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Smart Classroom: Improving Collaborative Learning through Pervasive Computing Technology

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Abstract

Smart Classroom enables the facilitation of collaborative learning among college students. In this setting, students create small groups to engage in collaborative work on group tasks or to find solutions to specific challenges. Each student in an intelligent classroom is equipped with a situation-aware PDA. During group conversations, student PDAs autonomously form mobile ad hoc networks. Each PDA monitors environmental data, including light, noise, motion, and the location of other PDAs. Afterwards, this data is used to regulate contact between the teacher and students, enabling group discussions and assuring the automatic distribution of presentation materials. Middleware enables spontaneous group communication and context awareness, which are vital elements for pervasive computing. It accomplishes this by offering assistance and resources during the execution and creation of application software. We have created Reconfigurable Context-Sensitive Middleware (RCSMS) for the following purposes. This paper will not only outline the qualities of a Smart Classroom and how RCSM can be used to create one, but also demonstrate how it may greatly improve collaborative learning. A course on senior group software engineering projects will make use of the digital classroom. College students can engage in collaborative learning through the utilization of Smart Classroom technology. In such a context, students form small groups to collaborate on group assignments or devise answers to specific challenges. Each student in a smart classroom possesses a situation-aware Personal Digital Assistant (PDA). During group conversations, student Personal Digital Assistants (PDAs) spontaneously form mobile ad hoc networks. Each PDA maintains a record of its surroundings, which includes the locations of other PDAs, light levels, noise levels, and movement. Subsequently, the system utilizes this data to initiate interaction between the instructor and the learners, thereby facilitating collaborative conversations and the automated dissemination of presentation materials. Middleware enables effective management of context awareness and impromptu group communication required for pervasive computing by providing runtime and development support to application software. Due to these factors, we have developed Reconfigurable Context-Sensitive Middleware, abbreviated as RCSMS. This paper will describe the characteristics of a Smart Classroom and the application of RCSM to establish one. It will also explore how the implementation of RCSM can greatly enhance collaborative learning. For instance, a course in senior group software engineering will make use of the smart classroom.

Keywords: Smart Classroom, collaborative learning, pervasive computing, situation-awareness, and Reconfigurable Context-Sensitive Middleware (RCSM).

Introduction

Over the course of time, technology has been employed to enhance the caliber of teaching. However, using technology to improve the quality of instruction is a highly difficult issue. Technology can be utilized in several ways to improve the quality of teaching. For instance, it can enhance students' capacity to cooperate in groups or the relationship between the instructor and students. Thanks to the widespread use of computing technologies, humans can virtually perceive their surroundings through physical computing and communication [1,2]. Although currently only partially achievable, this transparency is crucial for enabling a more seamless and uncomplicated connection between humans and computers. Pervasive computing environments are comprised of a variety of wearable, portable, and embedded devices that are connected wirelessly, potentially to fixed network infrastructures like the Internet. Pervasive computing is characterized by context awareness and ad hoc group communications [3-6]. A situation-aware device possesses the ability to ascertain the events and occurrences taking place in its immediate environment. However, there are various gadgets that can create networks dynamically by utilizing their ad hoc group communication capabilities. This feature has the capacity to support a diverse array of collaborative computing endeavors.

While several systems have been developed to enhance classroom instruction by incorporating emerging computer and communication technologies [8–14], only a few of these systems have placed a high importance on student cooperation during the learning process [8,11]. Through the networked environment of Interactive Classroom, students can actively participate in class discussions by using a virtual blackboard, an electronic textbook, and the Internet [8]. However, up until now, the employment of ubiquitous computing technology has mostly concentrated on enhancing programs for student surveillance, test readiness, and classroom note-taking. For example, Smart Kindergarten utilizes sensor data gathered from the children or their belongings to record the pupils' activities and monitor their educational progress [12]. Classroom 2000 gathers relevant classroom information, such as student notes and lesson plans [13], in order to create multimedia class files that may be easily downloaded by both instructors and learners via the Internet. Chen et al. (2014) have created a portable device-oriented testing system.

This presentation will introduce Smart Classrooms, which utilize ubiquitous computer technology to facilitate collaborative learning among college students. We incorporate mobile and portable devices, such as Personal Digital Assistants (PDAs), with the existing computer infrastructure, which includes PCs, sensors, and other devices, in a wireless network environment within the classroom. The mobile devices in Smart Classrooms are capable of being aware of the current situation. They can adaptively capture different classroom situations and create temporary networks that enable students to collaborate with each other and connect with instructors. The Smart Classroom will be used to demonstrate the significant benefits that a senior group software engineering project course may get from its adoption.

Background

Collaborative Learning

Teachers can captivate students who may typically lack enthusiasm in studying by promoting collaborative learning [15], creating an atmosphere where students actively participate and critically evaluate their own work. Collaborative learning promotes the active involvement of students in both classroom teaching and small-group studying. In classrooms that foster

collaboration, every student has the chance to contribute and recognize the work of their peers. There are four main features that can be observed in collaborative classrooms, as outlined in the range of pages 15 to 16.

S1) Knowledge Dissemination: Instructors provide learners with essential knowledge related to the subject content, teaching methods, and skills. The instructor utilizes the information, life experiences, language proficiency, coping strategies, and cultural background that each student brings to a collaborative learning setting.

S2) Collaborative learning is facilitated by the instructor, who promotes the sharing of knowledge and encourages students to apply their own expertise. The instructor emphasizes the importance of mutual respect, the exchange of information and learning methods, and the achievement of high levels of comprehension. Mediation occurs in a collaborative classroom when educators act as mediators to adapt the amount of information. Positive mediation outcomes allow students to make connections between newly learned knowledge and their previous understanding, provide guidance when faced with difficulties, and teach learners about the most effective learning practices.

S4) Heterogeneity: The presence of varied student groups in a collaborative classroom enhances learning by incorporating a variety of educational backgrounds, experiences, and perspectives, which enriches the learning environment.

Major Features of Smart Classroom

Elements That Are Crucial to a Classroom That Is Knowledgeable Collaboration is made possible in the classroom with the use of RCSM, which is a middleware that was developed expressly for pervasive computing applications. In a smart classroom, there are two categories of devices: those that facilitate mobility and those that facilitate infrastructure. Each classroom is outfitted with stationary infrastructure devices that transmit pertinent information to mobile devices. This information includes the amount of light that is present in the room as well as the relative positions of the mobile devices in reference to the infrastructure devices. The bulk of mobile devices are held by both teachers and students or students themselves. Students and teachers alike are able to more actively participate in classroom discussions because to the availability of mobile devices. PDAs are the forms of mobile devices that we use at the moment. Personal computers (PCs) and personal digital assistants (PDAs) are examples of devices that are currently capable of detecting light and position. These devices are considered to be infrastructure devices. Additionally, the RCSM is exploited by both categories of devices in order to facilitate a wide variety of applications that include collaboration. In this section, we will discuss the precise ways in which the characteristics of our Smart Classroom contribute to the enhancement of the process of collaborative learning:

Functionality of Smart Classroom Applications

The use of applications that facilitate learning through cooperation in a more straightforward manner. The Smart Classroom application bundle makes it possible for a teacher, a student, and a teaching assistant (TA) to participate in a number of activities that include collaborative learning. These activities can be found in the Smart Classroom. Additionally, the suite offers a wide range of communication options for teachers, students, and even the individual themselves, making it an extremely versatile tool.
Additionally, there are Teaching Assistants (TAs) employed by the organization that are eligible for employment. The following is a list of numerous characteristics that are linked with

applications that are used in smart classroom programs:
i) The application suite will send a notification to the student, based on the time and location of the student, in order to remind them of impending assignments and requirements for the class. The application module will ensure that the lecture notes on a student's personal digital assistant (PDA) and desktop computer are both up to date and consistent with one another before and after each class. This will be done both before and after each lesson.
The instructor or the assistant to the instructor is the recipient of this. The application suite ensures that the lecture notes that are stored on the personal digital assistant (PDA) of the instructor or teaching assistant are synchronized with the desktop computer before and after each session. This is because desktop computers are the ones that are responsible for retaining the original lecture notes.
iii) The application suite gives students the opportunity to trade and share papers that contain drawings, which helps to strengthen the students' capacity to communicate with one another. In addition, students can use it to synchronize drawing documents across many personal digital assistants (PDAs), which is another useful application. in order to make it easier for student instructors and instructional aides to communicate with one another a) The application suite makes it possible to provide course materials (lecture notes, survey forms, grading sheets, and timetables) to all of the students at particular times, such as at the beginning of a class when there is a low amount of light and noise.
b) The application package provides educators with the capability to design assessments for both individual students and for groups of students.
The instructor can also use the application suite to convey the outcomes of the examination to the students in the form of grades and feedback. This can be done by using the application suite. It is possible to carry out this activity with either individual pupils or groups of students.

For student-to-instructor/TA communication

For the purpose of storing text-based requests and concerns, students have the option of using the application suite on their personal digital assistants (PDAs). In order to enhance communication between teachers, instructors, and teaching assistants, this is done with the objective of achieving these goals. The questions are promptly sent to the personal digital assistant (PDA) of the instructor or the teaching assistant (TA) as soon as they are available in the classroom. When it comes to the application suite, students are obliged to submit their progress checks in a manner that is analogous to the previous example. Following the conclusion of the lesson, their reports are automatically transmitted to either the teacher or the teaching assistant of the entire class.
a) In order to plan appointments with the instructor, each student makes use of their personal digital assistants, also known as mobile devices. Following the delivery of a request to the personal digital assistant (PDA) of the instructor using the application suite, they are subsequently presented with a confirmation. In order to fulfill the requirements of the examination, students are expected to send their responses to the instructor through the application suite via email. In order for students to manipulate, exhibit, and present their academic work onto their personal digital assistants (PDAs) on the screen, the program suite is deployed by the students. Students have the option of using the application suite on their personal digital assistants (PDAs) to save text-based requests and concerns. This is done with the intention of improving communication among teachers, instructors, and teaching assistants. The queries are immediately transferred to the personal digital assistant (PDA) of the instructor or the TA as soon as they are available in the

classroom. b) In a similar fashion, students are required to submit their progress checks through the application suite. Following the completion of the lesson, their reports are automatically sent to the instructor or the teaching assistant of the class. c) Each student uses their personal digital assistants (PDAs) to schedule appointments with the instructor. They are thereafter provided with a confirmation after sending a request to the instructor's personal digital assistant (PDA) through the application suite. Students are required to provide their responses to the examination to the instructor using the application suite via email. The program suite is utilized by students in order to manipulate, exhibit, and present their academic work onto their personal digital assistants (PDAs) and the screen.

Development of Smart Classroom using RCSM

Within the scope of this section, we will discuss the process of establishing our Smart Classroom by utilizing our Reconfigurable Context-Sensitive Middleware (RCSM). Presented in Figure 2 is theThrough the utilization of our Reconfigurable Context-Sensitive Middleware (RCSM), this section will discuss the steps involved in the process of developing a Smart Classroom. The RCSM's architecture is illustrated in Figure 2, which can be seen here. Within the Smart Classroom, Personal Digital Assistants (PDAs) are utilized by both the instructor and the pupils. Every personal digital assistant (PDA) has its own unique collection of sensors. The students use their personal digital assistants (PDAs) to create mobile ad hoc networks that are dynamic and adaptable to their surroundings, taking into account elements such as their position and the amount of light that is present. There is a harmonious collaboration between these networks in order to handle particular difficulties. It is possible for application software to operate with personal digital assistants (PDAs), mobile ad hoc networking protocols, and a wide variety of information technology languages. In order to assist the construction of application software that is aware of its surroundings, we have built an application development framework in RCSM. This framework is intended to facilitate the process of developing applications that are aware of the situation. The situation-aware interface definition language, often known as SA-IDL, is a language that we have developed in order to express the attributes of application objects that are associated with situation awareness. pertaining to the internal structure of the RCSM. In a Smart Classroom, personal digital assistants (PDAs) are utilized by both the instructor and the students. One-of-a-kind sensors are included in each and every personal digital assistant. In order to collaborate on the resolution of a specific problem, students who use personal digital assistants (PDAs) establish mobile ad hoc networks that are dynamic and adapt to their environment, including their positions and the amount of light that is present. Personal digital assistants (PDAs), mobile ad hoc networking protocols, and a wide variety of programming languages are all compatible with application software.

1) A framework for the development of contextually aware applications: Our goal was to simplify the process of developing software for applications that are aware of their surroundings, thus we developed an application development framework in RCSM. The situation-aware interface definition language, often known as SA-IDL, is a language that we developed in order to characterize the "situation-awareness" features of application objects. As transparently connecting distributed and mobile situation-aware application objects over mobile ad hoc networks. The R-ORB protocol spontaneously senses the peer devices in the vicinity and establishes short-duration connection by efficiently analyzing the situation-readiness and the

desired communication partners of specific application objects. In addition, R-ORB provides a lightweight client-server communication primitive for the application objects to communicate with stationary or enterprise computing resources.

2) Situation-Aware Communication Management: Using mobile ad hoc networks, R-ORB offers a thin, transparent framework for establishing connections between dispersed, mobile, situation-aware application objects. The R-ORB protocol effectively assesses the situation-readiness and the preferred communication partners of particular application objects, allowing it to detect peer devices in the immediate proximity and establish a brief connection. Furthermore, R-ORB offers a simple client-server communication primitive that application objects can use to connect to enterprise or stationary computing resources.

The Casio E-200 PDAs were selected as the mobile devices for the teachers and learners since they came pre-equipped with the R-ORBs and other operational versions of RCSM. Each PDA employed an Intel Strong Arm 1110 processor running at a frequency of 206 MHz. Each PDA was equipped with a 64 MB RAM chip and a 32 MB Flash ROM. Furthermore, each PDA was accompanied by a D-LINK Air DCF-660W Compact Flash 802.11b adapter. The adapters were changed to include the mobile ad hoc network characteristics in order to enable ad hoc networking for mobile users within the Smart Classroom. In addition, each Personal Digital Assistant (PDA) is specifically programmed to operate as a location beacon, with the primary objective of facilitating infrastructure construction. Each PDA is equipped with an extra hardware component to enhance the detection of motion, light, and audio. In order to achieve this, a USB-compatible Xilinx Spartan II FPGA board from Trink Electronic was linked to each PDA. The board was outfitted with motion, light, and audio sensors. We have created a message module and a situation-aware ephemeral group communication service (SAEG) as part of the Smart Classroom application package. Presently, we are in the process of developing an information dissemination service (IDS) that manages the administration, evaluation, and collection of information for exams, utilizing the resources offered by RCSM.

An Example

This segment will demonstrate the utilization of the Smart Classroom in the CSE 461 Software Engineering Project I course. In this course, learners are required to collaborate extensively to accomplish a software design project. CSE 461 offers students the opportunity to acquire practical experience through collaborative projects. Both the instructor and the students in CSE 461 are obligated to possess PDAs. The students are given the development timetable and requirement definition for the group task. A certain project process paradigm is adhered to for the development of the software project. Students complete the program analysis, software design, and requirement specifications promptly. Students design a risk management strategy. Every individual in the group actively engages in the project, speaks verbally, and exchanges documents using personal digital assistants (PDAs) within the classroom. Each group of students examines and evaluates the analysis and design papers for the project. They then engage in a conversation about the documents, propose any necessary changes, and finally create a final version that is shared by the entire group. The instructor regularly engages with different student groups in the classroom and closely observes their development.

In CSE 461 classes, collaborative effort and direct engagement between instructors and students are mandatory in order to facilitate the creation of a proficient design document. The qualities of collaborative learning are exemplified by the cooperation of a group consisting of S1, S2, and S4.

The PDAs in the CSE 461 classroom has the capacity to form device groups, allowing students to cooperate on a design document while working in groups. This phenomenon arises from a variety of variables, including the existing allocation of students in classrooms, the class schedule, and the availability of other group members. The CSE 461 classroom encompasses both S1) and S4). S2) is exemplified by the context-aware interactions of the PDAs during a group assignment in CSE 461. The instructor's PDA can actively join a student group during a class meeting to observe and assess the group's progress, while also giving prompt comments. The characteristics of the student-teacher interaction (S2) and (S3) are as follows. To address all four of these attributes (S1)–S4), our Smart Classroom facilitates student engagement in instructor-led discussions and group collaboration.

Group collaborations:

The pupils' PDAs are positioned within the classroom using the RCSM's location detection sensor. RCSM SAEG facilitates communication among several PDAs within the same group when they are in close proximity to one other and have established a group. Figure 3 illustrates a rising trend in the number of students joining the organizations. Each student in the body has a different approach. The location detection sensor of the RCSM is used to identify the learners' PDAs in the classroom. Group communication is established when multiple PDAs within the same group are within range to communicate with each other. The SAEG (System for Automated Exchange of Goods) of RCSM (Regional Commerce and Supply Management) establishes this connection between them. As depicted in Figure 4. To foster collaborative design, students participate in group discussions, share design papers with their peers, and provide constructive feedback. The application suite facilitates the transmission and reception of design materials and comments.

Interactions between students and teachers: When an instructor approaches a group, they retrieve materials for the group discussion, such as design documents, as seen in Figure 5. After reviewing the design documents, the lecturer requests feedback from the class. The instructor's Personal Digital Assistant (PDA) uses our Smart Classroom application suite to send and receive design papers with comments to the student's PDA. The location sensor employs the environmental conditions of both the instructor and the group to determine their individual places. After the discussion session ends, the participants in the group go their separate ways. finished. The SAEG of RCSM is used for termination of groups smoothly.

Discussions

We have created a Smart Classroom that makes it possible for students to learn together by employing the internet and other forms of ubiquitous computing. This is done with the intention of enhancing both the quality and quantity of interactions that take place in the classroom between the instructor and the students. The capabilities of the Smart Classroom have been demonstrated through the use of a prototype course. When it comes to the Smart Classroom, the RCSM Object Request Broker (R-ORB) has already been implemented to facilitate the collection of scenario data and to make it possible to communicate with awareness of the current situation. In order to facilitate the development of situation-aware application software for the Smart Classroom, RCSM has constructed a framework for application development. The purpose of implementing the Situation-aware ephemeral group communication service (SAEG) and the message module of the Smart Classroom is to improve the ability of students and teachers to work together in groups and to encourage interaction between the two groups. At the moment, we are working on establishing information dissemination services (IDS) for the purpose of transmitting

files and transferring information, in addition to constructing various assessment settings for Smart Classrooms. The implementation of a security service, the development of capabilities for grading and examination-taking using resources provided by RCSM, and the process of completing a comprehensive review of our Smart Classroom are all upcoming tasks. Moreover, Smart Classroom will be improved with additional capabilities, such as the capacity to generate timetables, respond to inquiries, and schedule appointments all at the same time.

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