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A Vision of Cloud Manufacturing Service Paradigm for Group Manufacturing Companies: A Tendency of Manufacturing Resources Sharing

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Keywords: Cloud manufacturing; Cloud computing; Service oriented architecture; Manufacturing enterprise group; Networked manufacturing

Abstract. Manufacturing enterprise group possesses the greatest wealth of resources and knowledge for sustainable product and business development. These resources and knowledge have gradually become the key factor of core competitiveness and product innovation for manufacturing enterprise group. However, the resources in enterprise group are usually distributed in different subsidiary companies, which means they can't be centralized used and can't be made the most use of, constraining the competition and development of enterprise. It brings outstanding contradiction problems between the demand and resources sharing. By the comparison of different resource sharing and coordination schemas of current advanced manufacturing paradigms, and the analyzing of the resource requirements and tendency of the sharing and centralized control of resources in manufacturing enterprise group from the develop point of view, a new cloud manufacturing service schema vision for manufacturing enterprise group is proposed based on the Cloud Manufacturing idea to strengthen manufacturing enterprise group's management and control power, enhance service capabilities of its resources. As same as the cloud manufacturing idea, the schema promises elasticity, flexibility and adaptability through the on-demand provisioning of manufacturing resources as a utility.

Introduction

With the form of global manufacturing network, the focus of information-based application in manufacturing enterprise group is switching from the innovation in manufacturing to innovation in manufacturing services. The rapid development of network, IOT (internet of things), cloud computing and knowledge service provides a powerful tool for agility manufacturing and service innovation. "Manufacturing as a Service" is no longer only a concept. New demands have been put forward to manufacturing information software and services industry, which means the manufacturing resources, should be made an inventory of and the resource-sharing service should be provided.

In the case that various stocks of resources cannot be fully shared in the manufacturing enterprise group, when there is a surge in the number of projects, the resources will become relatively limited, the competition for resources will frequently emerge, resulting in lower product quality, longer development cycle and higher development cost. To solve the sharing problem, particular mechanisms and tools are needed to establish high degree of centralized and unified management of all the valuable resources within the group. However, traditional centralized management platform cannot provide such a large storage capacity. How to gather, share and integrate the stock resources within enterprise group is the starting point of Cloud Manufacturing [1] concept, based on which, the cloud manufacturing services platform regards all resources within the cloud for enterprise group as one virtual resource to realize manufacturing capacity expansion and meets the requirement of large-scale manufacturing by providing software services. In conclusion, the cloud manufacturing services platform meets the requirement of establishing resource-sharing services mechanisms.

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State of the art and research tendency

The governments and scientists pay lots of attention to the better sharing of the resources and better coordination among companies. However, In spite of any proposed manufacturing modes built on top of different structures and technical characters, the key point of all these modes at resources-sharing aspect is to make resources visible, available, reorganizable and applicable. Therefore, this paper will describe the state of the relevant technologies and the research tendency from the following aspects: resource-sharing, resource access and resource organization.

(1) Resource-sharing methods

Resource sharing methds can be classified into three categories: task-driven resources sharing [2], resource sharing by establishing specific resources sharing center [3] and aggregation of discrete resources [4].

As for the task-driven method which provides an application service for each resource, it has a 1:1 relationship between the resources and the applications. In this mode, the resource sharing and application are tight coupling and privatization because of the big grain degree, low utilization rate and the particular realization of information integration and process integration. Tthe poor scalability determines that this mode is not suitable for dynamic large-scale integration of the resources and application requirements.

As for the center services application mode which has a 1:n relationship between the resources and applications. It focuses on developing a specific and independent manufacturing service, rather than provide integrated and complicated manufacturing services with the integrated distributed resources and services. Though in this mode a certain resource can provide multiple applications by servicisation, the application scenarios and range are limited because of the customization service mechanism for specific application scenarios.

As for the concentrate resources application pattern, it has a n:1 relationship between the resources and applications, which means a user or a service is supported by multiple distributed resources. The present study mainly focuses on enterprise cooperation supported by network technology, establishing virtual enterprise to give rapid responses to market demands. Without consideration of resource services for multiple users or tasks, the coarse grained resource encapsulation can't meet the need of multidimensional dynamic resource combination.

(2) Resource-access technology

Resource access technologies, which connect resources to resource sharing platform, making resources visible and available, can be divided into two types: the tightly coupled[6] and loosely coupled[7]. The tight coupling cannot dynamically adapt to the independent adjustment of resources, resource integration extensible ability difference, cannot satisfy a large range, large-scale integration of resources demand. Loosely coupled access technology can guarantee the resources system based on autonomy to provide open, extensible resource integration capability. However, all of the current manufacturing mode are mainly aimed at software system resource access research, lacking of effective technical means to make the manufacturing resources, especially machine tools and other manufacturing hardware, be visible and available.

(3) Resource organization and application

Resource organization and application refers to how to organize shared resources to provide services, on the basis of resource access. According to different application goals, resources organization and application technology includes workflow management based organization[8], service portfolio based organization[9] and direct service organization[3].

The realization of resource organizing and applying based on the traditional workflow management technology cannot fully meet the dynamic business cooperation demand since it does not distinguish the relationship of business process logic and resource management logic in the control. Dynamic inter-organizational, interdisciplinary process adjustment is difficult.

Application method based on service composition, to provide seamless access across the enterprise application system, which can be simplified and effective solution to network manufacturing enterprise resource sharing and service interoperability issues, separating business

logic and resource management logic, has become a structural cross organization resource sharing and integration of the core and the mainstream application solution based on. The current portfolio of services to achieve the existence of two directions of the research train of thought, workflow based service composition implementation scheme and artificial intelligence based service composition implementation scheme. The first scheme is confined to the workflow development train of thought, second schemes are needed in the field of artificial intelligence technology breakthroughs, and such as semantic Web services based combination technology. Therefore, how to combine various research ideas, more intelligent, fast through the service composition process to realize the resources for quick assembly and application still needs further research.

Cloud Manufacturing paradigm for manufacturing enterprise group

The emergence of the cloud computing paradigm takes one step further to satisfy dynamic resource sharing and on-demand resource provisioning by leveraging virtualization technologies at multiple levels (namely hardware, platform and application)[1].

Cloud manufacturing is a new concept based on the idea and technology of cloud computing. The core is manufacturing resource virtualization and manufacturing capability servicisation, which means using technologies of cloud computing, internet of things and information processing to integrating all kinds of scattered manufacturing resources such as software, data, computing, knowledge, machining and detecting into a logical resource unity named Cloud Manufacturing Service Center (CMSC). And it can supply a variety of services for users through the dynamic resource organizations and applications. All users connected to the CMSC can request various activities in the whole life cycle such as product design, manufacturing, testing and management et al. CMSC will provide high-performance matching, searching, recommendation and services execution. At the same time, all kinds of manufacturing resources will be supplied to users by services to realize on-demand polymerization manufacturing.

From the view of the overall technical level, cloud manufacturing has advantages in:

On the resource-sharing and application mode aspect

Making full use of virtualization technology at different levels and a relationship of n:1:m between resources and services is established. That means on the base of gathering n discrete resources, a unified resource pool is determined. And through polybasic and multidimensional virtualization of manufacturing capacity of manufacturing resources, the cloud manufacturing services are offered. It also provides multi-level, three-dimensional services mode for manufacturing enterprises which is based on cloud service mechanism (cloud service, public cloud, private cloud etc). The application mode of n:1:m can be better meet the requirements of large scale, dynamic and extensible.

- On the aspect of resource joint technology

Cloud manufacturing is to realize the joint and perception of physical resources by the fusion of internet of Things, and gathering, fusion, evolution of data by fusion semantic computing technology. Cloud manufacturing also abstracts the resources at the level of manufacturing capacity through virtualization standardly, flexibly and in different granularity. Because of these it is possible of accessing all types of manufacturing resource, abstracting flexibly and ubiquitous perception.

- On the aspect of resource organization and application

Cloud manufacturing, which is full integration of service computing technology and the semantic computing technology, uses semantic service-oriented architecture, dynamic semantics-based service orchestration and composition mechanism and the intelligent, loosely coupled way of resources organization and application to achieve dynamic on-demand and three-dimensional integration, coordination and integrated application of resources.

Conclusions

In contrast to the conventional networked manufacturing approach, cloud manufacturing service schema vision for manufacturing enterprise group introduced in this paper strengthens manufacturing enterprise group's management and control power, enhance service capabilities of its resources, and

promises elasticity, flexibility and adaptability through the on-demand provisioning of manufacturing resources as a utility.

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