Supporting Knowledge Awareness for a Ubiquitous CSCL

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Abstract: This paper describes a computer supported collaborative learning (CSCL) in a ubiquitous computing environment. In the environment called CLUE, the learners provide and share individual knowledge and discuss about them. This paper focuses on *knowledge awareness map* and its design, implementation and evaluation. The map visualizes the relationship between the shared knowledge and the current and past interactions of learners. The map plays a very important role of finding peer helpers, and inducing collaboration.

Introduction

Ubiquitous computing (Abowd & Mynatt, 2000) will help organize and mediate social interactions wherever and whenever these situations might occur (Lyytinen and Yoo 2002). Its evolution has recently been accelerated by improved wireless telecommunications capabilities, open networks, continued increases in computing power, improved battery technology, and the emergence of flexible software architectures. With those technologies, an individual learning environment can be embedded in the real everyday life.

The main characteristics of ubiquitous learning are shown as follows (Chen et al., 2002; Curtis et al., 2002):
(1) Permanency: Learners can never lose their work unless it is purposefully deleted. In addition, all the learning processes are recorded continuously in everyday.
(2) Accessibility: Learners have access to their documents, data, or videos from anywhere. That information is provided based on their requests. Therefore, the learning involved is self-directed.
(3) Immediacy: Wherever learners are, they can get any information immediately. Therefore, learners can solve problems quickly. Otherwise, the learner may record the questions and look for the answer later.
(4) Interactivity: Learners can interact with experts, teachers, or peers in the form of synchronies or asynchronous communication. Hence, the experts are more reachable and the knowledge is more available.
(5) Situating of instructional activities: The learning could be embedded in our daily life. The problems encountered as well as the knowledge required are all presented in the nature and authentic forms. It helps learners notice the features of problem situations that make particular actions relevant.

Moreover, ubiquitous learning can be Computer Supported Collaborative Learning (CSCL) (O'Malley, 1994) environments that focus on the socio-cognitive process of social knowledge building and sharing.

The challenge in an information-rich world is not only to make information available to people at any time, at any place, and in any form, but specifically to say the right thing at the right time in the right way (Fischer, 2001). A ubiquitous computing environment enables people learning at any time and any place. Nevertheless, the fundamental issue is how to provide learners right information at the right time in the right way. This paper tackles the issues of right time and right place learning (RTRPL) in a ubiquitous computing environment.

Especially, we focus on language learning as an application domain of this research. That is because situations influence language. The user of this system is an overseas student of a University in Japan, and wants to learn Japanese Language. The other user is a Japanese student who is interested in English as the second language and plays an important role of a helper for an overseas student. The learners with PDA (Personal Digital Assistant) store and share the useful expressions that are linked to any place in everyday life. Then, the system provides each learner the right expressions at the right place. For example, if the learner enters a hospital, then the right expressions at that place are provided at that time for RTRPL. It is very important to encourage not only individual learning but also collaborative learning in order to augment practical communication among learners and accumulation of the expressions.

In order to induce collaborative learning, this paper proposes *Knowledge Awareness* (KA) map that visualizes KA information for ubiquitous learning environments. The map helps learner to mediate and recognize collaborators in the shared knowledge space. On this map, the system identifies learning-companions who can help solving a problem. The characteristics of the map are:
(1) Visualization of the objects in the map and expressions as educational materials,
(2) Visualization of the links between expressions and learners to induce collaboration,
(3) Recommendations of appropriate collaborators on KA map to help find suitable partners.
We are developing an open-ended collaborative learning support system, which is called CLUE (Collaborative-Learning support-system with an Ubiquitous Environment). CLUE is a prototype system for KA map, and facilities to share individual knowledge and to learn through collaboration.

Learning Theories for Ubiquitous Learning

CSUL (Computer Supported Ubiquitous Learning) is advocated by pedagogical theories such as on-demand learning, hands-on or minds-on learning, and authentic learning. CSUL system provides learners on-demand information such as advices from teachers or experts at the spot at the precise moment they want to know something. Brown, Collins, and Duguid (1989) define authentic learning as coherent, meaningful, and purposeful activities. When the classroom activities are related to the real world, students receive great academic delights. There are four types of learning to ensure authentic learning: action, situated and incidental learning (Hwang). Action learning is a practical process where students learn by doing, by observing and imitating the expert, and by getting feedback from teachers and their fellow-pupils. Usually, learning is promoted by connecting knowledge with workplace activities.

Situated learning is similar to action learning because trainees are sent to school-like settings to learn and understand new concepts and theories to be applied later on in practice. Knowledge is developed through the authentic activities and important social interactions. Cognitive apprenticeship methods try to enculturate students into authentic practices through activity and social interaction in a way similar to that evident in craft apprenticeship" (Brown, Collins & Duguid (1989), p.37).

Incidental learning includes unintentional and unexamined learning from mistakes, unexpected incidents, etc. For example, a child can acquire an unexpected result in the science lab by the mistake of dropping some other liquid to the given experiment that may lead a great discovery. Learners discover something while they are doing something else in the process; therefore, it is considered as a surprised by-product. Knowledge from incidental learning develops self-confidence and increases self-knowledge in learning.

There are three forms of experiential learning: action learning, future search, and outdoor education. Action learning is a social process of solving the difficulties, by involving that learners are doing things and thinking about what they are doing. In the classroom, action learning is a problem-solving process by developing knowledge and understanding at the appropriate time. The future search process is to develop thinking and understanding and is not about problem solving, but rather an exercise in developing insights, understanding, learning from one another, and reducing misunderstandings. Outdoor education is an outdoor program of team members to apply their new learning during an outdoor experience upon returning to the job in order to gain more insights through challenge activities. Learners integrate thoughts and actions with reflection from the outdoor experiences

Knowledge Awareness Map

What is knowledge awareness?

KA is defined as awareness of the use of knowledge (Ogata et al., 1996, 2000). In a distance-learning environment, it is very difficult for the learner to be aware of the use of other learners' knowledge because the learner cannot understand their actions in the remote site beyond Internet. KA messages inform a learner about the other learners' real-time or past-time actions: look-at, change, and discuss, that have something to do with knowledge on which a learner was or is presently engaged. For example, KA messages are “someone is changing the same knowledge that you are looking at”, “someone discussed the knowledge which you have inputted.” These messages make the learner aware of someone:

(1) who has the same problem or knowledge as the learner;
(2) who has a different view about the problem or knowledge; and
(3) who has potential to assist solving the problem.

Therefore, the messages that are independent of the domain, can enhance collaboration opportunities in a shared knowledge space, and make it possible to shift from solitary learning to collaborative learning in a distributed learning space.

KA messages are classified into two dimensions: time and knowledge separation. KA of type same time (ST) informs the learner that other learners are doing something at the same time that the learner is using the system. By using learners’ past actions, KA of type different time (DT) provides the encounters beyond time. KA of type same knowledge (SK) is a message about other learners’ activities to the same knowledge that the learner is looking at, discussing, or changing. This type is available for learners to find partners who have the same problem or knowledge. KA of type different knowledge (DK) enhances collaboration possibility with another learner (1) who has had something to do with the learner’s interests; or (2) who has different expertise from the learner’s interests.

For example, the message of type STSK, “Who is looking at the knowledge?” shows the existence of learners who are looking at the knowledge that the user is looking at. By this message, the user may start to discuss on the knowledge. Likewise, the message of type DTSK “Who changed the knowledge since I have last looked at?” facilitates to start discussion on the changing of the knowledge. Moreover, the message of type STDK “What knowledge are they discussing?” is useful to join into the discussion that interests the learner.

KA has a close relation with learner’s curiosity. Hatano and Inagaki (1973) identified two types of curiosity; particular curiosity (PC) and extensive curiosity (EC). EC occurs when there is a desire for learning and it makes the learner’s stock of knowledge well balanced by widening the learner’s interests. PC is generated by the lack of sufficient knowledge, and it is very useful in that the learner can acquire detailed knowledge. KA of type SK excites PC, and KA of type DK satisfies EC. For example, a message of type STDK stirs up the learner’s EC by attracting the learner to the particular knowledge when the learner focuses on nothing. Moreover, the message of type STDK about the knowledge leads the learner to collaboration by arousing the learner’s PC. In this way, KA induces collaboration by exciting the learner’s curiosity.

Knowledge Awareness map

Knowledge Awareness Map graphically displays KA information. This map provides learner with a clear grasp of some learners around knowledge that is separated from a learner-looking knowledge. With this, the learner can seek for the learner of the discussion companion interactively.

Learner's profile

The system collects learner's profile with two techniques:

(1) The action log of learner: e.g., the number of visit to the location;
(2) The explicit registration by learner.

The actions of learner in an open-ended learning environment can be classified as follows: (A) entering a new location, (B) entering a new expression, (C) making link to a WWW page, (D) asking a question, (E) answering the question, (F) modifying an expression, (G) participate a discussion, and (H) looking at an expression. These eight actions of learner are used as one of learner's profile. However, it is difficult to detect the interest of the learner from learner's actions only. Therefore, it is necessary that the learner register his/her own interests on the knowledge.

Strategy for recommending peer learners

When learner asks a question and seeking for a helper, the system recommends one to three persons. The type of the learner who participates in collaboration is shown below:

(1) Questioner: This learner has some questions and requires collaboration.
(2) Answerer: This learner answers the question of the questioner.
(3) Participant: This learner is interested in the question and wants to join into the collaboration.

The system recommends an answerer who can help problem-solving and some participants to a questioner using the following information:

(1) The login situation of learners:
Because of real-time discussion, the system selects only logged-in users as candidates.
(2) The profile of each learner:
Although the profile consists of the number of action times to the knowledge, the system has to evaluate totally. If the total of (A)-(D) actions of a learner is larger than that of (E)-(H) actions, then the system considers the learner as an answerer. Otherwise, the learner is a participant. The larger the total of a learner's actions, the more the learner is preferred to join into collaboration.
(3) The current action of learner:
The system gives a high priority to learners who are doing nothing (idle) in the learning environment. This consideration activates passive learners by stimulating their intellectual curiosity.

This paper proposes the level of interest (LOI) as follows:

$$LOI = \frac{\text{The number of the learner's actions to the expression}}{\text{The max number of other learner's actions to the expression}}$$

The range of *LOI* is from 0.00 to 1.00.

Visualization of KA

A link in KA map shows the relationship between web pages and learners. The length (*L*) of a link means the strength of the relationship and it is calculated by the following equation:

$$L = D(2 - LOI)$$

Where, *D* is a default value of link length.

The range of *L* is from *D* to *2D*. If a learner is very interested in a page, the link length (*L*) of between the page and the learner becomes short and nearing to *D*.

Implementation of CLUE

We have developed the prototype system of CLUE, which consists of a server and clients. Each learner's client of CLUE is Toshiba Genio-e that is a PDA with Pocket PC 2002, Personal Java, GPS (Global Positioning System), and wireless LAN (IEEE 802.11b). Especially, we selected this device to use GPS and wireless LAN at the same time. The server program has been implemented with a java servlet via Tomcat.

Based on (Abowd & Mynatt, 2000), CLUE deals with the following information:

Who: Current systems focus their interaction on the identity of one particular user, rarely incorporating identity information about other people in the environment. As human beings, we tailor our activities and recall events from the past based on the presence of other people. CLUE identifies not only the current user but also other users surrounding the user. CLUE provides the right information after interpreting the user-models of them. Especially, other people influence Japanese language. For example, we, Japanese people use different level of polite expressions according to the ages of other people

What: The interaction in current systems either assumes what the user is doing or leaves the question open. Perceiving and interpreting human activity is a difficult problem. Nevertheless, interaction with continuously worn, context-driven devices will likely need to incorporate interpretations of human activity to be able to provide useful information.

When: With the exception of using time as an index into a captured record or summarizing how long a person has been at a particular location, most context-driven applications are unaware of the passage of time. For example, the learner might get the right expressions at the certain time, e.g., morning.

Where: In many ways, the "where" component of context has been explored more than the others. Of particular interest is coupling notions of "where" with other contextual information, such as "when.

Why: Even more challenging than perceiving "what" a person is doing understands "why" that person is doing it. Using "why" information, the right information could be provided to the learner.

How: CLUE has to provide the right information in the right way. For example, if a user is using a desktop computer connected to the Internet via the broadband network, then the system can provide complete information with pictures, movies etc. However, when the user is using a PDA, the system should provide only the selected information.

CLUE has the following modules:

Learner model: This module has the learner’s profile such as name, age, gender, occupation, interests, etc, and the comprehensive level of each expression. Before using CLUE, the learner enters those data. In addition to the explicit method like this, CLUE implicitly detects learner’s interests according to the history of the visiting. Moreover, this system records whether the learner understands expressions.

Environmental model: This module has the data of objects, rooms, and buildings in the map, and the link between objects and expressions. For example, (Post office, location (x, y), “I’d like to buy a stamp.”) means the post office is located at (x, y) on the map and the expression is often used.

Educational mode: This module manages expressions as learning materials and dictionaries. Learners and a teacher can input and modify expressions during the system’s use.

Communication server: This server manages a BBS (bulletin board system) and a chat tool, and stores these logs into a database.

Location manager: This module stores the each learner’s location into the database.

Adaptation engine: This module recommends the learner the suitable expression and KA map.

Communication client: This is a client of BBS and chat.

Location sensor: This module sends the learner’s location from GPS to the server automatically.

Information visualization: This module shows KA map to the learner.

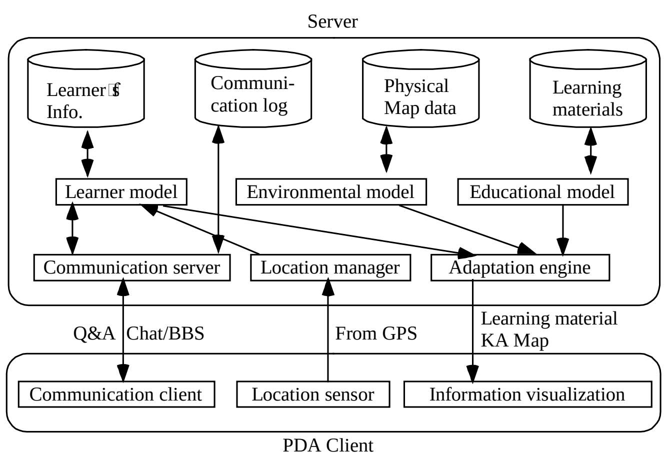

Figure1: System configuration.

Interface of CLUE

Interface of the collaborative learning environment of CLUE is shown in Figure 1. The map window (A) shows the current location of each learner. The face icon on the map means the learning status of each learner. For example, if a learner has a problem or question, the face turns into a fad one. By clicking the face icon, the learner can send a message to the learner corresponding to the icon. In addition, a rectangle icon on the map shows a landmark where a teacher or a learner gives some expressions, or where they communicate with each other. If a learner enters an expression at the place for the first time, then a new landmark is created in the map. By cling the rectangle icon, the user can see the web page of the place (e.g., the hospital), the expressions that are used in the place, or the communication logs about the expressions or the place.

If the learner approaches the certain place, the window (B) appears, which shows a useful expression at the place in English. If the current user has already learned all the expressions at the place, the expressions are not appeared. If the learner can correctly answer the Japanese expression corresponding to the English expression, the next expression will appear. Otherwise, the learner will be given the same expression in coming the place at the next time.

If the learner has a question about the expression, the window (C) shows the relation between expressions and other learners. The color of an oval icon shows the level of difficulty of the expression. A teacher gives the level. Moreover, the color of a rectangle icon shows the level of proficiency of the learner. The higher the level is, the more correct-answers the learner gives. From this KA map, the learner can find the suitable person to ask the question.

If the learner has a question about the place, the window (D) shows the people who have visited the place, and the window (D) shows the relation between people and all the places on the map.

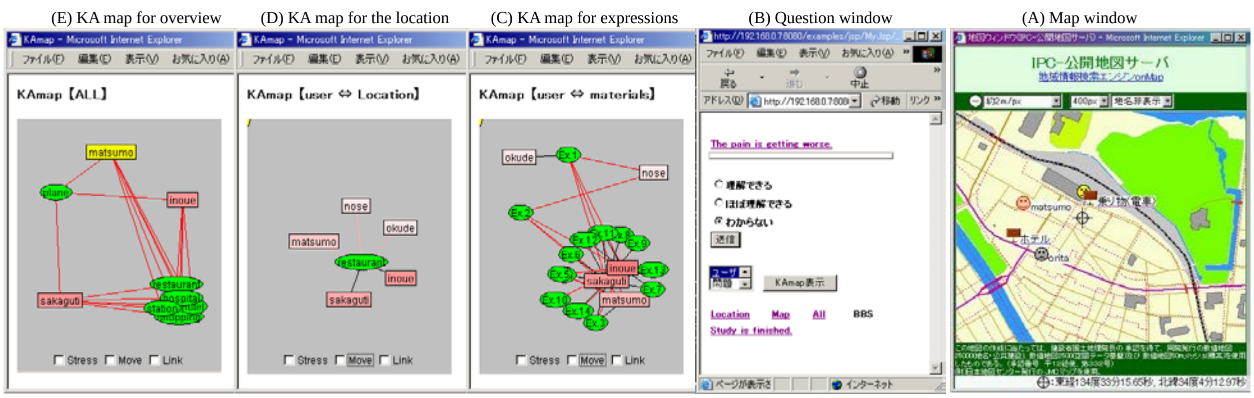

Figure 2: Screen snapshots of CLUE.

Related Work

Researchers in the educational systems area are attempting to provide technological support for cooperative and collaborative learning advocated by educational theories (Slavin, 1990; Webb & Palincsar, 1996; O'Malley, 1994). This paper focuses on an *open ended and collaborative learning environment*. For this situation, CoVis (Edelson et al., 1996), KIE (Linn, 1996), CSILE (Scardamalia & Bereiter, 1996), WebCamile (Guzdial et al., 1997) and Belvedere (Suthers & Jones, 1997) have been developed. CoVis focuses on making a collaboration process visible. KIE succeeds by helping students link, connect, distinguish, compare, and analyze their repertoire of ideas. CSILE and WebCamile support knowledge building for the creation of knowledge. Moreover, Belvedere that is a networked software system was implemented to provide learners with shared workspaces for coordinating and recording their collaboration in scientific inquiry. In such environments, distributed expertise and multiple perspectives enable learners to accomplish tasks and develop understandings beyond what any could achieve alone. Therefore, it is very important for learners to collaborate with each other. However, little attention has been given to the technical support for inducing collaboration in distributed leaning spaces connected via Internets.

In computer supported cooperative work (CSCW), a*wareness* is one of the most interesting topics, which can increase communication opportunities in a distributed workspace. Dourish and Bellotti (1992) defined *awareness as "understanding of the activities of others, which provides a context for your own activity*." In CSCL (computer supported collaborative learning), *Knowledge Awareness* (KA) have been proposed to bridge learners who are interested in the same knowledge and to create effective collaboration in a distance learning environment (Ogata et al., 1996; 2000). KA gives learner information about other learners' activities in a shared knowledge space. Its messages are, for instance, "someone is looking at the same knowledge that you are looking at", "someone changed the knowledge which you have inputted." These messages of KA encourage collaboration by exciting learner's curiosity and by active learning. *Sharlok* (Sharing, Linking and Looking-for Knowledge) has been developed as a testbed of the KA. Sharlok is an open-ended and collaborative learning environment, and it integrates a knowledge building tool with a collaborative interface tool. Sharlok allows learners: (1) to share their respective knowledge in its shared knowledge space, and to explore this knowledge space freely, (2) to make hypertext links between relevant knowledge, and (3) to collaborate about shared knowledge in an ad hoc group at real time. Evaluation of Sharlok showed that KA encouraged collaboration by exciting learner's curiosity and that KA effectively induced collaboration. In this paper, we described how to adopt KA to ubiquitous learning.

Conclusions

This paper describes a computer supported collaborative learning (CSCL) in ubiquitous computing environment. In the environment called CLUE, the learners provide and share individual knowledge and other knowledge on the WWW and discuss about them. This paper focuses on *knowledge awareness map* and its design, implementation and evaluation. The map visualizes the relationship between the shared knowledge and the current and past interactions of learners. The map plays a very important role of finding peer helpers, and inducing collaboration. In the future, we will try to evaluate CLUE. It has possible to reuse the conversational data that is stored during the system's use in a digital city. The learner can learn language with walking though the digital (virtual) city without moving in the real city.

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