An Overview of the Collaborative Learning On-Demand: Paradigm and Technology

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INTRODUCTION

Advances in communications and software technology are driving the Internet to become an open and distributed computing platform able to provide diversified services which can be ubiquitously accessed by many users.

Electronic learning-oriented services are well suited to be supported by and delivered through the Internet. They are strategic for enabling virtual universities, enhancing the skills of the employees of a company, and facilitating auto-training. Nowadays, a multitude of e-learning systems and applications have been developed which are based on specific learning models. Such models can be roughly classified as asynchronous or synchronous and self-paced or collaborative.

An asynchronous Web-based course is a popular type of distance learning which usually includes final tests. The learner is individually engaged in a self-paced learning process supported by hypermedia documents which usually contain text, audio, video and pop-up hints and hyperlinks to related topics.

Synchronous distance learning is almost synonym with the transmission of live lectures, but it embraces more diversified forms of learning in which the student is supported by several tools such as videoconferencing, whiteboard, chat box, etc.

Today in the Education research area, collaborative learning environments (virtual or real) are particularly interesting in that they are aimed at creating computer-based and multimedia-oriented learning processes where learners, that belong to a collaborative and interactive group, cooperatively construct knowledge. In fact, it has been proved that instructional methods promoting interpersonal discourse and social construction of knowledge (i.e., collaborative learning techniques) are more effective than methods which simply rely on the broadcast of information (classroom transmission metaphor) or on the asynchronous, self-paced access to on-line training materials (Cohen, 1994).

In this paper, an overview of the Collaborative Learning On-Demand (CLOD) paradigm along with its related technology is presented. CLOD is an original learning paradigm in which a small group of students cooperatively selects and controls the playback of a remote and archived multimedia session, exchanging questions with each other in order to discuss about the session contents (Fortino & Nigro, 2003). Both the control of the playback and the interactions between the students are cooperatively self-tutored. The CLOD paradigm is supported by the
Cooperative Playback Systems (CPSs) which are media on-demand systems providing cooperative playback sessions. In a cooperative playback session, the participants share the vision and the control of a multimedia session streamed by a media server, and interact with each other by means of a question board. From a network perspective, the construction of CPSs is efficiently enabled by the IP-based multicast technology which concurs to save network resources (e.g., bandwidth) and improve scalability (Kumar, 1996). IP-multicast allows for the transmission of a packet to a group of hosts which are identified by a multicast address belonging to the class D of IP addresses. The worldwide testbed of IP-multicast is MBone (Multicast Backbone) which, to date, cannot be accessed by all the users of Internet. However, private IP multicast-enabled networks (campus networks or intranets) can be easily set-up. It is worth noting that IP-multicast have promoted the proliferation of multimedia applications, systems and protocols useful for supporting synchronous learning according to the real/virtual classroom metaphor (Constantini and Toinard, 2001). To date, a few trials have been devoted to building CPSs. The most significant contributions in this direction are the VICRO C system, developed at University of Calabria, and the MASH Rover system, prototyped at University of California (Berkeley). In particular VICRO C addresses all the features of a CPS whereas MASH Rover only provides basic services.

The usability evaluation of VICRO C has shown that it efficiently and effectively supports the CLOD paradigm. In fact, on-going experimentations are confirming that the CLOD paradigm enabled by the ViCRO C system improves the learner’s productivity.

THE CLOD PARADIGM

Collaborative Learning on-Demand (CLOD) is a virtual collaborative learning paradigm which enables a self-tutored, interactive and cooperative learning process where a small group of remote students requests, watches and controls the playback of an archived lecture by exchanging questions with each other (Fortino & Nigro, 2003). CLOD borrows some of the ideas of the Tutored Video Instruction (TVI) and Distributed Tutored Video Instruction (DTVI) methodologies and tools (Sipusic, Pannoni, Smith, Dutra, Gibbons, & Sutherland, 1999). TVI is a face-to-face collaborative learning methodology in which a small group of students driven by a tutor goes over a videotape of a lecture. DTVI is a fully virtual version of TVI, in which each student has a networked computer equipped with audio (microphone and headset) and video (camera) facilities to communicate within a group. TVI and DTVI have proven real effectiveness in that the students involved in their experimentation have been shown to outperform students who physically attended the lectures. The substantial difference between CLOD and DTVI is that CLOD methodology does not assume the presence of a tutor which guides students to construct knowledge. This fact has a profound impact on the technical implementation of CLOD because, while in DTVI only the tutor has control of the videoconference recorder (VCR), in CLOD each participant to the playback session uses a shared VCR remote controller. In addition, being the learning service on-demand, CLOD needs to be supported by a video on-demand system (VoD).

The Internet MBone-based technology (Kumar, 1996; Crowcroft, Handley, & Wakeman, 1999) provides a rich set of tools for videoconference recording on-
demand and virtual collaborative learning which are the base for the development of multimedia systems supporting the CLOD paradigm. VideoConference Recording on-Demand (VCRoD) systems are VoD-like systems which allow a user to connect to a Media Server (MS) and request two kind of services: recording and playback (Holfelder, 1997; Parnes, Synnes & Schefstrom, 2000; Shuett, Raman, Chawathe, McCanne & Katz, 1998; Fortino & Nigro, 2003). Upon requesting a recording service, a user can either select a media session being transmitted over an IP-multicast address or send its own media session directly to the MS. This way, the MS archives the media session in a multimedia repository. The playback service allows a user to browse the list of the archived media sessions, select a particular media session and control its playback by means of a VCR remote controller. In addition, tools for multi-party, collaborative learning enables a group of users to interactively exchange audio/video live streams, text-based messages, and to cooperatively share whiteboards and document editors (MASH Consortium, 2001; MBT, 2001; Parnes, Synnes, & Schefstrom, 2000).

The CLOD paradigm is fully enabled and supported by the Cooperative Playback Systems (CPSs) (Fortino & Nigro, 2000) which extend the VCRoD systems by supporting cooperative group of users involved in CLOD sessions.

Several international research efforts are aimed at developing CPSs: the MASH Rover at University of Berkeley (MASH Consortium, 2001), the MBone Tools at University College of London (MBT, 2001), the Multimedia Lecture Board at University of Mannheim (MLB, 2001), and the ViCRO C at University of Calabria (Fortino & Nigro, 2003). Indeed, MASH Rover and ViCRO C are the only full-fledged CPSs. Although both are based on the multimedia Internet protocol stack (Crowcroft, Handley & Wakeman, 1999), they are implemented using different technology: MASH Rover is based on the TCL/TK script language and C++, whereas ViCRO C relies on JAVA technology.

**V I C R O C**: A COOPERATIVE PLAYBACK SYSTEM

The main functionality of the ViCRO C system can be summarized as follows.

*Group organization*, which contains group formation and group management. The former enables the creation of a group of users wishing to work on and control the same playback session. The latter deals with the following issues (i) how to share the starting time of a playback session for the synchronization of the group members; (ii) how to expel from the group a member who interrupts the others using an improper behavior. In particular, each Media Client (MC) wishing to join a cooperative session has to contact the Media Server (MS) in order to authenticate itself and receive the session key (or *Secret Share k*). The scheme adopted is based on asymmetric cryptography and a Certificate Authority (CA; Fortino, Russo & Zimeo, 2003).

*Media streaming*, which allows to multicast encrypted media streams based on the Real-time Transport Protocol (RTP; Schulzrinne, Casner, Frederick & Jacobson, 1996) to the cooperative group which is tuned on a Multicast Media Group (MMG). Encryption of media streams is based on an efficient technique centered on the Blowfish symmetric encryption algorithm (Fortino, Russo & Zimeo, 2003).

*Control sharing*, which enables a group of users to cooperatively control a media streaming session.
Joint-work, which allows the group participants to collaborate with each other by questioning on the contents of the cooperative session.

The architecture of ViCRO\textsuperscript{C} is depicted in Figure 1, which shows the basic components along with their protocol-based interactions and highlights the security-enhanced blocks. Media streaming and playing are supported by the Streamer and Player components which are based on the Java Media Framework (JMF) in which security was integrated, and are respectively located at the Media Server (MS) and Media Client (MC) sites. Cooperative playback control is enabled by the Multicast Archive Control Protocol (MAC\pi) which is a multicast version of the Real Time Streaming Protocol (RTSP; Schulzrinne, Rao & Lanphier, 1998). Collaboration among users is based on the COllaborative Protocol (CO\pi) which allows multicast-based exchanging of questions and annotations. Both MAC\pi and CO\pi are based on the Lightweight Reliable Multicast Protocol (LRMP; Liao, 1998). The Multimedia Archive keeps stored MPEG and RTP-based media files. The exchange of the secret session keys are enabled by the security-based join tool and the session key dispenser which communicate through SDP/SIP (Session Description Protocol / Session Initiation Protocol; Crowcroft, Handley & Wakeman, 1999) messages.

![Figure 1. The architecture of ViCRO\textsuperscript{C}.](image)

The usability of a CPS is mainly influenced by general factors, which are related to the network and to the desktop hardware and software environment, and by specific factors such as media on-demand service availability, easiness to set up a cooperative playback session, and degree of appeal and simplicity-to-use of the graphical user interface. Usability evaluation of ViCRO\textsuperscript{C} was carried out by using three different group of users in different scenarios based on a local cluster of PCs (Fortino & Nigro, 2003). Each user group is small (about 4-5 persons) and is formed respectively by professors and researchers, graduate students and students.
In order to have useful feedback by a user, a simple questionnaire was required to be filled out at the end of the playback session experience. The questions were about: (i) the perceived media quality including video and audio quality, and the quality of the lip synchronization; (ii) the perceived interactivity fluidity when playback control is applied and questions are sent to and received from companions; (iii) the friendliness and look & feel attractiveness of the graphical user interface; (iv) the degree of breakdown due to: (a) the lack of monitor space to layout all the GUIs; (b) the frequent pop-ups of the answer dialog, which allows replying to a question, and the voting dialog, which allows voting a control commands. Results of the analysis carried out show that: (i) the quality of service of the audio/video streams was considered good by the users; (ii) the control GUI was considered really intuitive and simple to use; (iii) when the interaction among users increases and the control actions are more frequent, user’s attention is taken away from the playback session and is focused on the interaction with answer and voting dialogs.

**CONCLUSION**

Collaborative Learning On-Demand (CLOD) is an original learning paradigm overviewed in this paper which enables a group of students to jointly work on and share a playback session. CLOD is fully supported by the Cooperative Playback Systems (CPSs). In particular, ViCRO\textsuperscript{C}, a full-fledged CPS developed at University of Calabria which also provides secure cooperative playback sessions, has been described. Usability evaluation of ViCRO\textsuperscript{C} have been carried out on the basis of three kinds of tests. Results indicate that media quality was considered good and the GUI easy-to-use. However, under conditions of high transmission frequency of questions and control commands, the attention of the session participants shifts from the playback to coping with frequent pop-ups of dialog windows. Based on this experience, ViCRO\textsuperscript{C} is being upgraded for embedding selective filters, which limit undesired questions, and timeouts, which regulate control command transmissions.

Moreover, appealing research opportunities are geared at (i) coupling a virtual reality based environment with a CPS so as to obtain a collaborative distributed virtual environment; (ii) creating personal and lightweight interfaces to CPS so as to allow a client using a personal digital assistant (PDA) to get in a cooperative playback session.

**REFERENCES**


Terms and Definitions

**VoD:** Video On-Demand is a planned system using compressed video streams to supply programs to viewers when requested, via a network.

**MBone:** It is the Virtual Internet Backbone for IP Multicast.

**JMF:** The Java Media Framework is a Java library for the development of stand-alone and networked multimedia systems.

**Multimedia Internetworking:** Multimedia internetworking refers to network infrastructures, protocols, models, applications and techniques which are being
currently deployed over the Internet to support multimedia applications such as videoconferencing, VoD, shared workspaces, etc.

**Usability Evaluation:** Usability evaluation can be defined as the act of measuring (or identifying potential issues affecting) usability attributes of a system or device with respect to particular users, performing particular tasks, in particular contexts.

**Media Encryption:** Any procedure used in cryptography to convert media objects into cipher media objects in order to prevent any but the intended recipient from reading that data.

**Certificate Authority:** An entity (typically a company) that issues digital certificates to other entities (organizations or individuals) to allow them to prove their identity to others.