Ontology-Driven Awareness in Computer-Supported Collaborative Learning

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Abstract

In the Computer-Supported Collaborative Learning (CSCL) system, Computer-Supported Collaborative Work (CSCW) is applied to Collaborative Learning (CL) and students work together in a learning group and interact with each other in order to achieve their common goal of learning. This study aims to analyze the ontology concept in CSCL and to design the activity awareness for CSLC by using the OWL web ontology language. Besides adopting the workspace awareness from CSCW, we analyze the educational awareness to fulfill the learning needs in CSCL. We defined the learning activity awareness, including presence, role, action, and history, and subsequently used OWL to implement the learning activity awareness. Such ontology-driven awareness is the primary key to a successful CSCL when running in the open and integrated semantic web.

1: Introduction

Beyond the formal learning in a traditional classroom, CL is an informal learning approach which emphasizes the natural collaboration of students as they study in a small learning group. The essence of CL lies in that students work together in a heterogeneous group, made of students of different backgrounds and degrees, to achieve a common academic goal. Through a CSCW system, also known as Groupware, people can work together in many modes, including asynchronous mode, distributed asynchronous mode, synchronous mode, and distributed synchronous mode [1].

Margaret M. McManus pointed out that CSCL applies CSCW to CL to enable student to participate sharing work in a network environment [2]. A CSCL system can be used in many learning domains such as school education, business training, and lifelong learning. In this paper, we focused CSCL on the school education and analyzed the learning practice based on the STAD (Student Teams and Achievement Divisions) approach [3].

The CL approach takes advantage of the knowledge exchange among the participants not only to achieve the learning goal but also to help the creation of new knowledge. Such learning benefits must be preserved in a virtual CSCL. The main component of collaborative learning in the web-based environment is to realize social context, group learning process and communication with each other [4]. In other words, learners are provided with intelligent browsing support for externalized knowledge from other participants [5]. Ontologies clarify the knowledge structure of a specified domain to enable knowledge sharing [6]. Thus, ontologies are adequate for describing knowledge of learning objectives and learning activities to provide knowledge reuse and knowledge composing.

Ruth Wilson dilated on the potential benefits of ontologies to the further and higher education, including the sharing of information across education systems, providing frameworks for the learning object reuse, and enabling intelligent and personalized support [7]. The development of CSCL ontologies is focused on overcoming drawbacks of current IISs from AI and ED [8], on interaction analysis support [9], on learning object respository [10], on context representation [11], on describing terms of learning design, learning contents and learning resources [12], and on defining collaborative learning tasks, goals and actions [13].

The related works above convinced us of an important role that ontology played in a virtual collaborative learning environment. With a well-defined ontology structure, CSCL can accumulate the knowledge representation of learning objects, including students' backgrounds, team information, instruction designs, learning activities, learning outcomes, etc. This meaningful information can be used to help the teacher adjusting curriculum plans and organizing the learning teams. Similarly, an effective knowledge representation enables an intelligent browsing and searching capability, which helps students requesting for relevant resources.

2: Activity awareness in CSCL

Awareness is an understanding of others' activities, which provides a context for your own activity.

Awareness of one's intension, action, and result is the key to success of cooperation. Activity awareness comes naturally to participants in face-to-face learning situation, but it is a great challenge to preserve it in a virtual learning environment.

2.1: Awareness elements in CSCL

Carl Gutwin and Saul Greengerg tabulated the elements of workspace awareness that should be considered in a groupware system [14]. The goal of CSCL is to help learning so we consider, based on the learning purpose, what awareness elements are necessary and relatively important while constructing the CSCL system. Both communication and internalization of knowledge are the cores of learning activities. Firstly in knowledge communication, the knowledge mainly comes from teachers and peers. Secondly in knowledge internalization, reviewing learning histories from others and ours can help recompose and internalize knowledge. Besides, being based on network, CSCL is applied to learning in the distributed asynchronous mode. Therefore, the location awareness is of less necessity in the CSCL environment.

Table 1. Element of learning activity awareness.

Element	Relevant Questions
Presence	What is the group structure? What status is the group working in? Who is around?
Role	What role does he play in the learning activity? What is he interesting in? What is his ability? Who has the same problem or knowledge? Who has potential to assist solving the problem? Who has a different view about the problem or knowledge?
Actions	Who is working on what object? What are they doing? What are their current activities and tasks? What is the status of the actions?
History	(from present tense to past perfect tense) What is the action tendency/model? What is the track of changes? Are there relevant information analysis and statistics

By adopting awareness elements from groupware together with the demand of learning awareness, we categorized the activity awareness elements into four groups: presence, role, action, and history. Table 1 shows a set of elements we considered to be the key activity awareness of learning, and lists relevant questions that a participant might ask himself during a cooperative learning work.

2.2: Awareness operation

The proceeding of awareness operation should be from user points of view, that is, the information is presented to meet user's expectation without disturbing user's work [15]. In this study, activity awareness is driven by events [16] in both active and passive ways. In the active way, system automatically collects the awareness information according to the user's operating context, including user's status, interest, intension, and the attribute of user's current operation. In the passive way, the proceeding of awareness operation is initiated by the user, e.g. searching by key words, and then system gathers the awareness information not only by the inputted searching conditions but also by the user's profile. No matter what way the awareness is proceeded in, the result information must be displayed in the form of user's expectations. The awareness information is transmitted for user's references through the steps of filtering, ranking, classifying, and sorting. The most important on the presentation of information is to prevent user's operations from being interrupted, which means the personalization support [17].

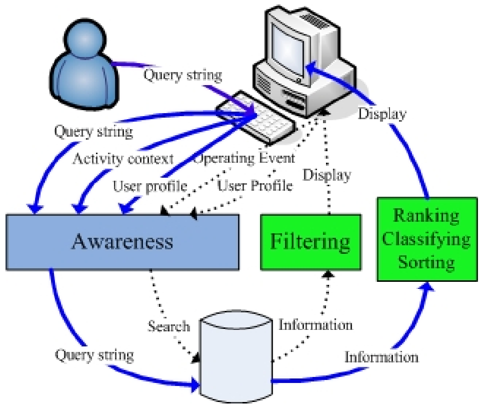

Figure 1. Awareness operation.

The path of dot lines in Figure 1 illustrates the process of active awareness. The high frequency and volume of this kind of information, which system automatically collects in accord with the user's operating events, is predictable and thus it has to be filtered before dispatching to the user. The path of solid lines in Figure 1 shows the process of passive awareness. The user asks for demanded information by inputting searching conditions to the system. Not only by the searching conditions but also by the user's profile and operating context, system executes information searching, ranking, classifying, sorting, and presenting for user references.

3: Design of ontology to support awareness

The CSCL environment can be applied to different learning fields, such as K9 education, further and higher education, employee training, and lifelong learning. Our study focused on the school education and developed ontologies for CSCL based on the STAD approach. While describing, analyzing, and defining ontologies for CSCL, we observed the practice of CSCL in three dimensions: participants and their activities, learning actions and results, and awareness supporting.

3.1: Ontologies for participants and activities

Participants and their activities in the STAD approach are summarized as below: (1) the teacher directs a collaborative learning on a specified subject, (2) students are assigned to different learning teams, (3) the teacher plans goals of learning, (4) the teacher introduces goals of learning to learning teams, (5) members of learning team take actions to achieve the common goal of learning, and (6) the teacher assesses both results of individuals and teams. Thus, we defined ontology classes and relationships between them, as shown in Figure 2.

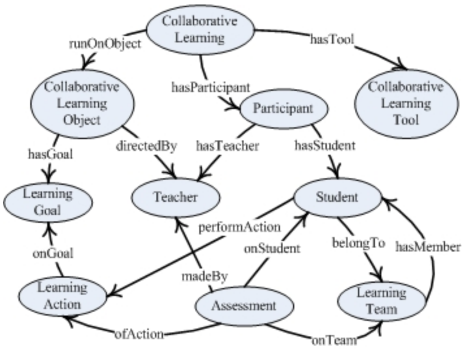

Figure 2. Ontologies for participants and their activities.

3.2: Ontologies for learning actions and results

Students play different roles and cooperatively work through the interpersonal communication and the mediation of group work situations. The forum is a general tool for the teacher and students to communicate with each other on learning actions. Transcripts and relevant attachments, sometimes with reference sources, are posted in the forum and valuable to record the learning process. Furthermore, the teacher plans the learning schedules and assigns the homework to students. The student also plans his own schedules of learning actions. Figure 3 shows ontologies for learning actions and relevant results.

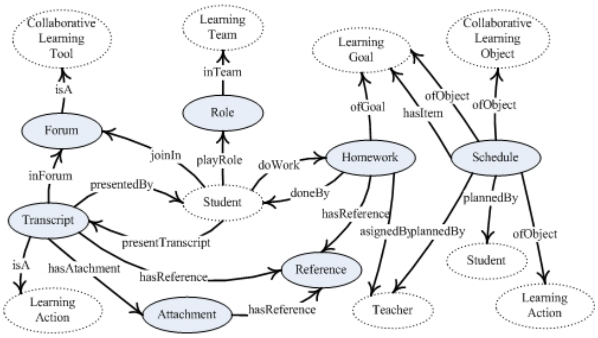

Figure 3. Ontologies for learning actions and results.

3.3: Ontologies for awareness supporting

In CSCL scenarios, the ontology classes that we described above are obvious, and are relatively upper-level concepts. For awareness supporting, we require additional import ontology classes, which are subtle in the background, to connect ontologies and to form the ontological awareness. Figure 4 shows the following implicit classes. (1) Status: It means the status of every learning object containing the whole collaborative learning subjects, participants, and students' learning actions. The event-driven awareness is always triggered by the status of learning objects. (2) Sequence: Activities or actions and their results are sometimes in sequence, which is important information toward the recording of learning progresses. (3) Subordination: The subordination existing in learning actions can be used to explore the network of learning resources. (4) Operation context: The operation context of user implies the series of learning actions done by students, which is the basis for getting efficient awareness information. (5) Awareness content: The awareness information is going to be dispatched to the user. (6) Notification: A special awareness message is with importance and timeliness. (7) Presentation: It contains tasks before the awareness information or notification message is dispatched to the user.

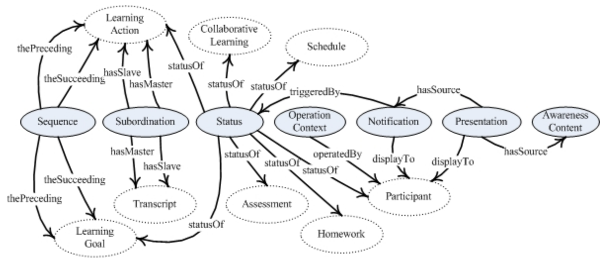

Figure 4. ontologies for awareness support.

3.4: OWL semantic structure

Being a kind of description logics, OWL has several key features: expressivity, automated reasoning, and compositionality [18]. Protégé is a free, open source ontology editor and knowledge-based framework [19]. We adopted OWL to express ontologies in CSCL and used Protégé-OWL to edit and visualize ontology classes, properties, and relationships between classes. We also executed the reasoner to inspect consistence of the owl file and used open-source Java API for the development of ontological CSCL system. Figure 5 is the portion of OWL ontology classes in Protégé.

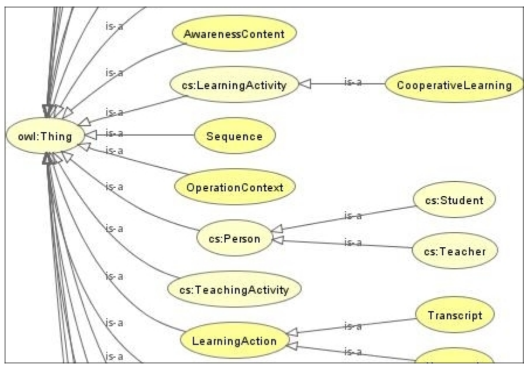

Figure 5. The portion of ontology classes in Protégé.

4: System architecture

The CSCL system, which supports ontology-driven awareness, consists of ontologies mentioned above and program modules. Description logics have the expressivity feature and use logics to express the reality of a specified domain, which makes the computer program easier to reason and access logical contents. Moreover, description logics also have the compositionality feature and can be used to define domain knowledge by directly transferring the practical object structure into the ontological class structure, which enables the reusability, the reorganization, and the management of ontological contents. Thus, for meeting the requirements of dynamics, flexibility, and efficiency, ontology is intuitional and fit for constructing contents and awareness support in CSCL.

The components of the system architecture shown in Figure 6 are separately described as follows.

- **Learning action module**: Learning action function is provided in this module that as well calls the event handling module to perform the message notifying or awareness processing.
- **Schedule module**: It manages schedules of goals and actions of learning and, if necessary, calls the event handling module to perform the notification function.
- **Context collection module**: The user's operations in system are recorded for subsequent usages in the event handling module, notification module, and awareness processing module.
- **Event handling module**: It handles events that trigger the awareness processing and notifying by monitoring the user's operation or by when receiving instruction from the schedule module..
- **Notification module**: When receiving the instruction from the event handling module, the notification function is in progress based on the status information.
- **Awareness processing module**: When receiving the instruction from the event handling module, it gathers the concerned data and the context information to generate awareness contents.
- **Presentation module**: When receiving awareness contents or notification messages, it executes the filtering, ranking, classifying, and sorting functions, and passes the presenting information to the dispatch module.
- **Dispatch module**: The final awareness information is dispatched to the users.

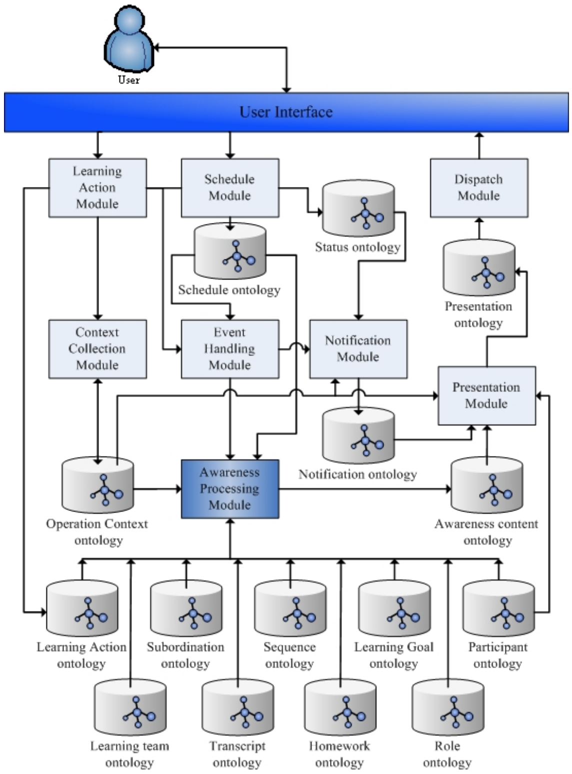

Figure 6. CSCL system architecture that supports ontology-driven awareness.

5: Conclusion

In this paper, we analyzed the practice of CSCL and defined the ontology concept to support the activity awareness, including presence, role, action, and history awareness. We used description logics OWL to define ontologies for learning activities and awareness supporting in CSCL, which enriches the expressivity and compositive flexibility of ontological contents. Based on the school education, CSCL awareness is clearly classified into three dimensions and is separately explored to: participants and their activities, learning actions and results, and awareness supporting. Both connections and operations among every system module and also among ontological contents are illustrated in the whole system architecture.

At present, XML is the exchange standard in the internet. As been written in XML, OWL can be easily exchanged on the web. In our study, ontologies for CSCL are designed with OWL, which matches the mainstream of the next generation semantic web. It is undoubted that ontology-based contents and software services will serve the foundation to the development of the network services of learning, which emphasizes the sharing and reuse of learning resources.

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