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Development of a distributed geometric modeling system based on peer to peer†

Sung-il Choi[1], Sangho Park[2,*] and Murali Subramaniyam[2]

[1]*Senior Manager, Genoray Co., Ltd., Korea*
[2]*BK 21 Mechatronics Group, Chungnam National University, Korea*

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Abstract

Distributed systems are required in industrial environments for collecting distributed information. The developed distributed CAD system has sharing of functions, which consist of a client and server as a Peer to Peer (P2P) system. It is constructed using CAD kernel and COM/DCOM technology to share functions on a network. In recent years, the distributed system has been applied to industries for combining work functions. Here, the requester is the client, and the provider is the server. The developed system in this study shares the functions among the systems through a P2P structure. All systems linked to a local network can use the functions of the other systems. The importance of constructing this kind of distributed CAD system is for transferring 3D model data for gaining access to the location of the providers. This system can perform many operations concurrently using other systems and can save time on work. Some of the operations performed and tested by the developed distributed CAD system are Boolean operation, obtaining properties, triangulation, and tessellation.

Keywords: Distributed system; Peer to Peer; Geometric modeling

1. Introduction

In global competition, market share and awareness are decided by those who understand the market and can reduce the life cycle quickly. It is essential to reduce production time to improve quality of products. Complex products are designed and produced by industries with enhanced technology. The need for and importance of collaboration have increased, as many workers and systems need to transfer various information. In general, a stand-alone CAD system is separated locally to design product, and to save cost, collaboration is undertaken with an external company by request. The concepts of a distributed system and collaborative design are introduced to support cooperative work. A computer linked by a network is an important tool for implementing collaboration because a network can communicate information from a remote site. Recently, the distributed platform has been applied by Tanenbaum and Steen [1] to design products in enterprises.

Many researchers have developed the distributed CAD systems and its methodology. However, the network's response time is delayed when obtaining the CAD data, as the size of the data is not small and may cause network traffic. As a result, the working efficiency is decreased. These factors hinder the efficient use of a distributed CAD system. Recently, a high quality hardware and network environment has been developed, which requires many different CAD systems. The developed system should be different from the old one and should have the merits of a stand-alone and distributed CAD system. In this research, a distributed CAD system based on P2P is developed for sharing functions and for performing the roles of both stand-alone and server. Here, Microsoft's COM/DCOM and Open CASCADE kernel are applied to construct the system that can share functions.

2. Related work

Li et al. [2] developed a client/server framework to enable a dispersed team to accomplish a feature-based design task collaboratively. Qiu et al. [3] proposed an approach to exploit trimming information in CAD models to simplify their geometry. Visibility culling was integrated into this approach to facilitate selective refinements. The work introduced here aims to support the visualization of multiple CAD models in a distributed CAD environment. To carry out collaboration among the distributed sites effectively and efficiently, the traditional model sharing method needs to be optimized. At present, CAD or PDM software vendors are fast improving the technology in this field.

From the viewpoints of distributed modeling, work can be generally classified into three categories. First, it consists of a client and a broadcast server. Here, the server plays the role of

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*Corresponding author. Tel.: +82 42 821 6643, Fax.: +82 42 821 8912
E-mail address: spark@cnu.ac.kr

an information agent and exchanger to broadcast CAD files and commands generated by a client to other clients. This research was performed by Nan and Wright [4], Quiang et al. [5], and Pahng et al. [6]. In this system, standalone CAD systems can be conveniently distributed through this mechanism, but due to the heavy weight client mechanism, it is hard to migrate to web applications. It bears no significance to the distributed system if a broadcast server encounters a problem. Second, it consists of a manipulation client and a modeling server. The data of the client are light weight, and they primarily support visualization and manipulation functions. The main modeling activities are carried out in a common workspace in the server side. This structure can be rented out to the modules as an Application Service Provider (ASP). Data consistency is easily maintained as the primary models are created and maintained in the server, but a server undergoes a heavy weight process. This research was performed by Li et al. [7] and Berg et al. [9]. In the last case, the services or modules of a system can be shared and manipulated by other systems. This mechanism enables convenient manipulation on remote services or applications. Due to the heavy burden of networks, the manipulation efficiency of systems becomes low, as found by Begole et al. [10].

Researchers conduct studies to share resources such as product information, assembly information or manufacturing information, and other related materials. Client and server structures are applied to carry out the distributed system to share the resource. Some operations are provided from the server, and these methods are for sharing the resource. In this study, the method of sharing functions is established, and a simple example is applied to the developed system.

3. System structure

In this research, the distributed system for sharing functions is developed using COM/DCOM technology and Open CASCADE kernel. The COM/DCOM in the developed system is used as a middleware to construct a distributed environment. The system can communicate among the modules through the COM in-process, and DCOM is applied to communicate with the remote system.

Fig. 1 shows the linked structure between COM/DCOM and the CAD kernel for communication in its system. It presents how-to-request operations and how-to-response-about request from System-1 to System-2. System-2 prepares for the request from System-1 through DCOM. System-2 performs the operation using the CAD components registered in the COM service. The result of this operation is returned to System-1 through the DCOM. Conversely, it is possible that System-2 can send a request and System-1 can respond.

The distributed system based on P2P is shown in Fig. 2. Each system can have a similar structure with the COM/DCOM and the CAD kernel, but the functions are different. The system used to request for some operations is the P2P client, while the system used to reply to the request after

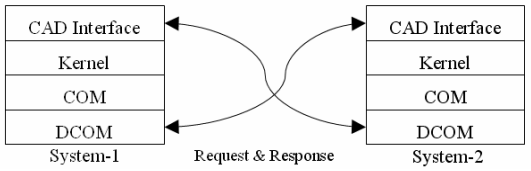


Fig. 1. Communication method for a distributed system using the COM/DCOM.

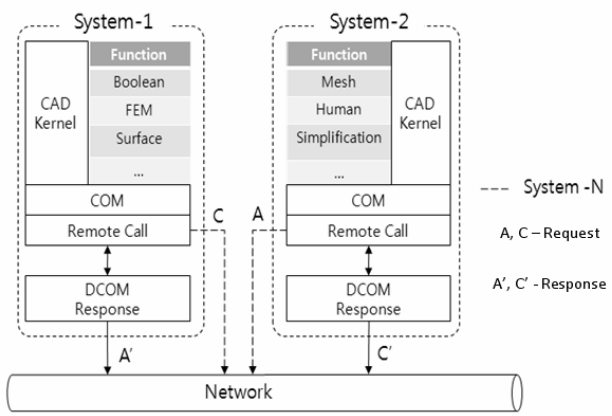


Fig. 2. Request and response flow of distributed CAD systems on a network.

the operation is the P2P server. In this system, the client and server, which are linked to a network, have the same level for renting and borrowing some functions. Fig. 2 presents the request and response flow of distributed CAD systems on a network. Here, System-1 can request for a remote call for simplification to System-2. After System-2 receives the request from System-1 for simplification function, System-2 calculates the simplification function and returns the result to the System-1 through DCOM. System-2 can request for a remote call for Boolean operation to System-1. System-1 returns the result to the System-2 in same manner. If the system uses its own functions, then it is like a stand-alone system. If the system needs other functions for operation from another system on the network, then it can request for some functions, as shown in Fig. 2. If the system is busy and is requested for by another system for any reason, then it announces its status to the request system.

The system that tries to request for an operation can decide its direction of communication. System-1 can operate its own functions as a stand-alone and can request for some functions to System-2, which returns the result to the System-1 in response. System-2 can request for any operations to System-1, which returns the result to System-2 in response. When the DCOM code is developed, the interface code is generated automatically after compiling its code and developed code. The codes for stub and proxy are included in the interface code. The stub and proxy codes are in charge of marshalling and unmarshalling. They provide security for the data when they are transferred to the network using COM/DCOM technology. On the client side, the program is compiled by the

interface code, which is automatically generated on the server side. The classes in the interface code can then be applied. When two systems have simultaneous access to another server, one of them registers to the access agent of the server, and another client recognizes the previous access status by the access agent of the server. Whenever the other client system is connected to the same server, the access status of the agent is updated. When clients request for the operation to the server, they communicates with CAD kernel through DCOM dynamically. Therefore, DCOM for CAD kernel provides no linked information about which client is connected.

4. Implementation and result

As mentioned earlier, the developed modeling system is based on P2P structure consisting of a distributed client and server, and Open CASCADE as a modeling kernel. Fig. 3 shows the developed system environment. When this system requests for functions from another system, it could serve either as a client or server to support the functions for another system.

The developed system can share functions among systems on the network when two systems have access to the server simultaneously. They can recognize the access status on the server through the access agent, as shown in Fig. 4. Request and response were tested for four functions between the requester and provider based on the P2P structure. The four functions were Boolean operation, tessellation, triangulation, and obtaining simple properties of the CAD model. These functions were included in the CAD kernel and applied for testing among systems with a P2P structure on the network.

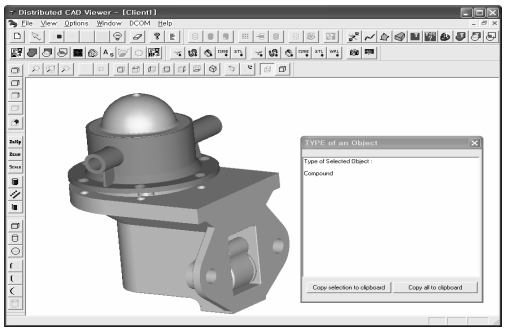


Fig. 3. User interface of the developed system.

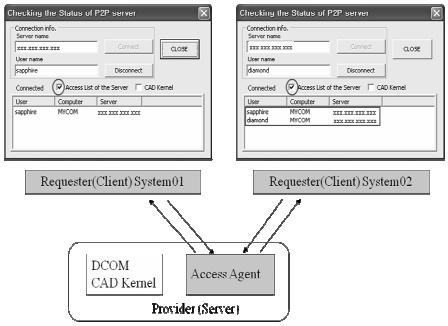


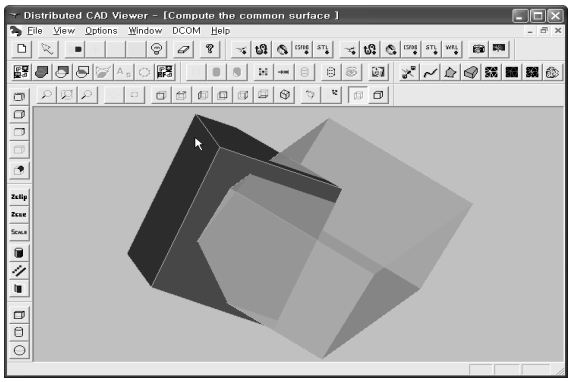
Fig. 4. Access status of the server before the functions are requested by the clients.

The systems can communicate with each other to share the functions; they can serve as requesters or providers for each other. Figs. 5 and 6 show the Boolean operation and the Tessellation, respectively.

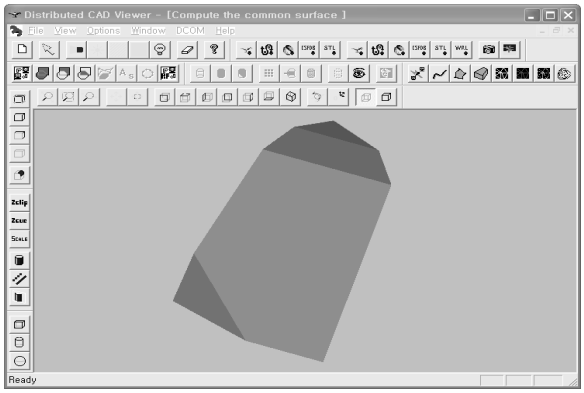
5. Conclusions

In this research, the distributed system based on P2P network was developed using CAD kernel and COM/DCOM. This system can share functions among other systems, which can either serve as client or server needed. This system can increase the usability of functions because it can be applied for multiple operations simultaneously. Moreover, it can be a client or a server alternatively. CAD systems can share the functions and distribute them to each system. In this system, resource sharing, accessibility, and fault tolerance are increased than in client and server systems. The finding of this research can be summarized as follows:

(1) Geometric modeling system can be realized either as a client or a server alternatively on a P2P network.
(2) The distributed system based on a P2P structure has the characteristics of a stand-alone and client-server.
(3) The possibility of sharing functions among geometric modeling systems is demonstrated.

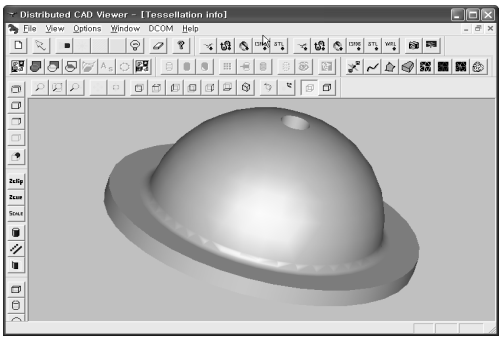


(a)



(b)

Fig. 5. Test for a Boolean operation of two primitives in P2P systems. (a) Two primitives for Boolean test; (b) Boolean operation result from the server side.



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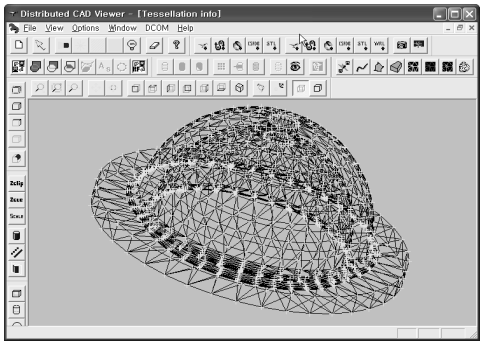

(b)

Fig. 6. Tessellation of a model using the provider of a distributed CAD system. (a) Test model; (b) Tessellation result from the server side.

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Sung-il Choi is currently working as a senior manager in software development at Genoray Co., Ltd., Korea. He was a researcher at Electronics and Telecommunications Research Institute (ETRI), Korea. He received his B.S. degree from Konyang University, Korea, in 1995. He then received his M.S. and Ph.D. degrees from Chungnam National University (CNU), Korea, in 1997 and 2009, respectively. His research interests include development of CAD interface, Virtual simulation, 3D Web solutions, geometric modeling and Micro Assembly.

Sangho Park is currently a Professor in Mechanical Design Engineering at Chungnam National University (CNU). He received his B.S., M.S. and Ph.D. degrees from Seoul National University, Korea in 1988, 1990, and 1995, respectively. He was a Senior Research Scientist at Electronics and Telecommunications Research Institute (ETRI). His areas of expertise and research interests include CAD/CAM, Virtual Reality, Digital Human Modeling (DHM), and Micro Assembly. The LID-Laboratory of Intelligent Design and Manufacturing (formerly CAD/CAM) is undertaking research under his advice.

Murali Subramaniyam received his B.E. and M.Tech, degrees from India in 2003 and 2005, respectively. Currently, he is pursuing his Ph.D. in Mechanical Design Engineering under the Brain Korea 21 program fellowship at Chungnam National University (CNU) and is working as a research associate in Laboratory of Intelligent Design and Manufacturing at CNU under Prof. Sangho Park. His research interests include CAD/CAM, CIM, DHM, and ergonomics.