EVE - II: AN INTEGRATED PLATFORM FOR NETWORKED VIRTUAL ENVIRONMENTS

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Abstract

In this paper, we present the design and implementation of an integrated platform for Networked Virtual Environments. This platform called EVE-II is an enhancement of the EVE distributed virtual reality platform, supporting stable event sharing for multi-user 3D places, easy creation of 3D multi-user3D places, H.323-based Voice over IP services integrated in a 3D spaces well as many concurrent 3D multi-user spaces.

1. Introduction

Networked Virtual Environments (NVEs) are multi-user virtual worlds, namely computer generated spaces, where participants represented by avatars can meet and interact. Nowadays, the use of NVEs is one of the most promising uses of virtual reality. Using NVEs as communication media, we can offer to members of virtual communities the advantage of creating proximity and social presence, thereby making participants aware of the communication and interaction processes with others [2]. Furthermore, NVEs could be the basis of Educational Virtual Environments where the users could collaborate in order to learn together. In the Educational Virtual Environments the avatars of the users are provided with additional behavior such as gestures, interactivity, movements and voice communication. The following basic requirements should be satisfied in order to implement an integrated platform for NVEs that can also support Educational Virtual Environments [9]: (a) high level of presence of the users, (b) multi-modal user-to-user interaction via chat, voice communication and gestures, (c) user-system interaction, (d) scalability, (e) consistency of the multi-user space and (f) Quality of Services.

In this paper such a platform for supporting NVEs, called EVE-II, is presented. EVE-II is actually an enhancement of EVE platform [1], [3]. Main improvements of EVE that has been integrated in EVE-II concern the sharing of multi-user events, as well as the audio communication among the users as described later in this paper. The emphasis on the new version of EVE platform has been given on the flexibility and extensibility of the architecture, its stability as well as the support of a more easy way for transforming standalone 3D worlds to multi-user places. EVE-II is based on Virtual Reality Modeling Language (VRML) [8] for the representation of the 3D worlds and for describing 3D objects. However, VRML does not provide support for multi-user virtual worlds [3]. Thus, there is a definite need for a multi-user extension behind the VRML. So far there is no standard in this area [3]. The Living Worlds (LW) working group of the Web3D consortium, which has been frozen, has made the first attempt for standardization. Other remarkable proposals are the VSPLUS proposal, which is a simplification of the LW proposal, and the SPIN-3D approach. However the aforementioned approaches for VRML data sharing have some limitations. LW is complex, VSPLUS does not support dynamic created objects and SPIN-3D requires a proprietary VRML browser [3]. EVE-II supports such an extension through a VRML parser satisfying at least the following requirements: (a) conformity with a standard VRML97 browser, and (b) easy transformation of a single user world to a multi-user 3D world. This paper is structured as follows. We initially describe the architecture of EVE-II platform. Afterwards, we briefly describe a prototype for offering e-learning services using EVE-II. Finally, we present some concluding remarks and our vision for the next steps.

2. EVE-II Architecture

EVE-II's architecture (Fig. 1) is based on a client-multiserver platform model. The current form of EVE-II constitutes an open and flexible architecture, which allows and supports the basic functionality that the platform is intended to offer. For that reason the servers on which the

platform relies, are the message server and two application servers, a chat and an audio server. This model offers scalability and flexibility to the EVE-II architecture, because we can add more application servers in order to offer more functionality and furthermore the processing load is distributed among the above set of servers.

In addition EVE-II is characterized from openness due to the fact that is based on open technologies and international standards. More specifically the implementation of the platform is mainly based on:

- VRML, for the representation of the 3D worlds and for describing 3D objects.
- VRML External Authoring Interface (VRML-EAI) [8], for implementing an interface between the 3D worlds and external tools.
- Java, for the development of the client-server model, and the network communication among the different components of our platform.
- H.323 [4], [5] for offering audio conferencing services through the Internet.

EVE-II in comparison with the previous version of our platform (EVE) is improved mainly on the sharing of events, as well as the audio communication among the users.

Concerning the sharing of multi-user events EVE-II, goes beyond EVE and other platforms [3]. Actually the VRML Data Sharing mechanism in EVE was based on the usage of a specific type of file (called SVE), which was maintaining every shared event and shared object in order to facilitate the multi-user communication and the initialization process.

The new approach for the sharing of the multi-user events is based on a VRML parser that has been implemented. This VRML parser runs on the server side, it is an extension of the SVE parser and it helps the server to recognise the shared events without the usage of an SVE file. Exploiting this new approach EVE-II has the following advantages in comparison with EVE:

- It offers enhanced stability through better interface with EAI as well as better support of avatar and avatar's gestures.
- It supports very easy creation of a multi-user space from a standalone one, through the integration of the VRML parser. Actually the shared events are commented out (i.e. marked with a "#"), in the original VRML file and in such a way the standalone world is transferred to a multi-user one.
- It offers server-side syntax checking of 3D spaces in order ti support better and faster sharing of multi-user events.
- It supports execution of shared scripts and VRML routes, and full support of scripts sharing (both on javascript and java format).
- It supports server-side execution of scripts, which offers better sharing of events, even if they are based on time-triggering.
- It supports dynamic insertion of shared object in multi-user places.
- It supports specific PROTOs (such as "chair" for avatar's sitting).
- It supports better initialization process.

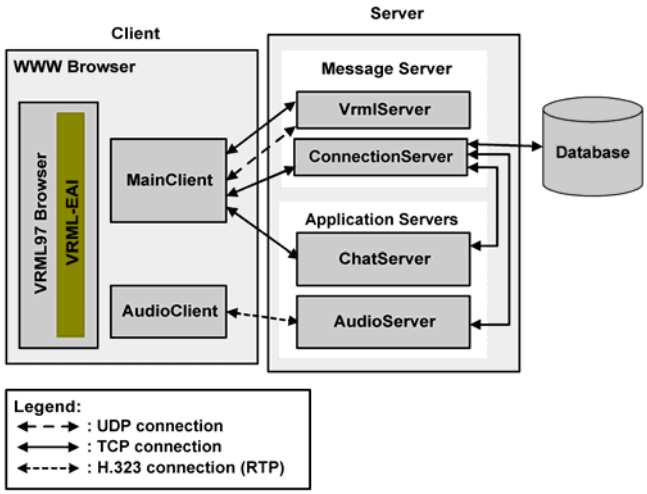

Figure 1: Architecture of EVE II

Concerning the audio communication H.323 protocol is supported. H.323 is an ITU recommendation, which defines a network architecture and the associated protocols necessary to voice and multimedia calls establishment. H.323 is a protocol suite that can be used in order to establish, modify and terminate multimedia sessions or calls. These multimedia sessions include both point-to-point and multi-point conferences and Internet telephony applications. Main reason for this choice was the H.323's modular structure that offers flexibility and allows the usage of many well-known codecs and mechanisms for the transmission of the data. Furthermore H.323 supports much more services than voice over IP such as videoconferencing that could be integrated in future versions of EVE platform

In the following paragraphs the main components of EVE-II architecture are described.

2.1 Server Side

The servers on which the platform relies, is the message server and two application servers, a chat and an audio server.

2.1.1 Message Server

The message server is responsible for the manipulation of the virtual worlds that are visited by the users of the system. In addition, this server creates and supports the illusion to the users that they are participants in the above virtual worlds and that they share a common space by updating the view of the world every time that a shared object is modified. Two servers, each of which is used for a specific sequence of operations, constitute this message server. These servers are the Connection Server and the VRML server:

- Connection Server: this server maintains a database, which the system accesses in order to authenticate the user and allow him/her to enter the virtual space of EVE. In addition, the connection server reports every entry or departure that takes place in the platform to all other servers.
- VRML server: this server monitors and records every event that takes place in the virtual space and reports these changes to all participant clients of the platform. Thus, by performing these continuous updates the system assures that the users will have the illusion of sharing a common space. The VMRL server also maintains constantly an updated copy of the world, which is sent to the clients when they enter the system. That way, the new users have the same updated view that the existing users already have.

2.1.2 Application Servers

The application servers are responsible for providing specific functionality to the participants of the virtual world. In the current form of EVE there are two application servers available, a chat server and an audio server.

- Chat Server: this server is responsible for the text chat support. It allows group chat, which means text chatting between multiple users, or whispering, which allows the one-to-one communication between two users.
- Audio Server: this server is responsible for the audio communication between the users of the platform. The audio server uses H.323 as its main protocol. H.323 is a multimedia communication protocol, which can transfer voice, video or data over IP networks, and is especially fitted for this application. The main audio service offered by the platform is the audio communication among all participants in a virtual world, or between pairs of them. So, the audio server is in fact an H.323 MCU, which supports audio conferencing among the platform users. By using H.323, compatibility with a large range of H.323 audio servers and clients is achieved and the use of audio as a separate service of the platform is permitted, whilst the numerous applications of H.323 can enrich the functionality of the platform – for example, by adding video conferencing capabilities in the future.

2.1.3 Client Side

As depicted in Fig. 1, in order the users' client to communicate with EVE's servers and have access to the provided functionalities they need a web browser, a VRML browser, the main EVE client and the audio client.

- Web Browser: The web browser is used for the communication with the web server of the system, which provides an initial interface and entry point between the user's client and EVE's environment.
- VRML Browser: The 3D environment of EVE is implemented using the VRML language. Therefore, a VRML browser, a plug-in, is essential in order to allow the navigation of the user's avatar in the virtual training space.
- Main Client: This client is responsible for (a) the primary connection of the user to the Message Server, (b) the interaction between the user's avatar and the 3D virtual space and (c) the text chat communication between the users of the same virtual space. In particular, the main client, which is a java applet, makes an initial connection to the connection server, which allows it to present the current connection status and when the user is authenticated, it passes on to the vrml server.

  During an initialization phase, the list of the current participants in the virtual space is retrieved, as well as some information about the user avatar. Then, the normal message exchange with the VRML server begins. The first message received always contains the world, in its current state, and the user avatars, so that it completes the initialization phase, and starts normal operation.

  During normal operation, this client is responsible for the interaction between the user's avatar and the 3D virtual space of EVE. In particular, every time that a user acts on an object, this client reports the modification and interaction to the VRML server of the platform that performs the update and transmits it to all other current participants.

  The main client also includes a chat client. This part of the main client is responsible for the text chat communication between the users of the same virtual space. Every time that a message is send from the client's side, this is passed to the chat server that in turn transmits it to the appropriate destinations.

- Audio Client: The audio client is a java applet that records the audio stream from the user's side and transmits it all appropriate destinations, allowing the

audio communication between participants in the same space. As already described, H.323 is used to support the audio services. The audio client communicates only with the audio server, which is used as a Multipoint Conference Unit (MCU), handling and mixing the audio streams that are sent by the clients, and forwarding them to the correct destinations.

2.2 Network Communication

The network communication of EVE, alike its architecture, is focused on providing the available functionality at the best possible performance. Therefore, for the transmission of the packets and the achievement of the communication of the connected clients with the host servers (message server, audio server and chat server) as well as for the server-to-server communication, there are three types of communication supported. Each of these types is found to be optimum for certain kinds of messages. Thus, we categorized the messages exchanged in the EVE communication platform in four basic categories:

- The messages related with the initial connection of a client to a server as well as the messages exchanged between the servers of the platform.
- The position messages that are related with the avatars' position and orientation in the virtual environment.
- The important messages, which correspond to messages that are vital for the consistency of the networked virtual environment (for simplicity reasons, we consider as important messages all messages except for the position messages).
- The messages related to audio streams.

In the following subsections, we describe why a connection type is selected for the corresponding category of messages described above.

2.2.1 TCP Communication

The main characteristic of the TCP communication is the reliability in the transmission of information packets.

Therefore, this type of communication is selected for the cases where the reliable delivery of the exchanged messages is essential and vital for the maintenance of the consistency of the networked virtual environment, even if that interferes some delay in the transmission.

For the EVE platform, this type of communication is selected for the following messages: a) the server-to-server communication, b) the initial connection of a client to the message server, which includes the authentication c) the messages that are vital for the consistency of the networked virtual environment, including the messages that create the 3D world and the avatars, when a new client enters the system.

A possible failure or loss in the delivery of this type of messages could cause serious inconsistencies in the presentation of the virtual environment and could introduce security issues to the EVE platform.

2.2.2 UDP Communication

The main characteristic of this type of communication is the high speed in the transmission of the information packets. However, one of the main drawbacks of the simple UDP communication is that it cannot assure the reliable and correct delivery of the data packets.

Therefore, this type of communication is selected for the transmission of messages that their possible loss or failure in delivery does not imply a severe impact on the consistency of the virtual world of the connected clients. Such messages are the position message, which carry information about the avatars' position and orientation in the virtual world, and their failure in delivery does not create important scene inconsistencies to the participants.

2.2.3 H.323 based voice communication

As described above, H.323 protocol suite can be used for audio communication, while the transfer protocol used to actually transfer the audio data is RTP. A client exchanges RTP packets with the audio server. As already described, the audio server, which serves as an MCU, mixes the audio streams and forwards them to the clients, making sure that sounds generated by a client are not sent back to it.

3. Case Study: Support of E-Learning Services

NVEs have a good potential to support e-learning services, due to the fact that the can provide the students with an opportunity to experience sensory interactive learning environments, which enable them to move from passive to active learning [3]. In addition, such environments are able to support collaborative learning among students at different locations by allowing them to share experiences about exploring a common environment. We call these environments Educational Virtual Environments [2].

The primary goal of an Educational Virtual Environment is to provide tools in order to reproduce conditions that augment interpersonal interaction in a physical educational environment, e.g. a classroom. This goal is effectively satisfied if the educational virtual environment is represented by 3D virtual worlds where the users are represented by human-like avatars. For this reason, the EVE-II communication platform is exploited in order to support an Educational Virtual Environment.

The implementation of such a prototype gives us the possibility to test every aspect of the system in order to offer specific functionality. The environment that have been implemented is a simulation of a classroom, it combines 2D and 3D features in order to provide the users with communication and collaboration capabilities and necessary tools for realizing collaborative e-learning scenarios, and it is accessible at http://ouranos.ceid.upatras.gr/vr/. The participants in the virtual classroom could have two different roles: tutor (only one user among the participants) and students according to its privileges in the EVE Community.

Figure 2: User interface of EVE-II for supporting e-learning services the training area

The users that participate in the virtual classroom are represented by avatars. The users' avatars are able to make various types of gestures: expressing opinions (e.g. agree, disagree), expressing feelings, mimics (e.g. happy, sad), as well as showing actions (e.g. move learning content, pick learning content). The virtual classroom is supported by audio collaboration, and text chat functionality. Also, it provides a specific place where the users can upload their content and show it to other participants in the course. This space is a 3D presentation table. Moreover this table offers more functionality such as shared whiteboard, or simulation of a brainstorming board. The user interface of the training area is depicted in Fig. 2. More information about the functionality supported by the virtual classroom is available at [2].

4. Conclusions - Future Work

This paper introduces EVE-II, which is a platform for Networked Virtual Environments. This platform can support multi-user 3D spaces along with chat and voice over IP communication. It is based on an open and flexible architecture exploiting well-known and open technologies and standards such as VRML, Java and H.323.

Our next step is the performance monitoring and evaluation EVE-II using networked simulators by conducting the necessary experiments and having this information available in order to trace a path on how the recourses for each type of message should be managed to achieve better performance. Furthermore, the integration of intelligent agents in EVE-II will be a major enhancement of the functionality offered. Intelligent agents can support educational process and they can offer intelligent help to the users for the usage of the system.

5. REFERENCES

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