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Collaborative Note Taking Using PDAs

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Collaborative note taking enables students in a class to take notes on their Personal Digital Assistants (PDAs) and laptops and share them with their "study group" in real-time. Students also receive instructor's slides in real-time as they are displayed by the instructor. As the individual members of the group take notes pertaining to the slide being presented, their notes are automatically sent to all members of the group. The system has been used in actual practice for a graduate level course on wireless mobile computing. In developing this system, special attention has been paid to the task of entering text on PDAs, efficient use of the screen real estate, dynamics among students, privacy and ease of use issues. We describe our system and report the findings of this user study.

Keywords: personal digital assistants (PDAs), handheld devices, collaboration, note-taking, text entry on PDAs, student collaboration

1. INTRODUCTION

In recent years, PDAs and wireless networking technologies have enjoyed tremendous market success. There is an abundance of different PDA and 802.11a/b/g products in the market. The two technologies are also being tightly integrated as evidenced by wireless equipped PDAs.

Despite this market success, these technologies are severely under-utilized [13]. PDAs are still primarily used for PIM (Personal Information Management) functions such as calendaring, to-do lists and contacts. More than 90% of the time, these devices remain switched off! This is despite several thousand applications being available on them. For example, Palm claims to support more than 19,000 applications (http://palmsource.com/) but the users typically use the same handful of applications.

There is a tremendous opportunity in using PDAs and wireless networking technology in education and learning [15]. To realize the full potential of these technologies, several issues need to be addressed. In our work, we are addressing the following two issues:

Difficulty in the use of PDAs – It is generally much harder to use PDAs compared with desktop or laptop computers. Apart from several other difficulties in the use of PDAs, text input continues to pose a serious challenge for users. Soft keyboards displayed on screen for use by a stylus or alternate text entry methods such as Graffiti are hard to learn and slow for text entry.

Disconnect between the functionality the users need in their context of use and what is being delivered to them – Porting PC applications to the PDA has not been a successful driver for their usage. Applications need to be developed that fit the use context of mobile users. In order to develop successful applications, one must develop a deep understanding of the application domain, understand the full potential and limitations of the devices and networks, understand the dynamics of mobile use, and then build the entire solution scenario keeping the human factors in mind.

Text input is an integral part of any note taking activity. Given the difficulty that users face in inputting text on handhelds, we have implemented a collaborative note taking technique. It facilitates rapid input of text on small, networked devices by allowing users to reuse text entered by fellow note takers [6]. In addition, slides used by the teacher are presented as a thumbnail image on student handhelds from which they can reuse words (see Fig. 1).

Fig. 1. The shared text input system accessed from a PDA. Users can quickly type in notes by re-using words from the slide image (bottom) or from the notes taken by their friends (middle). Users simply tap the desired word to paste it into their notes.

We believe that there are significant advantages to making note taking in the class a collaborative activity. Similar to an instant messaging application, text notes originating from a user can be sent to the note-taking server, which can redistribute them to all members of the use's study group.

We have implemented our collaborative note taking system keeping the above in mind and used it in a senior graduate level course on "Mobile Devices" in the Department of Computer Science, Naval Postgraduate School. Several graduate students used a combination of HP-iPAQ PDAs and laptop computers to receive slides, write notes and share them with their classmates. At the end of the course, we asked the students to fill-up a questionnaire and held meetings with them to receive their feedback. In addition, we analyzed data from the notes the system had collected.

Based on the results of our study, we report two significant findings. First, the study shows that sharing text in real time improves the efficiency of taking notes on PDAs. Students can reuse text from the slide image as well as from the shared text entered by other note takers. Secondly, the study shows that many students value the awareness and communication aspects of the system. Many students do not retype a note already written by a fellow note taker. Many students also use the system as a chat tool to communicate quietly during the lecture, supplementing the information presented by the instructor. However, some students also felt information overloaded as they try to pay attention to both the lecture and the notes showing up on their PDA.

The goal of this paper is describe our system, our experience in using the system, and the revisions made in the design for improved usefulness and usability.

2. BACKGROUND

PDA and wireless networking technologies have become immensely successful in recent years. In addition to general use, there are significant opportunities for using them in education and learning. Soloway *et al*. [15] makes a case for the use of PDAs in K–12 education in schools, promoting the idea of one PDA per student. Roschelle and Pea [12] further explore the opportunity provided by wireless Internet learning devices for K–12 learning and education. Several research prototypes have already been deployed, not only involving PDAs but also tablets PCs. Ultimately, all systems try to improve the classroom experience.

In ActiveClass [11], the goal is to augment participation in classroom settings when class size and diversity tend to create passive modes of learning. Students can ask questions from their PDAs and vote on other students' questions. At any time, the instructor can see the list of questions and choose to address the most popular ones. Unlike our system, ActiveClass does not support shared note taking. In ActiveClass, some students complained that their notes taken on paper could not be synchronized with the questions and answers brought up during the class. By integrating both, our system has the potential to solve that problem.

Pebbles [10] allows students to annotate presentation slides in real time by inking on their PDAs, augmenting opportunities for students to ask questions by directly leaving comments or questions on the projected slide. Students cannot take personal notes and notes are not persistent but rather ephemeral traces of ink used for real-time annotation of

slides. In our system, the notes are persistent and available to students during and after the class.

Livenotes [7] is essentially a shared whiteboard application that uses wireless communication and pen-based computing to allow a real-time conversation within a small group of students. Students record hand-written notes on their respective tablets, such that the same notes appear in real time on the tablets of their group members who are also running the software.

Classroom Presenter [2] focuses on providing the instructor with tools to annotate his or her slides in real-time from a TabletPC. The instructor can draw the attention of students on specific points and better explain concepts not originally shown on the prepared material by scribbling diagrams and adding text. This system does not support shared note taking or annotations by students.

With NotePals [5], students take their notes in digital ink on a PDA, and the notes are combined automatically into a shared document after the class. This system spreads note-taking responsibility across the group, and group members need only PDAs during their meetings. However, NotePals only allows note sharing after the class and it is not possible to reuse material from others during the class.

Debbie [3] allows the students and instructor in a pen-based electronic classroom to share written information during class. The instructor can draw freehand sketches directly on the surface of the instructor-station's video-tablet or electronic whiteboard. Each student can write freehand on his or her display to make private annotations to the instructor's material. The instructor can import portions of a student's workspace for viewing and discussion by the entire class. The instructor can also ask the students to sketch answers to problems that are related to the topic discussed. Because of this, class sessions tend to unfold as highly interactive activities.

StuPad [16] focuses on allowing students to add personal annotations on top of the slides being presented by the instructor. The underlying capture system is eClass (formerly [1]). One motivation of StuPad is to reduce the need for students to copy off notes already displayed by the instructor, so that students can better concentrate on the lecture. However, personal annotations are introduced so that students can still take notes for individual processing.

3. SYSTEM ARCHITECTURE

Our note taking system works in a client-server mode (Fig. 2) and has three main components:

− The user interface for creating notes
− A real-time slide extractor module
− The note server

Users access the system through a normal Web browser that is Java-enabled. In our current implementation, the teacher can only use Microsoft PowerPoint to present his/her slides. As slides are presented in the class, the system automatically captures the slide

Fig. 2. Collaborative note taking distributes notes and slides in real-time to student groups wire-
lessly connected from a PDA or a laptop.

Fig. 3. When logging, users can specify the list of their friend with whom they will share their
notes.

image and its textual content, and sends it to the note server. The server is mainly re-
sponsible for receiving slides and students notes, redistributing the notes to the appropri-
ate students (as specified in the study group list in Fig. 3), and storing all information
into a relational database. We now describe the key steps for using the system.

3.1 Logging and Taking Notes with Collaborative Note Taking

Fig. 3 shows how users enter their username and select the members of their study group with whom they want to share their notes. The selected members are prompted to accept/reject the invitation to join the group. It is important to understand that if Paul chooses to share his notes with Anna, then Anna will see all notes coming from Paul. But Anna might not have included Paul in her group. In this case, Paul will not see notes from Anna. We have also added the latest thumbnail image of the slide extracted by the slide-capturing tool, thus setting the context for the notes to be shared.

Fig. 1 shows the main interface separated into 3 areas. The top window is used to type in notes by reusing words from the slide image (bottom) or from the notes taken by their friends (middle). Users simply tap the desired word to paste it into their notes.

3.2 Reusing Words from the Slide and the Shared Text Area

At any time the user can reuse a word from either the slide image or the shared text area with a single tap. The system automatically inserts the selected word into the note at the current insertion point. This is similar to doing a copy and paste, but it's much faster and well suited to stylus input. We have explained in section 4 how we were able to extract words from the slide image.

Because of the limited screen real estate on the PDA (240 * 320 pixels), we have used a small thumbnail image to display the slide. To help users identify the text, the image is automatically zoomed in locally as users move the stylus over the thumbnail. In Fig. 4, top/left, the stylus was moved over "Initial testing" and these words are zoomed in. They remain zoomed in as long as the stylus stays over their bounding box. The image used to display the zoomed in version is the original image sent from the slide-capturing tool: this allows users to read the textual content clearly.
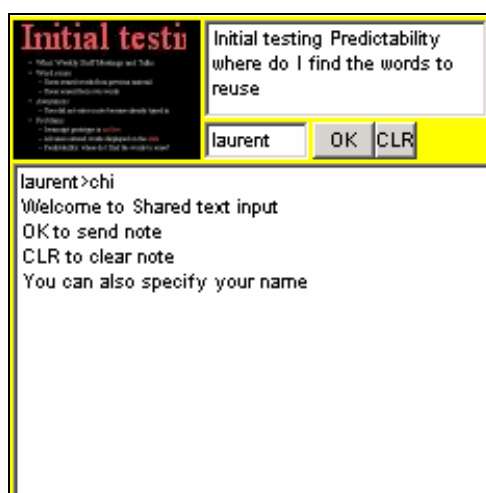

Fig. 4. The top/left displays the current slide; the top/right displays the current note; the bottom shows the shared text.

3.3 Note Retrieval after the Class

At their leisure, students can later access their notes from a standard Web browser (see Fig. 5). The system presents the list of the notes, grouped by date. Notes are displayed along with the slide that was shown at that time. By clicking on a thumbnail image, users can see a bigger version. Their notes are shown in normal font, but the notes coming from their buddies are displayed in italic, allowing quick visualization of content. Even if they did not take a note when a slide was presented, the system still displays the slide image. A button allows users to hide or display their friends' notes.
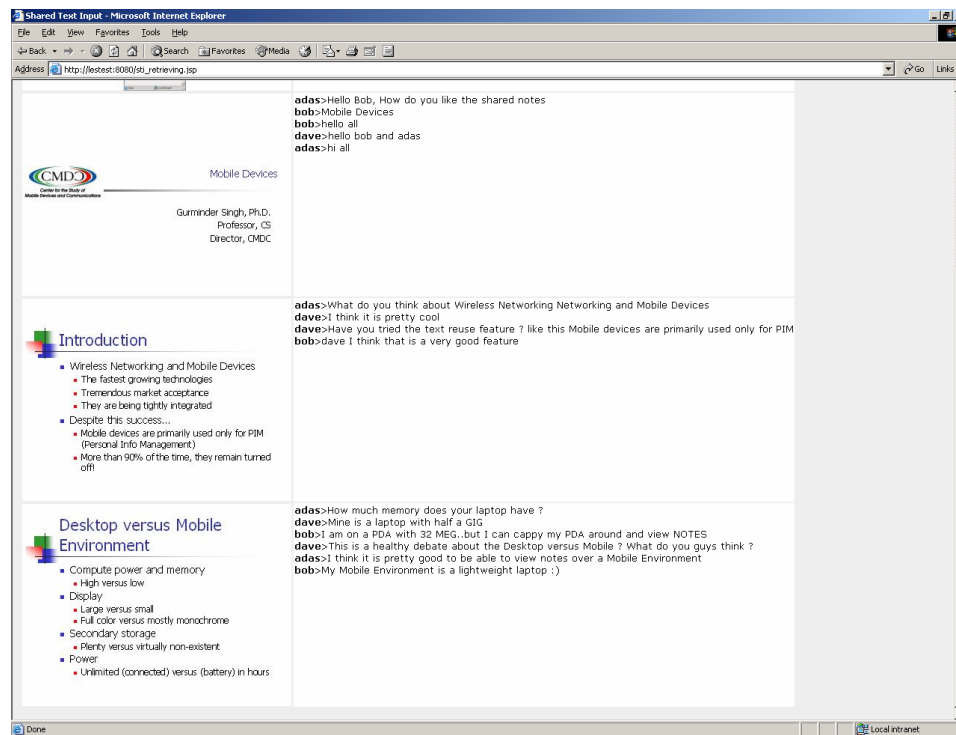

Fig. 5. Students can retrieve their notes after the class from a standard Web browser. Notes are sorted by time and grouped by slide.

4. IMPLEMENTATION DETAILS

The Collaborative Note Taking server is implemented as a set of Servlets and Java Server Pages (JSPs). It currently runs under Windows and uses the MySQL relational database to store all data, including slide images, textual content, notes and user preferences.

When connected to the system, the client applet uses a socket connection to receive and send notes from/to the server. The chat-like server component (spawned by the main

Servlet at startup) relays the text and notifies clients of slide changes. We have used an applet with a live connection to make the client applications more responsive to new slides and new notes.

A special add-on DLL was written for PowerPoint. The DLL is implemented in Visual Basic and is easy to install on the teacher's laptop. The DLL is automatically loaded when PowerPoint starts on the teacher's machine. When PowerPoint enters the slide show mode, it notifies our DLL for every slide change. Upon receipt of that event, our DLL accesses the PowerPoint Object Model to:

  Save the current slide as a JPEG image
  Extract the bounding boxes of the textual elements on the slide

5. USER TESTING

We deployed our system at the Naval Postgraduate School in Monterey, CA in a class of 20 students during a four- month period from March to June 2003. 15 students chose to participate in our experiment and we lent iPAQs to whoever wanted to use them.

5.1 Interviews and Observations Prior to Deployment

Prior to deploying the system, we observed that most students with laptops (10/20) opened PowerPoint and used the note field to take their notes during the class. One student used Word to take his notes. 2 students already had a PDA during the class, but they took their notes on paper; the PDAs were used to quickly check for references in Google using the wireless connection provided on the campus.

We also distributed a questionnaire to all students to understand their current note taking practices. Thirteen students responded. Students liked paper for its affordances and ease of use. Many students used laptops, but acknowledged problems with drawing. In these cases they still had a sheet of paper handy. Students said that they manually copied a lot of information already shown on the projected slides. One student explained that it was useful to remember; others found it annoying but forced to do it when the slides had not been handed out or made available electronically before the class.

Most students' notes are a linear recording of what the teacher says (10/13), but 9 students also declared including personal questions during the class. Most (12/13) students that used paper declared relying on arrows and links to create structure in their notes. It was interesting to observe that none of them could reproduce a similar strategy on their laptops. One student used a PostIt program to affix notes at specific locations on the slides within PowerPoint. All students said they did not have time to write everything they wanted. 4 students mentioned that the lecture was too fast; 2 thought that they wrote too slowly; 4 students declared asking for help during the class, and 7 after the class.

5.2 Feedback after 3 Weeks

Three weeks into the trial, an interview showed that 5 users had switched back to using their own laptops instead of the PDAs. Some said they had switched because they

could not keep the PDA after the experiment. However, these students still accessed the Collaborative Note Taking system from their laptop. This interview also identified several problems:

The slide image was too small to accurately select text.

Students who had switched to their laptop asked for a bigger interface: we developed a special version of the applet where all three areas (slide image, shared area, personal notes) were larger. We also added a check box on the login screen where users could specify whether they were logging from a PDA or a laptop.

Students wanted to see the notes of their friends after the class even if they were not present or did not take notes during the class. We modified the note retrieval pages accordingly.

Students wanted to be able to navigate into their notes during the class, and possibly modify previous notes.

Students did not like to check their buddies every time they logged in. We added a user preferences table in the database to store the buddies and added a few JSP pages to let students manage this list.

6. LESSONS LEARNED

6.1 Data Analysis from the Database

The database contained 1044 slides, captured during 33 classes. From the 15 registered students, 8 used the system to take notes and 7 never entered a note.

Three users only used the system for 2 days and we chose to remove them from the subsequent numbers presented here. The remaining 5 students used the system for more than 6 classes, with a maximum of 10. These active users took 399 notes. 8.5% of these notes contained words reused either from the shared area or from the slide.

The detailed count shows that 16 notes (4%) contained words reused from the shared text area and 18 notes (4.5%) contained words reused from the slide images. 24 words where reused from the shared area, compared to 114 reused from the slide images. These numbers show that students did reuse words suggested either by fellow note takers or extracted from the slide images in about 10% of their notes.

6.2 Post Experiment Focus Group

The analysis coming from the database does not tell us about the user experience. Also, not reusing words does not mean they were useless: students could have read them without clicking on them. To better understand these points, we conducted a focus group with 5 students at the end of the experiment. Two students were PDA users and three used laptops for connecting to the system.

Besides the size of the image slide, all students said that they could not reuse individual words from the slide image. Indeed, our initial slide-capturing tool only permitted the selection of a full line; since then, we have changed this component to allow the selection of individual words.

Two students also expressed privacy concerns: they were not comfortable with sharing all their notes, even with their buddies selected at the beginning of the session. To solve this problem, we added a "personal note" button on the interface to let them create personal notes, accessible only to themselves. The "ok" button has been relabeled "chat".

Because the data showed that 75% of reused words came from the slides (compared to 25% from the shared text area), we asked students for feedback on this subject. Despite the usability issues with selecting text from the slide image, students found it easier to locate a word from the slide image than writing it from scratch. On the shared text area, it was harder to locate the words they needed. Furthermore, students did not find it necessary to reuse words from the shared area because they knew they could access the notes of their friends later using the web page.

Two students specifically complained about information overload when the shared text area became too crowded. They had no problem seeing the slide image because it was in sync with the slide being projected. In a previous version of the system, the server filtered the notes before distributing them to connected users, in essence keeping only keywords. Students quickly turned down this idea: they really saw value in seeing the whole sentences written by their friends. This feedback clearly indicates that students found the shared notes useful even if they don't reuse words from them to include in their notes.

We also asked permission to look at the notes themselves. Some contained a URL. When asked about it, the student said that he often looked for additional references during the class and shared his search results with his friends. However, he complained about the lack of feedback: he did not know whether or not his friends liked this recommendation. We have not yet fixed this problem but since our system knows who reuses what, it would be simple to indicate some feedback to the recommender.

Although reusing words from the slide or the shared text area was useful, students still had to enter most of their notes using the soft-keyboard on the PDAs. Most of these PDA users were frustrated. For a while, one student tested a foldable keyboard plugged into his PDA. But this solution turned out to be frustrating as well: he would have to lean forward all the time in order to see his note on the small display.

Many students also complained about networking problems. Besides variability in the wireless coverage within the classroom, students told us that the PDAs would automatically switch off to save power. Unfortunately, the socket connection would not resume when students turned on the device. This engineering problem forced users to refresh the applet in Pocket Internet Explorer to start a new session. In doing so, they would also loose the content of the shared area.

6.3 Teacher Feedback

The teacher – an author of this paper – was very pleased with the experiment. The slide-extracting tool allowed him to make last-minute modifications before the class without having to copy the modified PowerPoint file onto the external Web server. Also, because slides are only captured if displayed for more than 4 seconds, he could quickly jump through slides or not show the entire document during a class; this feature turned out to be useful when he could not cover all of what had been prepared.

7. CONCLUSIONS AND FUTURE WORKS

The data we collected validates our hypothesis that reusing text from a slide or from other users in real-time is useful to students. But this experiment also shows that the system does not only improve text input; it also improves awareness among students during and after the class. Many students exemplified this: they really need to see the full notes rather than keywords. Furthermore, reading notes created by others was judged useful after the class. In that sense, the Shared Text Input system became a Collaborative Note Taking system.

We discovered problems with information overload in the shared text area and suggested a possible solution by filtering out similar notes before recommendation. However, presenting the image of the current slide was very useful and did not cause information overload. Besides some usability problems due to the size of the thumbnail image and the capturing tool itself, users could quickly reuse words without having to fish for the words.

Interestingly, laptop users who had access to a keyboard for text input also found the system useful and declared having reused words. This suggests that the system is useful regardless of the particular form factor used in the classroom.

Another experiment with 2 teachers and 40 students is under way. In addition to our current desktop, laptop and PocketPC Java-based versions, we have also developed a client for the DANA (Fig. 6), a PalmOS-based wireless device from AlphaSmart that becomes widely used in classrooms across the United States and in 15 other countries. As this experiment suggests, supporting a wide range of devices becomes a requirement for deployments outside the lab: students often prefer their own device, especially when it comes to their note taking.
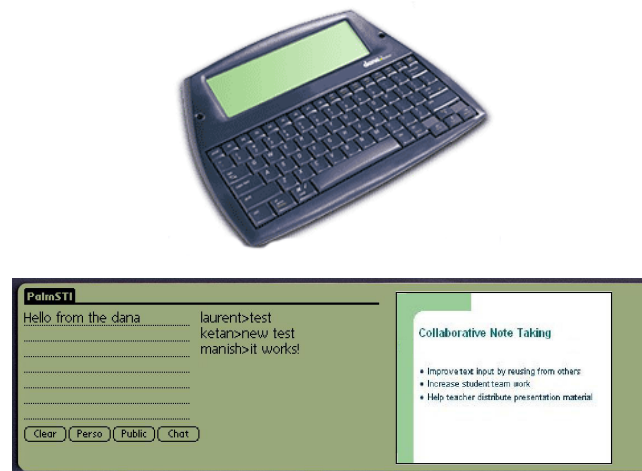

Fig. 6. Prototype of collaborative note taking on the DANA from AlphaSmart, featuring a 560 * 160 pixels screen running PalmOS4.1 and integrating a WIFI connection; Users type in their notes on the left, see their friends' notes in the middle and can reuse text from the slide image (right).

ACKNOWLEDGMENTS

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Prof. Singh has been involved with ACM and IEEE for many years in organizing conferences, editing special issues of journals, and publishing in their journals. He has published extensively and edited special issues of the Communications of ACM, ACM Transactions on CHI, IEEE Multimedia and ACM Multimedia Systems etc. Prof. Singh founded the ACM Virtual Reality Software and Technology Conference in 1994. He received his Ph.D. in Computing Science from the University of Alberta, Canada.

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