Aspects of a Collaborative Learning Environment using Distributed Virtual Environments

C. Bouras,
Computer Engineering and Informatics Dept., Univ. of Patras & Computer Technology Institute
GR-26500 Rion,
Patras, GREECE
bouras@cti.gr

V. Triantafillou
Computer Engineering and Informatics Dept., Univ. of Patras & Computer Technology Institute
GR-26500 Rion,
Patras, GREECE
triantaf@cti.gr

T. Tsiatsos
Computer Engineering and Informatics Dept., Univ. of Patras & Computer Technology Institute
GR-26500 Rion,
Patras, GREECE
tsiatsos@cti.gr

Abstract: A decisive factor for new technologies is always the added value with respect to the efficiency and capacity of traditional technologies. This also is true when considering the impact of new technologies in training applications. New types of applications have been developed along the last few years to incorporate information technology in the learning environment. The growing need for communication, visualisation and organisation features in the field of learning and training environments, the e-learning approach, has led to the application of virtual reality and the use of multi-user real-time communication platforms to support these needs. This paper presents the first approach of such a system as well as useful technologies and standards for its implementation.

Introduction

The implementation of an attractive, user-friendly and effective teamwork oriented learning environment, to offer synchronous and asynchronous training services, includes many technological and pedagogical issues. In this section a short description of the basic components, issues and requirements of Networked and Learning Virtual Environments (LVEs) are presented.

A simple Virtual Environment (VE) is a computer system, which generates a 3-D virtual environment, with which the user can interact and receive real time feedback (Normand et.al. 1999). If multiple are connected and interact to each other the above definition is extended to multi-user or Shared VE (SVE). A Collaborative VE-system (CVE) is an SVE aimed at a collaborative task. A Learning Virtual Environment is a CVE that is designed to offer additional educational tasks such as synchronous and asynchronous learning (Bouras & Philopoulos & Tsiatsos 2000) and (Bouras & Tsiatsos 2000). A LVE is a set of virtual worlds or a virtual world, enhanced with educational functionality.

The users are represented by avatars (graphically) that populate the LVE and can be provided with additional behaviour such as gestures, interaction, movements and sound. Every LVE must comply with a set of requirements in order to be used widely.

Users are offered a high level of presence through their representation by an avatar of his choice, which simulates some basic realistic actions, such as gestures and movement, giving them a shared sense of space, presence and time (Singhal & Zyda 1999). Users are also able to navigate in a 3D shared space in order to access

the content provided, to examine their knowledge, to interact with each other, to exercise their skills and to receive the information provided. Furthermore the user is informed for the presence of other users (avatars), of their arrival in the LVE and their leave.
A LVE must also provide their users with many types of interaction in order to enhance the development of users as autonomous active learners both in the immediate learning context and in the longer term. Two types of interaction is defined in a LVE:

- Multi-modal user-to-user interaction: chat, voice communication and gestures. This type of interaction is supported by manipulation of shared 3D objects. Real time applications such as audio communication, application sharing and whiteboard functionality are important features.
- User-system interaction, which is based on navigational aid and commands that the system provides to the user for a specific function as well as the manipulation of 3D objects. Furthermore, the users must be able to insert and change objects in the 3D world, sharing these activities with the other users. This type of interaction offers the user the capability to customise the total design and outlook of the VEs according to the needs of their specific themes. Therefore the user-system type of interaction satisfies the need for customisation.

Although immersive applications are more effective in the use of VR technology, the main feature of educational VR applications is the interactivity and not the immersion (Youngblut 1998, Sutherland 1968). Moreover, a VR application, which is designed for educational use should be suitable for widespread use and mature in the part of the technology. Considering these requirements, immersive VR technology is not mature and it is expensive. On the other hand desktop VR is more suitable for widespread use regarding the hardware and software requirements (Youngblut 1998).
A LVE must be scalable to a large number of users in order to support large virtual educational communities. This set of users can be divided in each virtual world that is a part of a virtual educational community, which is able to support a maximum number of simultaneous users. The LVE must be able to integrate any digital material into the platform.
Two other features of the LVEs are consistency and coherence. Consistency is realised by distributing and synchronising user input as well as user independent behaviour in order to achieve the impression of a single shared world. Coherence is used with the sense of a uniform structure of the provided services, concerning mainly the functional and operational characteristics rather than its visual representation in the VEs.
Except the advanced features that a LVE must support, it should also be able to run under a variety of hardware and software platforms, support different formats/protocols and provide adequate security mechanisms. The system must offer an easy and complete administration mechanism allowing easy management of training material and users.
The remainder of this paper is structured as follows. In the next section we describe a European project in the area of the collaborative learning environments for distance education and our vision for its implementation. We then present a review of tools, technologies and standards, which are useful for the implementation of such a project. Finally we present some concluding remarks.

Intelligent Distributed Virtual Training Environment project

INVITE (Intelligent Distributed Virtual Training Environment) [1] is a project in the framework of the Information Society Technology (IST) Programme of the European Commission. It started in February 2000, and it will run for almost 3 years.
The main aim of the project is to build a platform for synchronous tele-learning which can be interfaced with standardised content management and/or instructional management systems. In order to reach this aim the following objectives have been set:

- Identification of the relevant cognitive and social processes in collaborative learning situation and extraction of those factors into user requirements.
- Development of an integrated system based on distributed virtual environment technologies, including intelligent agents' real-time translation facilities, realistic avatar representation and enhanced interactivity of avatars.
- Evaluation of the prototype within different learning contexts.

[1] INVITE: Intelligent Distributed Virtual Training Environment project, IST Programme,. http://invite.fh-joanneum.at/

- Research results on social learning processes within virtual environments.

INVITE provides the user with VR experience so it will be built over a 3D VRML multi-user environment with smooth movements, extensive textures, 3D icons for manipulation and interaction within the environment and stereoscopic visualisation options. A virtual model will be used for the construction of the worlds. The user interface will be enhanced through the integration of 2D video and 3D worlds.

Full body-photo realistic avatars will be used for representing the user since they seem to be more effective when used in a collaborative environment offering gestures like waving, nodding, bowing, disagreeing etc. The possibility for using talking avatars (text-to-speech lip synchronisation, driven in real-time from voice) with movement capabilities and voice driven emotions will be investigated during the project.

In order to offer asynchronous learning services INVITE will integrate available asynchronous learning systems and support audio/video streaming of available content. Additionally, in order to manage the documents and other educational material a document repository will be implemented, to facilitate data visualisation and implementation of structured search engines. A common habit in training sessions is that all participants take notes on paper copies of the training material and usually the trainer presents his material in slides and allows access to it.

User interaction will be realised by voice/text chat, and online translation. Users will be supported through the application of intelligent knowledge based agents thus providing tools for personalised searching and facilitate the organisation of background information. In (Fig. 1) the main components of a virtual collaborative learning environment are presented (Triantafillou & Tsiatsos 2000).

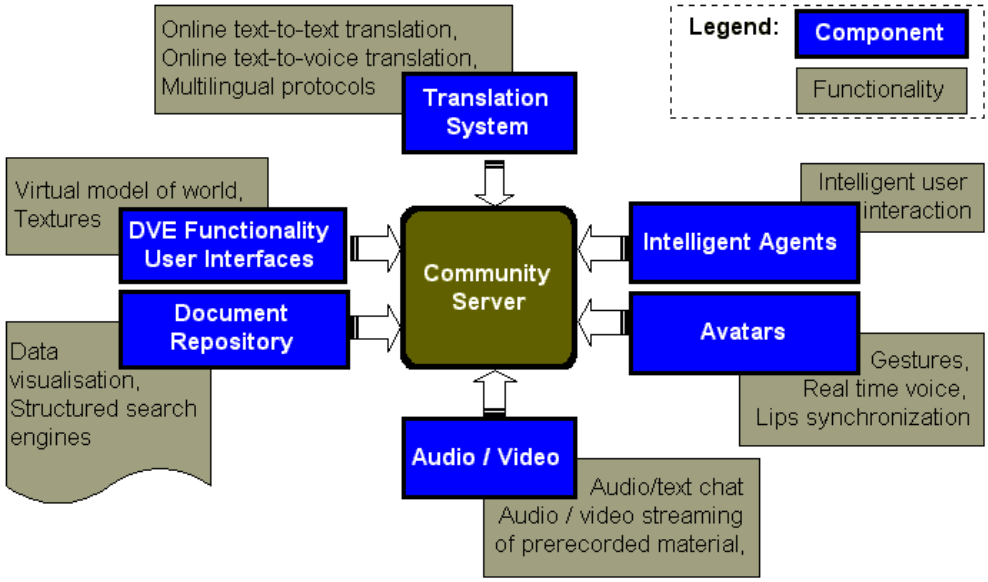

Figure 1: Basic Components of Virtual Collaborative Learning environment

Technologies

The range of technologies available for developing collaborative virtual learning environments is more varied than ever. The exchange and presentation of web based material, 3D content and the transmission of audio/video streams, of high quality, are now supported by a variety of technologies and tools. Integrated platforms consisting of a server for the virtual environment and a client for the presentation of the 3D graphics are now available. Efficient user-system interaction is supported by a variety of intelligent agents. On-line translation tools for text communication and text-to-speech translation allow multilingual user interaction.

VRML97 (Virtual Reality Modelling Language) and X3D (Extensible 3D) will be used for handling multimedia, 3D objects and shared virtual worlds over the Internet due to their platform independence and their capability to allow scripts to be embedded adding more functionality in the 3D scene. External user and 3D-scene interaction will be supported by VRML-EAI (External Authoring Interface).

In order to ensure maximum performance a commercial platform must be used. Such a platform should be open, allowing easy integration with other platforms and technologies, mature (since the whole project will be based on the platform), offer full support of VRML and other relevant technologies (HTML, Java) and run on a variety of systems/servers without major modifications to the code. The most promising platform seems to be the blaxxun Community Platform that complies with main features such as: full compatibility with VRML, audio/visual interaction, chat facilities, Java, JavaScript and EAI, 3D rendering and SDK support.
Rapid prototype development of the virtual environments can be supported by Parallel Graphics' ISB and ISA which seem to be the most suitable application tools to be used since they support the VRML 97 standard. X3D-Edit can be used as a graphics file editor for editing, authoring and validation of X3D files. AvatarMe' s technology (AvatarBooth) will be used for the capturing and creation of photo-realistic avatars.
Educational material (except documents) involves pre-recorded audio and video (streaming media). Most of the tools that facilitate real time support and electronic conferencing can be used to support communication between participants in a learning session thus covering the user demand for additional synchronous learning support. Microsoft Exchange 2000 Conferencing Server and Meeting Point since are open, offer a variety of features, conform to conferencing standards and can run over various platforms. OnLive platform supports only audio conferencing but its client can be used as plug-in in a web page. RealNetworks solution can facilitate pre-recorded streaming multimedia delivery and synchronisation.
User-system interaction in computer based learning systems is provided through intelligent agents (Fabri et. al. 1999). In INVITE a set of functions, like avatar and object handling, mobile communication interaction and collaboration will be programmed through intelligent agents. Also agents can be reminders, guides, guards and translators of the users. The use of declarative language implementations provide more advantages than procedural ones and for that reason the tool to be used should support KQML (Knowledge Query and Manipulation Language) for communication between the different agents. Java based tools (JAFMAS, IBM Aglets and AgentBuilder) have an advantage over other tools since they have the ability to run over different platforms.
HTML and XML will be used for their capability to facilitate efficient document exchange over the Web. XML offers more capabilities than HTML and can be used to provide metadata and various types of data on the Web. An efficient database management system will be used in INVITE to manage documents, user profiles and educational material. Since one of the main objectives of INVITE is to provide a tool that can run over a number of different platforms this consideration limits our choices concerning the DBMS to be used in INVITE. Oracle' s solution runs under different platforms and provides a number of important features like security, XML support, capabilities for producing dynamic XML or HTML documents from SQL queries over the Internet.
On of the most attractive functionality, which must be provided, is the capability for multilingual text communication and text-to-speech translation. In order to provide such functionality the system will interact with text-to-text and text-to-speech engines. The most advanced text-to-speech translation tool seems to be Speech Cube with the capability of running under different platforms allowing a wide variety of languages but the actual choice of the tool to be applied will depend on its openness and the cost. The most common used system for text-to-text translation is SYSTRAN, which also can run under a variety of platforms and translate from and to a number of several languages. Linguatec offers a flexible solution for text-to-text translation that can be used over the Web.

Standards

The efficient integration of systems relies on the application of world wide accepted standards. A number of organisations (public, private) are active in this field of technical standards like sub committees of the Joint Technical Committee of ISO (SC24, SC29, SC34), IETF WebDAV group, and the World Wide Web Consortium (W3C). In learning technology, interoperability standards and models for learning systems specific recommendations have been suggested the last few years and a number of committees and projects have worked towards that direction (IEEE LTSC LOM, CEN/ISSS, CENELEC, ETSI, PROMETEUS).
XML is will be used to facilitate the efficient document exchange over the Web and XSL will support the creation of virtual XML documents and the presentation of these documents of different media types. The distribution of interactive multimedia/hypermedia applications in client/server architecture across different platforms of different types and media will be based on MPEG 7 standard. MPEG-7 will be used to describe the various types of multimedia information and their relationships using a description language.

Information retrieval will be based on the application of Metadata to identify features shared by different documents. Metadata for learning material have also been specified such as: LOM, Dublin Core and ARIADNE. The approach of XMI, which specifies an open interchange model, will support the ability to exchange programming data between tools, applications and repositories. Learning technology standards will be used for the organisation and presentation of the learning material as well as a basis for the user interaction specifications. In this context the IMS specifications defined for easy discovering of data, data sharing over different platforms, operating systems and tools and ensure reusability will be considered.
User-system interaction will be based on the use of intelligent agents. KQML supports the communication between the different agents and the implementation of the performatives defined by KQML. KIF (Knowledge Interchange Format) (Ginsberg 1991) supports the interchange of knowledge among disparate programs.
User-to-user interaction in a LVE will be mainly supported by avatars and chat communication. The integration of avatars in VE will take into account the specifications for a standard humanoid (H-anim Group). In case these capabilities are not available electronic conferencing can be used. ITU's T120 and H.323 will be used for audio, video and data conferencing over the Internet.
Asynchronous learning services to the users will be supported by the delivery of pre-recorded educational material (audio & video) through the application of real time protocols. (RSVP, RTP RTSP).
The core module in INVITE is the virtual environment since it provides the main functionality and all modules will use this environment to interact through it. VRML standards for incorporating MPEG-4 technologies (face and body animation, streamed video and audio etc.) and the recommendations for SQL database access in VRML will be considered in the development practice of the project.
Communication between the different components of INVITE will lie on the protocols which support client, server, multicast streaming and network capabilities (VRTP) (Brutzman et. al. 1997), real time interaction (ISTP) (Waters et. al. 1997), and multi-user participation in virtual worlds (VIP).
Text-to-text and text-to-speech translation standards are set up for lexical resources and language engineering. In INVITE guidelines from currently advancing initiatives (e.g ISLE and XLT) which produce standards in the areas of multilingual lexicons, natural interaction, multi-modality, interchange of data among lexical resources from various translation systems will be used.
Tab. 1 summarises the components of an LVE, useful technologies and tools for its implementation, as well as standards, protocols and specifications to ensure openness and interoperability.

Components	Technologies, Tools	Standards, Protocols, Specifications
Avatars	Avatar Studio, Spazz 3D, ICA, Avatarme' s AvatarBooth	H-anim
Real time Audio/Video conferencing	Microsoft Exchange 200 Conferencing Server, MeetingPoint	H.323, T.120
Streaming Video	RealNetworks solution	RTP, RTCP, RSVP, RTSP, MPEG
Document Repository	XML, MPEG 7, medatada, Oracle 8i	LOM, Dublin Core, XML, XMI, ARIADNE specifications, IMS specifications
DVE functionality - User Interfaces	ISB, ISA, Java, VRML	VRML 97, VRML-EAI, VRML-MPEG4, X3D
Intelligent Agents	JAFMAS, IBM Aglets, AgentBuilder	KQML, KIF, OMG and FIPA specifications
Translation system	SYSTRAN, Linguatec' s Personal Translator 2000, SpeechCube	ISLE, XLT
3D Community	blaxxun community server	VRML97, Java, EAI, X3D

Table 1: Components of a LVE, useful technologies, tools and standards

Conclusion

INVITE aims at the development of a collaborative learning environment for distance education (reflecting real life collaboration) using distributed virtual environments. INVITE fills in a gap, concerning Networked Virtual

Learning Environments, both in terms of functionality and technology approach. INVITE is a real-time educational environment, where presence and attendance to the lectures could be made compulsory for inscribed students with Internet access. The students have the opportunity to participate at the real event of the lecture, with the ability to raise questions to real professors, or at a specially arranged and recorded event, where the lecturers are represented by intelligent agents that can be trained to ask commonly asked questions and problems. INVITE establishes virtual communities with a theme, rules, roles and moderation where useful services can be employed to facilitate educational procedures. INVITE will provide a tool.
The added value of INVITE is in both the technological and the pedagogical field. INVITE is capable of running on the average users' PC and is compatible with standards like VRML enduring openness and portability of the application. Also, INVITE will facilitate the inclusion of many real world features allowing manipulation of objects and exchange of information with objects and users. All interfaces between the different modules of the system are based on mature standards and INVITE is an open system, which can be interfaced with standard instructional management systems and data representation schemes.

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