Concurrent Engineering Based Collaborative Design Under Network Environment

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Concurrent Engineering (CE) is a popular method employed in product development. It treats the whole product design process by the consideration of product quality, cost, rate of progress, and demands of customers. The development of computer and network technologies provides a strong support to the realization of CE in practice. Aiming at the characteristics of CE and network collaborative design, this paper built network collaborative design system frame. Through the analysis of the network collaborative design modes based on CE, this paper provided a novel network collaborative design integration model. This model can integrate the product design information, design process, and knowledge. Intelligent collaboration was considered in the proposed model. The study showed that the proposed model considered main factors such as information, knowledge, and design process in collaborative design. It has potential application in CE fields.

Key Words : Concurrent Engineering, Collaborative Design, Agent, Network

1. Introduction

Concurrent Engineering (CE) is a kind of system method of integration, collaborative design product, and correlative course (include manufacture and support). This method makes the product development groups address all the factors of products in their whole lifecycle including quality, cost, rate of progress, and demands of customers. The drastic market competition at present pushes product development to adopt appropriate advanced technologies and methods, and designs product to fulfill market demands with the shor-

test time and the lowest cost. Thus, the theory and method of CE has received extensive recognition. Collaborative design is a method to accomplish design aims by at least two design departments, which have different design capabilities and task, through information exchange and cooperation with each other (Huang et al., 2005). Because market competition becomes more and more drastic, high quality of products, speediness of design, and innovation of products are needed in products design. This needs methods that experts in different fields and locations can cooperate effectively to fulfill the design task. Collaborative design is one popular method that can address the above issue. The fast development of internet and computer supported cooperative work (CSCW) technology provides powerful support to network collaborative design facing CE, and makes it become a common design style employed in different fields (Nevins et al., 1991 ; Wang, 1998 ; Huang, 1996).

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Because of the driving of practical demands and rapid development in information technology, network collaborative design based on CE has become a study hotspot in the field of products design. By now, the study of network collaborative design based on CE has not satisfied the practical demands very well because of the lack of systemic theories and sustaining tools. At the same time, there is a gap between the theory research results and practical applications. Therefore, an effective network collaborative design system frame for CE to solve the above issues is proposed in this paper and relevant issues should be studied.

This paper is organized as follows : Section 2 introduces network collaboration system frame based on CE. Section 3 analyzes network collaborative design modes based on CE. Section 4 proposes an integration model for network collaborative design. Finally, conclusions are given in Section 5.

2. Network Collaboration System Frame Based on CE

Through the analysis of characteristics and demands of network collaborative design based on CE, a novel network collaborative design system frame based on CE is built in this paper.

2.1 The characteristics and demands of network collaborative design based on CE

Network collaborative design is a kind of design method, which is under extended environments including multi-field design groups environment and computer virtual cooperation environment. This kind of design method takes the correlative parts' design task and carries on design work with cooperation, alternation, and collaboration in order to perform a-same product's design task (Maher et al., 1999 ; Park et al., 1999).

The basic characteristics of network collaborative design based on CE are multi-subject groups, cooperative design under different areas and environments, team's working with different specialties in different departments, using different design tools, and carrying out long-distance colla-

borative design based on Wide Area Network (WAN), discussing and amending design plans repeatedly and performing the product design with the highest speed and the best quality.

In order to realize effective collaborative communication among human intelligent, it demands that all the members in the team know the whole design plan in time, know the design progress at any time, obtain design results on each stage dynamically, and share design resource expediently. The details of demands are listed below.

(1) In the network product collaborative design, cooperative groups in different locations can switch between parallel and serial collaborations to carry out different kinds of design works of products using network technologies.

(2) The core is to overcome the space gap among collaborative groups via network connection and to realize the share of information, database, and knowledge which are beneficial to providing support and tools for collaborative design in different locations.

(3) Using network parallel collaborative design, we can shorten the product design time, reduce design cost, increase product quality, and strengthen market competition power.

2.2 Network collaborative design system frame based on CE

The collaborative design technology based on network can provide strong support in the duration of product concept and development design including specialists cooperated with work modes, design process, and executing methods. It can really realize the integration of Computer Aided Design (CAD), Computer Aided Engineering (CAE), and Computer Aided Manufacture (CAM). Therefore, an effective collaboration frame should be founded in order to achieve the integration successfully. A novel network collaborative design system frame built in this paper is shown in Fig. 1.

The design groups and collaborative design course control is called a process control layer. This layer as the core factor is the basis of special design course. It decides the design group's com-
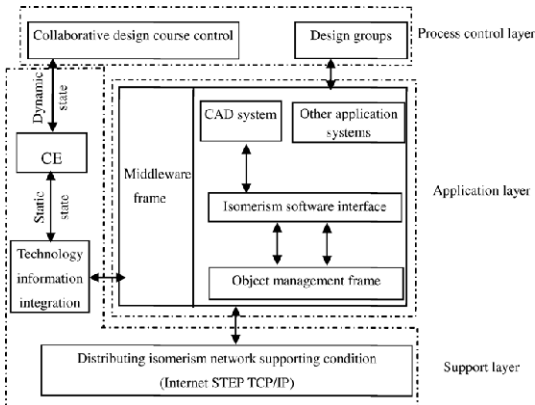
Fig. 1 Collaborative design system frame

ponents, personnel responsibility, popedom, tool's use, and resource distribution. The layer is also concerned with the design data flow direction, data format.

The second layer called application layer consists of CAD application system, isomerism software tool interface, object management frame, middleware framework, and other application systems. Among thatthese, CAD system is not only the input data receiver of customers, but also the output device of design model and design data. Through the object oriented technique of facing to object, the application layer can be sealed in an object management frame by isomerism software tool to realize the purpose of "plug and play". Data exchange between isomerism software tool interface and object frame should be bidirectional. In this layer, the most important part is middleware frame, which mainly performs two kinds of supporting functions. The oOne is that supplying support to design data treatment such as : the management of technologies and product information, the distribution and control of data resources, and the share of data by exchange. The other is that collaboration and management of design process which includes evaluating principle of design results and evaluating methods, assorting all design problems, expressing personnel opinions and idealsideas, control of the design results, assorting with administrative management and technology management, and so on.

The third layer called support layer contains

network supporting software environment and hardware environment such as distributed isomerism various computer hardware platforms. The software system is composed of operational system such as UNIX or Windows NT, Transfer Control Protocol/Internet Protocol (TCP/IP), Integrated Services Digital Network (ISDN), Common Object Request Broker Architecture (CORBA), and Internet network environment.

3. Network Collaborative Design Modes Based on CE

Different products have different design goals due to different use purposes, therefore, the products design should adopt different modes. The following different design modes in collaborative design under network environment are analyzed in this paper.

3.1 Collaborative design mode based on task management

The collaborative design mode based on task management is a kind of method that ensures completing the whole collaborative design task smoothly by collaboratively controlling of the course of each sub-task. This mode needs task management with powerful functions to realize task distribution, to define sub-tasks, to restrict management, and to control task courses of collaborative design.

In this kind of collaborative design mode, the tasks are divided into some sub-tasks. The process relation among the subtasks is defined as the constraint network. It carries on the whole collaborative design with the core of process, management, and control. The control of the project's whole progress is emphasized. The primary issue of each sub-task is that the sub-task should be performed on time. The core of this control method is process management that faces to product structure, unit function, normative and routine design according to design standards.

3.2 Collaborative design mode based on conflict resolving

In the product collaborative design, conflicts

maybe exist in each design course within each organization layer. The product development process is also the process of conflicts to occur and to resolveoccurrence and resolving. The collaborative design mode based on conflict resolving is a kind of design method to carry out full collaboration and management in the collaborative design by measuring and resolving conflicts at each stage. In this collaborative design mode, a conflict management system is necessary to set up. Design groups can define each sub-task's constraint according to design demands, build main constraint network, and measure conflicts. The capability to automatically resolve conflicts by conflict resolving system is needed. If it is unable to achieve, human-human collaborative decision-making and collaborative resolving will be carried out. This collaborative design mode mainly supports the resolving of the difficult problems in the product design process such as scheme design, concept mode-building, and local detail design (Huang et al., 2005).

3.3 Collaborative design mode based on information share

This mode means that the design groups take on the sub-tasks in the WAN collaborative virtual environment by sharing the design information and cooperating to perform design tasks. This mode needs to build a design information sharing system in order to ensure design groups adequately share the information and to provide kinds of collaborative communication support tools for the normal communication in time.

This collaborative design mode with the core of product structure information share emphasizes on the application demand of machine structure design, especially in the structure and detail design stage, the normative design, the changed style design, and the improved design facing to task distribution and product structure.

4. Integrated Model

Network collaborative design system is an integrated virtual design platform based on Internet. The key is to build a systemic integrated model

according to the characteristics of collaborative design and network collaborative design modes based on CE. The model includes information integration, process integration, and knowledge integration shown in Fig. 2.

This model regards information and knowledge management as the core by using Extensible Markup Language (XML), Virtual Reality Modeling Language (VRML), Hyper Text Markup Language (HTML), and Java computer languages. For information, course, and knowledge in this model, the model supports the integration of design principle parts in different locations and isomerism based on Internet. The model contains some issues such as: the product design information, information integrated collaborative design, integration and share of product data management, tasks distribution in process integration resolving collaborative design, and the collabora-
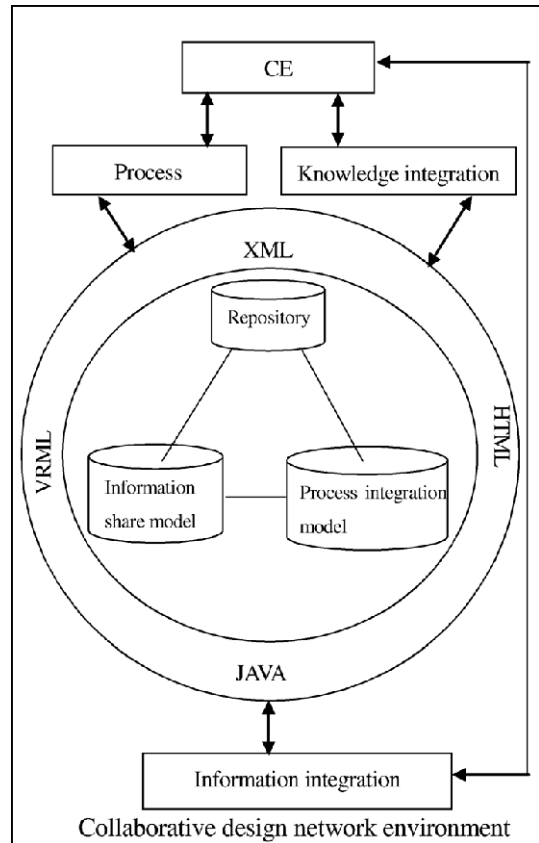

Fig. 2 Network collaborative design integration model based on CE

tive control of each subtask's course. The keys to address these above issues are to share succeed knowledge based on repository by integration and to create innovative knowledge using methods of communion and harmony. The model is able to support collaborative design model of all kinds and new models through the combination of these models combination (Caldwell et al., 2000 ; Huang et al., 1999 ; Tian, 2002).

4.1 Integration and share of product design information

Product design information is divided into product model information and product structure information.

4.1.1 Integration and share of product model information

Product model information includes geometry information, techniques information, and constraint information of product units generated by CAD system. Different CAD systems adopt different format to record information, and the application background of network collaborative design is dynamically allied with each cooperative partner. Therefore, it should adopt the product model information share sharing system that can be realized using VRML to realize visible collaboration of three-dimensional based on Internet.

4.1.2 Integration and share of product structure information

Product structure is managed by Product Data Management (PDM) system. For dynamically allied collaborative design in different locations, different enterprises adopt different PDM software. Thus, it is necessary to resolve the share of product structure information of isomerism PDM systems. The method of share and integration of product structure information is shown in Fig. 3.

At first, an information share model, which can realize product structure information share based on equal agreements, should be built. Then, we build a collaborative product information management system based on XML. This system can realize sharing information's management, pro-
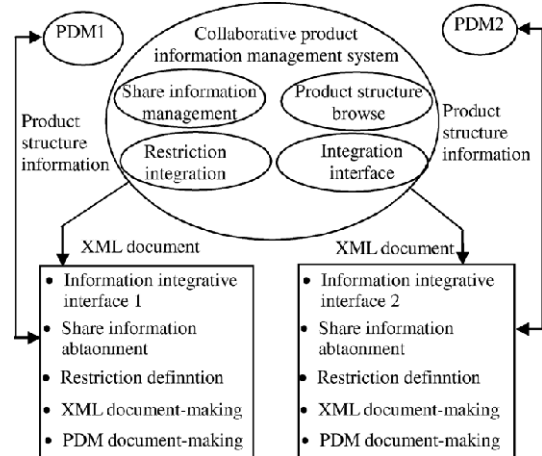

Fig. 3 Product structure information share and integration

duct structure's browse, constraint integration, collaborative support function, and integration interface based on the information share model.

In this system of product structure information share and exchange, the product structure information (XML document) came coming from isomerism PDM systems via integrated interface is integrated into product information system and becomes sharing information. This system provides visible graphics interface for consumer. At the same time, it provides XML document of sharing information to cooperative partners. The consumers in different locations can browse the information through the product structure tree. The relevant information can be inquired and searched for the design collaboration. Simultaneously, collaborative product information management system transforms product structure information created by PDM1 to sharing information and then transfers to PDM2 system. Therefore, the integration of product structure information is realized between isomerism PDM systems.

4.2 Process integration based on task management

In dynamically allied collaborative design, design goals, design styles, and cooperative partners are various. Therefore, the design should satisfy the following conditions. The design processes of sub-tasks should be different. Cooperative par-

tners are independent. The interface between each other should be connected. The cooperative styles are incompact, goal-driving. According to the final goal of the whole project, collaborative design process integration based on task management confirms how to carry out the project's whole executing plan. It contains to division of the project, to distribution of the main task of collaborative design into some sub-tasks, to definition of the sub-task's goal and course, and to expression of the design information constraint relation and time process constraint relation between task and sub-task. By Through the task management, realize the integration and control of collaborative product design can be realized.

4.3 Knowledge integration and intelligent collaboration

The knowledge integration and intelligent collaboration in network product collaboration include two aspects. One is to provide a good man-machine collaborative environment in order to make the designers gain the necessary knowledge conveniently, quickly, and friendly using the existent, visible knowledge that is managed by computer. The other is to build a good man-man collaborative environment by computer and network technologies in order to provide convenient, effective collaborative support measures, and to create new knowledge that can be used to support innovation design based on effective design ideals ideas, communion among the designers in different spaces and isomerism application environments. Knowledge integration model is shown in Fig. 4.

This model has two layers to realize knowledge integration. One is the knowledge management layer. At first, we build general repository that includes database, model-base, case-base, and method base. At the same time, we build knowledge management system. Multi-case collaboration management can be realized by the dominant of knowledge repository. Efficiency and quality of design based on the existent knowledge in the collaborative design process can be improved by the management of general repository, visible realizations, succeed knowledge's integration and share. In
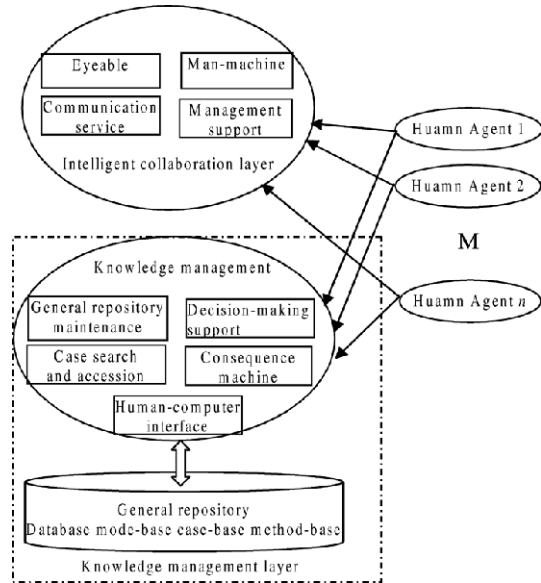

Fig. 4 The Knowledge integrated model in collaborative design

addition, it provides a good environment to produce potential knowledge. The other layer is the intelligent collaboration layer. Based on knowledge management and integration, main measures, which are emphasized by CSCW technology and Computer Supported Cooperative Design (CSCD) technology, and intelligent collaboration system with the main goal of collaboration agreement and knowledge integration can be built. By providing visible collaborative tool, tools such as conflict agreement support, communication service, and other tools to support man-man collaborative communion, a network human intelligent collaborative communion environment can be built. This environment can provide potential knowledge integration conditions to support producing the production of creative knowledge.

5. Conclusions

The realization of CE includes the function collaboration and process collaboration in each step within product development process. This paper has discussed the network collaborative design technology based on CE. Aimed Aiming

at the characteristics of network collaborative design, A a network collaborative design system frame based on CE is built. The modes facing in network collaborative design are analyzed. A network collaborative design integrative model based on XML and VRML technologies is proposed. The model covers information, process, knowledge layers, and the design in at different locations and isomerism.

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