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Cloud 3D Printing Information Research

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Abstract: 3D printing technology, as a major technological change in the global manufacturing industry, has gradually become the trend of The Times. As a service-oriented intelligent manufacturing system, cloud manufacturing has been widely studied by scholars at home and abroad in recent years. This paper takes cloud manufacturing as the carrier, studies the informatization of 3D printing service under cloud environment, elaborates the construction of 3D printing service information model in detail, and instantiates through Agent mapping model. This paper creates an implementation path for cloud 3D printing to provide on-demand precision manufacturing services.

Keywords: Cloud 3D printing; Cloud manufacturing; Information model; Agent model.

1. Introduction

3D printing technology has become a rapidly developing trend in the last decade and is considered to be a major change in the global manufacturing economy [1], in which 3D printer is its core equipment. With the maturity of 3D printing technology and the promotion of its application fields, enterprises with 3D printers will show explosive growth in the future, and how to achieve cloud 3D printing service information and service precision is an important part of achieving comprehensive 3D printing cloud services.

Cloud manufacturing [2], as a service-oriented intelligent manufacturing system, provides excellent mode support for the transformation of socialized, shared and service-oriented manufacturing in the field of 3D printing [3]. In recent years, domestic and foreign scholars have conducted extensive research on cloud manufacturing application systems for various vertical industries [4]. 3D printing, as a highly integrated digital manufacturing with design and manufacturing, is an excellent carrier for realizing cloud manufacturing services [5]. From the perspective of the ecological development of the cloud manufacturing industry, how to realize the cloud service informatization of many various types of idle 3D printers in society, and to realize the manufacturing of on-demand services through the cloud platform is a key research direction.

Therefore, this paper constructs a 3D printing task and service information model from the perspective of 3D printing information, and discusses the cloud 3D printing system under the Agent model.

2. Cloud 3D Printing Information Model

Information model is a method of abstracting and describing information and data in the real world. It is a structured way of understanding, representing, and organizing information so that it can be processed and communicated in computer systems or in the human mind. Task information model is a framework or structured model for various information and elements involved in a task. It describes the components of the task, the various elements in the execution of the task, the relationships between them, and how they interact and influence each other. Task information model aims to provide a framework for comprehensive understanding and description of tasks, which is usually used for centralized management of tasks, optimization of analysis and processing processes, and planning of specific execution processes. A service information model is a framework or structure that describes the various information and elements involved in a service, which helps to understand the components of a service, the relationships between them, and how they interact. This model can include various aspects of the service, such as service characteristics, processes, participants, data, resources, interfaces, and so on. Service information model can help people better understand the operation of services, so as to better design, implement and manage services.

3D printing in the cloud environment has the characteristics of high intelligence, integration and digital information, which involves various information and elements related to 3D printing, and it is necessary to build detailed information models for 3D printing tasks and services [6] to ensure sufficient flexibility and execution efficiency.

2.1. 3D printing task information model

As users' 3D printing needs are diversified [7], for complex and large number of printing tasks, the printing requirements can be centered, tasks can be decomposed from multiple perspectives and their attributes and constraint characteristics can be associated, such as material information, model parameter information, printing parameter information, etc., the overall form of printing tasks can be refined and concretized to form a task information model of frame structure. To ensure that the maximum to meet the user's personalized printing needs. The task information model of 3D printing can be formally described ={user base information, model information, customization information, business information, additional information}. The task information model constructed will be elaborated in detail below:

(1) DemanderBaseInfo (demand-side user base information) refers to the attributes associated with the account as a demand-side role, including user name, user ID, user IP, contact information (phone, email, address), real-name authentication, user rights, and additional information (demand preference, user level, and online status).

(2) FeatureInfo (Feature attribute information) is the

information directly related to the 3D model in the 3D printing task, including model file type (STL, OBJ, STEP), model size, model class, structural strength, surface curvature, and support structure.

(3) CustomizedInfo (demand customization information) is the user's limited requirements and constraints on 3D printing services, including delivery time, logistics, material requirements, fineness requirements, surface smoothness requirements, wall thickness requirements, color customization, function customization.

(4) BusinessInfo (business attribute information) is the information about business exchanges between the demand and service parties, including transaction mode, payment channels, payment ratio and contract regulations.

(5) AdditionalInfo (additional information) is other requirements other than the 3D printing service itself, including product assembly, product packaging, copyright information, legal compliance, technical advice.

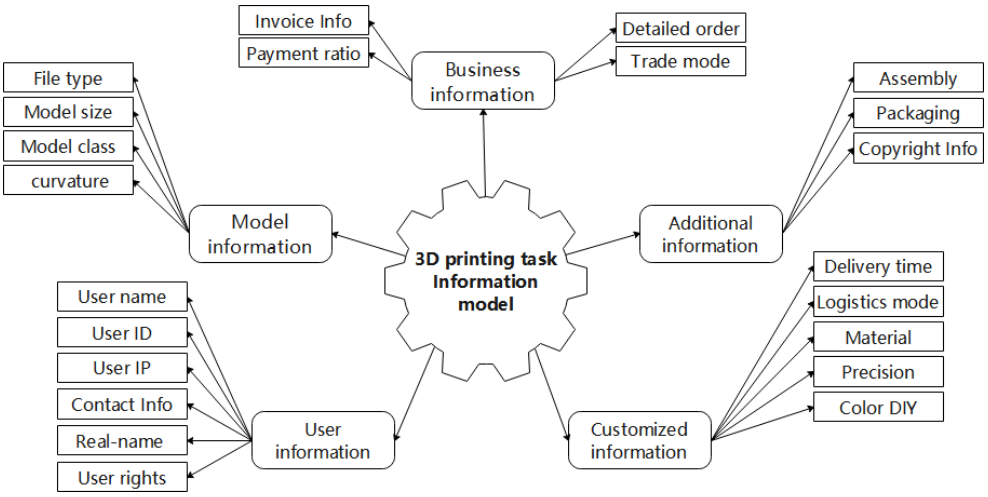

Figure 1. 3D printing task information model

2.2. 3D printing service information model

3D printing service information model is a structured framework model about providing detailed information and specifications of 3D printing services. It takes 3D printing equipment as the main body, standardizes and abstracts 3D printing service capabilities, encapsulates them into service information, and stores them in cloud-side collaborative data centers to build 3D printing service data sets and form a comprehensive service information network [8]. This information model helps to establish a transparent and clear communication bridge between service providers and demand-side customers, so that customers can understand the scope of service, requirements and conditions that the service can provide, so as to better meet customer needs. 3D printing service information model can be formally described ={service provider basic information, equipment basic information, printing capacity information, extended service information, business service information, service rating information, service security information, logistics and transportation information}, the following 3D printing service information model is introduced in detail:

(1) ServerBaseInfo (basic information about the server) refers to the attributes associated with the account of the service provider, including the name of the service provider, the ID of the service provider, the IP address of the service provider, the contact information (telephone, email, address, website), the enterprise authentication, the permission of the service provider, and additional information (service characteristics, positioning field).

(2) DeviceBaseInfo (device basic information) refers to the inherent properties of the 3D printing device itself, including hardware information (device ID, device IP, device ownership, device model, device type), software information (firmware information, operating system information, application information).

(3) AbilityInfo (printing capability information) represents the overall capability of the service provider to provide 3D printing services, including service capability information (service period, maximum production capacity, order situation), basic printing capability (number of equipment, material type, material inventory, 3D accuracy (height, resolution), and maximum size), Expansion capability (expansion of print size, material, quantity), equipment status (real-time status, future status, long-term status, service life).

(4) ExtendInfo (extended service information) refers to information about other related services that the service provider can provide in addition to 3D printing itself, including model design services, model optimization services, post-processing processing, industry-related services, value-added services, and other additional services.

(5) BusinessInfo (business service information) is information related to the business behavior of the service provider, including quotation information, financial information (transaction method, transaction process, financial type, etc.), standard business process, after-sales service regulations, etc.

(6) RatingInfo (service rating information) is information about the service quality and credit of the service provider, including customer evaluation, on-time delivery rate, performance ability, quality rate, technical rating, financial credit data, etc.

(7) SafetyInfo (service safety information) includes confidentiality agreements, compliance standards, production safety standards, etc.

(8) LogisticsInfo (logistics information) has logistics companies, logistics routes, vehicles, transportation costs, time data, logistics tracking, etc.

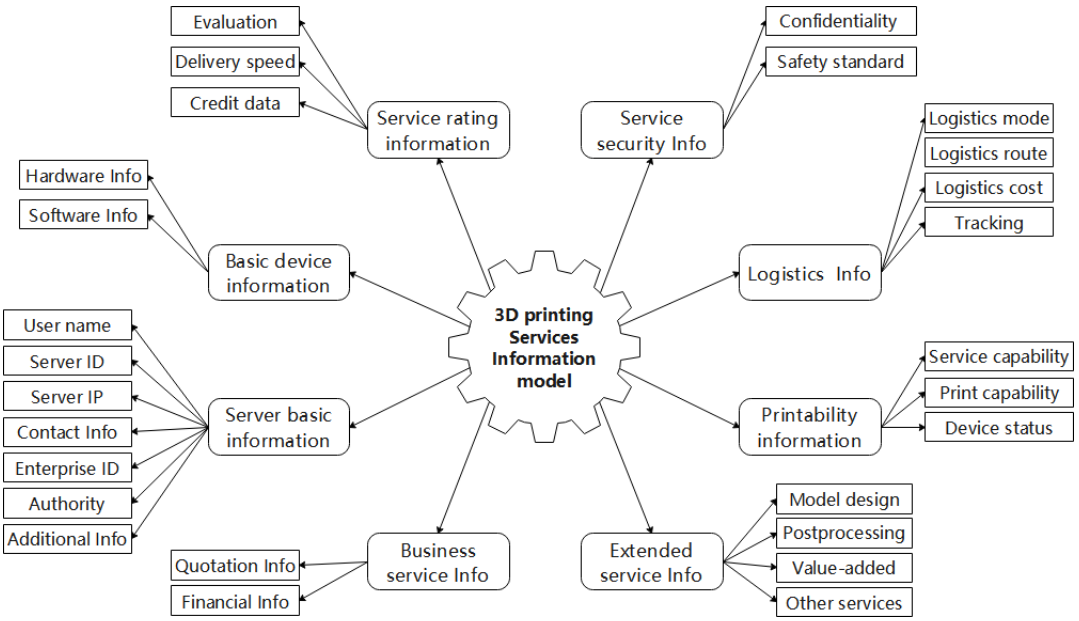

Figure 2. 3D printing service information model

3. Agent Mapping Model

3.1. Agent model mapping principle

Agent model is a concept in the field of artificial intelligence and computer science, referring to entities with the ability to perceive, make decisions and act [9]. These entities can be physically present, such as robots, or virtual, such as software programs. The Agent model emphasizes its ability to perceive information, reason or learn, make decisions, and perform actions in the environment [10]. These Agents can adjust their behaviors according to changes in the environment and their own goals, and have certain autonomy and flexibility. The core features of Agent model include autonomy, perception, decision making and execution, which can be applied to intelligent systems, automated control, AI decision making and other aspects, helping to simulate and understand the interaction and behavior between entities and the environment. Agent modeling is the process of describing Agent's behavior, decision and environment interaction and building entity relationship. This process involves abstracting Agent's characteristics, behavior and goals into a series of rules, algorithms or models, so as to simulate, analyze or predict its behavior and decision-making process in different environments.

A simple system can be run and managed by a single Agent, but such as the cloud edge collaborative manufacturing system proposed in this paper, which is complex in structure and involves multi-department collaboration, it needs multiple agents to maintain its normal operation. Multi-Agent System refers to a system composed of multiple independent agents [11]. Each Agent is an independent entity with autonomy, perception, decision-making and action capabilities, and can interact, communicate and collaborate with other agents to jointly complete system-level tasks. Multi-agent systems are of great significance for solving complex problems, optimizing system performance and realizing multi-level collaboration [12]. The construction of Agent mapping model is a systematic process. Combining the 3D printing task information model and 3D printing service information model proposed above, the following mapping process method is proposed. A Cloud-Edge Collaboration Multi-Agent (CECMA) mapping model for 3D printing services is constructed.

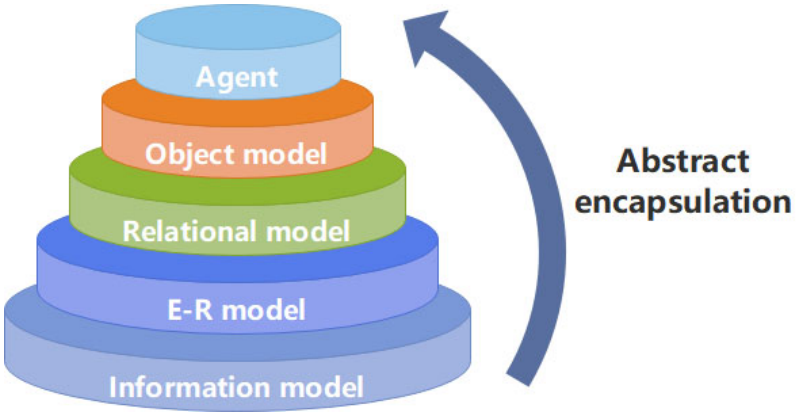

Figure 3. CECMA abstract structure

First of all, based on the analysis of the previously established 3D printing task and service information model, the corresponding E-R model is established, and the entity, attribute and relationship in the 3D printing information

model are visually expressed, which is conducive to the design and implementation of the database.

Then, a relational model is built according to the E-R model to describe the relationship and structure between the database tables, provide a database-oriented logical model for 3D printing tasks and service information, and provide a supporting basis for the specific design of the subsequent database.

The next step is to objectors 3D printing tasks and services on the basis of the relational model, identify specific entities in the relational model, determine their related attributes, abstract each task and service node as objects, and build a model representing objects and their mutual relationships in the system as a transition to the final Agent model.

Finally, the transformation of object model is extended to Agent, that is, CECMA model is constructed.

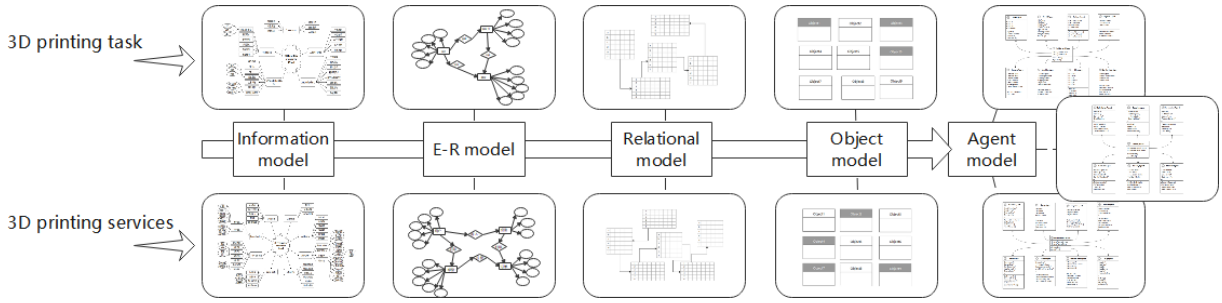

Figure 4. CECMA mapping process schematic

3.2. CECMA model structure

CECMA model consists of two parts: task Agent and service Agent, among which task Agent is responsible for the functions related to demand-side users, and its sub-agents mainly include model Agent, demand-side user Agent, demand Agent, business Agent, message Agent and extension Agent.

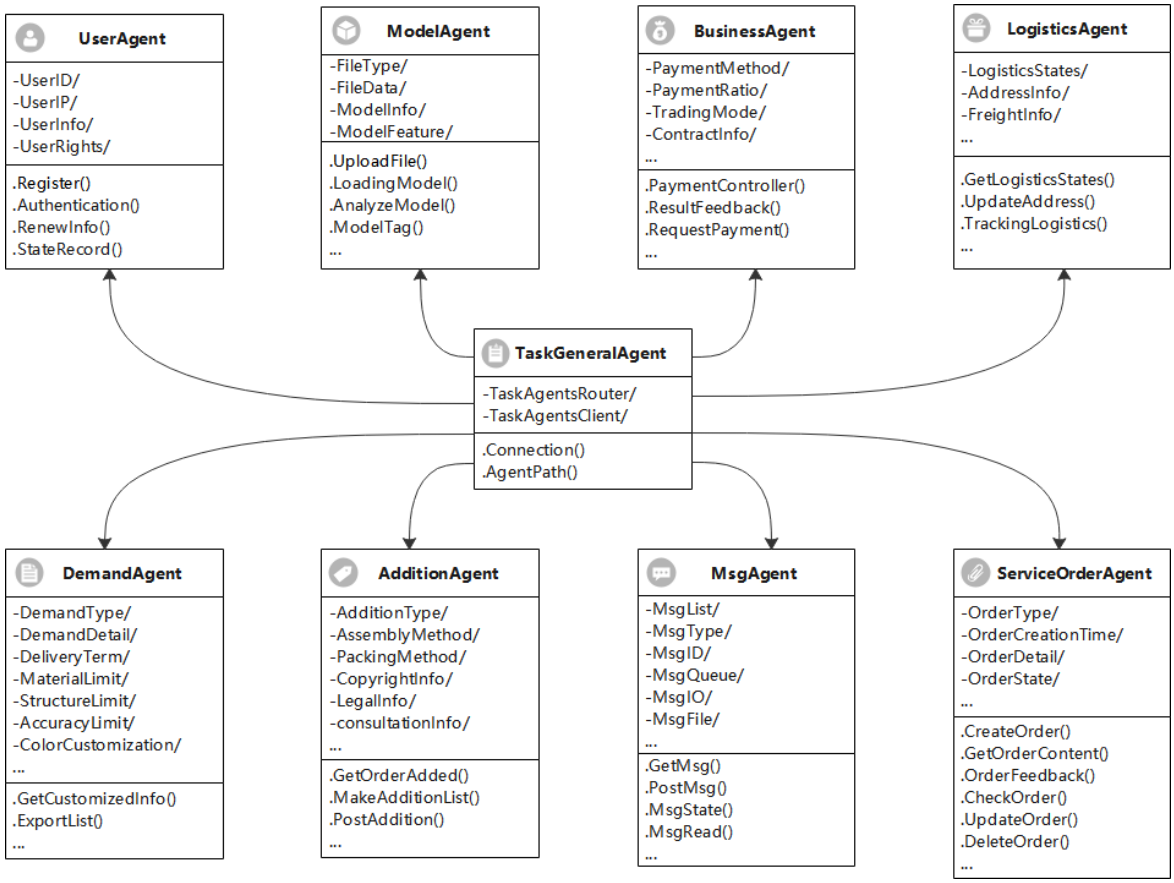

Figure 5. Task class Agent structure

Service Agent is oriented to 3D printing service providers, and its sub-agents mainly include service user Agent, service Agent, equipment Agent, logistics Agent, rating Agent, message Agent, security Agent and extension Agent.

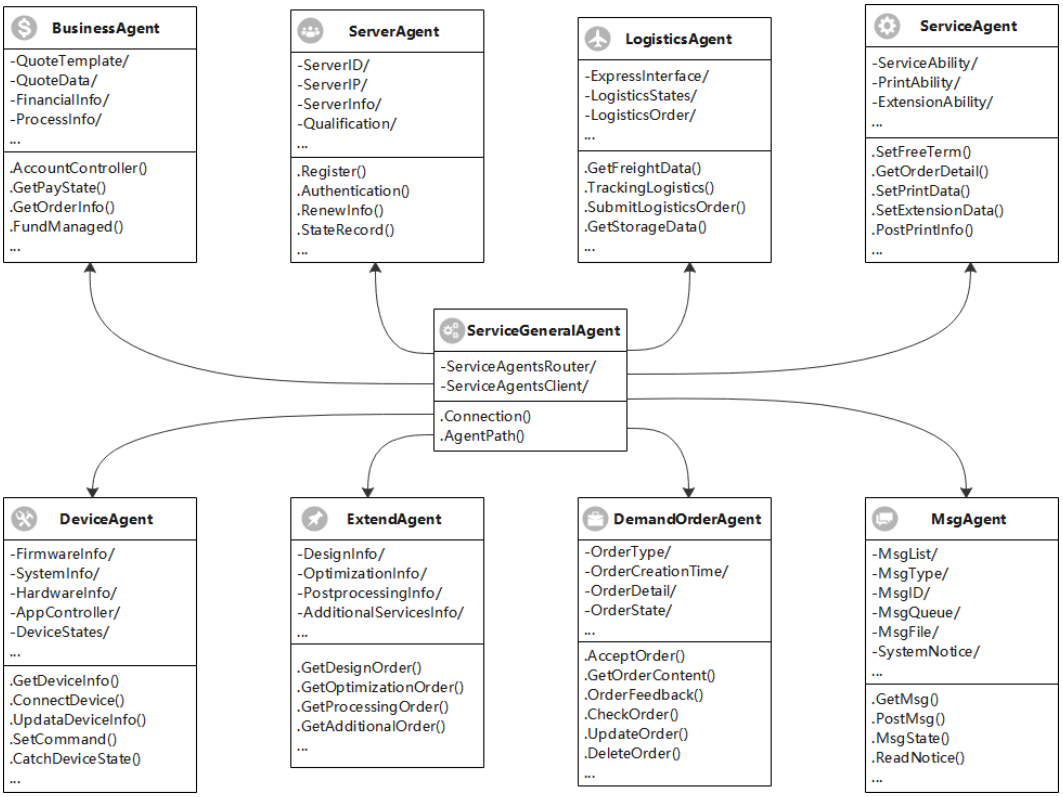

Figure 6. Service class Agent structure

4. Summary

Cloud 3D printing will develop towards comprehensive intelligence, service and autonomy in the future. This paper studies 3D printing in the cloud environment, constructs a complete information model, and establishes a cloud 3D printing service Agent, verifies the feasibility of precision manufacturing of cloud 3D printing, and provides important support for the development of new formats of 3D printing manufacturing in the future.

However, there is still a lot of work to be done, such as how to build a 3D printing composite scheduling model for the cloud environment. Therefore, in order to achieve the full application of cloud 3D printing and enhance the industrial competitiveness of manufacturing enterprises, it is also necessary to continue to deepen research under the promotion of relevant technologies.

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