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# Research Article
# Research on Information Management in Cloud Manufacturing

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## Abstract

**Background:** Information management play very important role in cloud manufacturing, it provides the basic service for the coordination of distributed manufacturing resources and is the central position in the entire cloud manufacturing. **Materials and Methods:** The information in the cloud manufacturing has the characteristics of variety, quantity and change frequently, the traditional information management system is difficult to meet the needs of cloud manufacturing environment information management. This study proposes an effective method to solve this contradiction, that is, use XML format to express resource information to eliminate ambiguity caused by different understanding. **Results:** Our solutions use cloud manufacturing resources in a transparent way and provide information storage, collection, query and update management. **Conclusion:** The practical results show that the method has good usability and efficiency.

Key words: Cloud manufacturing, information management, lightweight directory access protocol, XML

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## INTRODUCTION

Cloud manufacturing is an integrated supporting environment for enterprises and social resource sharing and integration, supporting the operation and management of enterprise groups. Based on cloud environment, advanced computer and information technology and the network, it packages and integrates the design, manufacturing, management, information, technology, intelligence and software resources scattered in different enterprises and social groups, shields the heterogeneous and geographic distribution resources, to provide all kinds of manufacturing services, so that the enterprise or the individual can get all the resources in the cloud manufacturing as well as the use of local resources to achieve the integration and optimization of all kinds of resources and to build a collaborative manufacturing environment oriented specific needs of the application[1-3].

Cloud manufacturing integrate the distributed resources for manufacturing companies, the number of subjects and objects are very large, distribute around the globe. It needs the support of information management of cloud manufacturing to link the subjects and objects. Therefore, the information management is central module of the cloud manufacturing system, any activity of manufacturing enterprises is conducted on the basis of information management. Cloud manufacturing information is the data which is about the subject, object and cloud manufacturing systems. The name of cloud manufacturing resources, the owner of manufacturing resources, load of resources are all cloud manufacturing information and information management objects[4-7]. Typical cloud manufacturing information examples are as follows: The number of nodes in a cloud manufacturing equipment, communication band width between the manufacturing nodes, an operation state of enterprise manufacturing, the name and version number of operating system running on the manufacturing node, the prediction for the number of jobs entering into queue within the next 5 min, current situation of online manufacturing users and so on[8-10].

Information management position in cloud manufacturing is very important, it provides the basis for the entire system operation is to ensure a coordinated distributed manufacturing resource base, at the center of the entire cloud manufacturing. Cloud manufacturing information management system is the cloud together into a whole organic basis, the need for specialized information management system for managing to achieve a cloud made of organic unity. Information management systems to support cloud manufacturing transparent use of resources, storage of information collection, query and update management. Manufacturing grid has a wide range of information, such as frequent changes in large quantities and characteristics of the traditional information management systems cannot meet the needs of cloud manufacturing information management environment, therefore, must be studied cloud manufacturing information management services[10-12].

The literatures[13-15] gives the definition of cloud manufacturing and the ideas of cloud manufacturing. It points out that the technology of cloud computing is based on the existing network manufacturing and service technology, which is based on integration of cloud computing, digital technology, high performance computing, networking and other technologies. It will provide a unified, centralized and intelligent management and management for manufacturing full life cycle (design, processing, simulation, testing, maintenance, sales, procurement and management). According to the idea of cloud manufacturing, the future users can like access to water, electricity, gas and internet information conveniently from the network to obtain all the required manufacturing services[16-19], so the cloud manufacturing has the following main features:

- **Heterogeneity and dispersion:** Cloud manufacturing has a wide variety of manufacturing resources, which runs through the entire manufacturing cycle and is distributed in different physical locations of enterprises and organizations. Different companies and organizations have different management standards and specifications for manufacturing resources, so the cloud manufacturing technology supports the aggregation of heterogeneous manufacturing resources[20]
- **Dynamic:** In the cloud manufacturing system, the manufacturing resources are not fixed, but with the state of the resources and the dynamic changes of the time. According to cloud user needs, cloud platform can at any time, dynamic, agile manufacturing resources. The dynamic of cloud manufacturing indicates that the demand of manufacturing resources and manufacturing resource provider is a kind of relation, i.e., the relationship between the manufacturing resource and the manufacturing resource provider[21]
- **Real time:** In order to provide real-time response to user needs, quickly and flexibly, cloud manufacturing services must reflect actual processing equipment and other resources in real time. Therefore, the service provided by cloud manufacturing has higher real-time performance[22]

- **Initiative:** In the actual manufacturing, if the enterprise lack of a processing equipment or their own processing equipment and other resources idle, it is unable to complete the order or get processing, which is a passive manufacturing. In cloud manufacturing mode, the user through the platform release needs, in the knowledge, semantics, matching reasoning and other technology support, cloud platform to actively seek the resources provided by the supplier, to achieve active intelligent rent-seeking. Therefore, in the cloud manufacturing, manufacturing activity has the initiative[23]
- **Service:** Manufacturing cloud manufacturing cloud services in the manufacturing of the entire life cycle, including the demonstration that service, design, production and processing services, namely, service, simulation, namely, service, business management, service, integration, service, etc., which is conducive to the production of modern business to service oriented[24]
- **Interactive:** The manufacturing services provided by the cloud manufacturing are interactive, that is, the interaction between the manufacturing resources and manufacturing capabilities and the interaction between users and services, including human-computer interaction, human-computer interaction, computer machine interaction and human interaction[25], etc
- **Synergy:** In many cases, a single manufacturing service cannot meet the needs of users, cloud manufacturing technology to support collaborative manufacturing oriented multi user collaborative and large-scale complex manufacturing tasks[26]
- **Open:** In cloud manufacturing mode, the platform for different industries, different companies, different users, different products, open, with a high degree of openness. By providing a manufacturing resource or manufacturing capabilities into the platform, compared with the existing manufacturing mode, the product variety, reducing the user's entry criteria. Highly open platform has more abundant resources, which provides a basis for fast and flexible response to user needs and dynamic establishment of different granularity[27]
- **Fault tolerance:** Manufacturing resource virtualization of the corresponding physical manufacturing resources is difficult to avoid all kinds of fault or run when errors occur, the cloud manufacturing efficient fault tolerance mechanism to in without the knowledge of the user, rapid replacement will occur or has failed the resources, improve the reliability of the cloud manufacturing[28]

## MATERIALS AND METHODS

**Representation for cloud manufacturing information:** The information of cloud manufacturing is used by users and applications distributed anywhere in cloud environment, it requires information management system to provide a unified representation, so that visitors can get the information they need from any location or device and properly understand the information meaning indicated. Information management systems provide the external representation of information not related to a specific platform. Here's platform-independent has two meanings: One is that the representation of information, the platform of information management and the provided environment have nothing to do; the other is the representation of information can be used by any platform to understand, visitors can use any programming language developed by the client application to access information.

In the cloud manufacturing, it is a development trend to express information in XML format. Information in XML format can be eliminated ambiguities brought by different understanding. At the same time with the change of technology development and capabilities of cloud manufacturing systems, you may need to customize the new information model. Customized information models need to follow certain rules, namely the emerging patterns of information must be considered compatible with the old information patterns can be relatively easily to the new mode mapping information to the existing old model, so that achieve interoperability between the old and new models. For example, Digital Manufacturing Laboratory of Ningbo Dahongying University requires cloud services, input data are: Service requester: Digital Manufacturing Laboratory of Ningbo Dahongying University; the service time: April 10, 2005; request for service: NC; bank account: DML. Information submitted by XM L represented as follows:

```
<parameters>
<name> DHY </name>
<time>
<year> 2005 </year>
<month> 04 </month>
<day> 10 </day>
</time>
<place> NB </place>
<authen>
<service>
<nodes> 202.114.83.1 </nodes>
<operation> Digital manufacturing </operation>
<name> bank service </name>
</service>
<flops> DML </flops>
</authen>
</parameters>
```

## Structure and function of cloud manufacturing information management

**Structure of information management:** In cloud manufacturing, the requester and provider of information distributed on different nodes in cloud environment, the relationship between requesters and providers are usually many-to-many model. Information management system use the service method to provide information for information requestor and provider. Information can be provided to the cloud user, applications and other modules using cloud environments. From the information collection to providing, the process involves several roles, these different roles joint effect to ensure the transmission smooth from the producer to the consumer. Typically, there are three types of roles in cloud manufacturing including information producers, information consumers and information intermediary. Information producers, in accordance with the specific strategy, report to the information intermediary by collecting information or information about their own information. Information consumers provide the information request service to the intermediary and the intermediary accordingly provide the consumers with the required information.

According to different information flow, there are three types of information management structure as shown in Fig. 1.

In linear models, consumers get the information they needed directly from the agency there. Producers of the information collect information and save in the agency, intermediaries need to save all the information producers information, information thus the scale of services will be limited, intermediaries can easily become a bottleneck of information service quality. This mode is more suitable for those who get static information or information does not change frequently.

In line model, consumers get the appropriate location information from the agency and obtain information directly from the producers. The intermediary only save location information and interface information, the specific content of the information is stored in the producers. This model is applicable in particular to obtain dynamic information update frequency higher than the access frequency.

As for triangle model, the consumer submits information to the intermediary, the intermediary put the request to the appropriate producer according to the requested content and consumer information, the producer send the information requested by the consumer directly to consumers. This model can meet the vast majority of cloud manufacturing information service. Therefore, in the cloud manufacturing, triangle model of information management structure usually is used.

**Functions of information management:** Information management system provide and manage basic operations to obtain information. Cloud manufacturing information services need to provide basic functions include registration information, update information and other information cancellation and information distribution.

**Information registration:** In a cloud environment, only after registration information can be used by the requester. Information registration is the first step in the use of information, it is conducted by applications, services or equipment under a cloud manufacturing management system. The registration information must be true and usually implemented by API of information management system. Registration to the information management system is based on the future behavior of a lot of work, it must be objective and true information content to avoid malicious users and virus programs registering false information in registration centers to damage the interests of other users.

**Information update:** Not only dynamic information according to certain rules require periodic updates, static information after registration as a result of the changes may also need to remove or modify, so that updated information is a basic operating information services. Authenticated by the user registration information has an information owner, that is the original registrant information. Only the original registrant himself or through authorized users can modify and delete the registration information. Other users, even cloud environmental managers cannot modify and delete the registration information in certain circumstances.

**Information query:** Information management information query is the most basic functions, any activities of cloud manufacturing environment must rely on the query results, such as resource discovery, it need to determine the appropriate resource target information based on the results of the query to use the information obtained to determine the next step how to operate. In most cases only a single query to obtain information, but a user might through browser way to browse all of the information or a certain type of information. Therefore, it need to provide information query interface to meet the different requirements.

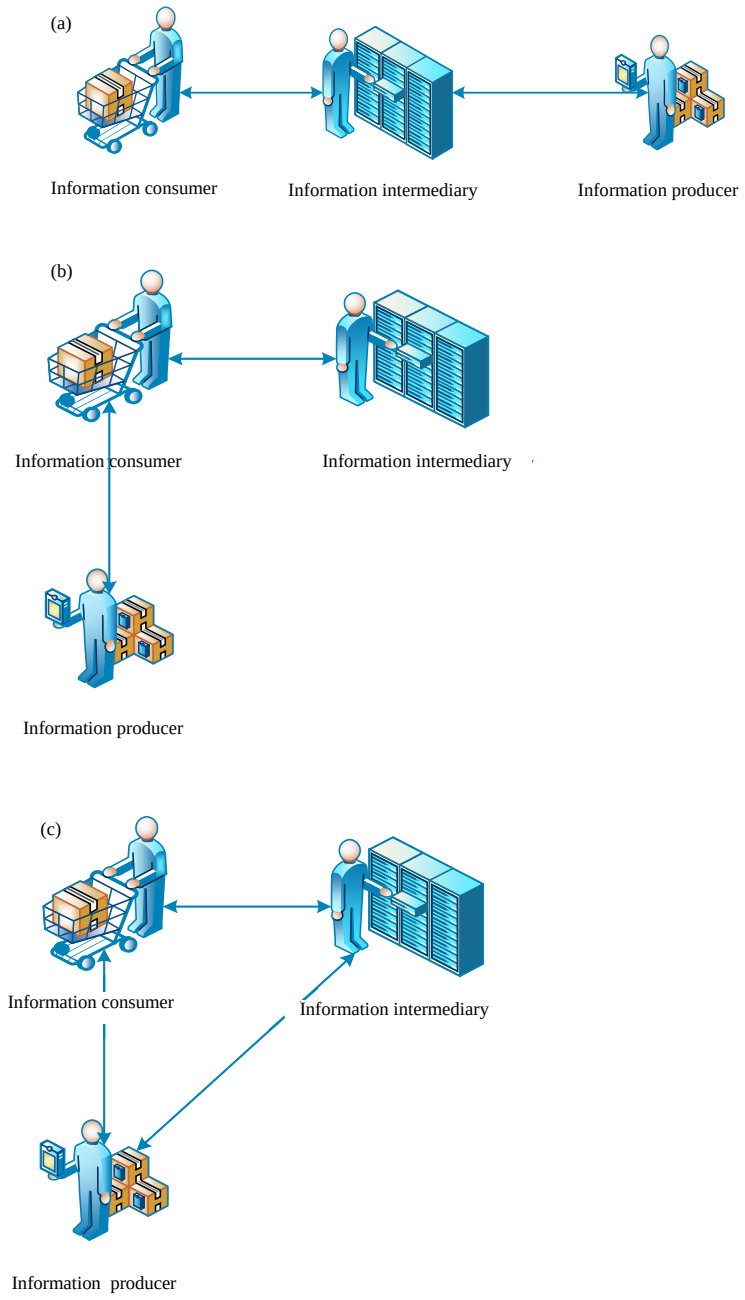


Fig. 1(a-c): Three kinds of information management configuration, (a) Linear model, (b) Line model and (c) Triangle model

**Information cancellation:** If the resource owner does not wish to continue to provide its own resources to the cloud users, only just simply withdraw the information, the resource will quit after the cancellation from the cloud environment. Information logoff operation only by following some specific users or applications, such as the registrant information, the agent that is specified in the registration of the information and cloud community managers.

As a lot of information in the cloud, in addition to resource owners can register various resources of information, there are numerous information registered by various sensors collecting information distributed in cloud manufacturing system, those information bring information cancellation problem. Since the sensor is not initiative cancellation appropriate information, this will lead to a lot of garbage information generated. Hence, it need to have an information garbage processor, get rid of garbage information which is no longer useful.

**Information distribution:** Information distribution includes two meanings, one is the dissemination of information from a registration center to multiple registries; the other is to distribute the new registered information to potential users that need the information. Manufacturing resources information also need to be distributed, in addition to consumers actively find resources in the registry, resources can also take the initiative to promote themselves to the user. At the same time the user's location in the cloud manufacture is not fixed, but the behavior of the user in the cloud manufacturing should not be restricted geographically. Information management system distribute information to the user node which user may log in, so that it can avoid the user to provide legitimacy to each login node authentication to realize single sign-on (SSO).

## RESULTS

### Implementation of information management systems in cloud manufacturing

### Server module

**Design features:** Information management system of cloud manufacturing is responsible for all information collection, organization, query, update and provide the distribution of information. Service information management system using the Lightweight Directory Access Protocol[3]. The LDAP are widely used in cloud systems, it has a hierarchical structure to support distributed system architecture, database structure is compact and flexible client/server architecture, etc.

The LDAP is part of an open, standards-based X.500 target directory, but easier than X.500 and has better scalability. LDAP supports TCP/IP protocol, suitable for use on the Internet[4]. Information management system in the cloud manufacturing uses the way of information directory management to realize the representation method of resources, organization type, recognition and access of resources and realize a complete and effective information management platform.

Cloud manufacturing information management system in a way to achieve the information catalog manager representation, organization of resources, access to resources and confirmation after confirmation of resources, the realization of a comprehensive and effective information management platform, which features embodied in the following aspects:

- Information management system achieve a complete and accurate representation for resource information
- Information management system effectively solves the collection and management of information resources in cloud manufacturing system through dividing the information into two kinds of relatively dynamic and relatively static
- Using the LDAP protocol, using distributed storage technology of full backup in data fields
- System monitoring software can provide near real-time information status of cloud resources to the user
- Information management system provides a complete set of application programming interfaces for cloud environments

**Information organization mode:** Information management system using LDAP as a representation of resource information, using OpenLDAP protocol software as the underlying support. According to the characteristics of cloud manufacturing, adopting the hierarchical approach, the information of the tree structure is shown in Fig. 2.

Information is stored on an LDAP directory server in cloud manufacturing, the directory is further divided into organizational units. Ou contains information entry, so the system is not only scalable, but also faster during the search or query process than traditional relational databases. The LDAP server can store all types of information, including e-mail addresses, DNS information, NIS maps, security secret key, contact lists and computer names. When accessing the LDAP information, the client by using the LDAP protocol to send the request to the LDAP server, the server checks the client privilege in the case of the corresponding permit operation to the database.

**Software diagram:** Software block diagram shown in Fig. 3. Information management system consists of registration

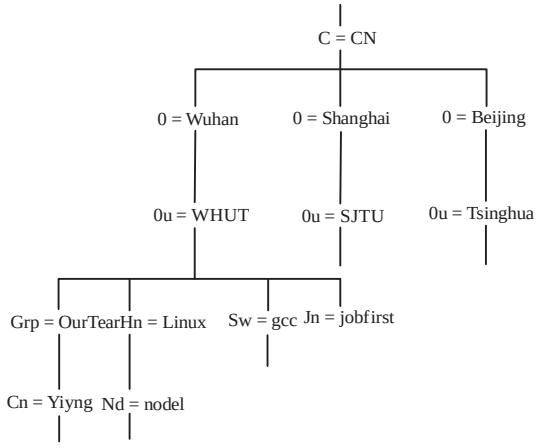


Fig. 2: Tree structure of information

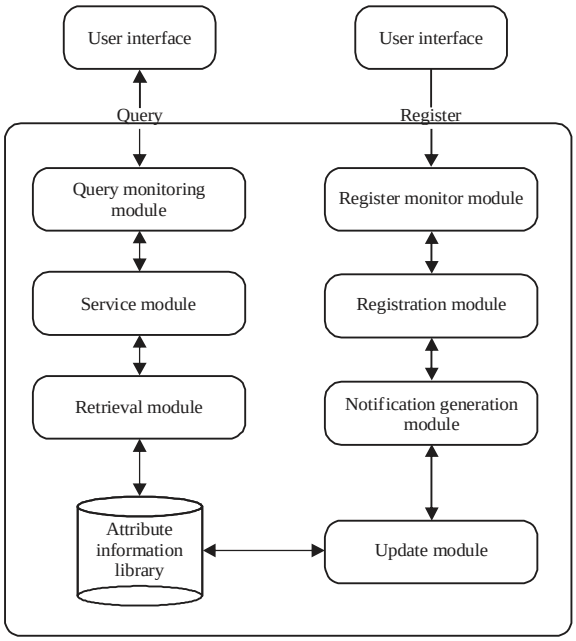


Fig. 3: Software module diagram

module, registration processing module, the notification generation module, retrieval module, service module, query module, update module and attribute information database and other functional modules.

**Implementation of client module:** Because information management system is implemented via the LDAP protocol, any mechanism to access LDAP can access the system. Users can query information through the Internet browser can also be accessed through a client application, you can also access the command line form. The API interface provided by the use of OpenLDAP as shown by the development of Java LDAP client browser interface, in this interface, the user can access the file system access as the same kinds of information.

Its internal work processes are as follows:

- Registration processing module listen registration request
- Upon receipt of a registration request, the registration process module calls the update module to update the attribute data repository
- Notification generation module is responsible for generating the update notification, update notification contains all of the information generated by the attribute information stored structure
- The registration module by periodically calling notification generation module generates an update notification
- Service module is responsible for monitoring the metadata catalog, cloud environmental monitoring programs and other programs sent to the query and then call the retrieval module
- Retrieval module to retrieve property information database based on the service module submitted search condition and then returns the results service modules
- According to the index data in the attribute database and the retrieval condition of the retrieval module, the query module sends out a query request to the system and then returns the results to the retrieval module

Because the information management system is implemented through LDAP protocol, anyone can access LDAP mechanism can access the system. Users can browser query information through the Internet, also can access by client applications and through the command line. Using Apl interface provided by OpenLADP the, users can access the information as well as access to the file system.

## DISCUSSION

At present, for cloud computing environment information management research has caused widespread concern in the academia and industry, many research institutes and universities have successively carried out some related research and many valuable results have been obtained. Literature[27] in the cloud computing environment, the introduction of agent technology, puts forward a kind of information management architecture based on agent, the agent's intelligence to the integration of information resources, cloud computing services intelligent. The paper puts forward a kind of service oriented information management system architecture with a certain self-adaptability[29], which can effectively implement the distributed workflow system. Combined with cloud computing technology, field engineering technology and data mining technology in literature[28], from cloud services architecture and domain driven design two dimensions of proposed an information management platform for. Literature[30] in distributed decision making environment and centralized decision making environment background under and puts forward the comprehensive utility cloud model based on income, time and reliability, it is proved that the validity of information management and amp; service model in the cloud environment. At the present stage of information resources cloud service architecture for the different areas of the background, cloud computing based multi-source

information resources cloud services are not the same model and the characteristics of different. Aiming at building information model, which is difficult to manage and apply complex and massive data problems, literature[31] puts forward a kind of information management system architecture for BIM application. Based on the background of manufacturing industry, literature[32] puts forward the information management framework of manufacturing cloud system and summarizes the key technologies of manufacturing cloud system. Literature[33] research on the system structure of information management platform for manufacturing cloud services for small and medium sized manufacturing enterprises and summarizes the key technologies involved in this platform.

The research work mentioned above respectively from a plurality of different areas of manufacturing field, education field and scientific research institutions in the field of geographic information and agriculture and other fields of information resource service model was studied, but there is different information resource service model in different fields, has not generality and basic suitability, cannot effectively solve the user's common problems.

In this study, our solution provides the transparent use of cloud manufacturing resources and provide support for information storage, collection, query and update management. The information in the cloud manufacturing has the characteristics of variety, quantity and change frequently, the traditional information management solution is difficult to meet the needs of cloud manufacturing environment information management. Information management is very important in cloud manufacturing, it provides the basis for the whole system to provide the basic service for the coordination of distributed manufacturing resources and is the central position in the entire cloud manufacturing. Cloud manufacturing information management need to have a special information management system to achieve the organic integration of cloud manufacturing.

## CONCLUSION

Cloud manufacturing is an integrated supporting environment for enterprises and social resource sharing and integration, supporting the operation and management of enterprise groups. Cloud manufacturing information management system is a bridge between the information provider and the resource provider to provide users with the need of cloud information. This study discusses the structure and function of information classification, information management and information management system. The next step is to study the dynamic information management and the security of information management in the cloud manufacturing environment.

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