A Peer-to-Peer Based Communication Environment for Synchronous Collaborative Product Design

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Abstract. Efficiency and timeliness of collaborative communication among geographically distributed design teams are vital to collaborative product design for synchronous exchange of product design information and faster product availability. This paper introduces a preliminary research work about P2P&VRML-based collaborative communication environment that attempts to support synchronous collaborative product design in the way of WYSIWIS (What You See Is What I see). A prototype with communication means of document co-sharing & editing, draft co-drawing, instant message and VRML-based visualization space is developed on the basis of JXTA platform. Collaborative model modification is performed by cooperation between document co-editing space and VRML visualization.

Keywords: Collaborative design, P2P, VRML, CSCW.

1 Introduction

Nowadays, market globalization is increasingly driving industry to be highly desired for synchronous collaborative product design environment to perform multi-sited product design cooperation with partners around the world. During design processes of complex product, such as automobile and airplane, accuracy, timeliness and efficiency of product design information co-sharing and co-operating among geographically distributed design teams are essential for companies to reduce design failure-rate as well as design iteration loops, to shorten lead-time for faster product availability, and to keep dynamic enterprise group competitiveness to market. With the expansion of internet and development of web-based technologies in the past decade, collaborative product design to support CE (concurrent engineering) has attracted more and more attention in the research field of CSCW (computer supported cooperative work), which is promising to get satisfied solution with highly synchronous collaborative capability to enhance enterprise group competitiveness and to make full use of resources in enterprise group. Synchronization and interoperation are the emphases for a collaborative product design system to ensure real-time interactions among distributed work teams. Establishment of a synchronous communication environment to make cooperation working in the way of WYSIWIS (What You See Is What I see) is a well-know problem in CSCW research field.

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Up to now, many collaborative design systems somehow supporting collaborative design activities, such as collaborative model annotation and visualization, are developed on the basis of C/S (client/server) or B/S (browser/server) network architecture. C/S or B/S is also relative common network architecture in almost all database, web, business, and communication applications. However, in C/S or B/S collaborative design environment, all the system grouping, operation, and communication have to rely on central server, single point bottlenecks always rise because of limited bandwidth, and system maintenance cost is very high as well. Bidarra, R. et al [1] developed a C/S based collaborative feature modeling system, named WebSPIFF. Fat server generates selection model with a set of feature canonical shape in VRML format; thin client directly visualizes VRML model under Java3D based scene; real time interactive model manipulation is performed by collaboration of feature shape selection on client side and feature parameter modification on sever side. Li W.D. et al. [2] developed a manipulation-client/modeling-server infrastructure to accomplish feature-based collaborative design environment, in which light face-based representation on the client side supports interactive visualization and manipulation, a heavy representation with features and part information on the server side provide primary feature-based modeling functions, and a distributed feature manipulation mechanism is presented to facilitate efficient information exchange for larger size 3D (3-dimensional) model. CollabCAD^{TM} [3] is a modeling-client/communication-server based commercial collaborative framework developed by using Java3D and RMI. Many open sources and standards have been adopted to achieve inter-application operability, e.g. Open CASCADE for 3D modeling engine, JPython/Jacl for client-side scripting, STEP for product data exchanges, XML (Extensible Markup Language) for geometry data storage and database connectivity, VRML for preview, and CVW (Collaborative Virtual Workspace, from Mitre Corporation) for collaborative functionalities like video, voice, text, and white-board conferencing. Event-transmission collaborative mechanism for one participating site to observe what is happening on the other site by executing received events individually is employed. Whereas, its collaboration environment is not heterogeneous since the same kind of sophisticated design capability is set up to all sites, and computing resources are not utilized efficiently due to the same execution process be repeated at different sites. OneSpace.net^{TM} [4] is another commercial collaborative product with manipulation-client/modeling-server to support multi-party 3D CAD design reviewing and engineering data sharing. However, its modeling ability is limited because of lacking sophisticated geometric kernel in server.

P2P (Peer-to-Peer) network closely mimics collaboration among persons in society. In P2P network, any computer or device, which can be connected with each other through network, is generally called peer; and peer acts as both client and server, that is, it is not necessary to have an intermediary or a centralized repository like server for communication between peers. P2P network technology has advantages, which C/S or B/S lacks, such as convenient direct exchange of data between peers to minimize workload on servers and maximize overall network performance, sufficiently utilization of large scalar resources from any other peer, and flexible and dynamical structure to enable join in and leave in voluntary and convenient way. In contrast with C/S or B/S architecture, P2P has the more promising potential to provide synchronous collaborations for large-scale distributed involvers in