Collaborative Learning for Everyone Based on Peer-to-Peer and Voice-over-IP Systems

ALEKSANDER BUŁKOWSKI†, EDWARD NAWARECKI† and ANDRZEJ DUDA*‡

†AGH University of Science and Technology, Cracow, Poland

‡Grenoble Institute of Technology, LIG Laboratory, France

*Corresponding author. Email: Andrzej.Duda@imag.fr

Abstract

In this paper, we explore new directions for future e-learning tools. Our idea is to use Peer-to-Peer (P2P) and Voice-over-IP (VoIP) technologies to enable collaborative learning communities. We start by analyzing the limitations of current e-learning tools and we outline the design choices for an e-learning tool based on P2P and VoIP technologies. We then discuss possible implementation options and outline expected results.

Keywords: E-learning; Peer-to-Peer systems; Voice-over-IP; Collaborative learning communities

1 Background

Even if the Internet and the Web have enabled a rapid grow of information and communication technologies used in learning, current technologies and tools for *e-learning* suffer from several problems:

- almost all technologies follow the traditional hierarchical learning model involving a teacher and a group of learners, a one-on-one instructional model,
- learners in a group usually work in isolation without collaboration or close communication,
- the cost of investment in e-learning may be prohibitive, for instance the professional video and audio equipment for multimedia distribution is expensive and requires highly qualified staff; running e-learning portals relies on qualified personnel and requires constant maintenance,
- using complex learning objects and advanced communication tools is not easy for all learners, because it requires some level of computer literacy and initial instruction, which can be a barrier for large adoption,
- finding relevant learning objects and delivery of the required material to learners may be time-consuming and usually require in-depth knowledge and expertise.

In our view, we can overcome all these problems with a new approach based on Peer-to-Peer (P2P) networking and simple to use communication technologies such as Voice-over-IP (VoIP) (Bułkowski 2006). We observe that existing e-learning tools have followed the development of the Internet and the Web, but widely deployed peer-to-peer tools have not been yet considered as a source of possible enhancement of e-learning technologies. We think that peer-to-peer technologies may

- enable wide and easy distribution of learning objects,
- change the traditional hierarchical teaching model into a flat one, a model in which *anybody can teach anybody*.
- support via the large scale distribution of learning objects the formation of collaboration communities with learners having common interests and objectives,
- provide an anchoring point for easy interactive communication between learners.

In the rest of the paper, we outline the design choices for an e-learning tool based on P2P and VoIP technologies (Section 2). We discuss possible implementation options (Section 3) and outline expected results (Section 4). Finally, we provide some conclusions (Section 5).

2 Collaborative Learning Based on Peer-to-Peer and VoIP

Our idea is to use P2P technologies for easy and large scale distribution of learning objects that will in turn enable the creation of collaborative learning communities. A P2P network may provide easy access to educational resources without the need for third party Web servers, which often require considerable management and maintenance effort. In a similar way to video or music files, complex learning objects may be easily disseminated among interested learners—P2P networks operate in an autonomous and spontaneous way with minimal management overhead. The advantage is that users can use P2P systems almost without any initial training.

2.1 Learning objects for P2P network

What learning objects need to be disseminated through our P2P network? Many different formats have been proposed for specifying learning content. It seems to us that the SCORM (Scorm 2004) format is the most popular one, even if several authors raise serious arguments against it as a suitable format for learning content (Wiley 2003). We can observe that many toolkits exist for creating, managing, and delivering learning objects in SCORM and many projects continue to work on e-learning tools based on SCORM. Thus, one of our design choices is to consider SCORM as a starting point in integrating and structured representation of complex information that may be exchanged via P2P technologies. However, we also plan to explore how more advanced formats such as IMS Learning Design can be also useful for our purpose.

2.2 Scalable searching

One of the issues in the current approaches to e-learning is finding and reusing learning objects. CODRA initiative (Content Object Repository Discovery and Registration/Resolution Architecture) proposes to build a federated infrastructure of content repositories (Rehak *et al.* 2005). The advocates of the project are convinced that traditional search systems used to integrate resource-sharing systems will ultimately not scale well. Thus, CORDA proposes a hierarchical architecture to enable easy searching of registered metadata across multiple content repositories. In our approach, we can take advantage of P2P systems to enable scalable searches without the need for complex federated infrastructure.

2.3 Precise indexing

Another problem in finding and reusing learning objects is the issue of a common language. The creator of a learning object needs to use a precise vocabulary to describe its content so

that potential learners can find and choose relevant objects. We propose to enable precise searching through the use of content-level metadata indexed with a specific domain ontology (Nawarecki *et al*. 2003, Celino *et al*. 2006). Domain ontology is a network of domain model concepts (topics, knowledge elements) that defines the elements and the semantic relationships between them. We plan to enhance current metadata specifications (such as LOM implemented in SCORM) with the use of domain ontology and to integrate them with search functionalities of a P2P system. In this way, a learner will be able to search for relevant learning objects in similar way as she can do it for a music file or a movie, but with much more precision with respect to the desired content.

2.4 Dynamic collaborative communities of learners

One of our goals is to get rid of teacher presence. If we can create a situation in which a learner can teach other learners, the teacher may have less load or even she may not even show up. In current distance learning systems, educational resources are usually conceived for a single learner that works on her own, in most cases in isolation from other learners (however, some interaction between learners is usually provided via fora or chat). Imagine that we distribute learning objects through a P2P network to a group of learners. The goal is to create a collaborative space of learners with similar interests to exchange knowledge, opinions, and experience so that they can learn, understand, and help/teach others. We can contribute in this way to collaborative problem solving in which anybody can learn something and anybody can teach anybody else. The resulting collaborative space may change the traditional learning model into an egalitarian community enabling mutual teaching and learning. In the proposed dynamically formed community of learners, the learning process may become more efficient, because its members may apply the principle of *learning by teaching*: the learners that understand different parts of the learning material can explain difficult matters to others. Usually it works well, because we start to understand a given problem sufficiently well, if we are able to explain it to somebody else. Thus, the whole group can make considerable progress even without referring to the author/instructor. In some cases though, more help will be needed and the learners can interact with the author/instructor.

2.5 Easy communication within a collaboration community

In current P2P systems, there is no communication between users exchanging files. In our view, we need to enhance a learning object with a sort of a *communication handle* that will enable easy interactive communication between learners. The enhancement consists of adding a means for anchoring a community of users interested in the content of a learning object: each learner that uses the object can easily communicate with other users or with the author/instructor related to the object. In our view, we can rely on existing widespread VoIP tools such as Skype, Gizmo, or recent Google Talk to offer easy communication between the learners working on the same learning object. This can be achieved by constructing a list of learners that have got a given learning object. At any time later on, a learner can contact other learners that use the object. Any other interested person such as an author or an instructor can be included in the list from its beginning. In this way, a learning object acts as a catalyst for a collaborative learning community.

2.6 Enriching the content

Our vision of a dynamically formed community of learners based on learning objects distributed on a P2P network may also enable a process of continuous improvement and enrichment of the content. Learners can modify a learning object or add new content in a

similar way to Wikipedia. We can even imagine that at the beginning, a template for a learning object is generated and progressively created by a collaborative community. If such a functionality is provided, we need to control the editing process to some authorized and authenticated persons. One approach to deal with this problem is to use the notion of a private virtual network such as Hamachi. This tool allows several hosts connected to the Internet to appear as connected to a local area network with all communications encrypted and authenticated. Joining the network is controlled through a password. P2P systems such as BitTorrent can operate over the network supported by Hamachi. We propose to explore how the concepts introduced by Hamachi can be used in controlling the edition of learning objects.

3 Implementation Options

Our project tries to explore some new ideas oriented towards the creation of dynamic collaborative communities of learners. We have started to implement them in order to validate the design choices and to provide an operational prototype that can be tested by learners. We discuss here main options for implementation of the prototype.

3.1 Learning Objects and Metadata

We plan to start with eXe, an Open Source tool that allows an author to create SCORM learning objects. It presents many of the elements which make up learning resources in forms that are technically simple and easy to use. In the eXe environment, these forms are known as iDevices (Instructional Devices). By building a learning sequence that includes a content structure and a number of iDevices users can begin to develop their own templates for content creation and reuse. Currently, eXe supports the authoring of Dublin Core Metadata which is then exported as a separate file with both SCORM and IMS exports. We plan to use eXe to create SCORM learning objects and enhance it with a support for metadata based on a domain ontology.

3.2 P2P Network for Collaborative Communities

There are several candidates for supporting P2P distribution of learning objects. Most suitable are BitTorrent, FastTrack, and Chimera. BitTorrent controls the distribution of a given object by means of a *torrent*, a file that contains metadata about the object to be shared and about the *tracker*, the computer that coordinates the object distribution. We can use a torrent to enhance a learning object with rich metadata. A tracker can serve as a point of contact for a collaborative community to bootstrap communication via VoIP. FastTrack supports the popular P2P Kazaa network so a first prototype would benefit from a large scale deployment. giFT is an Open Source project that works on a collection of various software components related to P2P networks. In particular, it provides a FastTrack plugin to participate in the Kazaa network. Finally, Chimera is a library that implements a structured P2P overlay routing infrastructure. It provides key-based routing in which messages addressed to any key incrementally route towards an overlay node responsible for that key. Such overlay can support distributed storage using a DHT (Distributed Hash Table) layer.

3.3 Support for Collaborative Communication

The last aspect is related to communication tools. For easy communication between the members of a collaborative community we need a suitable VoIP infrastructure. There are several possible directions. Similarly to Google Talk, we can build our infrastructure on Jabber, an Open Source project for instant messaging. It uses XMPP, the standard protocol for

instant messaging and presence technology based on XML streaming. A Jabber server may act as a point of contact for setting up a VoIP channel between two learners. Open client programs that allow VoIP calls over the Jabber network already exist, e.g. Jabbin. Skype has also raised some interest in applying VoIP technology in e-learning. Using Speechi learners can interact with an instructor using Skype. Gizmo is another VoIP tool, which unlike Skype builds on the public signaling protocol SIP. Setting up a SIP server as a point of contact for a collaborative community may be an alternative to using Jabber. If we choose this option, we will require some support for SIP signaling such as Asterisk, a popular and extensible open source VoIP system.

4 Expected Results

Our goal is to develop a first prototype to validate the ideas and to gather some data on user experience and system performance. With the first prototype, we plan to evaluate the efficiency of learning object dissemination and gather some statistics on collaboration of learners. We aim at providing possible learners with a new tool that will change the way users discover things and learn. Our research may have several practical applications. For example, we plan to create some initial courses in different domains: computer networks, knowledge management, and photography. One example of a learning object with the content enriched by the users may be a set of things to do during a hurricane alert: in a given neighborhood, a community of people add rules and hints on what to do in such a situation in a given place.

5 Conclusions

Our work aims at exploring new directions for future e-learning tools. The main idea is to use P2P and VoIP technologies to enable collaborative learning communities. The goal is to create a collaborative space of learners with similar interests to exchange knowledge, opinions, and experience so that they can learn, understand, and help/teach others. The resulting collaborative space may change the traditional learning model into an egalitarian community enabling mutual teaching and learning.

References

BUŁKOWSKI, A., NAWARECKI, E., DUDA, A., 2006, Peer-to-Peer: an Enabling Technology for Next-Generation E-learning. In *Fourth EDEN Research Workshop - Research Into Online Distance Education and E-Learning*, October 25–28, 2006, Castelldefels, Spain.

CELINO, I., DELLA VALLE, E., CERIZZA, D., TURATI, A., 2006, Squiggle: a Semantic Search Engine for indexing and retrieval of multimedia content. In SEMPS 2006, Dec. 6, 2006, Athens, Greece.

NAWARECKI, E., DOBROWOLSKI, G., CISZEWSKI, S., KISIEL-DOROHINICKI, M., 2003, Ontology of Cooperating Agents by Means of Knowledge Components. LNCS, Vol. 2691, *Multi-Agent Systems and Applications III*, June 16-18, 2003, Prague, Czech Republic.

REHAK, D.R., DODDS, P., LANNOM, L., 2005, A Model and Infrastructure for Federated Learning Content Repositories. In *WWW 2005*, May 10–14, 2005, Chiba, Japan.

SCORM-2004, 2004, Sharable Content Object Reference Model. Available online at: www.adlnet.org (accessed Feb. 2007).

WILEY, D., 2003, Learning Objects: Difficulties and Opportunities. Available online at: opencontent.org/docs/lo_do.pdf (accessed Feb. 2007).