Bandwidth Saving Synchronous Collaboration Environment for Virtual Universities

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Abstract

The University of Hagen is the first and only university in German speaking countries, which is (almost) exclusively based on distance teaching methods. As one of the largest universities in Germany it provides university-level education and related degrees. About 80% of the students are already professionals who study mainly in the evening and on weekends. The Internet becomes increasingly important as a medium for knowledge distribution and even as a learning environment. In distant education there is a high demand of synchronous web based collaboration tools. To provide our students, who are geographically distributed all over Germany and Europe, with synchronous communication facilities, we have developed a collaborative virtual reality environment for workshop-like events.

1. Introduction

This paper presents an approach to a web based bandwidth saving synchronous collaboration environment for workshop-like events. It addresses multi-user related problems like interaction and shared resources. The collaborative environment introduced here allows simultaneous usage of a shared 'virtual computer' in a team. A group of students is able to interact via audio-conference, text-chat (as backup) and virtual reality based non-verbal communication (gestures). Students and tutors are represented by avatars in virtual reality to avoid bandwidth consuming techniques like video conferencing. A real collaboration like in local seminar events is possible. Participants control the seminar-environment with their standard web browser. The remote seminar room is based on an open-source multi-user virtual reality client/server architecture, which is implemented in the Java programming language. The components used are mainly based on web standards like VRML and Java. All components are usable on desktop computers and wearable devices like PDA's (Personal Digital Assistants). The introduced environment was evaluated in engineering education, but is due to universal whiteboard concepts usable in all disciplines. The approach presented is based on low-cost PC hardware, low-bandwidth communication channels, and open-source/free software.

2. Virtual Environment

Participants of a workshop should get the impression of meeting each other in a common room. Therefore, a well known seminar room of University of Hagen has been modeled in VRML (Virtual Reality Modeling Language) [1].

Fig.1. User-Avatar, gesture

On the client side, a VRML-Browser-Plugin is used to display the virtual 3D environment. VRML as a text-based language is a powerful, nevertheless simple

language to build virtual worlds. These include 3D objects, light sources, and animations. This virtual room is equipped with a virtual projector and screen, to render a live audio/video stream (e.g. a lecture) or the desktop of a shared computer. All users of the collaborative virtual environment are represented by realistic human-like avatars (Fig.1). Every user is able to control gestures of his personal avatar. Some of these avatar gestures are especially adapted to a typical class-room situation, e.g. 'put one's hand up' and 'point to', to provide non-verbal communication to the users.

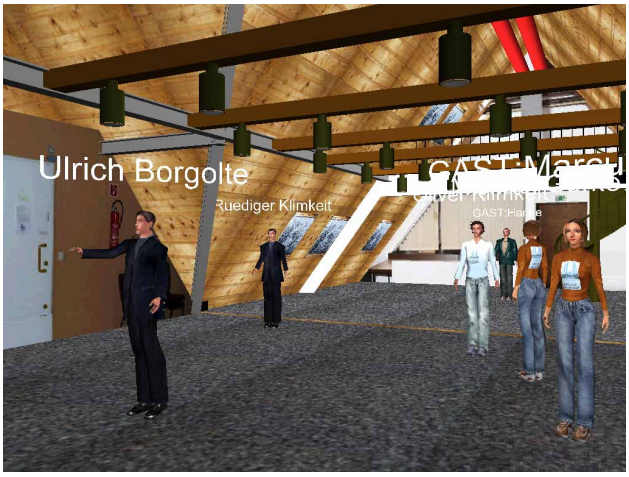

Fig. 2. User avatars in a collaborative virtual environment

The introduced collaborative virtual reality environment consists of

- a basic text chat, which is used if the other means of communication fail,
- a virtual seminar room with user avatars,
- a voice-over-IP audio connection, and
- a shared virtual computer as universal whiteboard.

3. Communication middleware

The communication middleware is based on the open source (a special license, free for educational use) VRML collaborative virtual environment DeepMatrix [2] which implements its functionality by Java-VRML coupling. VRML specifies an External Authoring Interface (EAI) which can be used by external Java-based applications to monitor and control the VRML environment. This is used to update the virtual world with the positions of the user avatars. DeepMatrix itself is a pair of client and server software implemented in Java [3]. The server is implemented as a Java application which communicates with all clients and provides them with updates of the 3D-scene. The client applet controls the local VRML-browser-plug-in via the EAI to update the scene (the positions of other avatars) and senses the local user movements to send new positions to the server. An additional DeepMatrix client, based on Eyematics Shout3d [4] Java 1.1 based VRML rendering engine, provides an own API for Java-VRML coupling. Since the Shout3d VRML-rendering applet is pure Java based, some caveats like slower 3D-rendering (the Java Virtual Machine is not allowed to use the clients graphics hardware acceleration) and the implementation of a subset of the VRML standard must be accepted. The most important advantage of the DeepMatrix-Shout3d client is that no additional software must be installed on the client computer (platform independent). The original Geometrek implementation of the Shout3d based clients does not allow any interaction between users of the VRML-browser based and the Shout3d based clients. We have modified the Shout3d-based client to provide shared rooms for users of both clients. Due to the limitation of the Shout3D VRML implementation avatar gestures and streaming video rendering inside the 3D-window are not realized.

4. A Virtual Reality client for mobile users

About 80% of our students are already professionals which study mainly in the evening and on weekends. For synchronous events at a fixed timeslot therefore is a need for mobile solutions of learning environments. We have modified the introduced Shout3d based DeepMatrix client that it can be used by mobile users (equipped with PDA's or smartphones). The modified Client is now based on a java application which runs on a Personaljava virtual machine. Personaljava [5] is a java runtime environment for mobile devices with limited resources (e.g. graphic resolution of 240x320 pixel, no hardware 3D acceleration). Implementations of Personaljava are available for Windows CE, Linux, Palm and Symbian OS based PDA and mobile phone platforms.

Fig. 3. Collaborative Virtual Reality environment on a Sharp Zaurus PDA, 206 Mhz ARM processor, embedded Linux, 240x320 pixel

5. Audio conferencing

Audio is the most important means of communication in seminars. To enable usage of only one connection line for the client computers, we decided to use voice-over-IP with the open source, MBone based RAT audio tool from UCL [6]. We are using RAT in unicast-mode with a unicast multipoint reflector. RAT supports the UDP basedH261 protocol and GSM-codec, which allows real time audio with a typical bandwidth of 10kbit/s for a single speaker. As a backup the unicast multipoint reflector is connected via software to an ordinary phone line. In case of problems remote users are able to use a phone to participate to the audio conference.

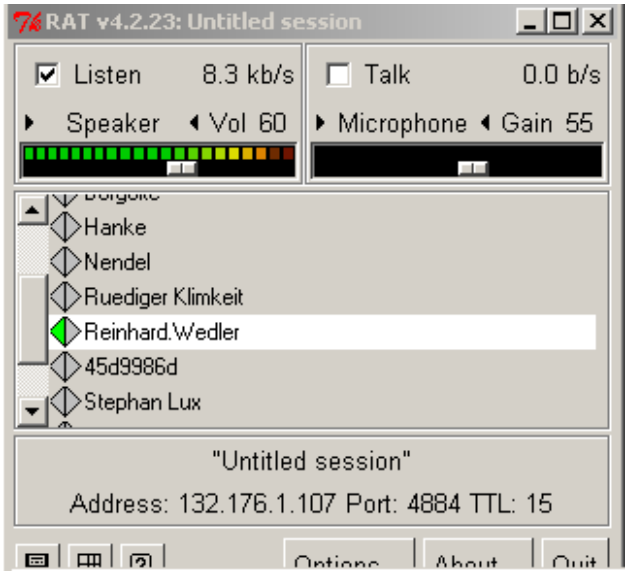

Fig. 4. Rich Audio Tool (RAT)

6. A shared virtual computer for collaboration

To provide the users with a kind of a white-board an universal solution was selected. Not only presentation software like PowerPoint is frequently used to explain topics to a group of users.

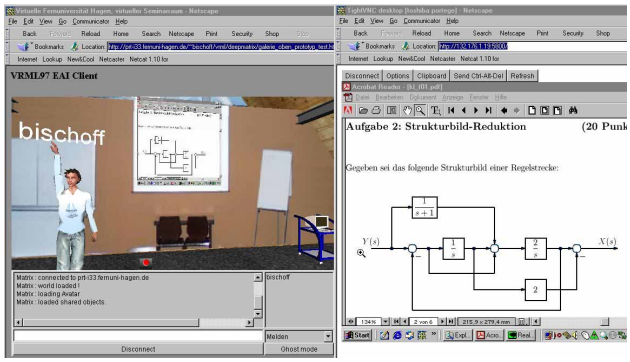

Fig. 5. VNC based universal whiteboard, shared remote computer

In different disciplines user groups need different software tools, or operating systems for seminars and workshops. An universal solution is a shared PC, simultaneously useable to all participants. A platform independent solution for simultaneously remote control of computers is the open-source 'Virtual Network Computing' tool developed by the AT&T Laboratories in Cambridge [7]. The HTTP-server which is part of the VNCserver utility is running on the shared seminar computer, which displays the desktop content of the

shared computer in a web browser-window. Connected and authenticated users are able to remotely control all installed applications. Documents and binaries can be uploaded easily to the shared computer via standard email attachment. The screen resolution an color depth should be reduced to 640x480x8 due to bandwidth limitations of remote modem users. To handle uploads and the prearrangement of the seminar event itself an asynchronous tool like a Wiki [8] is also provided.

7. User authentication module

Seminars at the University of Hagen are usually part of an examination, so an authentication procedure is required. The DeepMatrix-client-server system is initially intended for anonymous 3d-chat. Nevertheless the open source distribution of the DeepMatrix allows modifications to the Java source code to provide a connection to the existing LDAP-directory service at the University of Hagen. This modification is very convenient for the users because no extra passwords and administrational effort is necessary. LDAP, the Lightweight Directory Access Protocol was proposed in 1995 (RFC 1777) as an open standard for directory services on the Internet. The virtual university environment of the university of Hagen [9] is based on LDAP. The user authentication names for students of the University of Hagen are usually numbers. To provide a convenient interface for the learning group and the tutor, real names of the user are also fetched from the directory server database.

8. Instant Messaging as backup

Computer Supported Collaborative Learning (CSCL) environments for synchronous events are still difficult to handle. For synchronous communication like audio- or video-conferencing open TCP- or UDP-ports are required. Especially upcoming limitations of Internet access like firewalls and NAT-routers increase the need of backup solutions for synchronous events. To provide communication facilities to a group of students, and as a backup strategy for synchronous communication we use Jabber [10] based Instant Messaging (IM) Server and Clients. Instant Messaging is a very reliable tool to support the users because if technical difficulties arise, in the case of modem-users the only communication channel is occupied by the Internet connection. Particularly with regard to user awareness the ‘presence’- feature of Instant Messaging Clients is very important and useful. If a user lost the connection to the Internet during a synchronous event the tutor will be informed in real-time. Jabber itself is a XML-based open source protocol for Instant Messaging services. Jabber-based software is used by over a million of users worldwide. The protocol is maintained by the Jabber Software Foundation. Advantages of Jabber over conventional commercial Instant Messaging Services are interoperability with existing IM-services, a XML-based open source protocol and an easy way to adapt the server to existing services. Robust and secure clients for mostly all operating system and mobile devices like PDA’s and cellular phones are available. We have realised a Jabber based Instant Messaging service which is interoperable with the virtual university environment of the university of Hagen. We use the C++ based open source Jabberd with an additional xdb auth/check module [11] to provide a connection to the existing LDAP-directory service at the University of Hagen. This modification is very convenient for the users because no extra passwords and administrational effort is necessary.

9. Overcome firewall restrictions

The client applet of the DeepMatrix collaborative virtual environment itself, the VNC client and the RAT audio client are opening socket connections to the server applications. A user behind a firewall must contact the network administrator to open the required ports. An universal way to overcome upcoming limitations of Internet access due to firewalls is to tunnel connections through a VPN (Virtual Private Network). The data processing service center of the university of Hagen offers a VPN service based on IPSec [12], which allows all students to pass all TCP/IP traffic through a secure VPN tunnel. Another benefit of the usage of VPN is that the users get a routable IP address inside the university IP subnet, which avoids problems with limited internet access via NAT (Network Address Translation). Most of the broadband ADLS users today using NAT enabled WAN routers.

10. Evaluation and Test

The whole system was implemented and tested at University of Hagen in May 2004. A server at the university acted as main hub for a seminar. It hosted a chat application, an audio reflector, and a virtual reality server. In addition, this server hosted the shared applications (Acrobat and PowerPoint) which were remotely controlled by the participants. After a lot of tests in bilateral and multilateral collaboration sessions, a final seminar took place with a total of 12 participants from all over Germany. Some of them had modem-line connections (56kbit/s) only. The system worked very reliable and offered high quality communication to all participants. Seminars aided by the presented

collaborative virtual environment are now part of the curriculum in engineering education at the University of Hagen.

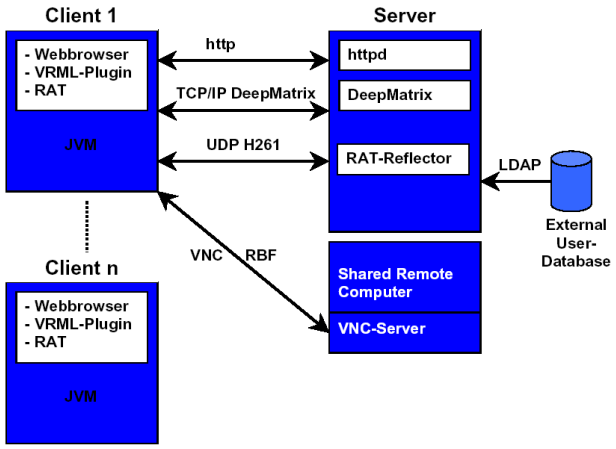

Fig. 6. Overall communication structure

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