Design of the Improved PDM and the Real-time Collaborative Viewing System

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ABSTRACT

This paper describes design methods of the improved PDM and the real-time collaborative viewer. The improved PDM system is designed based on UML. Database Searching speed on the network and automatic creation of UI through the UI builder have been studied in this paper. The real-time collaborative viewer has been designed to eliminate network dependency. It reduces the cost of implementation and management of the system. As the developed system is lightweight, it runs on all types of networks from high-speed LANs to wireless connections. Collaborators can check dimension errors, human factors, form errors, as well as mark up the important parts and deliver messages of their views over the Internet. Functions of 2D and 3D data viewing, markup and annotation, dynamic sectioning, printing services, and real-time conferencing combined with the PDM render real-time benefits to reduce production time to market and design cost. The usefulness of the developed system is confirmed through case studies.

Keywords: Dimension PDM, UML, Real-time Collaboration, Viewing system, Dimension verification.

1. INTRODUCTION

PDM and collaborative viewing systems are indispensable for the current design and manufacturing environment. Many kinds of PDMs and viewers are being applied in the manufacturing industry. However, there are several limitations. Dassault System's SMARTEAM [1] does not adopt standard UML in the design process. It is impossible to express multi-inheritance and to cope with various requirements of clients. MatrixOne PDM [2] supports multi-inheritance but it has difficulty to implement UI. In addition, most PDM systems drop their average searching speed when the data size is big. After relieving the reason of the low speed transmission as well as the drawbacks of the current PDMs, the improved PDM system has been developed for the fast transmission of data and convenient usage of the system.

For the collaborative viewers, Kan, et al. [3] have studied a real-time collaboration system for product design over the Internet environment by using Virtual Reality Modeling Language(VRML) and Java applet. Huang, et al. [4] have created a standard Internet based Design for X (DFX) shell that provides a framework in which many types of DFX tools can be operated. Chen, et al. [5] developed the Internet-enabled real-time collaborative assembly modeling system using Java RMI and STEP. However, there are following problems: (1) Those systems use the middleware such as CORBA. CORBA requires not only high performance hardwares but also is very expensive. (2) Since a lot of data are transmitted during the collaboration process, it is impossible to realize the real-time collaboration over the low speed network environment. (3) It is impossible to transmit information across the firewall installed in most companies. (4) Since the program to be installed in a client side is very large, it takes long time to execute the viewers.

To compensate for these drawbacks of the previous viewing systems, a real-time multi-viewer is developed on the open-architecture web server, Apache, in this paper. As the Apache is used for the viewer, it is inexpensive and does not require high-performance hardwares. In order to increase the data transmission capability, all transmission data are converted into parameters. This conversion reduces the transmission time and overcomes the network speed limitation. The developed system works well even over the low speed network environment. It runs on all types of networks such as high-speed LAN, dial-up modem, wireless connection and so on.

As the real-time viewing functions are constructed over the ActiveX control environment and the file size of the ActiveX control is light, client application for the design and dimension verification does not need to install the developed application software before using the system. Collaborators are able to perform real-time 2D and 3D viewing, precision measurement, markup and annotation, dynamic sectioning, printing services, real-time conferencing combined with PDM and so on over the Internet Explorer. The proposed system helps to reduce production cost, errors and lead-time to market. Performance of the developed system is confirmed and verified through case studies.

2. DESIGN OF IMPROVED PDM

2.1 Architecture of PDM

Fig. 1 shows the architecture of overall PDM. The DynaFramework serves as the foundation for the overall DynaPDM environment and is the underlying engine for DynaPDM's business process applications, modeling capabilities and integrations. Each function of DynaFramework Serves which are marked in Fig.1 is described in Tab. 1.

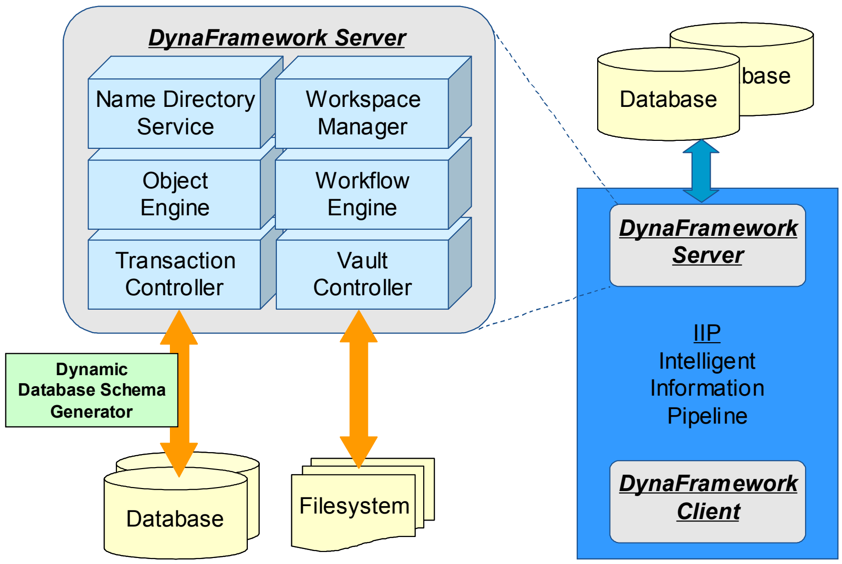

Fig. 1. Structure of the developed PDM system.

Server Name	*Functions*
Transaction Controller	Manage connection pool which connects with database. Manage distribution transaction.
Vault Controller	A kind of file server which provides logical file system.
Object Engine	It stores and manages UML based object transaction Engine, class definition and relation definition on database and provides powerful search function.
Dynamic DB Schema Generator	It reflects logical structure to physical database table.
Workflow Engine	A workflow engine built based on W*f*MC specification [9].
Name & Directory Service	A kind of directory service similar to LDAP [10] or Active Directory.
Workspace Manager	Service to manage personal working environment Information created by each DynaPDM user.

Tab. 1. Functions of DynaFramework servers.

2.2 UML Based Object Engine

Other PDM products also automatically create database schema through object model and search or add data by using object transaction engine. However its object model is not a standard format and can not cover various and complex

needs from different kinds of company which to introduce PDM system. For example, if the PDM product cannot support multi-inheritance or cannot support different and complicated relationships between Objects, it results number of limits on modeling process of company information. By this reason, the information system between actual enterprise and system becomes different and it decreases system application usability [9].
This system defines object model based on standard object model tool, UML. It enables not only multi-inheritance but also to apply company's information structure, which is modeled by UML and such as association relationship between objects, on system just as it is.

2.3 Speed Improvement of Data Searching

Generally searching data from larger database takes more time. Even though the system fully implements object model, if it takes longer time to search data for larger database, this is not a good system. To overcome this problem, IIP(Intelligent Information Pipeline) which does not effect total system performance under increasing data environment, was developed. IIP is a protocol which is located in the lower lever of DynaMOAD framework, a kind of RPC(Remote Procedure Call) and one of core technology of DynaMOAD framework. IIP automatically recognize kinds of data which is transferred to network and it is an intelligent transfer algorithm which uses the most optimized transfer routine for each different kind of data. The detailed methodology is as below. Below special process is created to result optimized performance for creating database schema based on object model.
Object transaction engine can predict in what structure the database schema created and it able to create optimized SQL for each request. Also when class specific property is changed, it finds the exact property which changes the value of object transaction engine among all different properties for class and creates SQL to modify updated value. Data search is more complicated.
There might be more than one class to search and it might have complicated inheritance relationship. After analyzing all those relationship the object which is needed for actual search is determined. Optimized searching SQL is created with same method as how database SQL Optimizer works. By this object transaction function, system's reply speed can be improved even under increased number of data. IIP have more quick response over 192% than Java RMI.

2.4 Automatic UI Generation

Making elaborated data structure is a key for implementing PDM system. However it is often overlooked of importance of UI. Even though delicate and logically seamless data structure is constituted, it is not a good system if user has difficult access to data. All UI in PDM system should work consistent way and should provide optimized screen configuration to increase data application. Those kinds of UI should provide with user the same way of vision no matter what it is rich client application or Web-based environment. To solve this problem, all screen configurations are saved and managed in PDM server through object transaction engine and also after analyzing actually used screen configuration method, user required information is able to be expressed efficiently.
This system designated the screen configuration tool, which performs above functions, as UI builder. This UI builder brings required screen configuration information from object transaction engine and automatically creates relevant real-time UI. This also works by same method in Web-based environment and actively creates HTML page. If PDM administrator or developer modify screen configuration, those modified screen is real-time reflected on Web or rich client.

2.5 Graphic User Interface of PDM Developing Tool

This is object modeler of DynaMOAD, PDM system developing tool. Ⓐ of Fig. 2 is composition tree of object level and it shows information of object, filed etc. Ⓑ of Fig 2 is menu which defines class related information and it can defines reference, event, numbering rule etc. Ⓒ of Fig 2 is input window to input each attribute.
Fig 3 is workflow modeler of DynaMOAD. Ⓐ of Fig 3 shows business process. Ⓑ of Fig 3 shows activity, sub level of business process. Also Ⓒ of Fig 3 is graphical process editor which can make and edit workflow on graphic.

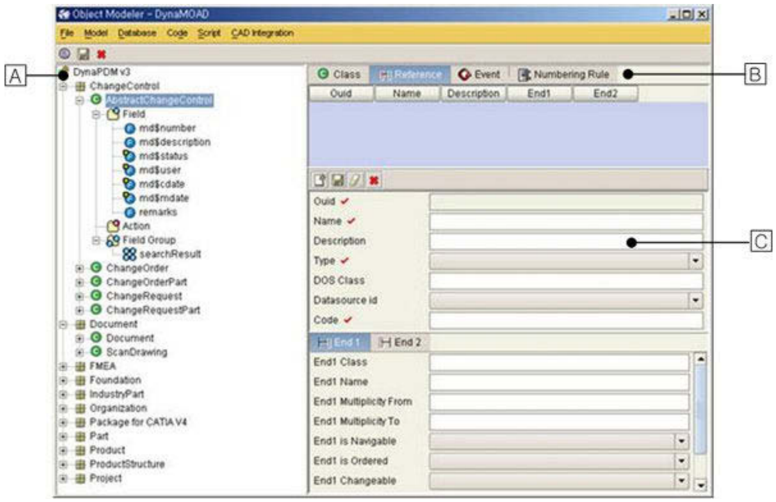

Fig. 2. Object modeler of DynaMOAD.

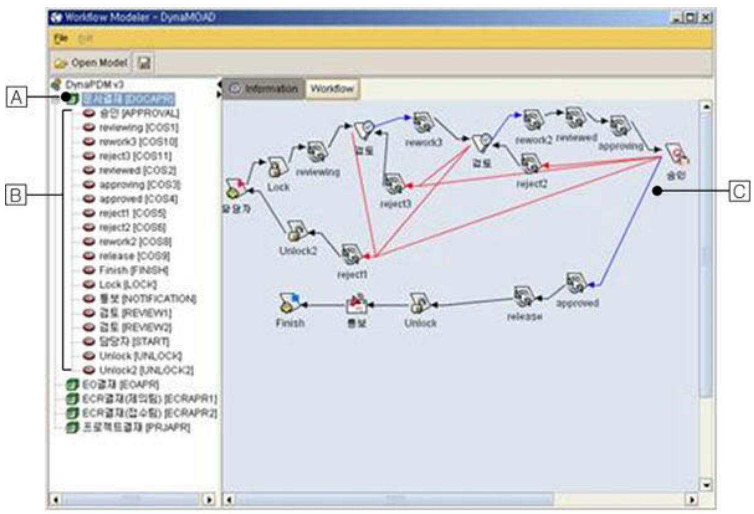

Fig. 3. Workflow modeler of DynaMOAD

3. COLLABORATIVE VIEWING SYSTEM

3.1 Architecture of Collaborative Viewing System

Fig. 1 shows the architecture of a collaboration server. As the collaboration server, four-tier architecture is proposed to enable a distribution processing when multiple users connect to the server at once. Four-tier client/server architecture is proposed to realize the real-time collaborative product design and dimension verification system. The first tier in the client region consists of an administration web page and viewing ActiveX control. The second tier is the web server. It controls clients by using the administration page. Clients communicate with the server through the HTTP protocol. The third tier, which is realized through the JSP(Java Server Pages) and the Servlet engine(Tomcat), is the web container dealing with dynamic web service. Tomcat of the Apache Software Foundation is selected to act as the engine of JSP and Servlet. The fourth tier, collaboration extension module, takes charge of the collaboration functions such as transmission of parametric data, files, markups and chatting information. This is realized through Java. Real-time viewing functions are constructed over the ActiveX control environment.

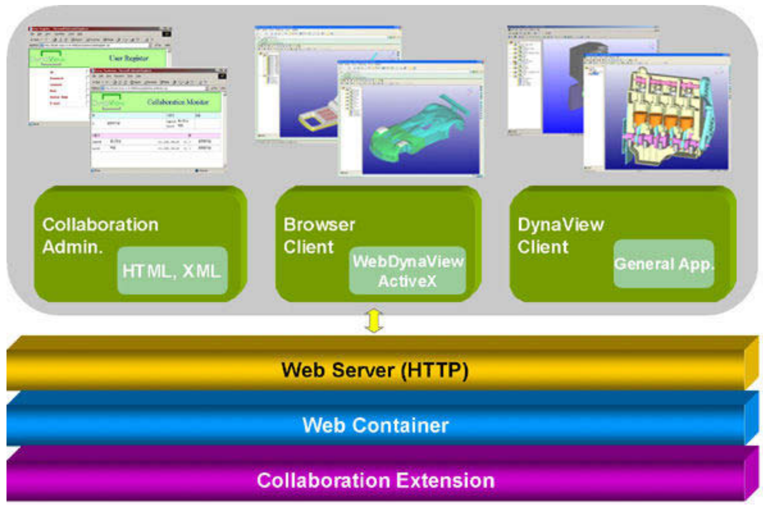

Fig. 4. Structure of the real-time collaboration system.

3.2 Real-time Collaboration Work

Collaborators are able to conduct real-time 2D/3D viewing, precision measurements and markup through the proposed real-time collaboration system. ActiveX control is downloaded directly into the client system from the server. In order to protect the collaboration work, communication between the client browser and the collaboration server is performed through the encrypted mode. Functions of the real-time viewer are constructed over the ActiveX control using the visual C++ and OpenGL. Fig. 5 represents a configuration of the collaborative ActiveX control. In the previous system [4], it is impossible to conduct real-time collaborative processes on low-speed network environment because a share of CAD data causes overload to the network. In order to accelerate the data transmission capability, the developed system is constructed to share the native file instead of the CAD file, and all transmission data are converted into the parameters.

Functions of the developed system have been constructed by using the ActiveX control plugged in the Internet Explorer. All contents of collaborative works are transmitted to multiple users through the collaboration server as shown in Fig. 5.

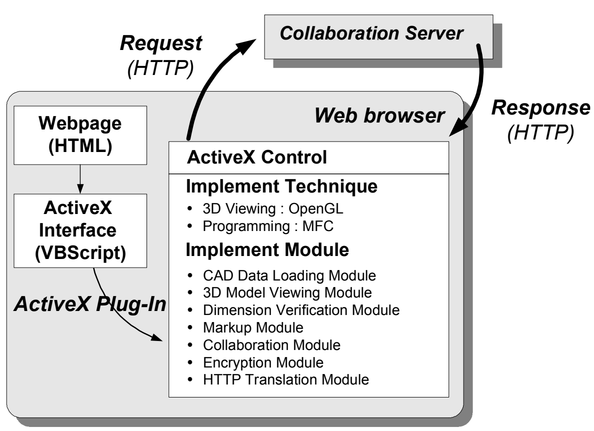

Fig. 5. Configuration of client ActiveX for the real-time collaboration.

In order to protect the collaboration work, communication between clients and the collaboration server is performed through the encryption mode. Moreover, the proposed system applies HTTP protocol to transmit data and to overcome firewall systems in companies. Fig. 6 represents workflows of the collaborative ActiveX control [11-13].

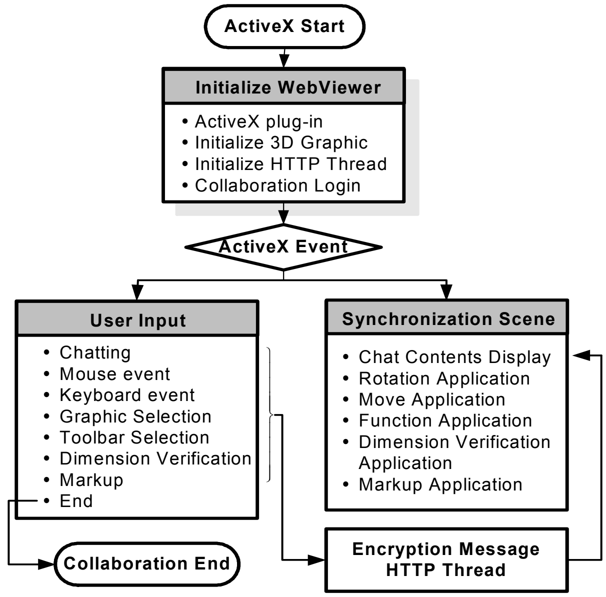

Fig. 6. Algorithm of the client ActiveX for the real-time collaboration.

Fig. 7. Structure of the native file converter.

3.3 Design of native file

In general, VRML is considered as a viewing tool of CAD data on the Internet environment. However, it takes much time to transform the CAD data into ASCII format by using the CAD API. Moreover, VRML has only the facet data. It is not sufficient for the dimensional verification. In order to overcome these problems, the proposed system uses the native file transforming the CAD data into optimal format through the translation server constructed by using the ACIS kernel and InterOP. The native file includes not only facet data for design verification, but also edge and topological information of CAD data for the dimension verification. New dimension verification results or mark up messages are included in the mark up file followed by a separator. In order to allow a lot of consultation from the clients, a hyperlink function is also used in the mark up function [5]. The native file size is reduced to around 90% through a binary conversion and compression processes. Fig. 7 shows a structure of the native file converter.

3.4 Case study – Real-time Collaborative Viewing System

Effectiveness of the proposed system is verified through design verification of car clutch parts. Fig. 8 shows a Graphic User Interface(GUI) and a start-up process of the real-time collaboration system. The symbols A, B, C, D, E and F in Fig. 8 mean verification and markup toolbar, management treeview, a login window, a dialog box for chatting, graphic set up toolbar and display area, respectively. Real-time collaboration procedure is described as follows:
Step 1: Access the web page and plug the real-time collaboration system in the user's web browser.
Step 2: Click the collaboration start icon, and input ID and a password through the login window.
Step 3: Select a session for collaboration.

Fig. 9 shows a design and dimension verification example. Collaborators related to the development of a new product are able to perform real-time collaboration according to the above steps.
If collaborators do not satisfy certain design results after the dimension verification procedure, they will leave verification message by using the markup and annotation function. As shown in A of Fig. 9, the rectangle and the arrow existing in the markup function deliver another verifier's message regarding the problem of the current design. Since this markup function can be added on the verification file as a hyperlink function, clients are able to deliver their opinions in detail.
If a collaborator wants to verify the thickness of the clutch cover, the collaborator should select the lines B and C after selecting the icon existing on the verification and markup toolbar shown in A of Fig. 8. These actions compute the minimum length between the lines. Dimension verification data of the clutch cover is given by 32.197 mm as D of Fig. 9.
E of Fig. 9 shows the distance of 28.000 mm between bolts by using the function to compute the minimum gap between circles. After selecting the angle measurement icon and clicking F, G and H points successively, the angle of 3 points, 83.342°, is obtained as I of Fig. 9.
K in Fig. 9shows a communication example among three collaborators by using a chatting function. This function assists collaborators to communicate design ideas in detail. Moreover, all collaboration contents, such as precision measurement, markup, annotation and chatting contents, are saved as a native file. After disconnecting the server, a design supervisor can modify the current design as an updated design according to the collaboration contents. All contents described above have been observed and controlled by collaborators participating the collaboration at the same time. Collaborators attending the collaboration session are able to express their design and production ideas at real-time.

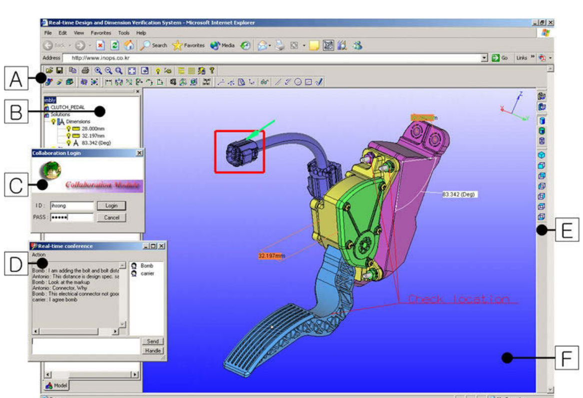

Fig. 8. Graphic user interface of real-time collaborative viewing system.

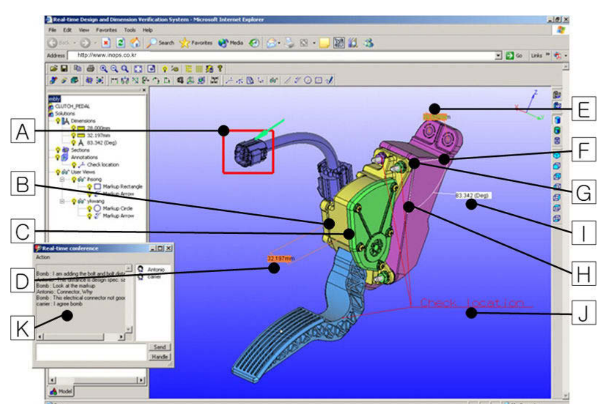

Fig. 9. Design and dimension verification.

4. CONCLUSIONS

The improved PDM and the real-time collaborative viewer have been developed in this paper. Following results are obtained:

(1) Standard type object models are designed through the UML. Development of the IIP renders the system reaction speed fast. Screen configuration data are taken from the object transaction engine and the developed UI builder automatically generates relevant UIs in real-time.

(2) As the native CAD file translator is developed through the InterOP and ACIS kernel, geometric topological information is maintained as a parameter in the lightweight CAD data. The real-time collaborative viewer is executed on the Internet Explorer through the lightweight parameters.

(3) Designers, customers and manufacturers, who are geographically separated, are able to verify design results and dimensions over the Internet. In order to protect the collaborative work, communication between clients and the collaboration server is performed through the encryption mode. To overcome the firewall in companies, HTTP protocol is used for the data transmission.

(4) As the system has an open-architecture structure and does not use CORBA, additional modules and /or functions are added to the system conveniently.

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