OVERVIEW ON AGENT APPLICATION TO SUPPORT COLLABORATIVE LEARNING INTERACTION

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ABSTRACT

Collaborative learning involves students working together to aid their learning and is considered an effective method to implement learning goal. However, it involves complicated processes such as have inconvenient assistance to manage the increasing demand for information and support extension of interaction and how to activate collaboration interaction and communication between different types of interactions. A collaborative learning model based on agent can improve learning effectiveness and give good impact to learning process.

This paper discusses the definition, classification and roles of agent to support collaborative learning interaction in e-learning. It overviews the rapidly use of agents to support collaborative learning and describes the types of interaction and communication tools to enhance interaction between all participants. We identify three types of major agents used in collaborative learning interaction; interface agent, information and internet agent, and collaborative agent.

Keywords: agent, collaborative learning, interaction.

INTRODUCTION

With the rapid expansion of communication and information technologies, working together in groups can be done effectively at a distance and at any time. Collaborative learning is a learning strategy where several learners interact with each other in order to achieve their common goals (Yacine & Tahar, 2007). According to Johnson and Johnson (1999a), learners learn better when they learn together and foster creative thinking as members in a group generated new ideas, strategies, and solutions more frequently than working individually. Moreover, online collaborative learning is regarded as an effective method for improving practical and highly advanced problem solving abilities and is being partly applied in the areas of action learning in companies, and of project-based learning and inquiry-based learning in schools (Bielaczyc & Collin, 1999; Johnson & Johnson, 1986b).

However, numerous studies show collaboration is more difficult in e-learning environments. These studies cite such components as physical separation, reduced sense of community, disconnectedness, isolation, distraction, and lack of personal attention as contributors to lack of success in various virtual programs (Kerka, 1996; Stonebraker & Hazeltine, 2004).

Furthermore, the presence of an agent in a collaborative learning is essential since the agent is a crucial part of the learning design process and now constitutes powerful tools that are utilized in most applications. Most of current collaborative learning systems integrate an agent to improve performance of learning. Generally this agent supports in synchronous and asynchronous environment. Yacine and Tahar (2007) have argued that the main features of agents (as well as the modularity, the adaptivity and the autonomy) can make them good tools for supporting collaborative learning systems.

The rest of the paper is organized as follows. In Section 2 we briefly introduce agent in collaborative learning. Section 3 firstly provides the types of interaction in collaborative learning and then types of communication that support interaction in cluster of agent. Section 4 gives the concluding remarks.
AGENT IN COLLABORATIVE LEARNING
The concept of agents in software engineering is not new, but it has begun to develop quickly and be successful in recent years. In this section, we examine the definition, classification and roles of an agent in collaborative learning.

Definition of an Agent
Agents cannot be easily defined, as seen by the numerous definitions cited by Franklin and Graesser (1996). In general, an agent is regarded as a function or software program that, when requested to do an action, understands the intention of the request and performs the action under the agent’s own independent judgment (Lin, Esmahi & Poon, 2005). According to Wooldridge and Jennings (1995), there are some common properties that most definitions include. Agents are autonomous which means that they act independently of any other entity. Agents are also interactive or communicative; they can send and receive messages with other agents. Agents also exist in some environment that they can sense and they act upon that environment. Agents can also exhibit other properties such as adaptability, reactivity, proactivity, mobility, responsivity and rationality. Shoham (1997) additional properties by continuously; agent would be able to learn from its experience.

In education situation, the autonomy of an agent means the ability to perform independently a task assigned to the agent by a person or other software. Lin, et al., (2005) explained the autonomous feature of agents reduces users’ burdens of learning activities, teaching activities, management activities, and so on. Chen and Ding (2005) have argued that it is impossible for educators to manage the large volume of information generated from learners’ interaction. Agents can process a huge amount of data, make direct interventions in the process, and interact with other agents for carrying out tasks. Thus, they can help users concentrate on the contents that they are studying (Suh & Lee, 2006).

Furthermore, agents promote interaction between a human and computer for the delivery of information, and interaction among human users for high-level achievements. Another advantage of agents in education is that they provide a learning environment customized to individuals, a unified learning environment, integration between local and remote resources, and a mechanism for users to concentrate on knowledge provided by the agents (Chen & Ding, 2005).

Classification of an Agent
Agent can be classified by the type of the agent, by the technology used to implement the agent, or by the application domain itself. Nwana (1996) proposes seven categories, as shown in figure 1, of agents as follows: 1) collaborative agent; have to negotiate in order to reach mutually acceptable agreements on some matters, general characteristics of these agents include autonomy, social ability, responsiveness and proactiveness; 2) interface agent is a personal assistant who is collaborating with the user in the same work environment; 3) mobile agent; their ability to move around some network; 4) information and internet agent; perform the role of managing, manipulating or collating information from many distributed sources; essentially, they help manage the vast amount of information in wide area networks like the internet; 5) reactive agent; shows a reaction or response to the user that should not wait to be told what to do next; 6) hybrid agent; refer to those whose constitution is a combination of two or more agent philosophies within a singular agent; 7) heterogeneous agent system; contain one or more hybrid agents which is belong to two or more different agent classes.
Roles of an Agent
The collaborative learning will be populated by a variety of autonomous agents that it can play many roles, hence personal assistants or knowbots. Agent roles are defined by four attributes: responsibilities, permissions, activities, and protocols (Wooldridge, Jennings, & Kinny, 2000). Roles signify the behaviors of an agent. The behavior of an agent is one of the most difficult aspects to model using current class diagrams. In addition to roles, agents can also belong to groups. Agents can belong to one or more groups and have one or more roles within each group because an agent’s group and role designations are dynamic.

Soller, Jermann, Muhlenbrock, and Martinez (2004) suggested three methods of supporting collaborative learning. The first method involves quantifying the learners’ joint work activities in a graph or other means and presenting the results to participating learners so that the learners can understand their collaborative acts. The second method involves monitoring and modeling all interactions among the learners and presenting differences between the ideal state and the current state. The third method involves analyzing the state of collaborative learning and providing advice for effective collaboration.

Soller et al., (2004) and Hmelo (2002) suggested that the common roles of agents that support collaborative learning are as follows: 1) monitoring the collaborative learning process; 2) giving feedback and guidance to activate interaction and collaboration among participants; 3) giving information on the current state of a learner’s interaction in the collaborative learning process; and 4) giving advice on the learning process according to the process and strategy of collaborative learning by comparing the current and ideal states.

Nowadays, there are a number of agents and their functions have been designed specially for support collaborative learning by many authors as shown in table 1. Each of them possesses its own view on the agent. The main idea consists to say that there is not a standardization concerning the components of a system, or the affected role to each agent in the system. The architecture of the system and the role given to each agent depend both on the type of application and the global functionalities of the system. Based on classification of agents by Nwana, we identified clustering of each agent.

From clustering, we can observe that the agents appear in a collaborative learning typically can have a great variance in physical attributes, and have different inherent functionalities. However, the most popular agents used in collaborative learning are collaborative agent, interface agent, and information and internet agent. Therefore, it is necessary to set some guideline for this multitude of agents, which have to interact in a collaborative learning and communicate with each other, and orient them towards the group-learning goal.
### Table 1: Example of Agent in support collaborative learning

<table>
<thead>
<tr>
<th>Author</th>
<th>Name of Agent</th>
<th>Function of Agent</th>
<th>Type of communication</th>
<th>Clustering of Agent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hee-Jeon Suh and Seung-Wook Lee (2006)</td>
<td>Monitoring Agent</td>
<td>collects, analyzes, and processes information on learners' collaborative learning activities and stores it in a workplace. In particular, the monitoring agent tracks the process of learners' collaborative activities according to the form defined by the workplace reference model and stores this information in a temporary workplace.</td>
<td>Asynchronous • discussion boards • Email</td>
<td>Information and Internet Agent</td>
</tr>
<tr>
<td></td>
<td>Facilitator Agent</td>
<td>analyzes the data in the workplace database that was collected by the monitoring agent, automatically produces learning advice and alarm messages and statistically analyzes collaborative learning.</td>
<td>Synchronous</td>
<td>Collaborative Agent</td>
</tr>
<tr>
<td>Khaing Moe San, et all (2005)</td>
<td>Mobile Agent as a Personal Agent</td>
<td>To assist the student and the human tutor</td>
<td>Synchronous and Asynchronous • Chat • Email</td>
<td>Mobile Agent</td>
</tr>
<tr>
<td></td>
<td>An Artificial Tutor Agent</td>
<td>Partially tries to replace the human during student interaction.</td>
<td>Synchronous and Asynchronous</td>
<td>Interface Agent</td>
</tr>
<tr>
<td></td>
<td>Information Agent</td>
<td>Takes the responsibility to control database and knowledge access</td>
<td>Asynchronous and Synchronous • Chat • Email</td>
<td>Information and Internet Agent</td>
</tr>
<tr>
<td></td>
<td>Question Agent</td>
<td>To prepare the question and evaluate the answer</td>
<td>Synchronous</td>
<td>Information and Internet Agent</td>
</tr>
<tr>
<td>Lafifi Yacine &amp; Bensebaa Tahar (2007)</td>
<td>Assistant Agent of Learner</td>
<td>It proposes to the learner an interface which makes the learning task easier for learner.</td>
<td>Asynchronous and Synchronous • Forum (public forum, group forum and subject forum) • Email • Chat</td>
<td>Interface Agent</td>
</tr>
<tr>
<td></td>
<td>Tutor Agent</td>
<td>To present the pedagogical objectives to the learner according to his/her final profile and his/her current knowledge state.</td>
<td>Asynchronous and Synchronous</td>
<td>Collaborative Agent</td>
</tr>
<tr>
<td></td>
<td>Collaborative Agent</td>
<td>Takes into account the collaboration process between learners as well as the associated problems</td>
<td>Synchronous and Asynchronous • Forum (public forum, group forum and subject forum) • Email • Chat</td>
<td>Collaborative Agent</td>
</tr>
<tr>
<td></td>
<td>Assessment Agent</td>
<td>To measure the learner’s knowledge level by proposing to him/her a set of exercise from various models and difficulties.</td>
<td>Synchronous and Asynchronous</td>
<td>Collaborative Agent</td>
</tr>
<tr>
<td></td>
<td>Assistant Agent of the Teacher</td>
<td>It propose to the teacher an interface in order to assist him/her in the creation of the concepts and the exercise of the subject to be taught.</td>
<td>Synchronous and Asynchronous • Forum (public forum, group forum and subject forum) • Email • Chat</td>
<td>Collaborative Agent</td>
</tr>
<tr>
<td></td>
<td>Mediator Agent of the Teacher</td>
<td>It facilitate the communication between the teacher and the learners or between teachers themselves</td>
<td>Synchronous and Asynchronous</td>
<td>Collaborative Agent</td>
</tr>
<tr>
<td>Zhi Liu, Hai Jin &amp; Zhaolin</td>
<td>Student Agent</td>
<td>A kind of learner assistant to support the learner to acquire the resources and services</td>
<td>Asynchronous</td>
<td>Interface Agent</td>
</tr>
</tbody>
</table>
### Teacher Agent
Act as an agent for teacher, specially, when the teacher is offline. It could record the questions from learners or forward the problem to other teachers. It also can give the learners a guide according to his background or his learning track.

### Instructor Agent
Takes an important role in the ELMS. It could support learning process, manage virtual collaborative group, response the requirement from users, and so on.

### Manager Agent
Several instructor agents and a manager agent compose a main container to manage the whole virtual collaborative group.

### Assessment Agent
Agent can reach a mutually acceptable agreement to overcome the subjective judgement and the unfair assessment. To negotiate the assessment of students and to achieve an agreement.

### Asynchronous Collaborative Agent

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**COLLABORATIVE LEARNING INTERACTION**

In collaborative learning, interaction plays an important role of the educational process and context. In addition, interactivity or interaction is fundamental to creation of the learning communities espoused by Lipman (1991), Wenger (2001), and other influential educational who focus on the critical role of community in learning.

**Type of Interaction in Collaborative Learning**

Definition of interaction by Wagner (1994) as “reciprocal events that require at least two objects and two actions. Interactions occur when these objects and events mutually influence one another”. Michael Moore (1989) first discussed the three most common forms of interaction in distance education: student-student, student-teacher, and student-content. This list was expanded by Anderson and Garrison (1998) to be six types of interaction that include teacher-teacher, teacher-content, and content-content interaction as shown in table 2.

**Table 2: Six types of interaction (Anderson, 2003)**

<table>
<thead>
<tr>
<th>Types of Interaction</th>
<th>Descriptions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Student-Student Interaction</td>
<td>Modern constructive learning design stresses the value of peer to peer interaction. Peer interaction is critical to development of communities of learning that allow learners to develop interpersonal skill, and to investigate tacit knowledge shared by community members as well as a formal curriculum of studies.</td>
</tr>
<tr>
<td>Student-Teacher Interaction</td>
<td>Student-teacher interaction is supported in online learning in a large number of varieties and format that include asynchronous and synchronous communication using text, audio, and video.</td>
</tr>
<tr>
<td>Student-Content Interaction</td>
<td>The web support more passive forms of student-content interaction, and also provides a host of new opportunities, including online computer-assisted tutorials, and the development of interactive content that responds to student behavior and attributes.</td>
</tr>
<tr>
<td>Teacher-Teacher Interaction</td>
<td>It creates the opportunity for professional development and support that sustains teachers through communities of like-minded colleagues. These interactions also encourage teacher to take advantage of knowledge growth and discovery in their own subject and within the scholarly community of teachers.</td>
</tr>
</tbody>
</table>
Teacher-Content Interaction

It focuses on the creation of content and learning activities by teachers. It allows teachers continuously to monitor and update the content resources and activities that they create for student learning.

Content-Content Interaction

It is a newly developing mode of educational interaction in which content is programmed to interact with other automated information sources, so as to refresh itself constantly, and to acquire new capabilities.

The recent emergence of collaborative learning modeling languages (Koper, 2001) allows educators to describe, in a language accessible on the web, not only the content but also the activities and context or environment of learning experiences. Together these capabilities afforded by the semantic web allow us to envision an e-learning environment that is rich with student-student, student-content, and student-teacher interactions that are affordable, reusable, and facilitated by active agents as shown in figure 2.

As the agents are autonomous, the interactions are usually fairly sophisticated – involving cooperation, coordination and negotiation. Thaipathump, Bourne, and Campbell, (1999); Shaw, Johnson and Ganeshan, (1999) have argued that student agents will be used for intelligent searching of relevant content, and as secretaries for booking and arranging for collaborative meetings, for reminding students of deadlines, and for negotiating with the agents of other students for assistance, collaboration, or socialization, and making collaborative learning effective in an any time or any place context. Teacher agents will be used to provide remedial tuition, and to assist with record keeping, with monitoring student progress, and even with marking and responding to student communications. Content itself can be augmented with agents that control rights to its use, automatically update and refresh it, repair and protect content, and track the means by which the content is used by students (Anderson, 2003).

Figure 2: Educational Interaction on the Semantic Web (Anderson, 2003).

The model illustrates the two major human actors, learners and teachers, and their interactions with each other and with content. Learners can of course interact directly with
content that they find in multiple formats, and especially on the web; however, many choose to have their learning sequenced, directed, and evaluated with the assistance of a teacher. This interaction can take place within a community of inquiry, using a variety of net-based synchronous and asynchronous activities.

**Type of Communication that Support Interaction in cluster of agent**

Collaborative learning can be either asynchronous (communications are sent and received at different times) or synchronous (communications are sent and received at virtually the same times). Asynchronous communication tools include e-mail, mailing list, discussion board, calendar, survey and pools, and newsgroup. Synchronous communication tools include chat, whiteboard, instant messaging, and audio-video conference. In both asynchronous and synchronous communications, students not only learn from their instructor, who provides content expertise and feedback during ongoing learning, but also from each other’s comments and feedback.

In addition, to analyses the available communication tools and their utilization in various types of interaction and relationship with cluster of agent in collaborative learning, we observe a group of communication tools that support each type of interaction as shown in table 3. Interaction between learners and teachers, and their interaction with content are available in synchronous and asynchronous communication.

Furthermore, these interactions will be supported by interface agent, information and internet agent, and collaborative agent working on behalf of all participants. Moreover, as learners, instructors and administrators observe and use agent technology in their own jobs, they will likely find increasing acceptance in e-learning (Bonk, 2004).

<table>
<thead>
<tr>
<th>Types of Interaction</th>
<th>Communications Tools</th>
<th>Type of Communications</th>
<th>Clustering of Agent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Student-Student Interaction</td>
<td>Email, mailing list, discussion forum, newsgroup, chat, instant messaging, audio conference, whiteboard</td>
<td>Synchronous and Asynchronous</td>
<td>Interface Agent, Information and Internet Agent, Collaborative Agent</td>
</tr>
<tr>
<td>Student-Teacher Interaction</td>
<td>Email, mailing list, discussion forum, newsgroup, audio-video conference, whiteboard, calendar, survey and pools</td>
<td>Synchronous and Asynchronous</td>
<td>Interface Agent, Information and Internet Agent, Collaborative Agent</td>
</tr>
<tr>
<td>Student-Content Interaction</td>
<td>Upload, download, calendar, e-book, online quizzes, exams and homework</td>
<td>Synchronous and Asynchronous</td>
<td>Information and Internet Agent</td>
</tr>
<tr>
<td>Teacher-Teacher Interaction</td>
<td>Email, mailing list, discussion forum, newsgroup, chat, instant messaging, audio-video conference, whiteboard</td>
<td>Synchronous and Asynchronous</td>
<td>Interface Agent, Information and Internet Agent, Collaborative Agent</td>
</tr>
<tr>
<td>Teacher-Content Interaction</td>
<td>Upload, download, calendar, e-book, online quizzes, exams and homework</td>
<td>Synchronous and Asynchronous</td>
<td>Information and Internet Agent</td>
</tr>
</tbody>
</table>
DISCUSSION
Agent application has been used in collaborative learning for some time, and a number of agents have been designed specially for collaborative learning purposes. In these systems, agents can play different roles: tutor, facilitator, monitoring, assessment, and information that they can facilitate collaboration processes such as coordination, teacher intervention and group interaction. However, there is no standardization concerning the components of a system, or the affected role to each agent in the system. It is necessary to make classification of agent by characterizing agents along certain dimension. Therefore more complete and systemic analysis is needed for understanding role of agents.

In addition, communication tools are used in collaborative learning to enhance interaction between all participants. These interactions will be supported by interface agent, information and internet agent, and collaborative agent working on behalf of all participants. It’s challenge to explore the application agent for collaborative learning in a multiplatform environment.

CONCLUSIONS AND FURTHER WORK
In collaborative learning systems, student can participate at any time and communicate with their instructors, classmates and administrator using tools such as e-mail, chat, audio video conference, bulletin boards, etc. However, in the context of collaborative learning, it is usually difficult for students to be aware of others’ activities and for instructors to overview the process and regulate the collaboration. This paper shows various agents and how they support interaction between students, teachers and contents in collaborative learning. Future work might discuss about computational model of collaborative learning interaction that the agents compute statistically, detect possible problems, and give advice both synchronously and asynchronously to the students and instructors.

We expect that the agent will overcome some of the problems faced existing collaborative learning systems. Hence, it may contribute to improve the achievement and satisfaction of online collaborative learning.

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