In terms of the cost of hosting applications in a Cloud,we assume a pricing plan which closely follows the actual pricing plan of Amazon EC2. The assumed plan is:Cost per VM per hour (1024Mb, 100MIPS): $ 0.10; Cost per 1Gb of data transfer (from/to Internet): $0.10[7].

B. Experimental results

Table 2 details seven different allocation strategy simulation results [4]. Figure 2 shows the variety of configurations of these seven different overall average response time and overall data processing time.

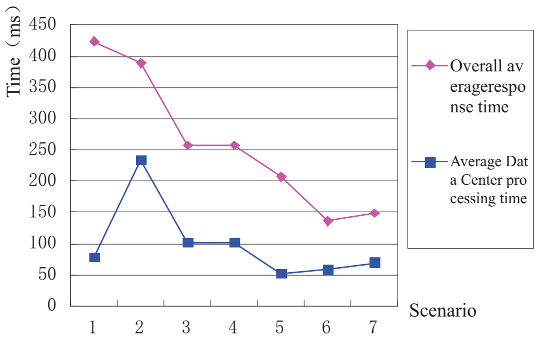

Fig. 2. Performance comparison with recent data center services agency policy

Table 3 shows the differences among different overall average response time and overall average data processing time under the condition of different total number of virtual machines and data centers, and figure 3 reflects this trend. Table 4 shows the differences in the costs caused by different subscriber size under the conditions of quality of services, where the subscriber size of the second simulation program is 10% of the first.

C. Analysis of experimental results

First, comparing the different configurations in Table 2 based on the above results. The comparison of the overall average response time of the first six configurations suggests that the closer the data center to the subscribers the more can improve the overall quality of service of the cloud platform, namely the average response time can be smaller. The configurations3, 4, 5 indicating that by using virtual machine load balancing strategy in the data center can further improve the quality of services of cloud platform. The improvement depends on the load balancing algorithms in a large degree, such as that Throttled load balancing algorithm is superior to Round Robin load balancing algorithm apparently. Therefore, a good load balancing strategy for large-scale distributed applications is very important.

Second, the comparison of the three different configurations in table 3 indicates the relationship between the data center and the subscribers the overall average response time. While the number of virtual machines of each data center has an influence on the overall average data processing time.

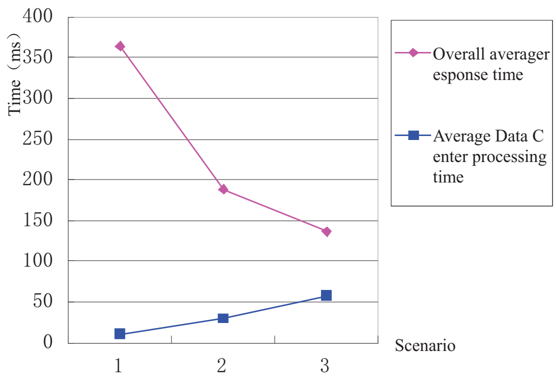

Fig. 3. Performance comparison with an equal number of virtual machine

According to the above observations, we can find that the 6th configuration with the closed data center services agency policy is the best configuration for this case.

The experimental results in Table 4 show that the user scale is the major factors of hardware cost. As the cost increases with the increase of user scale in the same quality of service. According to the following two equations:

$$C_C = C_A - C_B$$

When the construction system cost of self-built model and Hiring model are the same, that C_I and C_Γ are the same, we can be obtained:

$$C_C = \sum_{K=1}^{N}(R_V + R_T) - C_S\delta - \sum_{K=1}^{N}(W + \alpha_K Y) \qquad (1)$$

Therefore, cloud manufacturing service platform operator elects which model to build the hardware platform depending on the user scale. As shown in Table 4, when the user scale is 3.377 million, the annual rental fee of virtual machines and data traffic charges is $ 781,924.9, while the scale of 337,700 users, the cost is only $ 79,584.1. In the self-built model, such as hardware acquisition costs, system maintenance and management costs are clearly determined according to the number of users. Therefore, we can determine which model to choose to minimize the hardware costs in determining the user scale with the formula (1).

IV. CONCLUSIONS

As the product of manufacturing model, the cloud manufacturing service platform should grow up rapidly. This paper presented a strategy for building cloud manufacturing service platform on the basis of the cloud simulation software CloudAnalyst. And, we also descripted the process of the building strategy and demonstrates how to use CloudAnalyst to simulate a real-world practical problems through the study of the cloud manufacturing public service platform for the SMEs. The most important is we explained how to use CloudAnalyst to find the best configuration of building Cloud Manufacturing Service platform manufacturing and minimal hardware construction costs effectively. So, we provided an effective method for researchers who will build a cloud manufacturing service platform.

Since this paper mainly introduced a cloud manufacturing Service Platform building strategy, so in some instances we only analyzed the situation of the nearest data center services agency policy. In practical applications, researchers would find the best building strategy by comparing the actual situation of different cloud resource services agency policy, such as the minimum response time service agency policy and so on.

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