SUPPORTING ONLINE LEARNING TEAMS USING P2P TECHNOLOGIES

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Abstract

P2P systems have become popular for file sharing among Internet users. Due to improvement on network communications and the processing power of desktop machines, there is an increasing interest in exploring P2P technologies for developing groupware tools to support eLearning. Nowadays most online learning systems are centralized web-based, which show several limitations such as maintenance cost, scalability and having a single point of failure. P2P technologies are an important alternative to develop decentralized online learning systems in which students can be more than mere clients and can use their own computational resources for task accomplishment during online learning process. Unfortunately, current P2P systems cannot be used in a straightforward way for supporting real online teams since they cannot be customized for small group purposes and there are important security issues in such systems. In this paper we will present the design and implementation of groupware tools using a JXTA-based P2P platform, called JXTA-Overlay. We build on previous work in which JXTA-Overlay was successfully used for developing a customized file sharing system. The current paper will present the design and implementation of new groupware tools for online teams of a virtual campus. The proposed groupware tools include communication tools such as messaging and rooms and tools for learning *scenario*. By using the system, the members of a small online team of students can create learning scenarios corresponding to common work projects arising in online learning; then, they can use the learning scenario to define, assign and track a set of tasks within the learning scenario assigned to the members of the group. All in all, this work is a step towards using P2P technologies in the design and implementation of decentralized online learning systems.

Introduction

The fast development of the Internet has enabled the development of virtual organizations (Foster et al., 2001), which support the collaborative activities of a community of members. Virtual organizations appear in different forms such as virtual university campuses and virtual institutions. Virtual Organizations are thus considered a new paradigm of organization of a group of people having common

goals. Virtual campuses (aka Open Universities) are becoming a common approach to offer distance learning and teaching using online platforms, and are overcoming limitations and restrictions of face-to-face learning and teaching. In the case of virtual campuses, the members of the community (students, teachers, tutors, etc.) pursue academic goals collaboratively. As an example, the Open University of Catalonia (UOC: http://www.uoc.edu) offers distance education through the Internet in different languages to about 50,000 students and tutors from everywhere who participate in some of the 23 official degrees and other PhD/post-graduate programs, a total of more than 600 official courses.

An important feature of virtual educational organizations is the ability to share learning resources, such as in-class assignments and study material in the form of documents, and calendars for carrying out complex data-intensive learning activities. The objective is to offer on-demand, ubiquitous access to computing, data, and services for eLearning. Most of the current online educational institutions are still supported by traditional client-server applications (Gaudioso et al., 2003) that enable sharing among the members of the community. The issue in such applications is not to share but rather manage limited and controlled sharing just for the members of the virtual organization, which rule and decide how the sharing will take place, impose conditions on what is shared, by whom and how. The popular client-server systems have many well-known drawbacks. In such systems, the shared resources are centralized on servers and members of the virtual community (clients) access them through request protocols. Everything is done at the server side while at the client side just an interface is needed. This brings important non-functional limitations, such as lack of scalability and fault tolerance, low performance and bottlenecks as well as high costs in acquiring, developing and maintaining such applications. Indeed, in large server-based virtual organizations, such as the Virtual Campus of Open University of Catalonia, the centralized approach is rather expensive (and in some cases, prohibitive, such as when acquiring professional video and audio equipment for multimedia distribution) and not easy to maintain, requiring complex tasks, such as smart distribution of the load as well as synchronization and coordination of the resources. Besides being a single point of failure, centric approaches lack of scalability (as the campus grows up in number of users and in learning activities the performance of the system could diminish). In order to overcome these inconveniences, the most powerful and emerging alternative to client-server model to support virtual organizations is the decentralized approach, namely P2P networks. While in a centralized model, the client mainly uses an interface, in a decentralized approach the client may act as a client and a server at the same time depending on what operation it needs to perform and thus becomes a primary "actor" of the system by contributing, managing and controlling the resources.

In this work we approach the use of decentralized P2P approaches to support online collaborative learning of small groups of students. The main reasons and motivations for addressing P2P technologies are as follows. P2P technologies have appeared as disruptive technologies that allow the implementation of decentralized, therefore fault-tolerant, online learning systems. Moreover, such systems enable efficient sharing of information (through intelligent replication techniques) and direct connection in P2P fashion allows efficient file transmission as opposed to FTP approaches of centric applications. Further, P2P technologies allow for designing and implementing customized learning applications that support the needs of small groups, that is, such applications can be applications tailored to small groups of students. Unfortunately, current P2P systems cannot be used in a straightforward way for supporting real online teams since they cannot be customized for small group purposes and there are important security issues in such systems. Our approach is based on recent development of P2P technologies, namely JXTA library from Sun MicroSystems (Brookshier et al., 2002), which includes protocols for peer group management. Finally, one last motivation is that using P2P applications promotes the use of contributory systems which are built up by the contribution of computational resources by the students of the online campus.

We present the design and implementation of groupware tools using a JXTA-based P2P platform, called JXTA-Overlay. We build on previous work in which JXTA-Overlay was successfully used for developing a customized file sharing system. The proposed groupware tools include communication tools such as messaging and rooms and tools for learning scenario. By using these tools, members of a small online team of students can create learning scenarios corresponding to common work projects arising in the online learning; then, they can use the learning scenario to define, assign and track a set of tasks within the learning scenario assigned to the members of the group.

The Context: Online Collaborative Learning

Our academic context is the virtual campus of the Open University of Catalonia, where the learning goals pursued by many of the courses offered are based on the Project-based Learning paradigm (Zumbach et al., 2003). Courses based on this paradigm, such as “Software Development Techniques” in the Computer Science degree, requires groupware applications to manage small groups of 4–5 students to work collaboratively and thus share documents, source code, etc. in order to accomplish a software project. Moreover, we would like our students to be not only participants but also managers of their group space by sharing in a decentralized and collaborative way their common resources. Students will eventually form a small community having the same profile and each student is an

equal participant. Thus, collaboration in a P2P system is intended to be direct between group peers, following social rules and without the restrictions imposed by institutional regulations. Full autonomy, group monitoring, confidentiality and security are also crucial in this context. By considering these aspects, the learning process may become more efficient because group peers can be aware of the status information of the preferred peers, and interact directly and share resources with those preferred peers in order to provide additional scaffolding or social support when needed.

Current Status of Use of P2P Technologies for eLearning

Popular P2P file sharing systems such as Freenet, Gnutella, Overnet, and Bittorrent are not suitable for our goals pursued in an online academic context. These systems are actually not even appropriate to support virtual organizations in general. The main reasons are found in that such systems are not pure P2P but rather hybrid P2P and server-mediated systems. Indeed, they combine nodes made up of simple computers with large servers or lists of different servers (usually called super nodes), which provide file and peer searching and indexing functionalities for direct and rapid searching and downloading of files. Most importantly, in such approaches users do not have control on information sharing and hence cannot meet essential needs in on-line collaborative learning, such as for managing a customized and secure shared environment for small groups of students.

The use of P2P technologies in the context of e-Learning has been to date little investigated. A few works have pointed out the importance of applying P2P technologies to education. Edutella (Nejdl et al., 2002), for instance, has proposed a P2P architecture for exchanging RDF-based metadata by building upon Semantic Web techniques and the JXTA middleware. Berman and Annexstein (2003) considered P2P technologies as crucial in future educational systems. In particular, they propose to integrate them in a new personal knowledge management paradigm. In Jin et al. (2004) the authors suggest to combine P2P, Grid and e-Learning for developing powerful, efficient, scalable, mobile and versatile environments. Fakas and Karakostas (2004) provide a potential application of P2P technologies to online learning by defining a peer group in P2P networks as a set of peers formed to serve common interests or goals dictated by the peers involved, such as security requirements of the peers involved and the need for status information on the members of the group. Finally, in Bulkowski et al. (2006) the authors also propose to use P2P technologies for large scale distribution of learning objects that will enable the creation of collaborative learning communities.

Peer Group Management in P2P systems: JXTA Library Support

One of our motivations is to use the JXTA-Overlay platform for developing groupware tools for supporting learning and teaching activities of small online groups. Therefore, relevant functionalities for groupware applications are provided, such as the creation of learning scenarios that a group of students can perform, task management within a given scenario (task creation, modification, etc.), task assignment to group members, acceptance/rejection of a task as well as information and statistics about learning scenarios, tasks and their realization, groups and specific members of the groups. The specificity of the groupware tools is that any peer group can instantiate them. The objective is thus to develop groupware tools that can be tailored to the needs of small groups of students. To this end, an efficient management of peer groups is very important for the overall performance of the system.

JXTA library offers a series of protocols that allow efficient management of a group of peers through the rendezvous peer (or super-peer). Thus, the library offers the "Rendezvous Protocol" (RVP) for message propagation to a group of peers. The RVP provides mechanisms that allow the propagation in a controlled and efficient manner. The RVPs work together to form a PeerView which is a list of peers who are currently serving as Rendezvous Peers. Thus, PeerView is structured in a way that enables RVP's to send messages through a PeerGroup. A PeerGroup is a key piece in the JXTA library. A PeerGroup is a collection of peers that have agreed to use a common set of services. Any PeerGroup is assigned a unique peer group ID and requires the implementation of the group services (membership, discovery, resolver, etc.). The Rendezvous Peer is central point for a PeerGroup. Each PeerGroup is identified with a unique groupID and has its own policy defining group membership. It should be noted that peers can simultaneously belong to more than one PeerGroup; the netPeerGroup is actually the first group of peers to which a peer belongs in becoming member of the JXTA network. PeerGroups provide a series of services such as discovery, pipes, monitoring, etc.

JXTA-Overlay Platform

In order to achieve the above-mentioned goals, we use the JXTA-Overlay P2P middleware (Xhafa et al., 2008) with offers a set of primitives for supporting efficient peer group management and development of groupware tools. The JXTA-Overlay project is an effort to use JXTA technology for building an overlay on top of JXTA offering a set of basic functionalities that are most commonly needed in JXTA-based applications (see https://jxta-overlay.dev.java.net/)

The peer group management in JXTA-Overlay takes advantage of the *peerGroup* entity. The basic primitives for peer group management can be used in an independent way by any P2P application that uses peer group as a unit. Thus, the *peerGroup* can be used for executing tasks in the peer group's resources as well as to support online teams of students by developing customized groupware tools tailored to the specific needs of small online teams of students for which group autonomy, monitoring, confidentiality and security are important concerns.

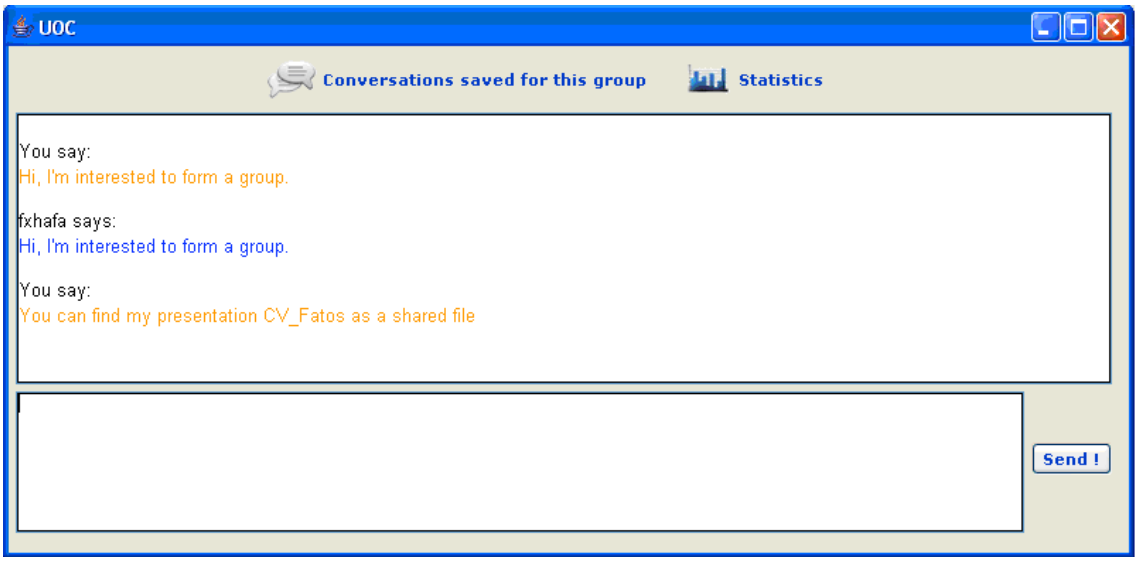
Groupware Tools in JXTA-Overlay Platform in Support for e-Learning

The groupware tools developed for e-Learning comprise: instant messaging, management of rooms, management of learning scenarios and task coordination among peers of a group (i.e., students of a study group) within a learning scenario.

Instant Messaging

JXTA-Overlay comprises also primitive functions for instant messaging and rooms, that is, direct communication (via text messages) among online Client peers and rooms. The particularity of this approach is that both instant messaging and rooms are instantiated within a group of peers, not only at *NetPeerGroup* (i.e. the whole network) level. Thus, instant messaging and rooms can be managed in a controlled and secure manner only by the members of a group of peers, which is very appropriate in an online academic context (see Figure 1).

Figure 1: Snapshot of Instant Messaging



Rooms

Besides the management of permanent groups, members of a group of peers can manage temporal group activity, that is, rooms for short online meeting, negotiations, etc. among members of a group. A user can create a room and invite some or all the members of group to the room. In order to create a room the user has to indicate a name and a description for the room; further, the user can select the peers to be invited to join the room. Upon sending the invitation, the peers will receive it and can either accept or decline the invitation (see snapshots in Figures 2 and 3 below).

Figure 2: Room Creation

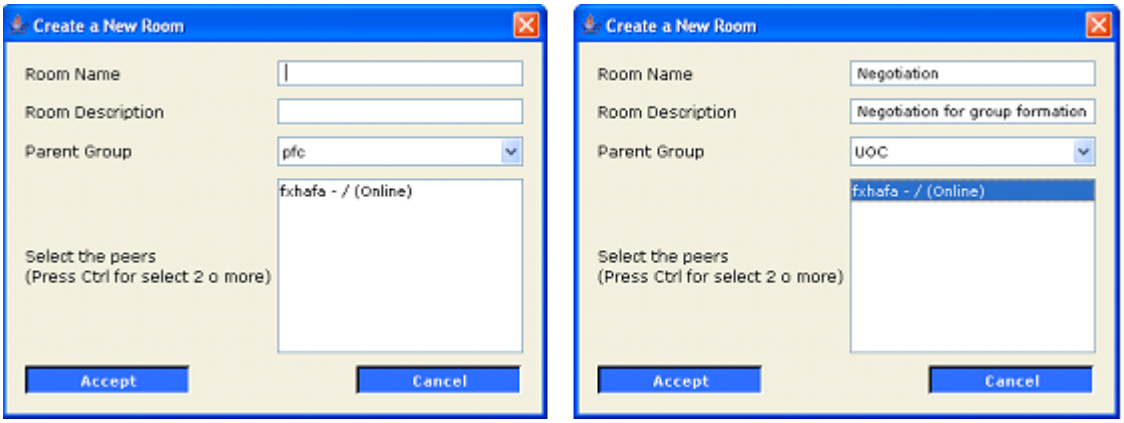
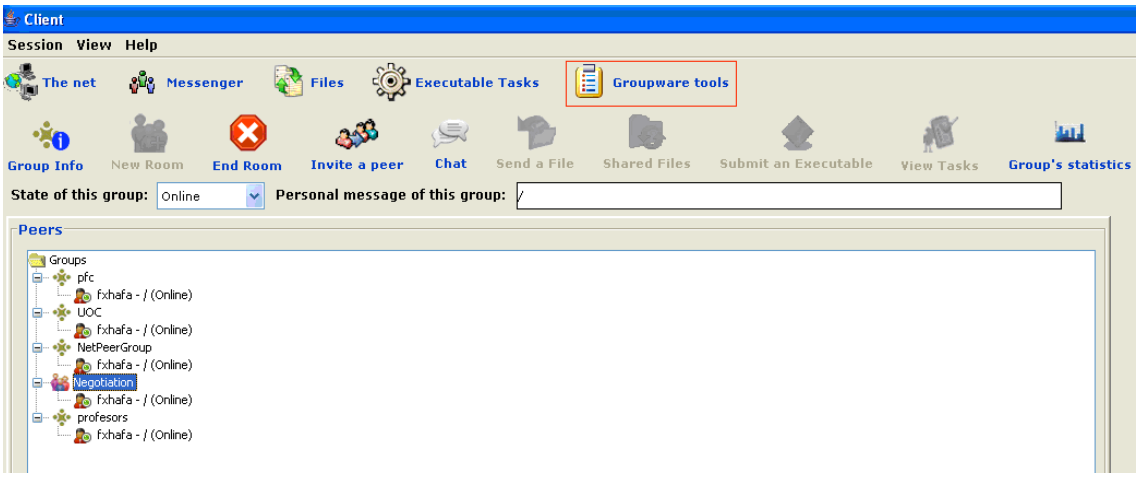


Figure 3: Confirmation of Room Creation (left); Invitation to Join the Room (right)

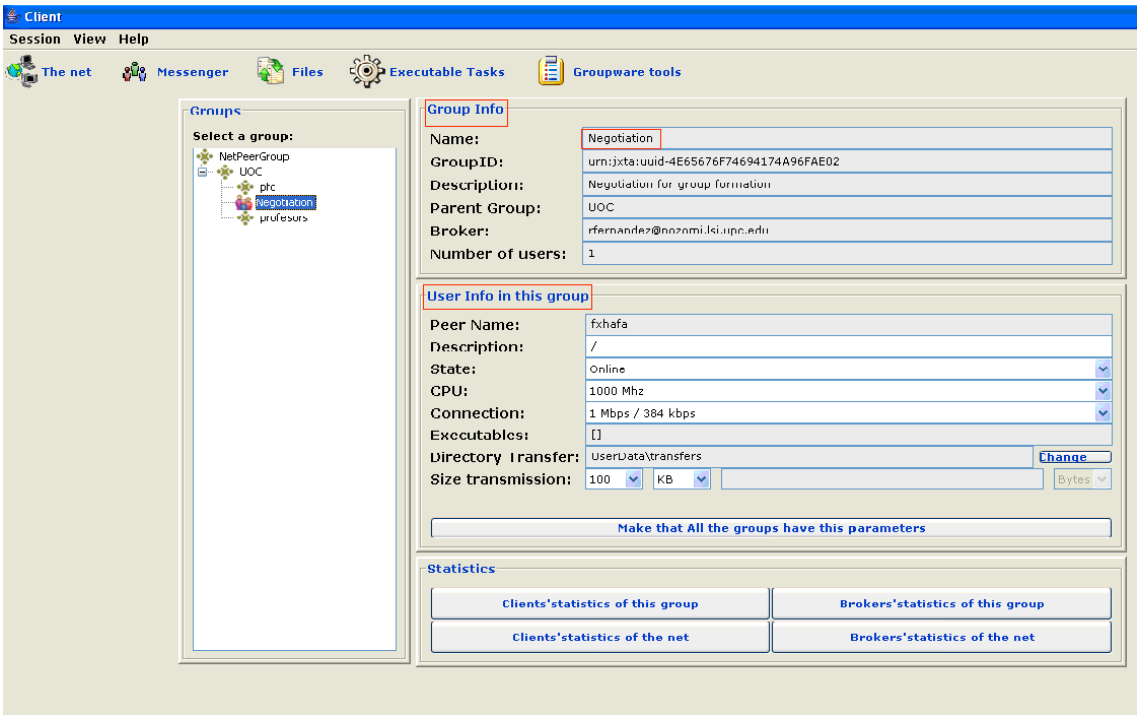
Rooms can be viewed online. For instance, the room Negotiation can be seen in the overall view of the Net (see Figure 4, under the Groupware tools).

Figure 4: View of the Net



Further, peers can consult the information relative to a room (the room negotiation, in this case) as well as the information on the peer that has crated the room including the characteristics of computational resources (such as CPU usage, bandwidth, the list of executable tasks, the chunk size used for file transmission; see Figure 5).

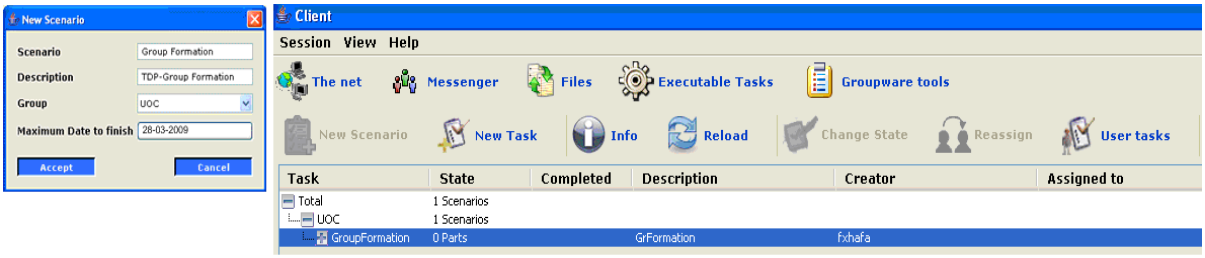
Figure 5: View of Group and User Information



Learning Scenarios

One common requirement for groupware tools for e-learning is to provide learning scenarios for groups of students, that is, the possibility that tutors and/or students could define and accomplish a learning scenario within a subject or a project development. Therefore, we defined and implemented, as part of groupware tools on top of JXTA-Overlay, a learning scenario, which in turn is composed of several (smaller) tasks. Moreover, it is possible to assign tasks to members of groups and monitor their completion within the specified time (see Figure 6: new learning scenario on the left and the view of the learning scenario in the Net). In this case, the learning scenario is called "Group Formation", which is the very first step in online collaborative learning.

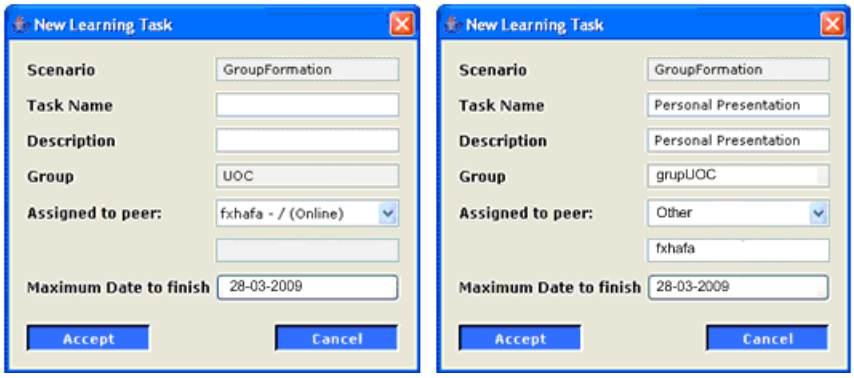
Figure 6: Creation of New Learning Scenario: Group Formation



Task Creation, Assignment and Coordination

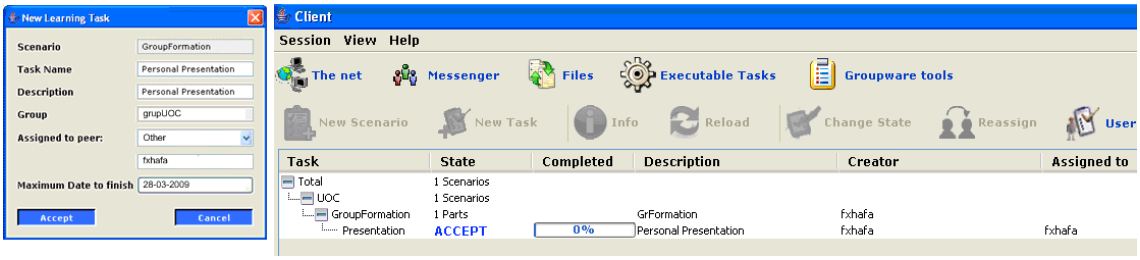
Once a scenario has been created, the owner of the scenario can create learning tasks within scenario. Thus, in order to proceed with a group formation scenario, a series of steps are to be accomplished, such as personal presentation, professional abilities, time availability, negotiation of group functioning rules, voting about important decisions, planning of the project into milestones, and so on. For each step, a task can be created within the scenario (see Figure 7 for a snapshot of the creation of a new learning task with GroupFormation scenario.)

Figure 7: Snapshot for Creating New Tasks within a Scenario. Task Creation and Assignment to a Peer within the GroupFormation Scenario



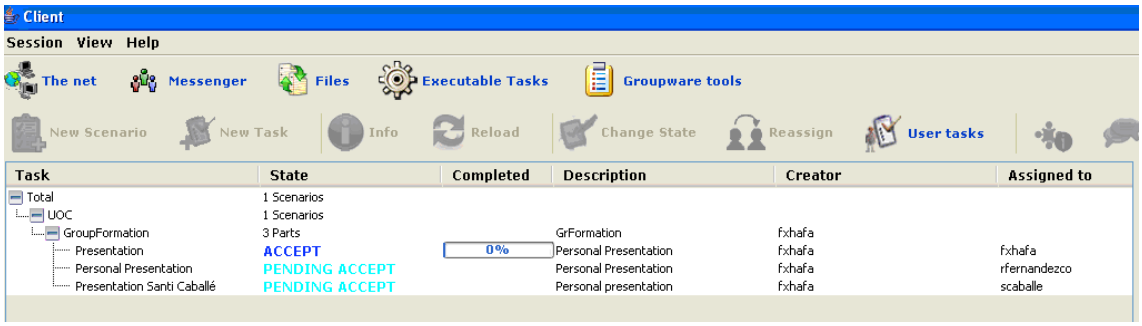
Task assignment and progress completion. Once the task has been assigned to a peer, the peer will receive a request for accepting or declining the task. A peer can be assigned many tasks and the information on the task can be seen in the Net. For instance, in Figure 8, we can see that a task *Presentation* within GroupFormation scenario has been assigned to the peer *fxhafa* who has accepted the task. Moreover, we can see the state of the task (progress completion), which is at 0% upon acceptance.

Figure 8: Status of the Task (in % of completion)



Further, we can see the state of the tasks of other peers. In Figure. 9, we can see that one of the peers has accepted the task but there are two other peers whose tasks are pending to accept.

Figure 9: Status of Tasks of Peers of the Group (in % of progress completion)



Attaching files to tasks. Accomplishing a task may need some additional information such as documents, computer programs, etc. Let us suppose that a peer would like to attach his/her CV to the task of Personal Presentation within GroupFormation scenario. In such case, the peer can attach files to a task, using the Shared files functionalities (see Figure 10).

Figure 10: Attaching a File to the Task (first step)

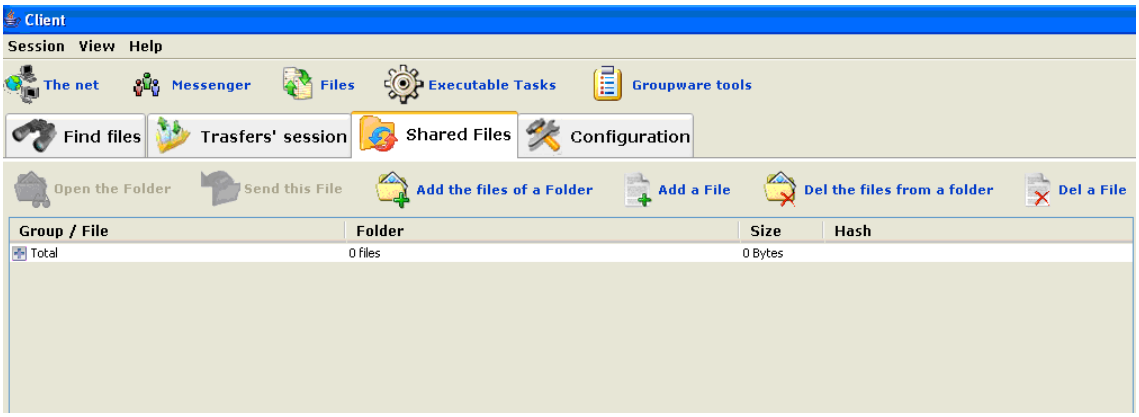
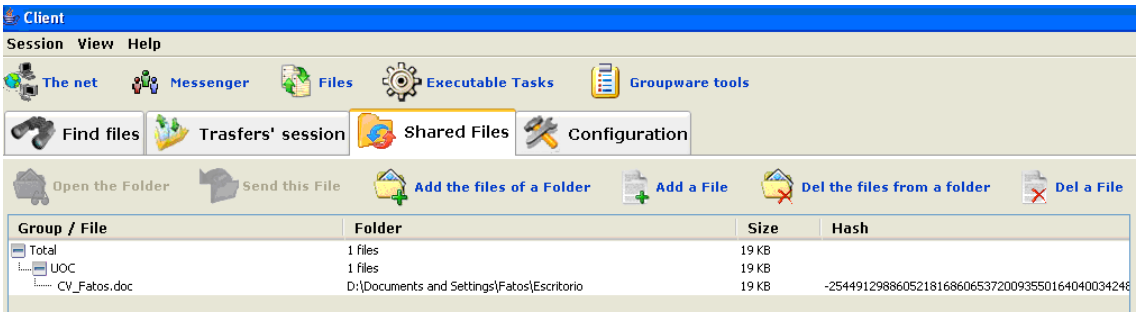


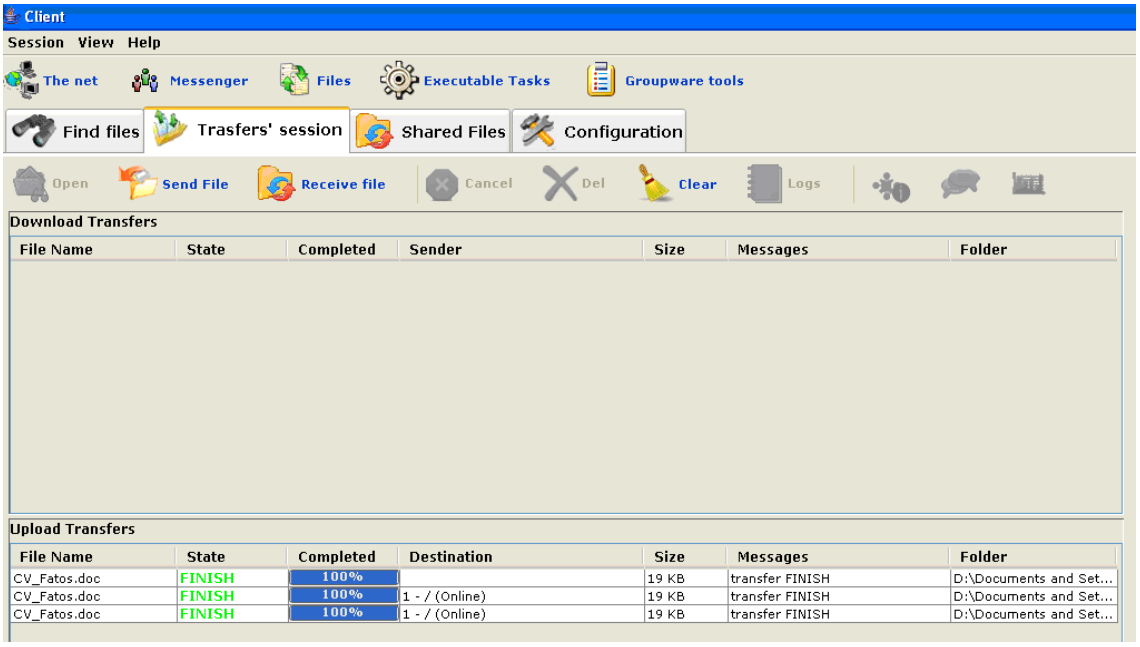
Figure 11: Attaching a file to a task (second step: file selection)

Figure 12: View of Attachment of a Document to a Task



Members of the group can also see the peers that have downloaded the attached documents.

Figure 13: Download Progress of a Document Attached to a Task



Summary and Future Work

In this work we have explored the use of P2P technologies as an important alternative to centralized web-based approaches for the development of online learning systems. The interest in approaching P2P technologies for online learning is manifold. Web-based learning systems show several limitations such as maintenance cost, scalability and have a single point of failure while P2P systems are decentralized, fault-tolerant, enable efficient file sharing and direct

communication among peers. Moreover, in P2P systems, peers can use their own computational resources for task accomplishment during online learning process.

After investigating the current status of P2P systems, we concluded that systems such as Gnutella and Freenet cannot be used in a straightforward way for supporting real online teams since they cannot be customized for small group purposes and there are important security issues in such systems. For our purpose of developing P2P systems that support online groupware tools, we considered JXTA, a P2P library which has a key feature: the efficient management of groups of peers through rendezvous peer definition. To this end, we have presented in this paper the design and implementation of groupware tools using a JXTA-based P2P platform, called JXTA-Overlay (https://jxta-overlay.dev.java.net/).

The proposed groupware tools include communication tools such as messaging and rooms and tools for learning *scenario,* task assignment and management within a learning scenario. By using the system, the members of a small online team of students can create learning scenarios corresponding to common work projects arising in the online learning such as group formation, project planning, etc.; then, they can use the learning scenario to define, assign and track a set of tasks within the learning scenario assigned to the members of the group. All in all, we believe that this work is an important step towards using P2P technologies in the design and implementation of decentralized and efficient online learning systems.

In our future work we plan to evaluate the proposed groupware tools in the real context of our academic context and compare the performance of the online teams using the web-based applications vs. our groupware tools. We also plan to investigate how mobile devices can be used in our groupware tools to enable the online learning activity “anytime & anywhere.”

References

Berman, K. A., & Annexstein, F. S. (2003) An educational tool for the 21st century: Peer-to-peer computing. *Proc of Ohio Learning Network Conference.*

Brookshier, D., Govoni, D., Krishnan, N., & Soto, J. C. (2002.) *JXTA: Java P2P Programming*. Sams Pub.

Bulkowski, A. Nawarecki, E., & Duda, A. (2006). *Peer-to-peer: An enabling technology for next-generation e-learning.* 4th Research Workshop on Online Distance Education and E-Learning, Spain.

Fakas, G., & Karakostas, B. (2004). A peer to peer architecture for dynamic workflow management using web services. *Information and Software Technology Journal*, *46*(6), 423–431.

Foster, I., Kesselman, C., & Tuecke, S. (2001). The anatomy of the grid: Enabling scalable virtual organizations. *International Journal of High-Performance Computing Applications, 15*(3), 200–222.

Gaudioso, E., & Boticario, J. G. (2003). Towards web-based adaptive learning communities. *Proceedings of AI in Education* (pp. 237–244). Australia: IOS Press.

Jin, H., Yin, Z., Yang, X., Fang, W., Ma, J., Wang, H., & Yin. J. APPLE: A novel P2P based e-learning environment. *LNCS*, *3326,* 52–62.

Nejdl, W., Wolf, B., Qu, C., Decker, S., Sintek, M., Naeve, A., et al. (2002). Edutella: A P2P networking infrastructure based on RDF. *Proc. of the 11th World Wide Web Conference*. CDROM ACM 1-58113-449-5/02/0005

Xhafa, F., Barolli, L., Daradoumis, Th., Fernandez, R., & Caballe, S. (2008). JXTA-Overlay: An interface for efficient peer selection in P2P JXTA-based systems. *Computer Standards & Interfaces*. In Press, available online.

Zumbach, J., Hillers, A., & Reimann, P. (2003). Supporting distributed problem-based learning: The use of feedback in online learning. In T. Roberts (Ed.), *Online collaborative learning: Theory and practice* (pp. 86–103). Hershey, PA: Idea.