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Design and Implementation of Whiteboard in Online Classroom

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In this paper, a remote teaching system is described, which is based on CSCW technology and modern multimedia communicating technology. The core part of the system is the whiteboard, with which users can communicate with each other, discuss on one subject, do collaborative design work, etc. This paper analyzes the whiteboard system framework and technical problems needed to be focused on, and proposes the corresponding solutions. We achieve good results in the practical application. In the end, this paper analyzes the problems and deficiencies of the system.

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1. Introduction

The whiteboard becomes an important tool for communication between teachers and students in the real-time online classroom, as it is very popular to learn through the network nowadays. Whiteboard is a shared virtual area, with which users can communicate with each other, discuss on one subject, do collaborative design work, etc. [1] All participants can see the contents on whiteboard, including texts, graphics and images. These data are stored in a whiteboard server or a multimedia database server. Each client can get a copy of the data. The users can add, delete or modify elements on whiteboard according to their authority, and the result of their operation will be sent to the server, which will then update data. Characteristics of the whiteboard mainly include: real-time and sharing in data transfer, interoperability of interaction among members, uneven distribution of a wide range of members, heterogeneity of networks and operating systems[2].

In the offline classroom, teachers and students can communicate by the use of blackboard. The role of whiteboard in online classroom is like that of blackboard in offline classroom as it is a shared virtual area for teachers and students. It can be visualized with whiteboard for teachers in teaching knowledge, demonstrating problem-solving steps etc. Students can be anywhere in a graphical way to answer teachers' questions and provide feedbacks on learning. Teachers and students can interact with each other in a timely manner by using whiteboard. All the participants will see the same contents in the window of the whiteboard with WYSIWYG features to ensure the synchronization and consistency of learning contents.

2. System Architecture

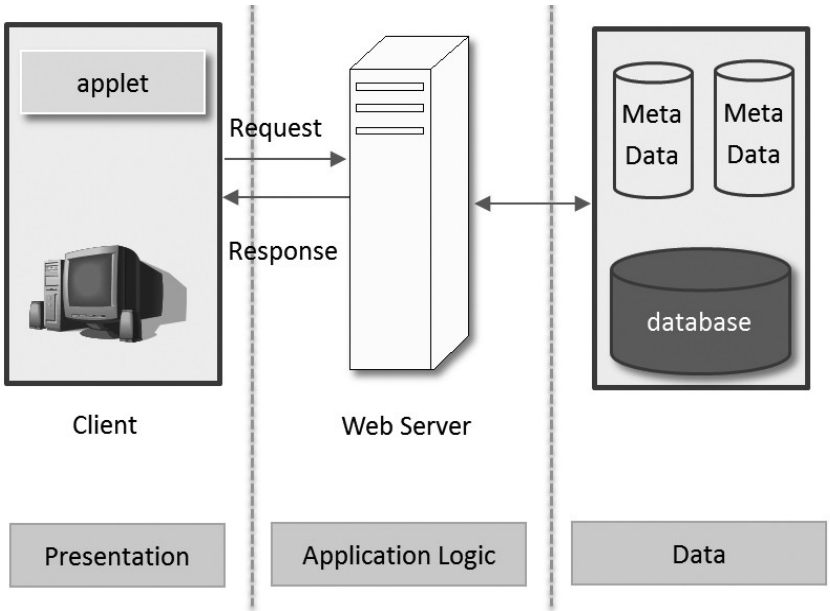

Figure 1: System Architecture

Whiteboard is a typical collaborative system. Users in a cooperative system need to sense the presence of other members and their behaviors and states, so it has collaborative awareness, which is the difference between cooperative system and non-cooperative system.

Collaborative awareness is divided into different levels, which are listed as follows:

a) the number of participants in the system and who they are;

b) the state and messages of each participant;

c) operating sequences on shared objects.

Whiteboard consists of three layers, which are presentation layer, application logic layer and data layer, as shown in Fig. 1.

The presentation layer is the interface between the users and the whole system. It consists of view pages including HTML and Applet, with which the users can interact with the system and get various status data.

Application logic layer includes web server and servlet application server. During running of the system, the servers will start the appropriate threads to respond to the users' requests and do business logic processing.

Data layer is composed of the database system. All the metadata, including real-time data and historical data of whiteboard are stored in the database. Servlets access and update the database via JDBC.

After logging in the whiteboard, the users may input text messages or draw on whiteboard using mouse or keyboard. The user interface is as shown in Fig. 2. The graphics and text messages can be sent to others while interacting with other users.

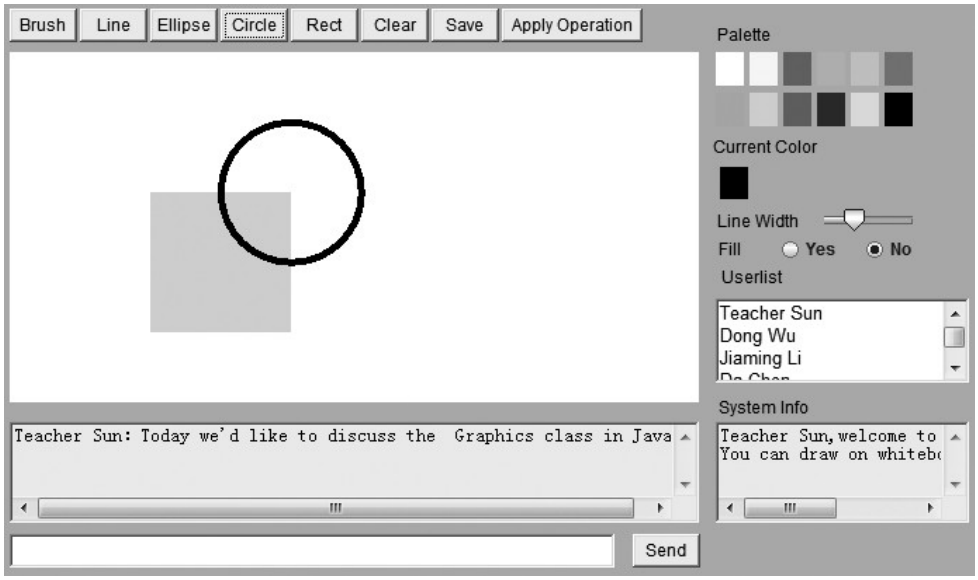

Figure 2: User Interface of Whiteboard

3. System Modules

The whole system is divided into login module, drawing module, message module and access control module. After a user logging on, drawing module will send, receive and process information from the message module under the control of the access control module.

(1) Login module

In whiteboard system of online class, each client needs to connect to the server first. After logging in the system, teachers can create whiteboard space and inform students of the whiteboard space name which is unique in the system. If the teacher sets a password, then the students need to enter the correct password before login. Only after connecting to the server successfully, can teachers and students perform various operations.

(2) Drawing module

Drawing module is the key part of the whiteboard system. After users' operation on whiteboard, drawing information is parameterized, and then transferred to the message module. On the other hand, drawing module receives datum from message module which contains

operations done by other clients, the operations will be repeated on the local client to show the final drawing result in the user interface.

Before drawing, users need to choose drawing tool which by default is brush. After the drawing tool being selected, the relevant attributes need to be set, such as line width, fill color etc. After drawing, the operations will be transferred to other clients by message module.

(3) Message module

Message module is responsible for all the transmission of information in the whiteboard system. It receives messages from the drawing module and transfers the messages through network under the control of the access control module. Finally the messages will be forwarded to each client of the online classroom.

By default, teachers have the authority to draw on whiteboard, while students can only view drawing results. Teachers' drawing results will be transferred to server by message module and then be forwarded to client of each student. Of course, if the students obtain operating authority of the whiteboard, the operation information of the students will also be sent to the other clients of the teachers and students.

(4) Access control module

The role of whiteboard system includes teacher and student who are granted different authorities. The authorities of each role can be modified as needed to ensure security and operability of the system. After login, teachers can create a whiteboard space and invite the students to enter. Teachers have the highest authority in their own whiteboard space, and any operation can be carried out. During the class, teachers can grant some authorities to students as needed. For example, a student is asked to answer a question, and then the student has the authority to draw on the whiteboard which can also be revoked by the teacher.

4. Key Techniques

Although there are already many remote teaching websites, their main work is concentrated on the development of multimedia courseware, and the interaction between teachers and students is not paid enough attention. Interactive tools are provided in some teaching system, but their forms are mainly bbs, chat rooms with text, or message boards. Graphics-based CSCW tools such as whiteboard are rarely provided. On the other hand, many CSCW systems are based on C/S structure, which is suitable for local applications because of the client software installation problem. Using Java applet technology will avoid the client installation problem.

In the implementation of whiteboard system, we focus on message processing, concurrency control and graphic information description. We propose a new message queue handling method and improve description of graphic objects to improve system efficiency and ensure the consistency of client content.

4.1 Message Handling

When the users input text or graphic using keyboard or mouse, the whiteboard on the local machine will display the information input by the users, and then the information will be stored in a message object. The message object will be serialized into byte stream and transferred to the server, as shown in Fig 3. The server will receive the data from byte stream, which will then be deserialized into message object. The message object will be copied to message list of users who are in one group with the sender; and the new messages will be sent to the corresponding client later.

In order to improve the efficiency of message processing and reduce the amount of data transferred through the network, once the server receives a message, the message is appended to the message list of each client except the client sends the message. The advantage is that when there is a client requesting for message to the server, the server only needs to return the message list corresponding to the client. There is no need to read all the messages to determine whether it is a new message or not to the specific client. After the client receives the messages from the server, the messages are appended to the local message list, and the corresponding message list on server will be cleared, thus message processing efficiency can be improved. Messages generated by local client are directly appended to the local message list, which will reduce the amount of data transferred.

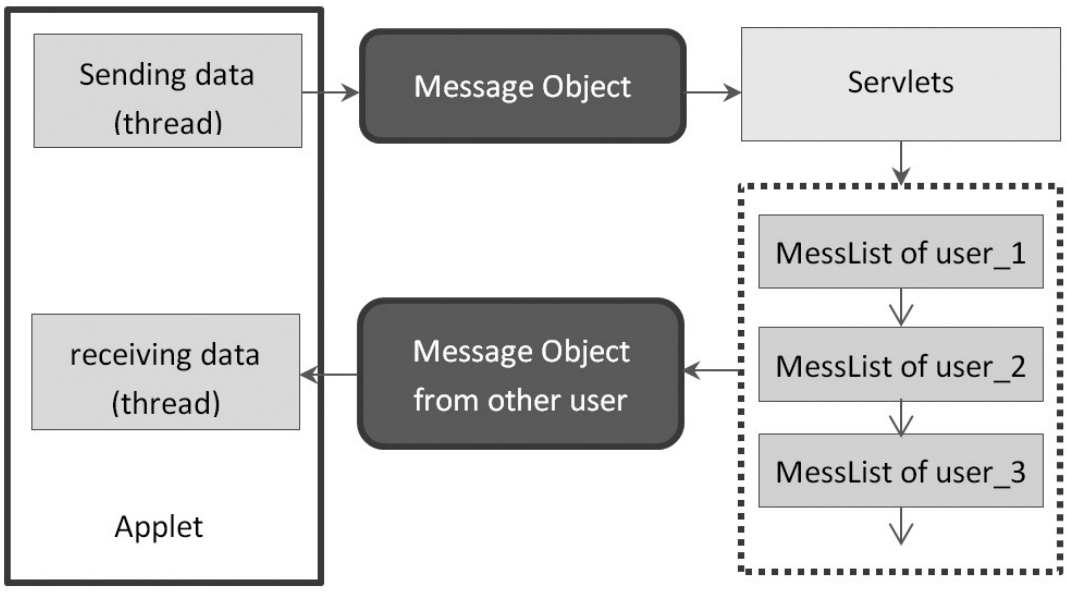

Figure 3: Message Transfer Model

4.2 Concurrency Control

Whiteboard is a Sharing Application [3][4], which shares control of an application between two or more users, in order to meet the needs of more than one person to work together. Sharing application is an important mechanism to support group communication activities and its principle to follow is WYSIWIS (what you see is what I see). When the sharing application receives information from any user, all participants distributed in the network will see the results of its execution. Characteristics, as listed below, of multi-user interactive applications are different from those of single user applications:

a) each user should be able to share the output of the application;

b) each user has the authority to apply operation to the application;

c) the response to each user should meet real-time requirements;

d) synergistic mechanism should coordinate actions of each user.

In our system, we use authorization method, also called floor control, to meet the above characteristics. Only one user, called floor holder, has the authority to operate at a certain time, while others can only wait for the results to display. Specifically, the way of our system work is as listed below:

1) the sharing application is started by one user who will be floor holder by default;

2) other users can apply to be a floor holder and their requests will be placed into a waiting queue;

3) when the current floor holder releases the control, the first user in the waiting queue will then be the new floor holder.

4.3 Graphic Information Description

There are two ways to share the content of whiteboard. In the first way, the content of the whiteboard will be converted to a bitmap, whenever the content updates, and a new bitmap will be created and then transmitted through the network. The implementation of this way is most intuitive and easiest, but the bitmap transmission through the Internet requires more bandwidth; if the whiteboard is updated frequently, the network may be blocked by a lot of data. In the second way, the constituent elements of the whiteboard content are described by a vector. The change of whiteboard content is reflected in the change of the elements' shape, position, etc. The information will be transferred through the network, and whiteboard client only need to modify local parameters after receiving the changes. This approach greatly reduces the data transmission through network, and is an ideal choice. To enable all users to identify changes in whiteboard, elements, maybe displayed in whiteboard, need to be described, and all the elements in whiteboard need to be stored in local at each client.

The second approach is used in our system. Color, shape, start point and end point are defined for each graphic object, and text message is represented by a string object. In order to ensure consistency of each client displays, we add a member of timestamp in graphic object.

Since the number of elements in the whiteboard is uncertain, it is not suitable to use an array to store whiteboard elements. Java provides Vector class to solve the dynamic growth of the array size problem during the system running. Vector class defines a set of elements of object, which works much like an array, but its size will grow automatically when larger capacity is required. Finally, the data will be converted into a byte stream using Java serialization technology [5][6].

5. Conclusion

We design and implement the whiteboard system based on CSCW in this paper. Whiteboard is a shared virtual area, with which users can communicate with each other, discuss on one subject, do collaborative design work, etc. This paper analyzes the whiteboard system framework and technical problems needed to be focused on, and proposes the corresponding solutions for concurrency control and graphic information description. Of course, the system can be improved. In practice, single media of whiteboard is not enough. In order to achieve better interaction effects, it also needs to use other medias, such as audio and video, etc.

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