Study on an Intelligent Ecological Management Mode Oriented to Miniature Building CAD Design Services

Jing Hong
College of Mechanical and Architectural Engineering, Taishan University, Taian 271000, China
Email: hongjing126 @ 126. com
*Corresponding Author: Jing Hong; email: hongjing126 @ 126. com; phone:13468032510

Abstract: The collaborative design technology is one of the key development directions in the field of CAD technology, and a healthy ecological environment is also a prerequisite for the robustness and coordination of the architectural design management system. Taking design alteration in the construction process as an example, this paper uses advanced network computing theory and service-oriented concept to build a collaborative design management mode oriented to miniature building CAD design service, which is based on an eco-design environment model of multi-party coexistence. The management mode, oriented to miniature architectural design services, has not only flexible distributed feature but also active customized function, so as to effectively promote the further development for CAD technology in the building design domain.

1. Introduction
With the in-depth application of computer aided design (CAD) in the field of civil engineering, various advanced key technologies will be deeply applied, such as intelligent computing technology, virtual reality technology, integrated technology, and collaborative computing technology. These technologies have greatly shortened the designing cycle of the engineering project, improved the designing quality, and achieved the significant economic benefits. As an important branch of engineering applications, building CAD generally focuses on numerical calculation and graphics drawing of construction engineering, as well as limited traditional network computing. Taking the architectural and structural CAD as an example, the current design and research of CAD system mostly focus on the internal field of building design specialty. While compared with the complex and varied engineering environment in which building CAD design is located, it is difficult to carry out the related rule reasoning and service activities based on other expert systems outside the field of professional design. In view of the above-mentioned working characteristics, building CAD technology can only meet the requirements of collaborative work among multiple professions within the design department, and the interactive demands can not be effectively satisfied with other parties participating in the project, such as project developer and construction contractor. This makes the current application of building CAD technology very passive, which is unable to serve the users really and satisfy the external collaborative work’s needs.
2. Working mechanism oriented to miniature building CAD design services

According to the technical code of multi-planning united cooperation platform recently issued by the Ministry of Housing and Urban-Rural Development of China[1], which belongs to a draft for comments, its basic purpose is to standardize the construction of multi-planning united cooperation platform, unify project planning and implementation, promote the coordinative governance of department space, deepen the reform of the examination and approval system, optimize business environment, and enhance the quality of government services, so as to achieve data sharing, space co-management and business cooperation. Through such a multi-planning united cooperation platform, it requires all departments to coordinate project construction conditions, propose construction requirements in the unified manner, and assist relevant departments to strengthen the information platform of supervision and evaluation, so that platform users can achieve rapid exchange of views between related departments and improve business function of communication efficiency.

With the in-depth development of advanced technologies such as machine learning, artificial intelligence, cloud computing, and big data, more advanced intelligent nodes can be added to the computing nodes and related services configured for computer networks, so as to further improve the running quality of collaborative management between departments in various economic social affairs. In the field of computer network management, in order to improve the speed of network computing and solve large complex computing problems by expanding problem-solving scale, the current network computing technologies have developed from traditional serial computing and centralized computing to advanced computing technologies such as distributed computing, parallel computing, active computing, cloud computing, and so on. Through the high integration of advanced technologies, this provides powerful computational theory and technical support for the sustainable scientific development of high-performance intelligent network architecture. Taking active computing technology as an example, active computing, as an intelligent network architecture’s computing form that allows users to program network intermediate nodes, can provide related services and node resources needed for active network code’s running, and can actively provide management services for users. In here, if the active computing is introduced on the basis of distributed computing to form a collaborative computing pattern, the network computing power will be greatly improved, and especially the working ability of the building collaborative design will be significantly strengthened [2-6]. At the same time, the services-oriented network management is a network management system that takes network service as the object to be managed. By providing a method for the client to simulate the user’s requesting service, it can test the network service, detect and analyze the running status of the service, so as to monitor the operating and changing rules of network services. Therefore, the high-performance intelligent network management system, based on advanced computing technology theory and service-oriented concept, should be able to adapt to the complex and varied engineering environment in which building design is located, and effectively meet the interactive needs of other expert systems for engineering design business outside the field of professional design.

In the course of project construction, with the increase of construction scale and the acceleration of construction rhythm, design alterations have become a relatively frequent and important link. Among the specific types commonly seen in building design, design alterations, caused by drawing review and collision detection, are usually completed before the construction of a building project. Because the parties participating in the project have fully negotiated the contents of the changes, the implementation of design alterations will be more direct and continuous, so as to show the static and passive characteristics. However, the design alterations, proposed by the project developer and construction contractor during the construction process, are mostly caused by construction conditions, construction methods, resource market, and project increase or decrease. Such design alterations have dynamic and proactive features, and then considering that the construction site has cross-regional, complex and comprehensive technical characteristics, these will result in more slow and indirect implementation of design alterations. In addition, a regular workflow of design alteration is as follows: firstly, design alteration should be fully negotiated between parties including construction supervisioner, building designer, construction contractor, and project developer, no matter which party
proposes design alteration; secondly, the design department will provide the corresponding drawing or instruction after the above departments’ confirmation; finally, design alteration is signed by the supervision department and issued to construction contractor for implementation. Such a workflow is not flexible enough because of involving many negotiation links, it has a profound impact on the project construction’s continuity and periodicity, which is not conducive to the project’s successful construction and completion.

In view of the actual situation of the above-mentioned design alteration management, design alteration should be regarded as the miniature building CAD design service during the construction of a building project, which deeply combines computer network’s intelligence computing technology and service-oriented concept. At the same time, such a miniature design service requires proactive and flexible maneuverability to handle, validate, and respond to design data sent by project developer and construction contractor. With the deepening reform of the business model and management structure of China’s construction industry in the future, large-scale collectivized construction enterprises will gradually become dominant in the project’s construction market. Such construction enterprises will be transformed from traditional specialized single design or construction business model to multi-specialty integrated business model including investment, development, design, construction, operation, service, and so on[7]. Under the vertical integrated management mode of construction project, multi-professional construction activities belong to the internal management scope of the same group company, which is very beneficial and efficient for the integration and circulation of project resources. It can be convenient and proactive for processing and feedback of miniature building CAD design service, which is aimed at design alterations proposed by the different project participants in the construction process. In addition, with the notable improvement in educational level and construction experience of the technical management talents participating in the project, the provider of design alteration, considering the limited authorization appropriately permitted by the project designer, can provide the change scheme that meets the site’s construction conditions and actual requirements. According to such a working mechanism, the provider can log on to the authorized design platform of the designer, and make the miniature designing works for the construction drawing’s design alterations, such as modification, deletion, addition, reduction, and so on. The parties, located on the distributed client side, actively participate in collaborative discussions on design alterations, and then the designer performs professional design verification and issuance. Through the above working steps, the miniature CAD service can be determined and recognized, which will enable the provider of design alteration to get the change directive in time and successfully complete the subsequent executive tasks. Due to the closed and smooth working circle of the above design change business, the processing of miniature CAD design service, based on a running mechanism of distributed collaborative designing management, should be able to adapt to the complex and varied engineering environment in which building design is located, and effectively meet the interactive needs of other expert systems for engineering design business outside the field of professional design.

3. Eco-design environment model oriented to miniature building CAD design services

Along with the active exploration of architectural designing ecologicalization in recent years, the scientific concept of ecology has been integrated into the architectural design, gradually realized the patterns of ecological architecture design, and correctly guiding harmonious coexistence and environmental protection between buildings, human being and natural environment. To this end, it is necessary for the designers of construction projects to adhere to the ecological concept, integrate the building and the nature effectively, build a virtuous circle system of balanced development of the building and the ecological environment, and create an efficient and low-cost ecological building, so as to provide a more comfortable and healthy living environment and satisfy the pursuit of a high-level life for people[8], thus, the principles of ecological architecture design must be actively observed in the future, so as to achieve friendly and sustainable development of the construction industry without affecting the natural environment and ecological environment.
On the other hand, when talking about the specific eco-design concepts and forms, people including so many project designers usually regard low-carbon environmental protection principles and green ecological concepts as a fixed model of green ecological building design, which are widely applied to the modern architectural design process and the specific project entity[9]. In fact, people have great limitations in recognizing such a green ecological architectural design mode, and do not fully consider the working relationships and coordination problems among other parties involved in the project construction activities. Since such working relationships and coordination problems have the important affections on the green construction goals, such as quality, safety, cost, schedule, energy conservation, environmental protection, and so on, these require people to extend the application scopes and expressive forms for green ecological design pattern.

As an important branch of the construction industry, the architectural designing department should not only emphasize the development trend of its own architectural designing ecologicalization, but also form an external working characteristics relative to its own internal system, in which all the parties participate collaboratively. In order to establish the friendly interactive environment oriented to all the parties participating in the construction project, an interactive designing environment is also based on the concepts of eco-design environment, such as harmonious coexistence, green environmental protection and sustainable development. According to the above-mentioned distributed collaborative managing mechanism for design alteration, a collaborative eco-design environment model, based on eco-design requirements of multi-party coexistence, is shown in Figure 1.

![Collaborative eco-design environment model](image)

**Figure 1. Collaborative eco-design environment model.**

**4. Management links and running example oriented to miniature building CAD design services**

Based on the above-mentioned collaborative eco-design environment and advanced computing technologies, the management of miniature building CAD design service is implemented according to the instructions of the service users, which is generally restricted to the designer’s total authority and other parties’ limited authority. On the one hand, the client’s active application can directly load the local management code to realize the function of changing, adding and deleting to miniature building CAD design services, so as to correspondingly realize the distributed collaborative designing cooperation between the project designer and other parties. On the other hand, other parties will preferentially choose the default download location from the nearest neighboring node according to history record, and actively execute the corresponding application management; or else the participating party will report the new miniature building CAD design service to the designer, then it can call and execute the corresponding management application from the designer again, which can complete the miniature designing service management after loading. Finally, through the collaborative
approval of the project designer, the implementation of miniature building CAD design service will be realized in order to meet the interactive needs of other expert systems for engineering design business outside the field of professional design.

In order to realize the management function of miniature building CAD design services, software design system, based on multi-party interaction, needs to configure three fundamental Java classes including ActiveNode1 class, ActiveNode2 class, and ActiveLoad class. Wherein, the Java application of the service layer’s ActiveNode1 class corresponds to the service layer’s management; the Java application of the network layer’s ActiveNode2 class corresponds to the network layer’s management; at the same time, the download function of management code is configured for the network layer’s ActiveNode2 class, which corresponds to ActiveLoad class. These Java application configurations enable the software system to have corresponding functions of designing management, such as finding target nodes, sending management commands, receiving messages, detecting changes, analysing data, and configuring parameter. Taking design alteration in the construction process as an example, the participating party can actively send the service data of miniature building CAD design, which is based on application layer, and then the project designer will receive the service data, and send the corresponding instructions about the service management of design alteration. After receiving these instructions in time, the participating parties can successfully achieve the aim for acquiring design alteration’s instruction, and complete subsequent tasks. Management links and running exemple oriented to miniature building CAD design services, based on the collaborative eco-design environment, are as follows:

1. The node of participating party chooses the code file of service management by the limited authorization, this working step is shown in Figure 2.

![Figure 2. Choosing the code file of service management.](image)

2. The node of participating party starts the download function, and downloads the code file of service management, this working step is shown in Figure 3.

![Figure 3. Downloading the code file of service management.](image)

3. The node of participating party saves the code file of service management in the local server, this working step is shown in Figure 4.
(4) The node of participating party loads the code file of service management, and gets the related rules of steel bar replacement that are based on the application layer, or enters the designing platform of the project designer. Thus, the participating party can modify the steel bars that were originally unsuitable for the corresponding reinforced concrete members.

(5) Taking the rectangular beam L-1 as an example[10,11], because of the dense spacing of the steel bars at the bottom of the beam, which is not conducive to the quality of concrete pouring, the project contractor proposes a corresponding request about design alteration and provides the specific designing plan according to the above-mentioned working procedures. The executive result of design alteration is shown in Figure 5.

![Figure 5. L-1 reinforcement drawing.](image)

5. Discussion
In the field of artificial intelligence, expert systems are classified according to the system architecture [12,13], wherein either knowledge base or reasoning mechanism is separately distributed on a computer network, or knowledge base and reasoning mechanism are simultaneously distributed on a computer network, that are all called a distributed expert system. This kind of expert system is characterized by distributed processing of the problem to be solved, that is, a problem to be solved is divided into several sub-problems, which are solved by each subsystem separately, and then each system will communicate with each other and cooperate closely in the process of solving sub-problems. According to the principle of a certain choice or compromise, it can be solved through cooperation, reasoning and integration.
In here, multi-party collaborative building CAD design management effectively reflects the idea of computer network’s collaborative computing. It dynamically assigns a part of management function of building CAD design services to the network system participating nodes, which is authorized limitedly by the project designer. At the same time, the participating nodes can autonomously initiate and solve miniature building CAD design services through their own computing abilities, which gives expression to cooperativeness and extendibility for customized management functions and CAD services. Therefore, in such an intelligent CAD system based on collaborative eco-design environment, intelligent computing nodes can be joined by the limited authorization, and the management functions of CAD design services are partially decomposed and distributed to intelligent computing nodes, so as to remarkably enhance compatibility of intelligent CAD design on cross-system platforms and extendibility of the new CAD design services.

6. Conclusion
An intelligent ecological management mode, oriented to miniature building CAD design service, presents the characteristics of high-efficient distributed application and management, has the active and customized management functions, and can meet the needs of the participating parties’ collaborative work. At the same time, according to the above-mentioned collaborative working mechanism, the design of a miniature building CAD design service’s management system is carried out, which has completed the phased simulation experiment, and preliminarily achieved the expected results. Furthermore, such an collaborative working mechanism can also conform to application standards and interaction characteristics of technical code for multi-planning united cooperation platform, so as to quickly realize the corresponding business functions of exchanging views and improving communication efficiency between departments. In the next step, the design of such a collaborative eco-design management system should be further studied and improved to promote the high-level development of CAD application including the construction field.

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