NotePals: Lightweight Note Sharing by the Group, for the Group

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ABSTRACT

NotePals is a lightweight note sharing system that gives group members easy access to each other's experiences through their personal notes. The system allows notes taken by group members in any context to be uploaded to a shared repository. Group members view these notes with browsers that allow them to retrieve all notes taken in a given context or to access notes from other related notes or documents. This is possible because NotePals records the context in which each note is created (e.g., its author, subject, and creation time). The system is "lightweight" because it fits easily into group members' regular note-taking practices, and uses informal, ink-based user interfaces that run on portable, inexpensive hardware. In this paper we describe NotePals, show how we have used it to share our notes, and present our evaluations of the system.

Keywords

CSCW, PDA, pen-based user interface, digital ink, mobile computing, informal user interfaces, NotePals

INTRODUCTION

Communication of ideas and experiences is one of the biggest challenges facing a workgroup. Group members spend much of their time alerting colleagues to new information, explaining ideas to them, or searching for a person who has needed information. The NotePals system attempts to give group members more direct access to their colleagues' thoughts and experiences by allowing them to view each other's personal notes. By automatically capturing notes taken in any context and making those notes accessible to an entire workgroup via the web, we have found that group members can more easily benefit from their collective experience.

The NotePals system operates by capturing group member's notes and some of the context in which those notes were written (e.g., the author, the topic, and the time the note was created). These notes are then uploaded to a shared note repository that all group members can access through note "browsers." These browsers allow group members to retrieve all notes taken in a given context or to access notes through other related notes or documents.

Shared notes from meetings can capture group members' detailed thoughts and differing perspectives. If one person in the meeting creates an important diagram or list of ideas in his personal notes, all group members have easy access to that information. This information can be retrieved by listing all notes taken by that person during the meeting and browsing for the desired pages. Alternatively, if a presentation was given during the meeting, group members can browse for the slide that was visible when the desired pages were created and find them next to the slide.

At a conference, shared notes that one group member takes during a session can benefit other members that did not attend that session. Group members may take more detailed notes than they would without NotePals, because they know that other group members will be looking at their notes. When the group reviews the conference later, they can retrieve the notes taken during each presentation and discuss them in detail. Group members may also discover each other's impressions months after the conference, because their notes can be shown next to the conference paper in an on-line proceedings.

NotePals can capture group members' thoughts and experiences because it is "lightweight," fitting easily into groups' existing processes. Note taking is a natural activity that nearly all people engage in to record their ideas and experiences. NotePals captures this natural activity with an informal ink-based user interface [8]. This

lets users focus on taking notes, instead of correcting a handwriting recognition system. Also, NotePals runs on Personal Digital Assistants (PDAs) that are inexpensive and very portable.

This paper gives a detailed description of the NotePals system and shows how it can be used to share notes as in the above examples. We begin by describing the NotePals user interface. Then, we will describe usage experience that has shown us the value of shared notes. The next section presents two user studies we conducted, and this is followed by a description of two task-specific NotePals browsers that we built as a result of one of the studies. We finish with related work, future plans and conclusions.

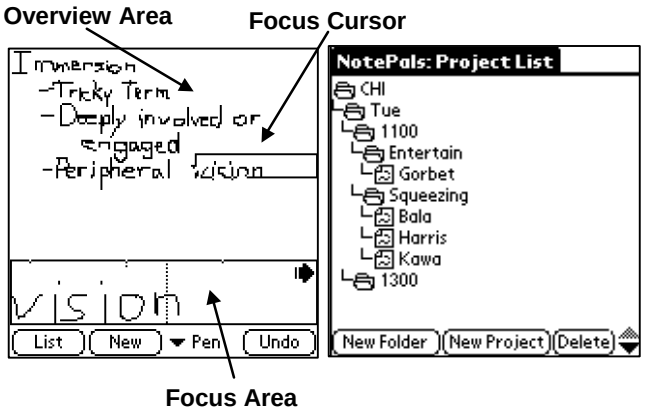
NOTEPALS USER INTERFACE

The NotePals system, first described in [4] and demonstrated in [6], includes a PalmPilot-based interface for taking notes and a web browser-based interface for viewing notes. Each interface had its own requirements and challenges, and we discuss them here separately.

Note-taking Interface

We wanted the note-taking interface to run on a device that was as inexpensive as possible, usable in almost any environment, and capable of uploading notes to a central repository with little effort. We considered using paper-based notes that could be copied or scanned. Although paper may be natural to use, copying would require collation of the notes for sharing and scanning excludes performing handwriting recognition on the notes due to the lack of timestamps on the ink.

Instead of paper, we chose to use PDAs. In particular, we chose the 3Com PalmPilot, a pen-based PDA that over a million people already use for personal information management [1], and which currently sells for under $300. In addition, the PalmPilot has a simple mechanism for exchanging information with other computers. Placing the Pilot in a docking cradle connected to a desktop PC and pressing the HotSync button causes an application-specific data exchange program to run. This platform enabled us to create an informal, electronic ink-based note-taking system that allows users to share notes with



(a) (b)

Figure 1. (a) The NotePals note-taking interface on a Pilot. Ink can be drawn in the Overview Area or the Focus Area. Erase and undo are also supported. (b) The NotePals

little effort.

The Pilot's size makes it easy to carry, but also difficult to draw on. An unrecognized, ink-based interface is hard to design for a two-inch square screen. A user's hand can obstruct her view of words on the screen. Resolution is also a problem. Even if users can write very small words, the 160x160 pixel resolution makes them hard to read.

The interface we created to deal with these problems is shown in Figure 1(a). Users write in their own handwriting directly on the page at the top of the screen (the "overview area") or in the box at the bottom of the screen (the "focus area"). Words drawn in the focus area appear in the overview area inside the "focus cursor," shrunk to 40% of their original size. Once the user has filled up the focus area with text, a quick right to left swipe of the pen moves the focus cursor forward, clearing space for the next word. This interface allows many words to fit on one page, despite the small screen.

Each page of notes in NotePals is created within a "project." Projects are organized in a hierarchical set of folders, as in Figure 1(b), which gives users a way to group notes into topics. New project names are entered using Graffiti (the Pilot's text shorthand) rather than using digital ink, but it is also possible to pre-load a list of project names. To give extra context, users can assign each page of notes a "Type" that indicates what kind of information it contains (e.g., action item or new meeting header). Other contextual information, such as the author's name and the time the note was created, are recorded automatically.

Users can also control who has access to their notes. By default, notes are public, but they can either be marked private so that only the author can view them or they can be marked group-visible, which makes the notes visible only to the author's workgroup.

With this system, group members can take personal notes in any environment and make those notes available to their entire group, if they wish. In order for this sharing to take place, all they have to do is remember to dock their Pilots with their desktop PCs once in a while. Docking causes the NotePals data exchange program, or "conduit," to upload their notes to the group's web repository.

Browsing Interface

Shared notes are accessed on networked computers through conventional web browsers. This makes notes viewable at most group members' desks and in many meeting rooms.

When group members wish to review notes, they point a web browser to the group's web repository. After entering their name and password, they can view a subset of notes by selecting note properties (project, author, date, type, and keyword). The notes are sorted by the time they were created, with notes from different authors interleaved (see

Figure 2[1]). Users can sort notes by their properties (such as author or type) and change the subset of notes viewed by selecting a new set of properties. Clicking on a thumbnail shows individual notes at full size, as shown in Figure 3.

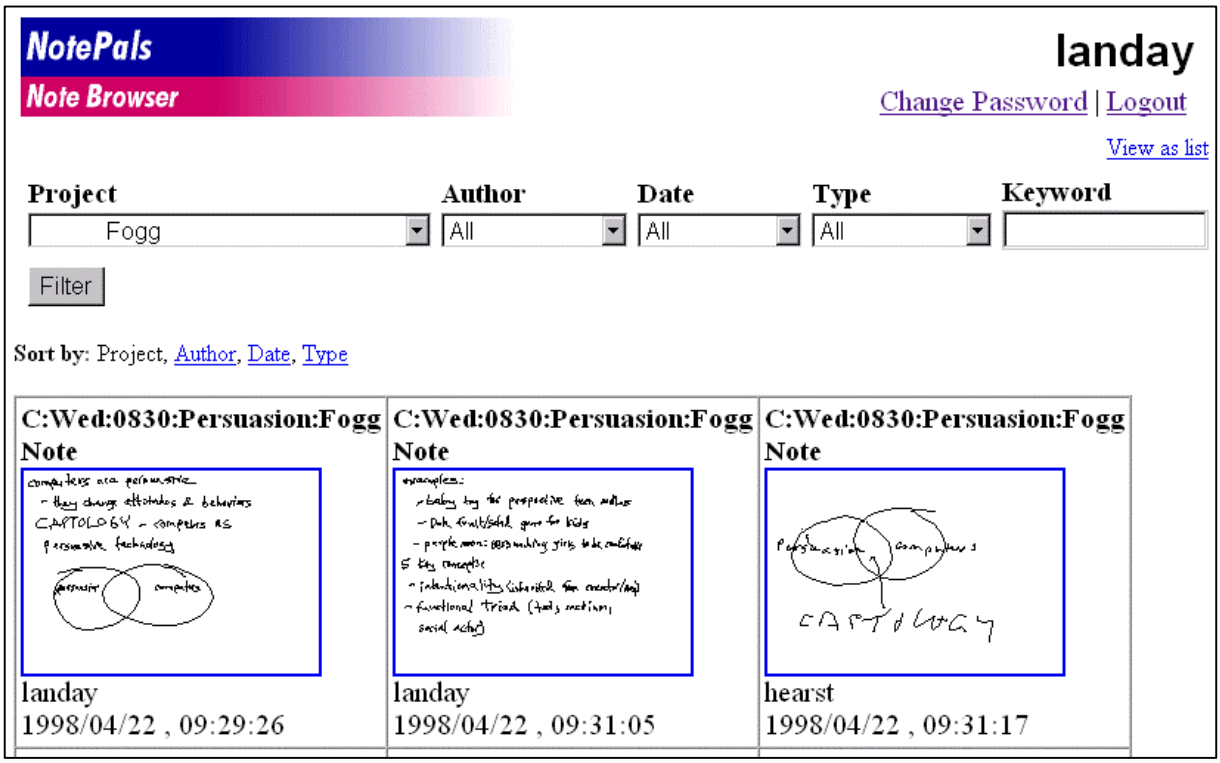


Figure 2. Web-based NotePals Note Browser shows thumbnails of the notes matching the selected properties.

The NotePals system made it possible for our research group of about 10 people to take shared notes regularly. The following section shows how we use our shared notes.

USAGE EXPERIENCE

We have been using NotePals for sixteen months and taken over 3000 pages of notes. The ability to share notes has proven quite useful in conference settings and shown great promise in classroom settings as well. Many of us also find NotePals useful for our own private notes, which indicates that the system can fit easily into our existing note-taking practices. Here we describe these usage patterns in detail.

Note Taking at Conferences

We began to see the real value in shared notes at the UIST '97 conference. Two of the authors took a combined 128 pages of notes during talks at this conference. Afterwards, at a conference review meeting, the entire group viewed the shared notes through a web browser projected onto a large screen. The easy accessibility of these notes enabled us to have a very detailed review, because participants asked questions about things written in the notes, and the authors used their notes to recall details.

Inspired by this experience, we prepared for a greater challenge, the CHI '98 conference. Since this conference has multiple, simultaneous tracks, it was not possible to determine which notes went with which talk by time alone. Therefore, we pre-loaded the list of talks into NotePals as projects. Six members of our research group took over 350 pages of notes at the conference.

After the conference, we had an even more detailed review that extended over three group meetings. Notes were displayed on a large screen, as before, and each talk was discussed in detail. This review was important for those who were unable to attend the conference and for those who attended but could not be in every session of interest.

For group members that were not present at the review, their notes served as their "voice" in the meeting, though notes were occasionally too hard to read. Group members that were present used their own notes to jog their memory (as before), and other group members asked them questions about the content of their notes. After this review, many of those present felt that they had a better understanding of what happened at the conference than they would have had without the shared notes. This benefit appears to be due mostly to the fact that the notes were displayed in the same place at the same time, and

[1] This browser can be viewed at the following web site: http://guir.berkeley.edu/notepals/guir

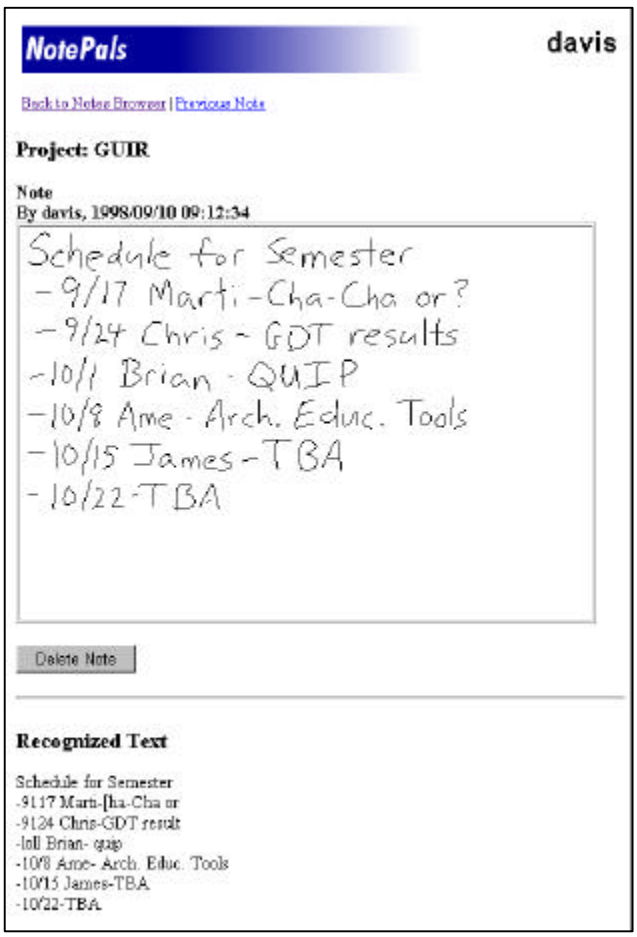


Figure 3. A note shown at full-size. The recognized text was added as a result of our group note taking study.

partially to the fact that they were visible to all group members.

Since the conference review, we have found new value in these shared notes. Though an individual may not have attended a certain talk and may have forgotten about the review of that talk, she can easily access other group members' impressions of that talk. This effectively gives the entire group access to an impression of a talk just because one group member attended it. Such knowledge may be useful when one of us is writing a paper and wants to quickly check out a reference from this conference. We explore this possibility further below.

More recently, we have taken notes at the UIST '98 and CSCW '98 conferences, as well as in medium to large-sized grant proposal meetings. In particular, we have had success taking NotePals notes on the paper-based CrossPad [3]. This portable device digitizes ink as it is drawn and is more natural to use than a PDA. The digital ink is uploaded to a desktop PC and a transfer utility, written using a Java API [9], transfers the ink and attributes to the NotePals web repository, and allows the user to specify a project for the notes.

Note Taking in Class

Three group members, two of whom have not worked on NotePals, have also successfully used shared notes in their graduate operating systems course. This course requires students to read research papers that are discussed in class. The goal of the course is to teach them how to analyze these papers critically and how to recognize common themes. As such, much of the "content" of the course is contained in the discussions that the professor leads during each class.

These students said that there was more information presented in class than they could record alone. Not all of this information is important, but it is hard to determine which points are worth remembering. Each did his best to record the important points presented in class, but all relied on each other to improve their coverage of the topics. The students used NotePals so that they could benefit from each other's notes after lectures or when preparing for exams.

Right before the midterm, the three students met for a total of six hours over two evenings for a study session. They found that projecting their NotePals notes was a productive and an effective way to study as a group. Many times during their discussion the notes helped them recall information they had forgotten. Often, viewing a note would lead to questions and discussion to clarify a particular concept, and sometimes this would lead them to look at other information such as the papers themselves, on-line summaries, or the instructor's lecture notes.

NotePals was valuable in this class environment because the students felt a strong need to recall as many important ideas as possible from class discussions. It is unlikely that the notes would be so valuable if all of the lecture content were contained in distributed lecture slides, or if there were not exams driving these students to pool their resources.

Personal Note Taking

It is worth noting that several group members prefer taking all of their personal notes with NotePals, regardless of whether or not they *need* to be shared. Some simply like taking all of their notes on a device that fits in their pocket. Others like the fact that notes are automatically stored in a computer format that is easy to retrieve, duplicate, and share if needed.

For example, one of the authors uses NotePals to take notes during weekly meetings with students. He makes the notes accessible to the student so that both can have a shared record of work plans. Though students seldom need to refer to these notes, this author is assured that the plans are available to the students if they should ever need them.

Few of us ever make our notes private, preferring instead to make notes accessible to the rest of the group, in case

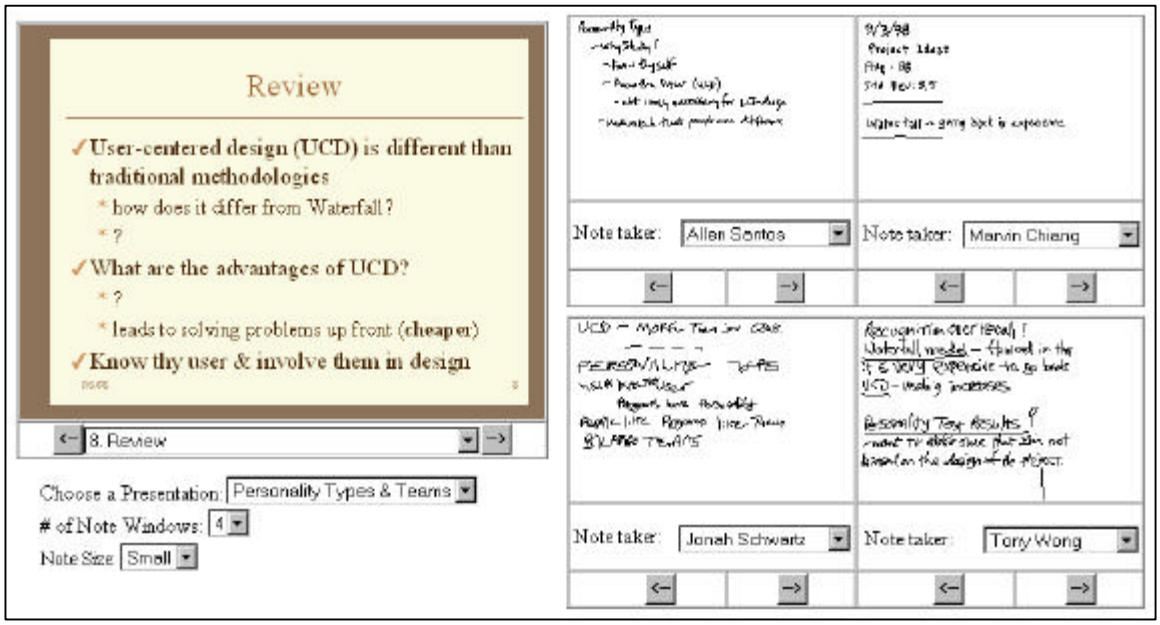


Figure 4. A web interface for browsing presentation slides along with multiple users' notes.

they *might* one day prove useful. This may however be due to the inconvenience of changing the note property from the default value of public.

USER STUDIES

As we were beginning to use NotePals in our everyday lives, we also conducted two studies to evaluate the strengths and weaknesses of the NotePals system. The first of these studies measured the quality of the note-taking interface and revealed some problems that we have since addressed. The second study looked at how meeting notes could be shared after a large group meeting and showed us the value of making shared notes accessible from other documents, such as meeting minutes. Here, we describe these findings.

Note Reading/Writing Speed Study

Our first evaluation of NotePals, reported in [4], compared the speed of creating and reading NotePals notes versus paper notes. The study found that it took 64% longer on average to write NotePals notes because users had difficulty moving the focus cursor and often lost track of its location on the page. Another group of participants who read these paper notes and the on-line NotePals notes could do so with almost no errors, but NotePals notes took on average 37% longer to read. These results indicated that creating legible notes with NotePals was possible but slow, and the interface tended to make bad handwriting worse.

This study made it clear that providing ink-based note-taking interfaces on small PDAs would be challenging, and we have tried several approaches to improve the situation. First, we allowed the right-to-left swipe to be drawn in the focus area[2], and made the cursor snap to a grid so that it could easily be dragged and centered on a line of text. Also, users often lost track of the cursor's position on the page because their attention was directed to the focus area. To alleviate this problem, we enhanced the focus area with the two position cues shown in Figure 1(a). A vertical line indicates that the end of the page is ½ a screen-width away, and tic-marks similar to those on a ruler give a coarse indication of horizontal position. We believe these changes improved writing speed and legibility.

We are in the process of adding Graffiti support to NotePals so that Pilot experts can add ASCII text to their notes using this recognized shorthand alphabet. We are also experimenting with new methods for creating ink-based notes on small screens. Finally, we are continuing our exploration of note taking on the CrossPad. With a combination of these approaches, we hope to improve the ease of taking notes on portable, inexpensive devices.

Group Meeting Study

Our second evaluation, described in [5], focused on the use of shared notes to create meeting minutes from a real meeting. Each member of a research group of about 15 people was given small paper pads that simulated the ideal NotePals interface. We used paper so that problems with the existing interface would not affect the study. For three consecutive weekly meetings, about half the group took their personal notes on these pads.

[2] This gesture was originally made in the "Graffiti" area below the display.

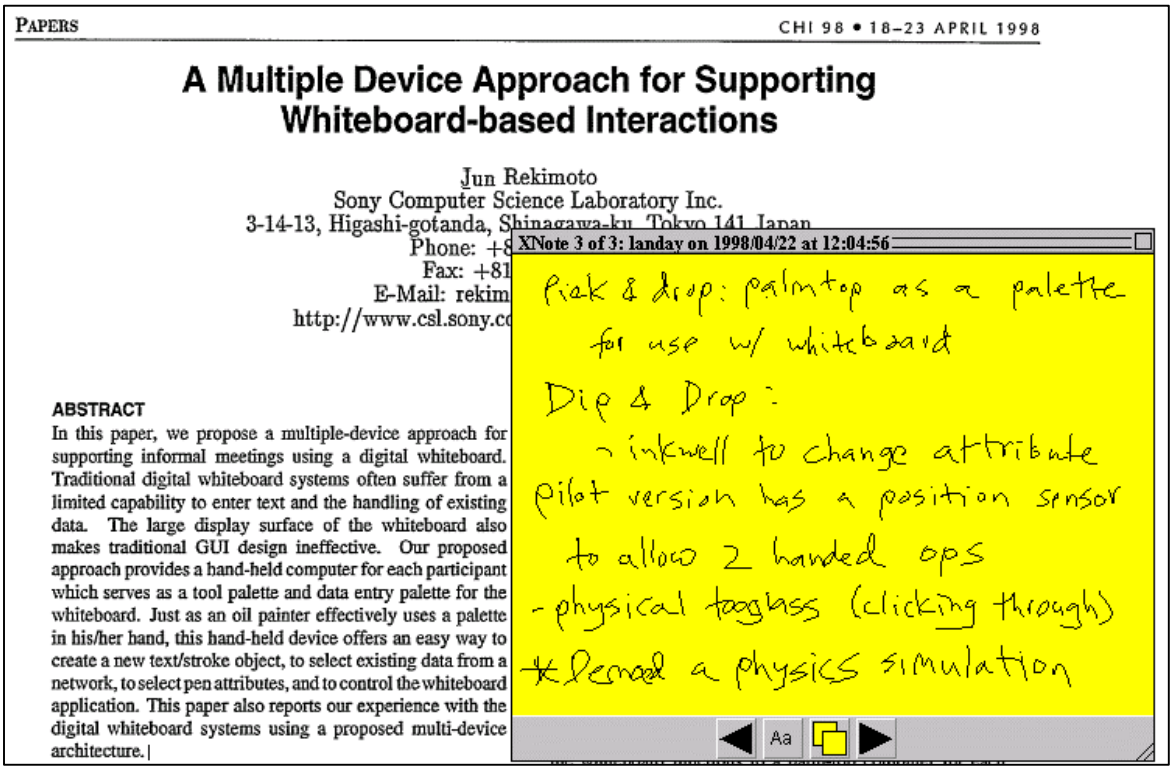


Figure 5. An interface for viewing notes taken during conference presentations. Hyperlinks can be made between ink in the note and portions of the underlying paper. The recognized text corresponding to the handwriting can be displayed by clicking on the "Aa"

Since our focus was to provide a shared meeting record and we did not know what form these records would take, we worked with a participant from each meeting to assemble the notes into a useful meeting record. After each meeting, participants were asked to compare their regular, scribed meeting minutes with our group record.

We made several interesting discoveries. First, we found that many participants had difficulty reading each other's handwriting, especially in records that changed handwriting styles every few lines. (A participant performed this interleaving of notes to imitate meeting minutes.) This discovery led us to separate individuals' notes into distinct, non-overlapping regions in later systems (see Figure 4). It also led us to add off-line handwriting recognition[3] to the NotePals browser, as shown in Figure 3. This recognized text is not accurate enough to provide an exact transcript of all notes, but it catches enough keywords to make searching for text faster than browsing through hard to read notes. Note that the lack of timestamps and stroke data would have made this almost impossible with scanned notes.

Second, we discovered that participants did not like "minutes" that were automatically created from their personal notes, because the large group size made the jumble of personal perspectives incoherent. They began to see real value, however, in *combining* personal notes and presentation slides with the regular minutes. The key insight appeared to be that a single, unifying document is needed to provide a structure when there are too many sources of notes to make sense of them all. This caused us to begin looking at the possibility of combining outside documents with shared notes.

TASK-SPECIFIC NOTEPALS BROWSERS

This drive to combine shared notes with unifying, outside documents has resulted in two new browsers that we have recently started to use. The first is specific to the task of finding shared notes in the context of presentation slides, and the second, to finding shared notes from on-line conference proceedings.

Browsing Notes and Presentation Slides

With the new goal of making shared notes accessible from contextually related documents, we developed a browser interface that combines notes with presentation slides. In this system, presenters start their PowerPoint presentations with a special tool that logs when each slide is visible, while the audience takes notes with NotePals. After the meeting, slides and personal notes are uploaded to the system. The browsing interface, shown in Figure 4, allows users to see the notes of up to five people synchronized with the presentation slides. Cycling through slides or notes changes all other views to keep them in sync.

[3] NotePals uses ParaGraph's CalliGrapher handwriting recognition SDK when notes are uploaded [16].

Recently, a prototype version of this system was used in an undergraduate UI course taught by the author. Each of the fifty students was provided with an IBM WorkPad (equivalent to a Pilot) for taking notes. Students could view lecture slides next to the notes taken by other members of their project groups. We felt NotePals would prove useful to these students because much of the learning in this class happens through class discussions, and lecture slides are used mostly to frame these discussions. The value of NotePals appeared limited in this situation because the students reported that the slides were "very complete."

Browsing Notes and Conference Papers

We also developed a new browser for conference proceedings and notes that may make our conference notes useful far into the future. The notes taken during CHI '98 were combined with on-line proceedings to create the interface shown in Figure 5. This interface shows personal notes attached to conference papers and also allows viewing of recognized versions of the notes[4].

This browser was built on top of the Multivalent Document architecture (MVD) [17]. MVD documents are composed of "layers" of related data and dynamically loaded "behaviors." For example, each note is comprised of the original handwriting image layer and a recognized text layer, allowing the user to manipulate the handwriting.

Because these notes are linked automatically to conference papers, this interface can make group members aware of others' impressions of a presentation long after the presentation has taken place. In the future, we will experiment more with this interface.

RELATED WORK

NotePals was inspired by many previous systems. Here we compare and contrast our work with similar research in two main areas: computerized meeting rooms and personal ink-based note-taking systems.

Computerized Meeting Rooms

Some meeting room systems seek to improve specific kinds of meetings by structuring meeting activities. The Electronic Meeting System, for example, leads a group through brainstorming, idea organization, voting, and comment phases [14]. These tools can improve the quality and number of ideas generated by a group, but they are inappropriate for other styles of meetings.

Other meeting room systems make no attempt to structure meetings, but instead give participants new means to communicate and record meeting activities. These systems often give participants access to traditional applications that have been group-enabled [11, 15, 18]. Some of these systems have been shown to help groups create documents that better reflect a group's ideas and decisions.

These meeting room systems share some problems. They may shift a meeting's focus to document creation, redirect some of the group's attention to complex computer interfaces, and they often require participants to type during meetings, which can be disruptive.

Another class of meeting room systems tries to enhance natural interaction styles or record keeping methods, without shifting the meeting focus or process. WeMet [23], for example, provides access to a shared drawing space running on multiple workstations. Tivoli [12] allows users to manipulate handwritten text in structured ways on a LiveBoard [7]. Tivoli notes and meeting audio can be captured together, allowing participants to access the audio from the notes after the meeting [13]. Similarly, the Classroom 2000 project [2] records classroom audio, presentation slides, and the professor's LiveBoard notes, and provides ways to browse through them after class. An early prototype of this system merged handwritten notes taken on Apple MessagePad PDAs with lecture slides. Unlike Classroom 2000, we do not assume classroom settings, and we focus on the sharing of notes between meeting participants.

These more natural systems have been influential in our work with NotePals. We have implemented many of these ideas in cheaper, more portable systems than the traditional computerized meeting room. This is important for supporting informal meetings or conferences. Unlike these systems, we also focus on the *sharing* of personal notes and information between group members.

Dolphin allows co-located and remote groups to link personal notes and documents in shared spaces [19]. NotePals also links notes and documents, but we make these links automatically when possible.

Personal Freehand Note-taking Systems

Since typing can interfere with many note-taking situations, we have also taken inspiration from research in informal, personal note-taking systems. Freestyle allows personal, handwritten notes and annotated documents to be shared using electronic mail [10]. NotePals also takes advantage of the simplicity of informal, personal note taking, but has more automated sharing and supports note taking *away* from the desktop.

The PARCTab [20] was an early handheld CSCW system that supported a simple shared drawing application. This showed that small devices could be used collaboratively. There has also been research in portable, handwritten note taking and audio recording systems, such as Filochat [21] and Dynomite [22]. Handwritten notes written with these systems can be used to access audio that was recorded when they were created. The simplicity of these note-

[4] This browser can be viewed at the following web site: http://guir.berkeley.edu/notepals/chi98

taking interfaces and the automatic recording of audio context makes these systems very similar, in spirit, to NotePals. NotePals, however, uses even cheaper hardware and allows personal notes to be shared. Interviews of Dynomite users showed that free-form ink can be lighter weight and more expressive than text entry.

FUTURE WORK

For some users, the PalmPilot is simply too small and can be uncomfortable for ink-based note taking. We plan to extend NotePals in the immediate future by exploring more natural methods for entering notes. This includes improving our initial support for the paper-based CrossPad [3], evaluating solutions based on scanning-in handwritten notes, and creating a better PDA interface. We have also recently implemented text search of the ASCII text generated by our off-line handwriting recognizer.

Our long-term goal is to add inexpensive systems that capture audio and whiteboard notes so that we can support meeting environments without expensive equipment, such as the LiveBoard [7]. We will also continue to look for useful ways to share personal notes and to explore methods for linking these notes with related documents and captured information. Finally, we will continue to evaluate how sharing can be beneficial to workgroups.

CONCLUSIONS

NotePals is a lightweight note sharing system that gives group members easy access to each other's experience through their personal notes. The system captures notes and related documents of interest to a workgroup and provides a central repository for this information. NotePals fits easily into a workgroup's regular practices and uses portable, inexpensive hardware. We have built a note-taking client on a handheld device using a novel focus plus context user interface, as well as a paper-based system using the CrossPad. A field study found that shared notes are more valuable if retrieved using task-specific browsing interfaces that group related pieces of information and make them accessible from each other. Usage experience with NotePals has shown that shared notes can add value to meeting, conference, and class records.

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