Shared VRML (Virtual Reality Modeling Language) Browser for Collaborative Assembly Design

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ABSTRACT

Previous tools for collaboration on WWW do not support real-time interaction and three dimensional data exchange. We developed Shared VRML Browser(SVB) to overcome these limitations. The SVB, an extension to VRML browser, allows to fetch and navigate in three dimensional world WWW and share URL and user interaction among the paticipants using IP-Multicast. Using SVB, we have experimented to sharing of an assembly product model among the team members across the network. While several aspects of this system need further development, the implications of design and manufacturing engineers as well as customers being able to routinely work in this fashion are far reaching

Keywords: World-Wide Webs, VRML, Collaborative system, Assembly, IP Multicast

1. Introduction

With the emergence of a more integrated global market place and increased competition, engineering companies are changing the way they work. Many companies are taking strong interests in concurrent and collaborative approaches to design and manufacturing. But, current design and manufacturing systems do not support product development in what engineers spend most of the time : supplemental tasks such as gathering and organizing informations, communicating with clients, suppliers and colleagues, negotiation of tradeoffs, and using each other's services.

To overcome these difficulties, we need an open, network-oriented environment for concurrent engineering and rapid prototyping. Recently, the World-Wide Webs(WWW) [Berners-Lee, 1992] service is widely being used for data exchange and collaboration in the internet wide area network. WWW, in conjunction with tools like Mosaic[Berners-Lee, 1994], is an extremely effective mechanism for individuals to share distributed information. However, access to this information on WWW is unidirectional with limited real time interactions. Furthermore, it is limited to predefined data by a client/server model. While this client/server model is ideal for archiving, we are convinced that real-time sharing of interaction between two or more engineers requires a publisher-subscriber communication model. Also, we need three dimensional data in WWW to securely share the model data rather than static images.

Currently there is an emerging standard for a networked virtual environment named Virtual Reality Modeling Language(VRML)[G.Bell et al., 1994]. It is conceptually similar to the core Web text standard HyperText Markup Language(HTML)[Berners-Lee, 1993] and encodes computer-generated graphics into a compact format for transportation over the network. 3D using VRML enables an entirely new paradigm of navigation in WWW and can greatly enrich information space on WWW. However, current 3D browsing using VRML in WWW is not yet support real-time collaboration because it does not support real-time interaction among paticipants.

We have difficulty in collaboration for assembly design using such WWW service. Here, we present a new collaborative system for assembly design with the following features. It should provide a three dimensional shape, properties, behaviors, and their placements in 3D space and be easily customizable to fulfill the needs of a team. It should be capable of using the Internet effectively and support data exchange interactively. Finally, it should interface to an archival site in the Internet to access the WWW. With these in mind we developed a Shared VRML Browser(SVB). The SVB is an extension of VRML browser and allow the participant to conduct WYSWIS(What You See is What I See)[Stefik et al., 1987] in which everyone sees the same thing all the time, by the sharing of URLs(Uniform Resource Locators)[Berners-Lee, 1993], camera direction, and user interactions. SVB interacts bi-directionally with Mosaic using Common Client Interface(CCI)[D.Thomson, 1995] to provide 2D based information. In our collaborative system, two communication models, client/server and publisher-subscriber models are integrated to acquire data and multicast user interaction. This paper discribes how client/server and publisher-subscriber paradigms are reconciled.

2. Related works

Many tools are being developed to facilitate collaboration on WWW. First, WWW Interactive Talk(WIT)[Ari Luotoren, 1995] is a form-based discussion system which was announced shortly after the WWW 94 conference in CERN in order to allow discussion on WWW technical matters to be stored in a more structured fashion. Second, Hypermail[Kevin, 1994] is a utility that can be used to convert mail archives to hypertext format on WWW. However, these collaborative systems do not support real-time interaction among the paritcipants.

So, recently Shared Mosaic[Vinay, 1995] is being developed to support bi-directional collaboration and is an extension of NCSA's WWW browser XMosaic. Using Shared Mosaic, we can conduct WYSWIS type of collaborations. It is a loosely controlled session, therefore anyone can drive in WWW highway and give others a Tour of the sites(URL's). However, Shared Mosaic does not support visualization and interactive navigation of three dimensional environments. Using shared Mosaic, the scientists, architects and engineers who need a sense of three dimensional shape, behaviors, properties, and their placements in the three dimensional space cannot interact with the semantic content of the information. There is another collaborative system, webcast[Burns, 1995]. webcast enables a group of a

Mosaic instances to traverse and share a set of WWW documents via MBONE(Multicast Backbone)[Casher, 1993]. webcast is an intermediary between Mosaic and the MBONE. However, webcast like Shared Mosaic does not support three dimensional data and various user interaction.

In order to support the three dimension in WWW and to conduct WYSWIS kinds of collaborations we have been undertaking the development of Shared VRML Browser(SVB) by integrating the VRML browser and Mosaic. SVB enables a group of SVB instances to traverse and share a set of WWW URL's, camera direction, and participant interaction and support Multicast-IP based group collaborative sessions. IP Multicast allows the transmission of a single packet to a subset of all the possible destinations. Members of this subset are said to form a multicast group. In the Wide Area Network(WAN) situation, participants may be required to have an MBONE connectivity. While IP Multicast is scaleable, it does not provide reliability, packet ordering, or fault-tolerance. To remedy these deficiencies, in our system, we use Reliable Multicast Protocol(RMP)[Montgomery, 1994] to provide more reliable multicast and more elaborate session information.

3. Overview for Our Collaborative system on WWW

This section describes overall concept of our collaborative system using SVB on WWW and relation among each component module in this system. In the next section, it is described about the component modules in detail. Overview of this collaborative system is shown in Figure 1. Our system consist of the following four components ;

- SVB : it can fetch VRML on WWW and multicast URL's and user interaction for collaboration.
- Mosaic : it provide user with 2D based information related VRML.
- Communication Broker : this component is in charge of establishing or updating communication and provides informations to the paticipants in the current session.
- Vat and nv : our collaborative system were assisted by the use of MBONE collaboration tools like Visual Audio Tool(VAT) that support audio conference and Net Video(NV) that support live video conference[Vinay, 1994].

In our collaborative system, both publisher-subscriber and client/server communication models are combinded.

- Publisher-subscriber model : this model is used to share user interaction and informations on MBONE (RMP).
- Client/server model : it is used to acquire data that is saved in web server (HTTP[Berners-Lee, 1993]).

In order to support the publisher-subsciber communication model, we have developmented Shared Data Units(SDU) which is information unit to multicast in collaborative system and will be described in the next section in detail. Before sending or receiving SDU, each each participant must join a group session. Once several participants have joined to form the group, each participant can be sent SDU to the paticipants in the group. The connection between Mosaic and SVB in the local host is a unicast connection using CCI. This is specified with the hostname of the running Mosaic instance (usually local host is fine) and the CCI port on which Mosaic is listening. In relation between SVB and the Communication Broker, if communication status is changed in the Communication Broker, the ststus informations are passed SVB to update communication variable in SVB. Also we extend web server in order to support request of dynamic information for paticipants using Common Gateway Interface(CGI) [McCool, 1994].

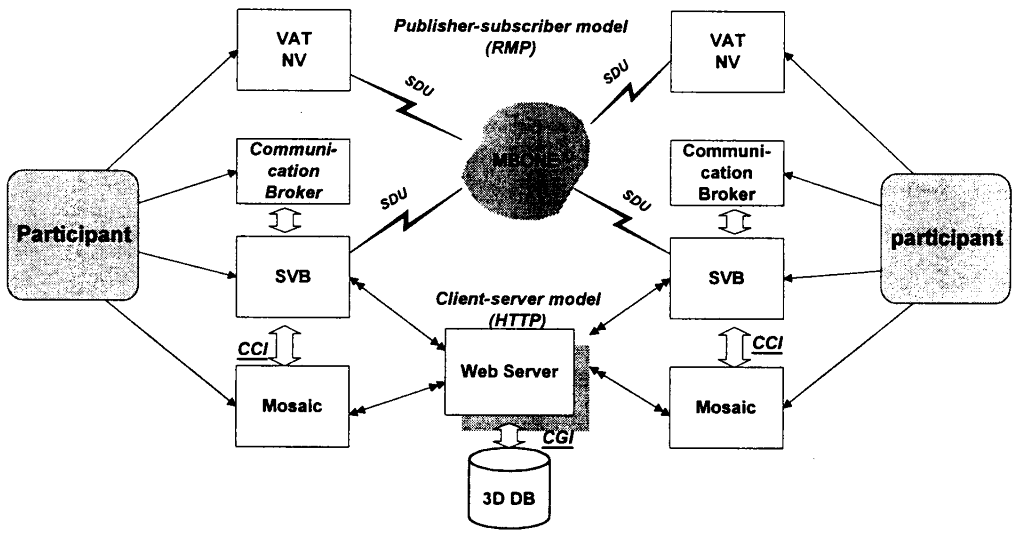

Figure 1. Overview diagram of Collaborative System using SVB

4. Design of Components in Collaborative System

4.1. Extension of VRML

We need modification of VRML to integrate VRML browser with Mosaic and multicast a set of URL's and user interacition. In order to fetch and multicast both HTML and VRML at the same time, "name" field in WWWAnchor which is node to be used by an anchor in VRML is divided into two fields, that is, "Mosaicanchor" and "SVBanchor" field. "Mosaicanchor" field is the string containing the URL for the auxiliary information(HTML, audio, sound, video, etc). "SVBanchor" field is containing the URL for VRML. An example of the revised VRML is given below.

```
WWWAnchor {
   SVBanchor "http://chopin.kist.re.kr/dochi/vrml/lathe.vrml"
   Mosaicanchor "http://chopin.kist.re.kr/dochi/vrml/lathe.html"
   Sepatator {
         Material { diffuseColor 0 0 .8 }
         Cube {}
   }
}
```

Also, in order to share 3D space and paticipant's view position WWWAnchor need a new field. the field is "Positionanchor" field. If user pick a WWWAnchor node containing "Positionanchor" field in VRML then view position move new position by content of the field. For example

Positionanchor " x_position y_position z_position x_dir y_dir z_dir rotate_angle "

4.2 Design of Shared VRML Browser(SVB)

SVB has three features. First, SVB is a browser for the world described by VRML and may navigate to other VRML world on WWW while Mosaic is a browsing tool for HTML document on WWW. Second, SVB is integrated with Mosaic using CCI to provide both HTML and VRML based information. Third, one SVB may send a set of URL's, camera direction, and various user interaction to each participant in the same group session by multicast and the other SVB's receive the URL's and reflect the information of camera direction and interaction based on the received data. Figure 2 shows the intercommunications among different modules of SVB.

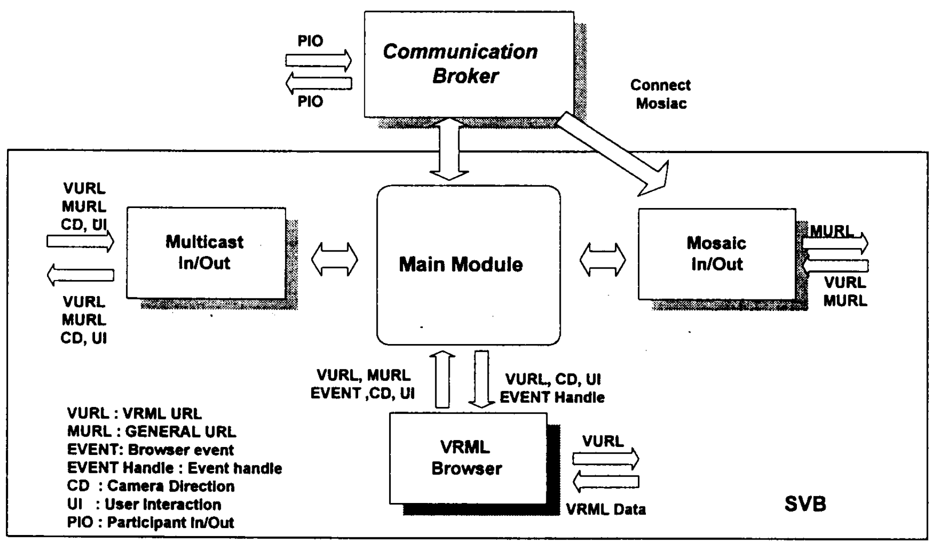

Figure 2. Shared VRML Browser(SVB) and Communication Broker

- Main Module : module that is in charge of initialization of each module and distribution of incoming messages among the component modules of Figure 1 and event handling from the VRML browser.
- Mosaic In/Out : module that is in charge of the bi-directional communication between SVB and Mosaic. This module sends the URL received from the main module to Mosaic or on the contrary, pass URLs received from Mosaic to the main module with CCI.
- VRML Browser : It can fetch a vitual world of VRML, and then render the world, and a user may navigate into new world which is hyperlinked by clicking an anchor object. When it receives CD(Camera Direction) or UI(user interaction) data from the main module it changes virtual world environment by the data as well as it sends CD or UI to the main module when a user want to

share view point or interaction with objects. UI contains object name which is picked and color of an object.

- Multicast In/Out : This module multicast messages received from the main module to a group session as well as pass messages received from other paticipants to the main module.

4.3. Communication Broker

Communication Broker initialize RMP objects and establish communication to multicast and receive messages. And it is in charge of establishing communication into Mosaic(Fiqure 2). Once multicast communication is established, paticipant can view information of other paticipants named as Paticipant In/Out(PIO) in current session(Fiqure 2). If global variables for communication is changed by a paticipant, then the value of changed variables is sent to SVB. Function of the Communication Broker is shown in Figure 3.

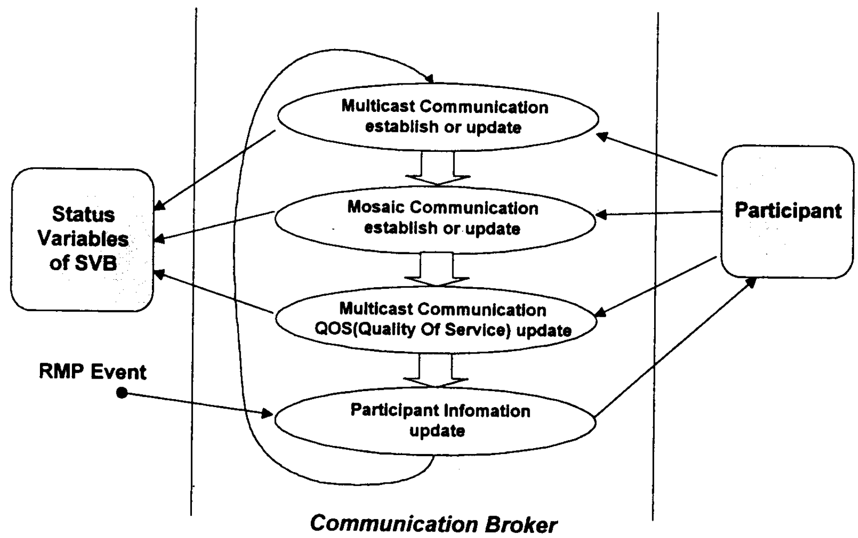

Figure 3. Function of Communication Borker

4.4 Shared Data Units(SDU)

When new informatin is generated by each paticipant, it has to multicast into paticipants to support real-time interaction among paticipants on WWW. In order to be effective and extendable multicasting, we need a communication protocol. In our system, we call unit of information to multicast Shared Data Units(SDU). SDU consists of four elements below(Figure 4).

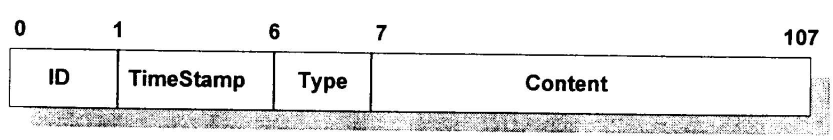

Figure 4. Structure of SDU(Shared Data Units)

- ID : is a unique number of SDU and use to avoid information collision.
- Timestamp : needs to synchoronize information with Greenwich Mean Time (GMT).
- Type : specifies types of information which is shared.
- Content : is content of type element.

4.5 Extension of Web Server

We extended the web server in order to support request of dynamic information for paticipants. So we need a new feature, Common Gateway Interface(CGI) which is standard for external gateway programs to interface with information servers such as HTTP servers. In our system, the extended sercer provides VRML as well as HTML based information to paticipants by query dynamically.

5. Application to Assembly Design System

We have applied the collaborative system using SVB to assembly design. An assembly is composed of a number of parts that are connected[Lee, 1985]. A connection is specified by one or more mating conditions. However, the mating conditions vary according to assembly shapes and applications. As a result, current assembly systems are used for only limited applications like making exploded views, checking its assemblability and others. In designing an assembly, the designer wants to know the relations among the parts, the way they are shaped and what is the important point in its design and to share them with other designers or customers effectively. Using the collaborative system with SVB, we have developed collaborative assembly design system where a designer can share 3D assembly model between/among other designers or customers on WWW.

In our system, a designer can design a part and give some part mating conditions for another parts and he/she should explain the way each part is designed and why he/she assign this mating condition. The system gathers designed parts, mating conditions and their explanations. Then the system build engineering database. Currently, the engineering database is simulated by the UNIX file system, that is, each part and its mating conditions are saved in a file. In this file, the BOM(Bill Of Material) information and the information of component part is saved. Each file has the following contents.

1. Part Name
2. Part Code
3. Part Geometry File
4. Part 2D Draft
5. Mating Parts List with Mating Condition

In our collaborative assembly design system, a designer can select several parts of assembly for inquiring through formed HTML document to query dynamic information of assembly. If a designer queries an assembly model via CGI interface, the CGI gateway program creates VRML from each part information and HTML from the assembly information. Then they are sent to the client. The generated VRML file is composed of the tri-meshed 3D shapes and is anchor positions for each part information. The HTML file has the part names which composed of assembly and BOM information. When a designer selects some parts in Mosaic form, slected information is multicasted to other participants. Collaborative assembly design system based on collaborative system with SVB is shown in Figure 5.

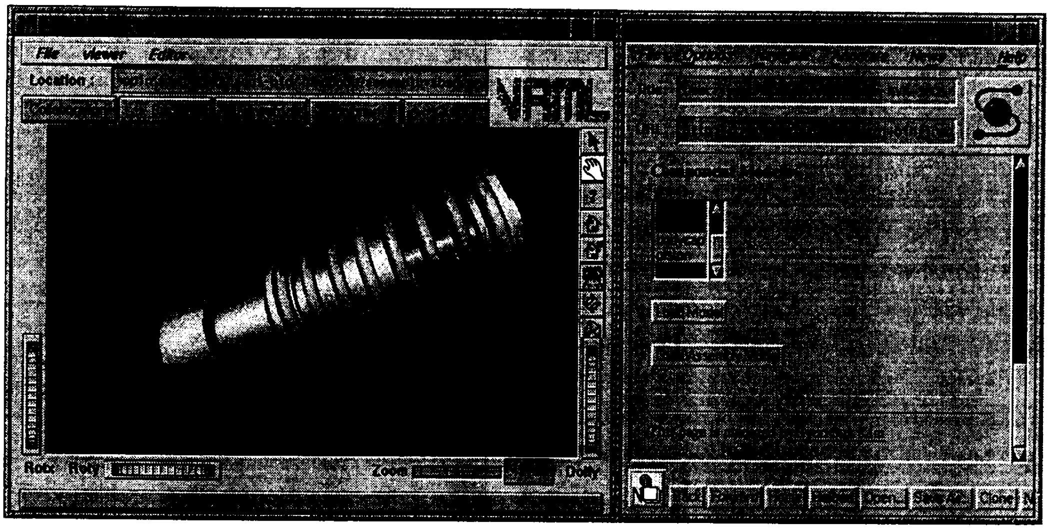

Figure 5. Query through formed HTML document.

SVB was developed with the Open Inventor object-oriented 3D toolkit[SGI, 1994] which is based on the industry standard OpenGL[SGI, 1994] application programming interface and OSF/MOTIF for user interface. Currently, SVB supports VRML, an open, platform-independent file format for 3D graphics on the Internet and it fully implements a VRML transport mechanism. To support the CCI, we use version 2.5 of NCSA Mosaic. Our collaborative system were assisted by vat and nv to support audio-video conference on MBONE. As an example, collaborative work session on WWW using SVB is shown in Figure 6.

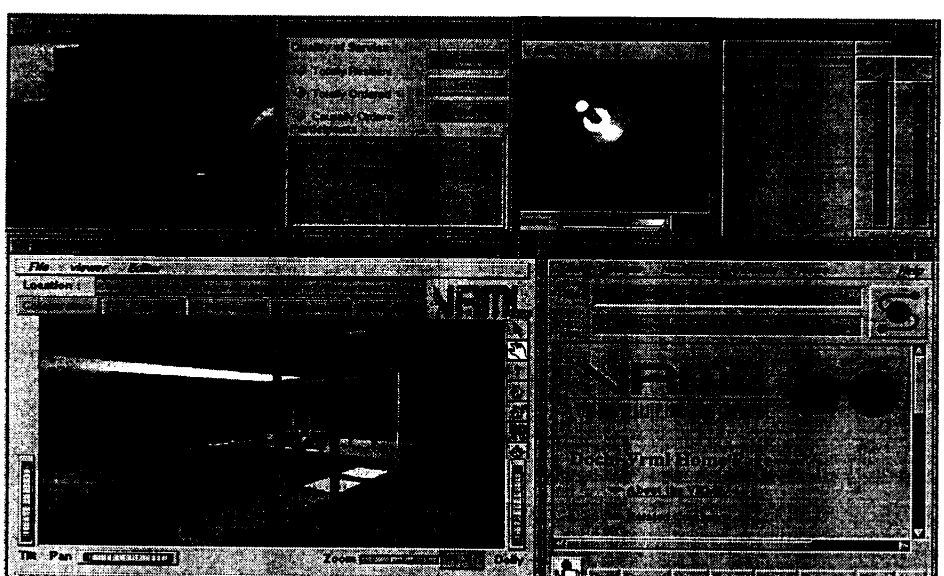

figure 6. Total collaboration system using SVB

6. Conclusion

In this paper Shared VRML Browser(SVB), an extension to VRML browser, is introduced with its design and implementation details. SVB allows to fetch and navigate in three dimension in WWW and share a set of URL's, camera direction and user interaction with the session group using IP-Multicast. Also, in this paper we have discribed how client/server and publisher-subscriber paradigms are reconciled to collaborate interactively on WWW.

We have applied the collaborative system using SVB to sharing of an assembly product model among the team members across the network. While several aspects of this system need further development, the implications of design and manufacturing engineers as well as customers being able to routinely work in this fashion are far reaching and SVB may serve as a starting model for bilateral collaboration among multi-participants on WWW.

7. Future directions

Currently, the collaborative system using SVB can share URL not URL content. It may overload the HTTP server because of multiple simultaneous requests with the same URL. To prevent overloading, SVB will support sharing of URL content in the near future.

The next area of investigation involves sharing of various user interactions. Currently, SVB does share the camera direction and object name which is picked and the color of an object. SDU should be extended to share behaviors using standardized data structures known as Protocol Data Units(PDUs) which is one of the current Distributed Interactive Simulation(DIS)[Zeswitz, 1993] standard axioms. Also, in order to support various real-time interaction of DIS we need new server which combined with MOO(Object Oriented Multi-User Domain) and client like HotJava.

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