# Architectures Supporting e-Learning Through Collaborative Virtual Environments: the Case of INVITE

Ch. Bouras
*Computer Technology Institute, Greece*
*bouras@cti.gr*

G. Hornig
*blaxxun interactive AG, Germany*
*guido.hornig@blaxxun.de*

V. Triantafillou
*Computer Technology Institute, Greece*
*triantaf@cti.gr*

Th. Tsiatsos
*Computer Technology Institute, Greece*
*tsiatsos@cti.gr*

## Abstract

*The growing need for communication, visualization and organization technologies in the field of e-learning environments has led to the application of virtual reality and the use of collaborative virtual environments. This paper presents a system architecture to support such environments, defined by user needs and using state of the art technologies.*

## 1. Introduction

New types of applications have been developed in order to incorporate information technology and its advances in the learning environment. Many systems already support e-learning, using different types of learning methods as well as different technologies to implement these methods; many of which have good potential but are either too difficult or expensive to implement. On the other hand, many technologies are applied in systems offering small functionality or complexity to the system. A lot of research work has been developed in the last few years concerning e-learning systems. The need for communication, visualization and organization is a strong prerequisite for providing efficient e-learning platforms. Many research projects have been engaged in this area during the last few years [1]. Although research projects try to fit in technological advances to produce up to date technological e-learning systems, commercial products available seem to focus more on the already available technological solutions to provide efficient e-learning solutions. Products like InterWise Millenium 3.2 [2], Centra Symposium 4.0 [3] and LearnLinc 4.5 [4] are promising and leading software solutions for synchronous teaching environments. All these tools enable large groups of dispersed individuals to interact, collaborate and learn in real-time over intranets, extranets and the Internet. Most of the commercial web-based training solutions lack sufficient realization of real-time communication features, meaning a shared sense of space and presence. In general, third party applications refer to features such as application sharing and video conferencing. So there is a definite need for integrated solutions that can offer a much higher degree of usability and that do not demand additional technical requirements as in the case of most commercial systems.

In this paper we present a system architecture to support collaborative e-learning using collaborative virtual environments. This system applies various technologies, such as collaborative virtual environments, on-line translation, real-time audio and intelligent agents, integrating them in a flexible and efficient way to support various training models in virtual environments. A community of learners and tutors is possible. In addition this system makes it possible for the participants to use the communication space for their own needs. Interaction between all members is not dependent only on the lesson or the role itself. In the next section we describe a European project in the area of the collaborative learning environments for tele-training. We then present our methodology for designing the system and our vision for its system architecture.

## 2. 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) Program 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 standardized content management and/or instructional management systems. In order to reach this aim the following objectives have been set: (a) Identification of the relevant cognitive and social processes in the collaborative learning situation and extraction of those factors into user requirements. (b) 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. (c) Evaluation of the prototype within different learning contexts. (d) Research results on social learning processes within virtual environments.

In the following paragraphs we present both the first steps for the development of the INVITE system: design and system architecture. To present these steps in a uniform and understandable way, we present a summary of the user requirements and the basic learning models.

## 3. User Requirements

Before the development of the system we gather a first set of user requirements, in order to include this in our scenarios and then to define the functional specifications of the system. According to the users' opinions, the proposed e-learning system should conform to the following set of requirements:

- To be easy to use
- To offer user-friendly help
- To easily integrate existing digital materials
- To support audio communication
- To give the lecturer the capability to administer her/his own courses and to monitor the learners' progress and participation
- To support multi-modal interaction between the users through visual communication, realistic user representation, and real-time display of users' movements
- To support application sharing and text communication
- To offer tools for recording the communication in learning sessions as well as whole learning sessions
- To visualize the learning environment as realistically as possible
- To offer an interactive and shared whiteboard
- To support audio and text translation into other languages
- To leave certain degrees of freedom for the learners giving them the option of self control in order to enable them to work autonomously

In short, users want an e-learning system that can support three types of training: **synchronous training** (on-line lectures from a trainer on a specific theme), **asynchronous training** (autonomous training using educational material and notes from previous lectures or minutes from collaboration), **collaborative training** (on-line communication and collaboration between the members of a usergroup on a specific theme).

## 4. System Design

During the system design phase we "compile" the user requirements and training types into functional specifications of the system and then (in the implementation of the system architecture) we will choose the available technological solution that will apply in the INVITE system. The main issue here is which technology we should use.

### 4.1 Functional Specifications

In order to satisfy the user requirements, our proposed INVITE system should support a collaborative virtual environment which is a set of different virtual worlds that offers the users the ability to navigate and interact in a 3D shared space. The main functionality of the system is the following:

**3D visualization of a virtual learning environment:** The realistic visualization of the classrooms can only be accomplished by a 3D model of a virtual learning environment [5]. There are three main categories into which all of the virtual worlds created can be classified: Lectures' Virtual Rooms-LVR (for synchronous training), Subject-specific Collaborative Virtual Rooms-CVR (for collaborative training), Private Virtual Rooms-PVR (for asynchronous training). Also an entry point (Entry Virtual Room-EVR) should supplement the above structure of the INVITE virtual community, where the users should enter in order to inform themselves about the specific lectures, meetings and news.

**User representation by avatars:** Full-body, photo-realistic avatars will be used for the visual representation of the users in a realistic way. Photo-realistic avatars are more effective when used in a collaborative environment offering multi-modal interaction between the learners via both gestures and mimics (like waving, nodding, bowing, disagreeing, etc.) as well as real-time movements of the users [6].

**Autonomous/asynchronous learning services:** In order to meet the need of offering autonomous learning, INVITE will integrate available asynchronous learning systems and it will support audio/video streaming of available content. Additionally, in order to manage documents and other educational material, a document repository will be implemented, to facilitate data visualization and implementation of structured search engines. Tools for the recording of lectures and storage in the repository will also support autonomous learning activities.

**Chat, audio, and multilingual collaboration:** In order to meet the need for learner/learner and learner/teacher interaction, we will offer chat and audio communication. For data communication, both application sharing and whiteboard functionality will be used. Furthermore to facilitate the collaboration between multilingual users, we plan to offer audio and text translation capabilities.

**Lecture administration:** The teacher/trainer can use administration and moderation tools in order to administer the on-line lecture and to moderate the users respectively.

**Intelligent help**: The INVITE system will provide the users with many capabilities and useful functionality (as described above). In order for the users to use this functionality effectively and easily, they could be supported by intelligent agents, which will help, trigger, and guide them, according to their profile [7], [8].

In the following paragraph we present a range of technologies and standards which are useful for the implementation of the above-described functionality.

### 4.2 Technologies and Standards

The range of technologies available for developing e-learning oriented virtual environments is more varied than ever. According to the above-described functionality, the main components of such a system are the following: streaming video, document repository, avatars, DVE functionality/user interfaces, 3D community, translation system, real-time conferencing, and intelligent agents. Each component, their functionality and the useful technology and standards for its implementation are depicted in Figure 1.


**Figure 1. Basic Components, Functionality, technologies and standards for a Virtual Collaborative Learning environment**

## 5. System Architecture

According to the above criteria, the system architecture is defined by some basic principles. The system should be based on a variety of communication protocols, be scalable, be platform independent and be based on open standards. Our proposal is based on several components that provide all the needed functionality. These components are the following: the Virtual Worlds Platform, the language server, the voice server, the agent server, the document repository, the streaming server and the avatar server.

The Virtual Worlds Platform includes all virtual community features and acts on server side as an integration platform through the extended API. For multi-user language translation services, there is a language server connected to the API of the virtual worlds server. Other services are the voice server for voice communication between clients or groups of clients, and an agent server that works as support for client agents and can provide services. A document repository allows managing several kinds of documents and works as a document archive and supports versioning.

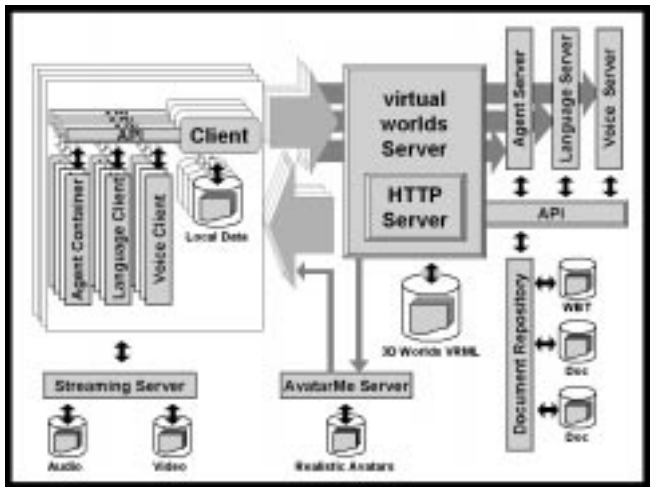


**Figure 2. INVITE Architecture**

The AvatarMe Server [9] provides user-specific access to personal avatars, which can be accessed from outside the system. The client side has the ability to store data locally. The open architecture of the client software is synchronized with the virtual worlds server and allows the adding of client functionality through an client-API. This is used to integrate local agent containers, language support clients and a voice client connected to 3D events and avatar functionality, like gestures or lip synchronization. In the following paragraphs the above modules are described in more detail.

**Content Management Module-Document Repository:** The content management module stores, archives and retrieves documents. Meta-Data support the retrieval of content. MPEG-7 will allow the retrieval of information within video data. Existing content from CBT and WBT can be integrated, if the content was created according to standards like XML. Other learning - content standards like LOM or Dublin Core will be supported.

**Virtual Worlds Platform Module:** The Virtual Worlds Platform [10] provides server and client technology for synchronous and asynchronous

communication. There are text chat, message boards, user registration, user profiling and tracking, encryption, instant messaging, list of friends, question and answer modules, 2D and 3D user home space, public meeting places, 2D and 3D shared objects. Objects can be interactive web content, like 3D-VRML [11] or HTML and other data formats specified in MPEG4.

**Agent Module:** The agent module consists of the agent container on the client side and the agent server. Functions for information retrieval in documents and pre-recorded sessions include: order translations, converting into other formats, synchronizing local with central data and storing recorded sessions for reflection. The technology that will be used to implement this module is blaxxun server agents and IBM aglets [12].

**Translation Module:** The translation module can translate online chat and stored documents. It can translate on demand, just in time, or as a background service for later use. Translation and look-up is possible for several languages and also for specific use of terminology. For this module we will use Linguatec' s solution [13].

**3D Worlds Module:** The client software is able to visualize dynamic 3D data in high quality and performance. The 3D Worlds module is part of the blaxxun' s Virtual Worlds Platform and provides functions for representing relations in 3D space, like participant groups or any data that is useful to be viewed in 3D. The functionality is easily adaptable due the client API [10].

**Avatar Module:** For the purpose of immersive creation of learners, tutors and other roles participating in the learning environment, there is a photo-realistic representation available on the Internet, hosted by an Avatar server. The H-Anim standard is a starting point for Avatar functionality. 3D visualisation of participants as avatars is required for better self-creation in collaborative learning situations [5].

**Streaming Video Module:** The 3D Worlds module offers the possibility for streaming media content. Depending on other system requirements, the streaming servers from Real networks and Microsoft are supported, and content can be viewed on a screen in the 3D environment or in 2D with the client plug-ins from the server vendor. The technology for streaming content will change with the implementation of MPEG-4. The 3D client supports also the MPEG-4 standard.

## 6. Conclusion-Future Work

In this paper we have presented the INVITE project approach for the architecture of a system which targets the offering of collaborative e-learning services using collaborative virtual environments. The design of this architecture is based on the requirements of the target groups, who are professionals of certain organizations. To achieve this we have designed a system that applies various technologies, integrating them in a flexible and efficient way to support various training models in virtual environments.

Our next step is to implement the first functional prototype and to engage the end-users in its evaluation. Re-usability of learning content will also be one of the most challenging parts of the future. The improvement of standards, as well as the dissemination of standards and meta-data, is the key to efficient implementation of learning systems. Another goal is soft skill training, which will be more in the foreground in the future. Rich multimedia communication will help to give all participants the possibility to use it for more purposes than they can imagine today. Users on both user sides may need templates for organizing their daily learning. The present situation, where one tutor supports many learners needs to be enhanced by the possibility to have many tutors supporting one learner.

However, beyond all techical augmentation we must bear in mind that only good teachers can be good learning facilitators - a rule for real world and for virtual learning environments.

## 7. Acknowledgements

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## 8. References

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