COLLABORATIVE DESIGN REVIEW IN A DISTRIBUTED ENVIRONMENT

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Abstract

This paper investigates how collaborative environment technology can be used to integrate geographically dispersed design teams and other technical and non-technical members from within and outside the organisation to support collaborative product design reviews. The creation of such a collaborative environment for design will allow participants from different phases of the product development cycle to collaborate and form a virtual team. A new framework is proposed to extend the current advances in collaborative technologies to provide access to local and global resources within design teams and the deployment of private and public design review workspaces to provide an efficient collaborative design environment. Also, a prototype collaborative CAD environment has been developed and the results are discussed in this paper.

Keywords: Collaborative Design, Shared Workspace, Design Review

1. Introduction

In the past few decades, the global financial market has seen a shifting trend of the leading industries in focusing their visions more towards the international market than just the home market. This ‘globalisation factor’ has urged them to span the growth of their business to other parts of the world and utilise the resources available there. At the same time it has raised the standard of competition among them. There are some other factors that arise with time and seeking for a better collaboration, like increasing the role of the component and service suppliers in the decision making policy of Original Equipment Manufacturer (OEM) in giving the final shape to the product \cite{1}. The strategies are followed by industries in de-constructing and concentrating on the core competencies leading to the implementation of the concept of distributed virtual enterprises. In such distributed virtual enterprises, the actors comprised of different cultures, different languages and concepts, using different tools and processes. A collaborative Product Commerce system is the dominant technology for managing inter-enterprise data and providing design teams with a virtual design space. Better collaboration during the design stage can help in reducing design time typically by 25-40\% \cite{2}. To prevent inconsistency among sub-solutions, designers must communicate and negotiate with each other sufficiently so that the needed information flows timely, knowledge about the design is shared, and design activities are well coordinated \cite{3}. Product design review is a typical scenario of collaborative product development. A typical design team is comprised of members from multiple disciplines and also geographically
dispersed. The design review and the engineering change approval can take place in a collaborative environment during the detailed design stage of the product development through the web site and the conferencing tools [4]. The author in [5] describes numerous ways of conducting design review.

This paper has been structured in a way to cover the various aspects of the collaborative design review, starting from available commercial and research-based tools overview to the proposal of new system architecture and its implementation results.

2. Related work

In this widespread market world, many leading CAD industries have already begun in-house development and offer some kind of collaboration functionality within their CAD products/services. Similarly many third-party vendors have developed collaborative tools that can be used along with existing non-collaborative products.

2.1. Commercial solutions

Although there are several tools currently available in the market, claiming to aid the design collaboration, only some of the common ones have been considered here because of their distinctive features and different approaches towards providing collaboration facility for design. For an off-line collaboration, email-based eDrawings Professional [6] serves as a strong candidate as any members can be approached for their feedback/review without the concern of registration or a special system set-up. It provides most of the tools necessary for reviewing the CAD models along with the ability to review Analysis files. Pro/COLLABORATE [7] is good for design members who want to share both CAD and non-CAD files and work in a project management environment. However it is more suitable to Pro/ENGINEER members as only they can initiate the whole process of sharing design information and only Pro/ENGINEER CAD files can be reviewed. CATweb Navigator [8] can initiate the process of collaboration with any standard Java-enabled browser with no extra plug-in to be downloaded. Sharing, viewing and editing of models with normal browser make the whole process easier and quicker on different platforms. OneSpace.net [9] works in the similar way but has additional facilities of collaboration: real-time text-based meeting, and editing of CAD models by sharing the application during the meeting. Additionally it supports several CAD file formats and also has better security for data-protection during the review meeting.

Unigraphics NX [10] and CollabCAD [11] products best support the real-time collaboration as they provide different channels of collaboration like text/audio/video/whiteboard-based meeting for the design review. They also permit editing of CAD models by all the members present in the meeting. Unigraphics NX supports CAD/CAM/CAE compared to CollabCAD that supports CAD/CAM only. CollabCAD has Client/Server architecture; only restricted number of members can access the system collaboratively. With regards to maturity, CollabCAD is still in the process of development and quite new compared to the well established ones.

2.2. Distributed virtual reality based solutions

The proposed system and its implementation are based on the distributed VR technology, it is important to discuss this domain as well. As stated in the Roadmap for Future Workspaces [12] the current state-of-the-art will allow real-time collaboration between distributed sites especially in aerospace, automotive and building construction sectors, but critical security issues and network bandwidth limitations and their associated costs restrict effectiveness. At present the distributed Virtual Environments are not tightly integrated with the useful engineering tools and they are less user-friendly. In commercial sectors, various toolkits are CAVElib, Division’s dVS, Sense8’s WorldToolkit and Panda3D and in research category the list includes MR toolkit, GIVEN++, DIVE, BrickNet, Alice/DIVER, Aviary, Maverik/DEVA, VR Juggler, Bamboo and Dragon [13]. Some other popular distributed environment like Avango, MASSIVE, FAVE, DIVE, Ygdrasi, etc are highlighted by [14, 15].

DIVE [16] provides architecture for implementing distributed multi-user interactive virtual environments in a heterogeneous network environment. The framework is developed around the concept of shared distributed world database. FAVE is generic software Framework Architecture for Virtual Environment created for developing VR applications [17]. For creating synchronized distributive VR applications, the application must start up in the same state and receive only changed data at run-time providing remote distributivity with low network traffic. These applications have been used for developing applications in Urban modelling, Simulation and visualisation of gas explosions and
fire, and in Medicine field.

It is found that none of the system/toolkits/services mentioned so far discuss about setting private/public area within shared workspace or use of local/global resources in any noticeable way.

As Hydra [18] is an in-house development and provides the necessary features along with needed technical assistance, it is used as the base for developing the prototype application for the proposed system in CAD field. It is similar to DIVE and FAVE, Hydra is a software framework for developing flexible distributed, multi-user interactive visualization and simulation applications [18, 19]. It can deploy and control many interconnected applications like CAD, CAE and Virtual Reality applications at geographically remote locations and can be manipulated by multiple users. The distribution module of the HYDRA uses CORBA with TAO providing distribution protocols for data distribution enabling flexible deployment of software components and multi-user interaction over different operating system. The developer of Hydra has also provided a visualization interface, called viSpaces.

The next section will explore how current distributed system can be further extended to exploit the local and global resources of companies and support human-human collaboration through private and public shared workspaces in a business setting.

3. Proposed system design

There is a need for better way of utilizing the shared workspace and also the resources available with some of the team members. Based on these requirements and the current trend in the industries a system design is being proposed here. Figure 1 shows an overview of the system architecture to illustrate how the overall system would shape to enable collaborative design review by geographically distant team members.

Client here is considered as a virtual team member situated geographically apart from other team members during the design review meeting. The local resource exists locally on the computer system of the clients. Only this client of that system can access this resource directly and manipulate it. This resource here can be a CAD system for 2D/3D modelling, a finite element analysis system for stress/displacement analysis of parts, or any simulation system like assembly simulation or motion simulation system. A global resource is similar to a local resource but is public in nature so provides unrestricted accessibility by any team member (client) during the design review meeting. Shared Workspace is a virtual workspace containing design information brought through individual resources and accessible by all the team members over the network.

3.1. System operation

In this architecture, team members, referred here as clients, are geographically separated from each other. The clients connect to the shared workspace using the interface provided by the executable application on their computer system. This way shared design information becomes available to team members. On a request made by any team member, the client connects to the local resource available on his computer system. Depending upon the resources available, the respective information is pulled to the shared workspace through the application interface and which in turn updates all the clients’ applications. Similarly other team members can make their design information available through their resources to this shared workspace. As this local resource is held by the client, only he/she can decide what design information needs to be shared. Other members access this local resource indirectly. As the connection with a resource is maintained, the member holding the respective resource can carry out the design changes needed during the review process itself. Every other team member can see the changes in the design from their own locations.

Besides the local dedicated resources, a global resource is also maintained in this environment. This global resource can be residing anywhere geographically but can be accessed by all members over the network. The design data for global access/sharing by every team member can be put in this global resource. The team members using
collaborative tools can provide feedback like accepting or rejecting the design changes or requesting the further changes immediately. Here, clients can participate in the design review process from any computer with any operating system connected to the network. This will lead to an efficient design review process.

3.2. Client-side system architecture

Figure 2 shows detail architecture of this client-side system. The descriptions of its individual components are described below.

3.2.1. Client application

A client is a member of virtual team collaborating together to discuss the design related issues during the design review meeting. It is an external physical entity interacting with this system. Each client has a front end (a visual interface) that would allow him/her to visualise and interact with the design data and also to collaborate with other team members (clients) in real time. To initiate progress and conclude the design review one of the team members will need to act as a team leader during the meeting. It is also possible that any client can share the design information with other members of the team through the local resource that is dedicated (private) to him/her. He would be the person responsible for editing and manipulating the design information to apply the design changes if required by the members during the review. This would be particularly in a case where the client representing any organisation can share the design information for visualization purpose but needs to restrict other members from manipulating or editing it directly in his private resource. Indeed all the clients can have direct control over the global resources where they can apply the design changes raised during the review.

3.2.2. Local services

The client application would use this services to perform the requirements of the client such as visualising and manipulating the design data, navigating to study it, and providing feedback for communicating their views to others participants. Local resource service provides the way of sending commands to a local or global resource to do specific tasks like requesting to load a CAD model, sectioning the model (in the case of CAD modelling), or changing the load pattern / its orientation (in case of FE analysis simulation). The scene data management service of Shared Workspace would manage the design data retrieved from resources so that all the clients can access it from their terminals for visualisation purpose. The rendering service retrieves the most current design information from the scene data management service of Shared Workspace and prepares a scene for visualisation. The GUI service allows clients to interact with the scene objects directly. It also allows clients to do specific operations for which communication with the local or global resource is not required, e.g. moving the components in an assembly, viewing an exploded view, or measuring a part. Such operations will be performed locally at client-end without affecting what other team members’ view at that time.

3.2.3. Shared workspace

Shared Workspace has a high-level object-based description that is rendered by the user interface at each client’s end participating in the design review meeting so that they can visualize and interact with shared design objects. All the clients
share the design information through this virtual shared workspace.

Scene Data Management Service manages the design information received through the local or global resource. This design data is stored in a high-level object format so that it can be shared, distributed and rendered by all the client applications to form a scene for visualization purpose. Whenever a local service interacts with a local or global resource and looks for anything to be updated in the scene, it updates its dataset and the Distribution Management Service then updates it for each client. Team-management service is needed to take care of the administration related tasks that include managing team-member’s database, authentication, control passing mechanism, maintaining the privately shared workspace with the right members only. The real-time conferencing service will aid collaboration among the team members efficiently besides the sharing of design information using text, audio, video, whiteboard tools/services.

This shared workspace can further be classified in two types namely publicly shared workspace and privately shared workspace. All the design information that is available in publicly shared workspace can be read and visualised by all the clients in the meeting. In case of privately shared workspace some part of the design information contained in shared workspace will be accessible to only few team members who are already in a mutual agreement. This could be important when some team members are working for the same organisation but located in different regions and want to exchange ideas or discuss design issues that are not meant for rest of the team members who belong to different organisations. Figure 3 illustrates a case of using these types of shared workspace. Client A, B and C all have equal access to Public area of shared workspace whereas the accessibility of Private area in the shared workspace is limited to Client A and B only.

3.2.4. Local resource

A Local Resource describes a part of the system that is dedicated and available only to the client accessing it directly. Only this client can modify/manipulate the design source for any design changes proposed and approved during the design review. Once the design changes are applied by the owner client, the refreshed data is sent back to the shared workspace. Global Resource is similar to a Local Resource but the only difference lies in that the local resource is dedicated to only one client who can access it directly whereas all the clients can access a global resource directly.

4. System implementation and results

The primary author of this paper took Hydra framework as foundation and added functionalities to assist collaborative design review specifically in CAD modelling field. A CAD Plug-in module has been developed so that the design team member can connect, access and edit CAD models in a CAD system (local resource) and share updated design models with the other team members anytime during design review meeting. SolidWorks® CAD package is used here as a CAD System.

The plug-in module creates the virtual reality model corresponding to the actual CAD model for display purpose. It directly communicates with the CAD system using different APIs provided by the CAD System. Figure 4 shows CAD plug-in work with Hydra System to give exposure to CAD System.

Besides visualization of model, the system also displays CAD system alike components and features-history in tree-structure format. It also shows the
dynamic characteristics like mass related properties for this model. Client can modify CAD model in the CAD system and the design changes would be reflected immediately in the visual interface of the distributed review system. Design team members use text-based chat tool to give any feedback during the review.

5. Conclusion

This paper proposed a framework which considers the integration of resources and methods of working in a collaborative product development setting. In particular, the integration of local and global resource with private and public shared workspace to provide a rich collaborative design environment was introduced. A part of the proposed system was implemented to help in conducting the design review process for CAD Modelling. The implemented CAD plug-in is now integrated within the HYDRA architecture.

6. Future research work

It is possible to extend interfaces to other kind of CAD systems and create a heterogeneous CAD environment for reviewing purposes. Besides this, further research could be carried out to integrate other simulation software like kinematics and stress analysis, assembly, maintenance into the design review environment to support multi-functional teams. This will offer a powerful design review and problem solving environment for distributed design teams.

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References