Proceedings

CoPADD 2006

1st International Workshop on Collaborating over Paper and Digital Documents

November 4, 2006
Banff, Canada

Proceedings produced by Beat Signer
ETH Zurich, November 2006

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Is a paper map a mobile shared display?

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ABSTRACT

This paper presents a discussion of work combining paper maps with electronic information on handheld devices for use in a mobile context. We consider the benefits of paper, electronic media, and mixing the two in relation to the domain of group navigation. A prototype design is described that attempts to utilize these benefits toward providing a lightweight, ad hoc group navigation support system. Of particular interest is the extent to which an augmented paper map can be used as a shared display, to enhance communication and awareness of the activities of group members while navigating together.

Keywords

Mixed-media interfaces, group navigation, mobile maps, augmented maps, CSCW

1. INTRODUCTION

One interesting class of paper-based or paper-inspired technology are mixed-media applications. Such applications combine static media on paper with electronic media. Often such systems are designed to replace or augment purely paper or purely electronic systems/practices already in use, such as poster advertisements, or to integrate paper and electronic information that had previously been isolated, such as post-it notes and an electronic address book. Designers need to understand how a mixed system differs from pure paper or digital systems, in order to make the case for mixing media at all, and to create systems that make effective and appropriate use of both media.

The advantages of a particular media can only be considered in light of the intended context of use. Portability, tactility, low cost, visibility are all potential advantages of paper, but portability is not advantageous for a wall calendar, for example. The same can be said of electronic media.

Designers of mixed-media systems must also carefully consider how to integrate paper and electronic media. Approaches vary in how the paper and digital content are integrated visually (e.g. being juxtaposed, or indirectly linked via referent cues), structurally (e.g. having the digital content annotate the paper content, or using the paper content as an organizing dimension for the digital content), and interactively (e.g. by providing a digital lens overlay, or interacting with paper content by pointing or other gestures). Again, the appropriateness of a specific approach will depend on the activity being supported.

In our work, we have considered how to interact with paper geographic maps, using handheld devices to express geographic queries and present dynamic information to aid in navigation and planning. In this scenario the benefits of a paper map include portability, manipulability by rotating and folding, ability to use as a primary resource in isolation from the electronic information, and importantly the presentation of detail over a larger area than a portable mobile device could by itself. The mobile device, when used in conjunction with the map, can provide detail where the map provides context, time-dependent or other dynamic data, and personalized or context-specific content.

2. PROTOTYPE DESCRIPTION

Our prototype system (called Marked-up Maps) provides the ability for mobile devices such as PDAs and smartphones to be used as pointers to express queries directly on a paper map. The map is queried by selecting an information category and then circling a region, swiping a street section, or selecting landmarks. Results are presented on the mobile device that performed the selection. The mobile devices and the paper map are integrated by affixing a grid of small, malleable RFID tags to the underside of the map, and using mobile devices equipped with RFID readers. The paper map can be folded, written on, used by itself, and stowed away. Details of the implementation can be found in [1].

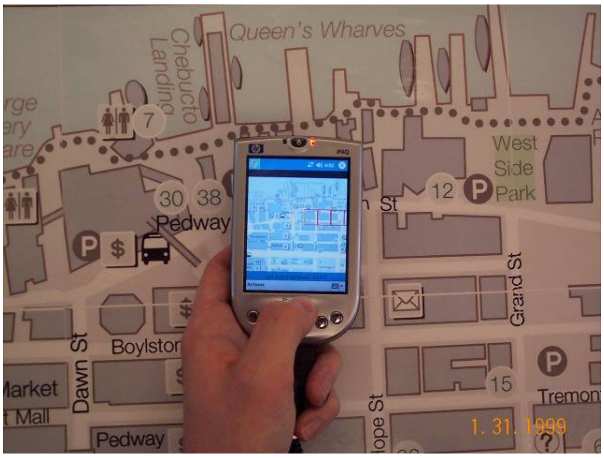

Figure 1. Querying a map by swiping part of the length of a street. The region selected is displayed on the device during the selection operation, allowing the user to verify their selection. Collected results then appear in list form.

In prior studies we have examined the impact on task completion and spatial knowledge retention of the map's presentation, the structure of the electronic content, and of how the map and mobile device are integrated [2,1]. A map's presentation should of course be appropriate for the set of tasks one hopes to accomplish using it, but map presentation itself is not the only consideration for a markup interface. The markup interface is effective for information retrieval when the map provides a reasonable organizing dimension upon which a desired set of tasks can be accomplished, when ways of querying the map are made apparent in the presentation (for example swiping city streets, circling regions, selecting landmarks), and when the information available can be effectively organized according to the dimension suggested by the map (e.g. by visible landmark or map grid square) [2]. In this paper we present some simple extensions to our prototype that are intended to facilitate group navigation.

3. SUPPORTING GROUP NAVIGATION

Using the system in a mobile context has proven too awkward for a single person while moving, as the paper maps have typically required both hands to manipulate. Instead, the handhelds have been used with the map only while sitting on a bench, or the map has been placed on several kiosks throughout the region being explored. The general procedure employed when a single person used a portable map was to look at the map to determine the current location, then to decide what is interesting nearby by retrieving information about the various nearby items using the handheld, and finally stow the device and use the map to get to the chosen destination. While use by a single person is constrained to occasional use while stationary, we are interested to know whether a group of people could usefully employ the interface when mobile. Beyond this pragmatic motivation, the prototype may provide direct benefits to groups when navigating, as discussed next.

3.1 Motivating Scenario

To understand the motivation for considering our prototype for group navigation, imagine the following scenario. You are out with a group of colleagues during a business trip in Tokyo, and are at Kanda train station near your hotel, trying to find a place nearby to go to for dinner (figure 1). Your colleague Joanne opens a guidebook and starts to look for options with her co-worker Francis. Another colleague, Bob, was in Tokyo last year and recommends a traditional Japanese restaurant. He isn't sure if the restaurant still exists, but knows the location and says he thinks

Figure 1. Some of the colleagues in our group navigation scenario.

it's nearby. You bring out your tourist map, and Bob identifies the corresponding region on the map – it looks to be a fair distance.

Joanne and Francis then ask you for the name of the region you're in because they haven't found any mention of the train station or the hotel. You look on the map and say Kanda Suda-cho. Meanwhile, another colleague has started reading the ads on the back of the map, and begins suggesting restaurants that sound promising. You tell him to try and stick to restaurants near K4 on the map. Joanne and Francis interrupt to ask for another region name, they don't see mention of Kanda Suda-cho, you see a larger region named Kanda Surugadai . They have that in their book. You make note of two restaurants that seem to be nearby, one of which is traditional Japanese like Bob's recommendation, but you all agree that there's no guarantee about the quality of the advertised restaurants.

Joanne and Francis have stopped looking at the guidebook and walk over. They have found two recommended restaurants that serve sushi and are in Kanda Surugadai. You try to locate one on your map. While you know the region, the precise address is hard to locate. You find the street but it seems to be quite far away. Instead, you ask if the traditional Japanese restaurant you found is listed in the guidebook. Joanne starts looking.

Despite everyone's efforts, the hunt for a restaurant is problematic in many ways. To understand why, it is useful to consider both the structure of the map and guidebook, how they were utilized, and how they influenced the planning activity [5]. First, there was one map and one guidebook – members of the group had to make do with sharing a resource or be content to sit out. Second, the map and guidebook were used by different groups more or less in isolation. Nothing about these resources encouraged them to be used together; despite communication between the guidebook users and the map users there were potentially many details that were not shared. Third, the map and guidebook operated at different levels of spatial resolution. Joanne had to first look for the train station, then two different region names from the map before finding a level referenced in the guidebook. Finally, the resources were insufficient in isolation, but difficult to use together. The guidebook offered recommendations without enough detail to pinpoint their locations, and while the map identified a few restaurants directly, these were unrated, paid advertisements.

4. DESIGN

4.1 Map as Shared Display

A key aspect of the design is the single paper map, which we view as a large, static, malleable and portable public display. Because mobile devices interact with the map directly to express information-seeking queries, this may increase visibility of intent to the group. In addition, this leads to more individuals interacting with and becoming familiar with the map presentation, which should facilitate discussion. Because the paper map is linked to electronic resources, the map can concentrate on displaying spatial layout and important landmarks, rather than littering the presentation with a narrow range of content.

As a paper map, results can be marked directly on the map and the map can be kept out along the route, while the mobile devices are put away. This design also permits additional mobile devices to participate at any time. Because the map is a tagged artifact, new mobile devices only need to point to the map to establish a link, and can then begin interacting with the map.

4.2 Locating results on the map

While users may recall the region selected on the paper map by the query, they will often need to identify the precise location of specific results. Results can be related back to the map on the mobile device by selecting a menu item on the device. The title of the active result is displayed, along with the corresponding map grid square index to locate the region on the paper map, and a small image of that grid square with the precise location of the result identified. Users can choose to pencil in the location on the paper map if they want.

Mobile devices can also “mark” locations electronically by saving them. This anchors a specific result directly to the corresponding map grid square, which becomes visible to all devices. Right-clicking the marked area on the paper map directly brings up the associated result, or a list of results if more than one item has been marked in that region. Devices can also perform a query to retrieve all marks in a region. This feature may further increase awareness of the information seeking activities of others in a group.

5. CONCLUSION AND FUTURE WORK

We believe that our prototype design is an improvement on the typical map and guidebook toolset for navigating and planning in groups. It provides a clear integration between the map and guide resources, can accommodate any number of mobile devices, and promotes awareness of the queries (through direct interaction with the map) and results (through marked map sections) of others in the group. However, contextual evaluation is required to understand the parameters that impact effectiveness, such as determining exactly when it is beneficial to know the intentions and actions of others in the group, and whether the prototype constrains usage patterns as it did when used by a single person. Finally, we are considering additional methods of sharing information among mobile devices, while maintaining the lightweight interaction style of the current design.

6. INTEREST IN WORKSHOP

In my research I am very interested in ways that paper resources can be incorporated into systems supporting mobile activities such as wayfinding and spatial data collection. This includes systems incorporating digital pen technology [6], and systems providing digital content graphically such as the one presented here. In particular, I am interested in how different approaches to integrating paper and digital resources provide (or do not provide) awareness of the system’s state and the activities of others.

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The Emergence of Representations in Collaborative Space Planning over Digital Paper: Preliminary Observations

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ABSTRACT

As interactions move off the desktop and onto digital paper artifacts, new patterns of use emerge. Understanding and accounting for these patterns is a requirement if one is to design effective interfaces to support collaboration.

In this paper we describe preliminary findings based on the observation of a collaborative session during which a group used a variety of digital paper documents while planning for an actual office move.

We examine aspects of the document-centered interaction and observe how symbols inscribed on digital paper artifacts emerge, are agreed upon or re-negotiated seamlessly within the interaction. These findings are then discussed in terms of implications for the design of collaborative applications that explore the semantics of interactions to provide services during and after meetings.

1. INTRODUCTION AND BACKGROUND

The familiarity and affordance of paper documents can make co-located interactions of small groups using digital paper artifacts very effective. It is less clear how computational support for collaboration can be fruitfully integrated.

Recent years have witnessed the emergence of initiatives aimed at providing computational assistance to groups of people collaborating. These initiatives share a premise that computers need to become more aware of the users' actions, and to provide services that allow for functionality to fit within the "human collaboration loop". The paradigm of choice is therefore that of *computational assistance*.

We have been pursuing for years systems that enhance user natural practices via the exploitation of multimodal and multimedia features, including the use of paper (e.g. in Rasa and NISMap [2]). One aspect of the investigation we hope to further in the present paper has to do with the nature of the inscriptions performed by users on digital paper artifacts (and other such surfaces affording free form handwriting and sketching such as white boards). The familiarity of users with the materials and the association of their use with flexible, unconstrained inscriptions cause these inscriptions to become hard to recognize and parse from within computational systems. Even in domains for which highly formalized languages constrain in principle the nature of the inscriptions - such as in the military - we see in practice the emergence of new symbols ("carcass-borne IED", meaning an Improvised Explosive Device embedded in an animal's carcass), created in response of changing requirements that surface from the dynamic nature of the situation these users are trying to cope with at a representational level.

Understanding how symbols are forged and how their semantics are established is therefore of primary importance in systems that wish to support natural user practices in the course of which representational systems have to be created or evolved [4]. Rather than emerging from an intentionally concerted effort in which designers assemble to decide on new symbols, we find this to be a natural occurrence that takes place seamlessly in the course of going about business.

Our primary focus in this paper is therefore on examining the mechanisms through which symbols inscribed onto digital paper artifacts emerge from interactions, and how these symbols are related to meaning. In previous work [4] we discussed the importance of context and the role of spoken, written and diagrammatic and/or iconic language in altering the meaning of symbols, illustrated by work of military officers in a command post. Here we use a video-based interaction analysis approach [7] to report preliminary observations from a collaborative session in which a group of employees plans for an actual office move, focusing on the digital paper inscriptions and their creation.

We start by discussing the method employed (Section 2). In Section 3 we present the analysis of the interaction. The discussion, including implications for collaborative system design are presented in Section 4.

2. METHOD

2.1 Participants and context of performance

Participants were Adapx's employees that volunteered to have their activities observed and recorded. This group of employees were tasked with different aspects of planning for an office move, and included representatives from Human Resources, office administration and a specialist in logistics, along with decision-makers.

Considerable previous preparation had already taken place before the session we report on was recorded. Participants had walked the space, collected guidelines from upper management, prepared materials for discussion, and discussed informally amongst themselves and with the experimenters.

In the particular session that is described in this paper, three participants sat around a table in a meeting room to finalize a set of recommendations to be presented to management. This group was tasked with determining the placement of employees within the new space, and handling the logistics of arranging phone lines, internet connections and furniture.

2.2 Infrastructure and Procedure

We collected the data using our research platform for real-time collaborative image annotation over digital paper. We chose to make only certain aspects of the technology apparent by only displaying the electronic ink transmitted in real-time by the digital pens (similar to Paperpoint [5] functionality). The ink, overlayed on an electronic image of the document, was projected on the wall of the meeting room in which the session took place. We chose to hide the support for remote collaboration, the multimodal recognition e.g. of handwriting and speech, sketches, and 3D pointing gestures that the underlying system is equipped to do (as described in [1] and references therein). The introduction to the system was therefore very brief, just showing how writing on different documents caused the ink to appear overlayed on electronic images.

Participants were asked to forward to the experimenters those documents that they intended to bring to the session. These documents - two organizational charts, floor plans of the new office space at two different scales - were then printed by the experimenters on digital paper [1]. Blank sheets of digital paper were also made available.

Participants were fitted with close-talking microphones, and video was captured using three cameras - two high-quality PointGrey Scorpions and a handycam. These cameras provided a tabletop, face (for a one participant) and room view respectively. A Nokia SU-1B running experimental Bluetooth streaming provided the digital ink that was displayed and recorded.

This session lasted about one hour and a half. Videos and audio were synchronized and composed into a single video showing prominently a view of the meeting table upon which the digital paper artifacts were placed. A video log was built and segments of the interaction in which digital paper artifacts played a mediation role were selected. Here we report on those concerned with the emergence of new notational marks.

2.3 Transcription Notation

To describe the interaction we use a notation based on Conversation Analysis (summarized in Table 1). This notation includes mechanisms for describing pointing to parts of digital paper artifacts, and the performance of inscriptions on these artifacts. These were inspired by Frohlich et al's [3] notation for representing pointing to user interface elements and performance of user interface actions respectively. We are less interested at this point on the dynamics of pointing, and constrain the notation to indicate just targets rather than trajectory. Interface actions are likewise restricted at this point to free form writing performed with digital pens. We furthermore represent concurrent action by transcript line grouping. If Figure 4, for instance, lines 7 to 9 represent a block of concurrent action in which the three participants spoke concurrently. In most cases some concurrency takes place, as we are focusing on the events surrounding the inscriptions, which take place in a broader context that includes speech and sometimes manual gestures. We find a high degree of multimodal actions (i.e. a rich mix of speech, manual gestures and writing on digital paper), something to be expected in this kind of scenario [6]. In general, the participant performing an action is indicated by their initials (A:, B:, C:). In cases in which a single participant is performing all the concurrent actions depicted in a block of lines, e.g. lines 1, 2 and 3 in Figure 2, we will just provide a single marking indicating the single participant performing all the concurrent actions (in this particular case this would be A:, the leader).

=	Line continuation
(.)	Micropause (0.1s)
(1.2)	Pause in seconds
( )	Un-transcribed activity
((mumbles))	Transcriber's description
——Target	Pointing to a target
______Target/Symbol	Writing symbol at target
Right <u>h</u>ere	Emphasis (underlined)
o::kay	Stretch of preceeding sound
'one'	Softened sound
>right<	Quickened sound

Table 1: Transcription notation.

In terms of naming the targets of pointing and inscription, we rely on the structure of the main documents analyzed (Figure 1). We identify targets on the organizational chart by the names of the employees contained within chart elements, e.g. we use "Daniel" to mean that location in which the employee of that name appears in the chart. Similarly, we identify targets in the floor plan by referring to spaces, which are categorized as "offices" or "cubicles". These are further distinguished by numbers - we follow the nomenclature established by the participants themselves (shown as labels 1C to 16C and 1O to 5O in the floor plan.

3. ANALYSIS

The choice of symbols used to represent the various aspects of interest to the participants as inscriptions over the digital paper documents emerged implicitly, or as a result of subtle negotiations taking place as the need for new categories presented itself. We see at play the fluid use of spoken, written and iconic language to construct context which constrains the interpretation of human activity and reduces the amount of communication necessary to convey meaning, as described in [4].

We find a first instance of a representational convention being established early in the interaction (after 9:26 min). The first few discussions and examination of the floor plan were performed, and the group proceeds to identify the employees being moved over at the first stage. They turn their attention to the organizational chart, and the group leader (which made most of the inscriptions) starts to go over a list of people management that has indicated should move.

In Figure 2 - lines 1-3, the leader (A:) scans the organizational chart looking for people "moving over on 1 July". Concurrently, he marks Colette's "box" in the organizational chart with an "X".

After marking other employees in a similar fashion (untranscribed segment indicated by line 20), a special case surfaces, of people that need to have a space in the new office, but would still require a space at the old office as well (the category of "dual headed" or as it is later called "fully floating" people). The choice of marking these people with two "X" marks is explicitly clarified (lines 17-19) by a multimodal action - speaking "I'll put two just to show..." while writing another "X" mark. The double "X", having it's meaning established, is used with a more indirect reference once again, when Francis's situation as "dual headed" is first marked (line 21) and then glossed by the speech in line 24 - "Francis is gonna be fully floating".

After working for some time over the floor plan, the group reached a critical decision - where to place the manager of the team being moved over at the initial stage - the "lab" (meaning research personnel). That in turn determined the general cubicle region in which members of this group would be allocated. A decision was made

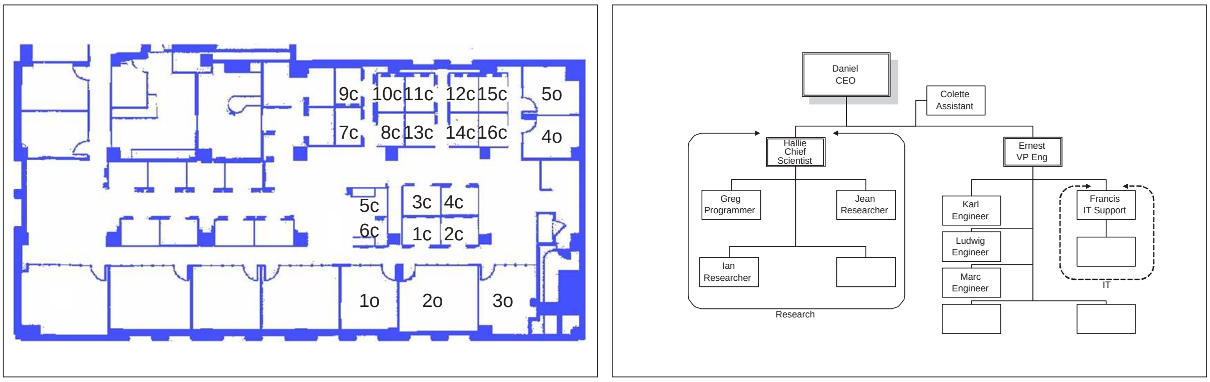

Figure 1: Two main documents used during the interaction (organizational chart structure, names, positions modified for privacy).

```
 1 A: Specifically moving over mmhh on (.) =
 2   =one july will be mmhh (.)
 3                        ----Colette/X

 4 A: Colette will be moving over

 5 A: uhh (.) Lynn will be coming up from=
 6   =Portland and moving into the space
 7            ---Lynn/X
 8   =again as part of the july piece

 9    (  )

10                                 ----Ernest/X
11 A: mmhh Ernest will require and office on=
12   =the exchange building and he::re that we=
13   =need to identify

14 B: ri::ght

15 A: just to be able to go back and forth
16              ((moves finger back-and-forth))

17         ----Ernest/X
18 A: I'll put two just to show that he's fully=
19   =dual headed

20     (  )

21    ----Francis/X ----Francis/X
22 A: An::d (.)   honestly (.) until we get firmly=
23   =set I think we all know that that=
24   =that Francis is gonna be (.) fully floating
```

Figure 2: People moving over on 1 July are marked with “X”s.

not to specify in detail the space allocation for these people, but rather to let the manager make this decision (“so they won’t feel we are micromanaging them”). Members of this group belong therefore to a category of people for whom only generic assignments are made, representing a space within the general area reserved for them. Figure 3 shows how the notation - an “L” followed by a number - developed.

Initially, just a number is used to label the lab members, and almost immediately after the number 1 is written down close to the first lab member (Greg), it gets prefixed by an “L” (Figure 3 - line 6). In line 7 the notation is explained as being an abbreviation of “lab one”. This elicits no reaction from other participants, and the labeling proceeds as “lab one” and “lab two” are voiced while the labels “L2” and “L3” are concurrently written as another participant speaks the names of other lab members (lines 8-10).

While careful not to appear to be “micromanaging” the managers, the group paradoxically moves on to assign specific offices to the top executives and their administrative support. These assignments take into consideration “workflow” factors (who needs

```
 1  A: Specifically within the engineers we've got
 2  B:                                     We've got Greg

 3                        ---Greg/1
 4 A: Greg (.) so there's one

 5 A: I'll just put ell one
 6              ---Greg/L1

 7 A: That's lab one

 8 B: Ian Jean
 9 A:       Lab two (.)   lab three
10 A:           ----Ian/L2   ----Jean/L3
```

Figure 3: The “Lab” personnel get labeled.

to be close to whom), but also the relative position of the employees within the hierarchy, such that the larger offices get assigned to people that are positioned at the top of the organizational chart. Now that actual spaces are being assigned, a different nomenclature is chosen (Figure 4).

```
 1 A: I'm gonna put Daniel

 2 A: Daniel's in number two (.) right?
 3 B:                            yeahh

 4 A:                   ---Daniel/2 in a circle
 5 A: So I'm gonna do that and circle it
 6 B:                        Yeahh

 7 A: Hallie's in five (.)
 8 B:              mmhhmmhh
 9 C:                    Number five

10 A: I'm gonna circle it
11              -----Hallie/5 in circle

12 B: Francis is in four
13 A:                    ----Francis/4 in circle
```

Figure 4: Actual office assignments are made.

Once again we see features of the notation being explicitly advertised while bing laid on paper - “I’m gonna do that and circle it” (Figure 4 - line 5), being in addition “echoed” in line 10, until it becomes commonplace and is silently applied without further considerations in line 13.

In Figure 5 we find more explicit negotiation emerging as a result of a symbol already assigned (a circled “1”) being used while referring to a different type of space - a cubicle instead of an office.

Besides revealing the importance attached to the distinction between cubes and offices (the latter appearing to be symbols of sta-

```
 1 C: I need to be close to Daniel

 2                      ___C1
 3 A: We can give you one if you want

 4 C: Number one (.) ye:ah:

 5 A: Ok
 6     (( nods ))

 7 A: Number one then (0.3)=
 8   =cause that's the main swing door

 9 A: 'one'
10    ----Colette/1 in a circle

11 C: Put a one see

12 C: That way they can see this is a=
13   =cubicle and not an office
14 A:                      ----Colette/1C

15 C: Cause you have the offices are=
16 A:                        >right<
17 C:=circles as well
18 A:                >right<

19 C: So the cubicles should be like one see=
20   =two see
21 A:          Two tees (.) right?
22 A:        ------C1/Colette
```

Figure 5: More explicit negotiation elicited by use of existing symbol in a different context.

tus and therefore very desirable), this dialog also reveals the public nature of the inscriptions, in the embedded assumption that others will be reading them. In line 12 (Figure 5), the importance of making the notational distinction is that "that way *they* can see this is a cubicle and not an office" (our emphasis). We discuss this and other aspects of the analysis in the next section.

4. DISCUSSION

The notation is crafted apparently with the intention of making the inscriptions transparent and accessible (to whomever "they" in Figure 5 -line 12 are). Despite this intention, the resulting diagram is cryptic, having been created and evolved while the interaction unfolded. The symbols carefully chosen to show things of relevance (such as the fact that this person is not taking an office, but just a cubicle) ends up being meaningless to anyone but those that participated in the interaction.

New representations and categories emerged as part of the act of marking itself. The semantics emerged naturally from the context surrounding the inscription actions, built via multimodal language [4]. Very little effort was therefore in most cases spent on establishing the meaning. In many cases this was deemed to be self evident, in which case no mention to the chosen symbol was made. In other occasions light weight clarifications were weaved in, e.g. to explain what two "X"s were meant to represent. More explicit negotiation ensued when symbols chosen by the person applying them failed to capture a semantic distinction, as in the case in which offices and cubicles were marked similarly.

One may ask how and if collaboration technology could help make the unfulfilled goal of making the representations transparent a reality. While we have shown that it is possible to take advantage of the formalized nature of aspects of communication, such as military standardized symbology and communication to build robust adaptive systems [4, 2], there is little in the nature of the symbols and language used in this interaction that appears to offer cues a system could employ to automatically extract meaning.

Two general lines of investigation in terms of automated support could potentially be explored to address this problem: 1) reliance on human interpretation of un-mediated presentation of the context surrounding the creation of an artifact, and 2) the introduction of interface mechanism that would provide the system with enough cues to make recognition possible.

As an example of the first approach, one could augment digital paper artifacts in such a way as to provide links to the multimodal context in which symbols were created, giving users with filtered access that would suffice to provide them with the information they require to make sense of the meaning of document annotations. The success of such an approach depends on how relevant the segments selected for presentation actually are to understanding the context of the interaction. Further research is required to determine whether there would be salient temporal or linguistic features that would offer guidance in selecting such relevant segments.

The second approach might for instance be explored via structuring of documents so as to make available check boxes or other embedded mechanisms that could be used by participants to make transparent some of the aspects of interest. The challenge in designing such a mechanism is of course finding a balance between the inconvenience it introduces to users and the additional assistance a system might provide in return.

Acknowledgments

This material is based upon work supported by the Defense Advanced Research Projects Agency (DARPA) under Contract No. NBCHD030010. Any opinions, findings and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the DARPA or the Department of Interior-National Business Center (DOINBC). The authors thank Ed Kaiser for fruitful discussion. We also thank Scott Lind, Denise Johnson and Annette Giarde for their support; Xiao Huang and Alex Arthur produced parts of the software used and were instrumental during the data collection; Candice Erdmann transcribed the speech.

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General Framework for the Rapid Development of Interactive Paper Applications

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ABSTRACT

We present a component-based framework that supports the rapid development of a wide variety of interactive paper applications. The framework includes authoring and publishing tools as well as a server that supports the linking of active areas on paper to a wide range of different media types and services.

1. INTRODUCTION

The Anoto digital pen solutions were originally developed for the capture of handwritten information and interactivity was limited to specific command buttons for actions such as sending data or changing pen stroke attributes. Recent developments in the pens and patterns have seen other more general notions of interactive paper documents and applications evolve based on real-time streaming of the data. For example, the Fly pentop computer provides a number of interactive desktop applications where the user can, not only interact with the applications via the pen, but also draw their own interfaces. The PaperPoint application [8] based on an Anoto pen with streaming functionality allows PowerPoint presentations to be controlled and annotated based on a printed overview of the slides. These new technologies open up a whole new range of possibilities for experimentation with interactive documents, paper-based interfaces to applications and general forms of bridging the physical/digital divide.

It is therefore vital that the necessary infrastructure and tools are available to support the rapid development of a wide variety of applications and facilitate experimentation with alternative forms of interaction and design. It should be possible to compose complex applications from existing components and to be able to easily integrate different kinds of media, information sources and application services. Not only desktop applications should be supported, but a range of possible input/output channels that could be combined with interactive paper in interesting ways. Last but not least, tools are required to support both the authoring and printing of interactive paper documents.

In the context of the European projects Paper++ [6] and PaperWorks [7], we have developed such a framework and demonstrated its flexibility by implementing a wide variety of applications including interactive paper maps and brochures, paper-based interfaces to a range of applications, for example PowerPoint and an image retrieval service, interactive notebooks for lab-based experiments and also interactive tabletops. Interactive documents can be created on the fly with links generated automatically as demonstrated by Print-n-Link [5], a system that allows users to search for PDF articles on the web and print interactive versions of them with links to information about citations and document retrieval services. The framework was developed to support any type of technology that can track user actions on paper including a prototype pen based on conductive ink [4] developed within the Paper++ project. We have also had access to a prototype version of an Anoto pen with streaming functionality and therefore already have a great deal of experience with the development of interactive paper applications based on Anoto technologies.

In this paper, we discuss the requirements of such a framework and present the main features of our solution. We start in Section 2 with a description of the software tools and printing solutions offered by Anoto. Section 3 then presents iServer and iPaper which together provide a component-based server architecture for interactive paper applications. Section 4 describes the authoring and publishing tools that we have developed to support the generation and printing of interactive paper documents. Concluding remarks are given in Section 5.

2. ANOTO FUNCTIONALITY

The Anoto Digital Pen and Paper technology [1] was originally aimed at the digital capture of handwriting and sketching on paper. One of the main business applications to date involves the automatic capture of form data in large organisations such as insurance companies and in healthcare. The form documents first have to be digitally authored and then they are printed along with the Anoto pattern which is read by an infrared camera integrated in the digital pen to track the movement of the pen across the paper. The position data is transmitted to a computer either wireless, via Bluetooth, or by means of a docking station connected directly to the computer. Once on the computer, the data is processed either by Anoto software or specialised application software such as the Forms Automation software by Hewlett-Packard.

In order to use its technology, Anoto provides a range of developer tools. We describe them in this section and highlight some problems and limitations of the Anoto tools when presenting our general framework for interactive paper solutions in Section 3 and Section 4.

The Anoto License Model: In order to be able to use Anoto-enabled documents, a developer needs an Anoto License. Licenses confirm to a strictly defined model. The Anoto pattern space is divided into pattern pages. Pages are grouped into books, which in turn are grouped into shelves. Every shelf belongs to a segment. Licenses are issued at the level of page, book or shelf. A license has a pre-defined validity and Anoto ensures that a licensed pattern space will not be used by anyone else until the license expiration date.

The Forms Design Kit: The Anoto Forms Design Kit (FDK) allows graphical designers and software developers to build forms to be used with Anoto functionality. The main part of the FDK is the Forms Design Tool (FDT), a plug-in for Adobe Acrobat that allows the generation of Anoto-enabled documents. By using the FDT, a designer can take an existing PDF document and add *pidgets*, *user areas* and *properties* to the form layout, and then generate a PostScript file containing the pattern specified by the Anoto License in use.

Pidgets are used by Anoto for enabling the interactivity from paper to the computer. There exist pidgets to inform the application that an interaction has been started on a new page and pidgets to signal the end of the interaction. These pidgets are composed by a special icon and a special pattern defined elsewhere in the licensed space. The insertion of a pidget actually means pasting a piece of pattern and replacing the underlying page pattern. In addition to the PostScript file, FDT creates a Paper Application Definition (PAD) document containing the specification of all pidgets and active areas to be used at runtime within the application service.

The Paper SDK: To overcome some of the limitations of the FDK and to give greater flexibility to developers, Anoto recently made available the Paper SDK. This product includes the PAD and Print Generation Module (PPGM) which was used to build the FDT. The PPGM is an MS Windows C library enabling software developers to access core Anoto functionality such as the generation of the pattern or advanced functionalities such as colour reduction or printing profiles. It can be integrated into applications and allows developers to build add-ons for any type of specific authoring tool used by the designers.

The Software Development Kit: Once an Anoto-enabled document has been provided, the Anoto SDK can be used to build the application. The SDK provides a *Pen API*, which is a basic framework for server-based applications (Java servlets or Microsoft ASP). Additionally, by using the *Service API*, Anoto provides a solution for stand-alone applications.

The Anoto Pens: Anoto-enabled pens are available from various manufacturers (Logitech, Maxell, Nokia) and they are all optimised for the existing Anoto capture applications (e.g. form filling). More interactive applications require functionality, for example for user feedback, which is not yet available on these pens. Even though the pens are equipped with LEDs and integrated vibration functionality, these feedback mechanisms are not accessible by any software API. Projects such as [3] tried to overcome these problems by coupling the pens with other devices. In the case of the PaperPoint application, we have also coupled a pen with a laser pointer to avoid the problem of the speaker having to use two different devices during their PowerPoint presentations. While such solutions allow one to experiment with the possibilities of different functionalities being integrated into a pen, clearly they remain at the prototype level and are far from optimal. Generally, a number of issues with regard to pen design arise from the development of more interactive applications where the pen is used not only as a writing device but also a pointing and selection device. The Fly pentop computer demonstrates the tendency to integrate more functionality into the pen in terms of not only processing power but also input/output devices such as speakers. One could also consider better support for mobility in terms of WiFi connectivity and GPS. Clearly the decision of what functionality should be integrated into the pens remains an open issue.

3. ISERVER AND IPAPER

The Integration Server (iServer) is a main component of our framework for interactive paper applications and enables cross-media linking between arbitrary physical or digital resources. It provides a set of concepts for link definition and a Java framework to create and activate cross-media links. Links within the iServer framework are always bidirectional and directed, which means that they have at least one target and one or more source *entities* (multi-headed/multi-tailed links). Links can not only be defined between entire entities (*resources*) but also between parts of resources addressed by the abstract concept of a *selector*. By providing specific implementations (plug-ins) for the resource and selector concepts, new types of resources can be added to the cross-media information platform. However, the general link server functionality, including user management, multi-layered links etc., is defined on the iServer level and can be shared and reused by any iServer resource plug-in. More details about iServer, including a full specification of the general link model, can be found in [8].

As part of the European project Paper++ we have developed an iServer plug-in for interactive paper (iPaper). Based on the concept of documents and pages as well as different forms of shapes (rectangles, polygons etc.) for the definition of active areas within a page, links may be defined from an active paper area to any other iServer resource. An active paper area may also be the link target of an iServer link. Note that the iPaper plug-in is general and does not depend on any specific pen technology (e.g. Anoto). The only input required is a *document identifier*, a *page number* and the *(x,y) position* with a given page as shown in Figure 1.

This brings us to the second part of the iPaper client-server architecture, the *iPaper Client*. The iPaper Client is responsible for communicating with a hardware device and transforming the captured data into the neutral *document*, *page* and *(x,y)* format to be handled by the iPaper plug-in on the server side. Therefore, the iPaper Client is based on a set of interfaces that have

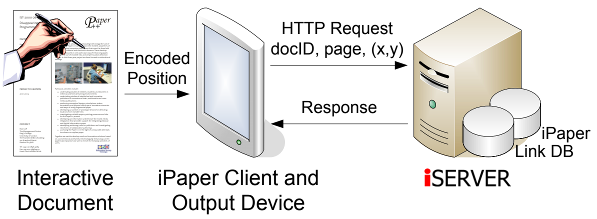

Figure 1: iPaper client-server architecture

to be implemented for any device to be used together with the iPaper architecture. The introduction of these interfaces brings flexibility in supporting different types of input technologies. Within the Paper++ project we have implemented a device driver for an inductive pen prototype. However, it was easily possible to add support for Anoto's Digital Pen and Paper functionality at a later stage. Our iPaper driver for Anoto pens is based on direct processing of binary COM port streaming data and does not make use of any Anoto SDK functionality.

Since the iPaper plug-in does not depend on a specific pen technology, all existing iPaper applications could immediately also be controlled by the iPaper driver for Anoto. It is even possible to control a given interactive paper application from different pens (e.g. inductive pen and Anoto pen) at the same time. Basically, any technology that allows the position within a document to be tracked can be used as an interaction device for our interactive paper platform (e.g. ultrasonic tracking as used by the Mimio whiteboard solution or camera-based tracking systems). Note that the use of the iPaper architecture in combination with Anoto pens introduces some form of flexibility when it comes to the definition of active paper areas. While Anoto's FDK only supports the definition of rectangular shapes, iPaper supports a variety of shapes, including arbitrary polygons. It is further possible to define an active area by composing a set of shapes to form a *complex shape*. In addition to the single-layered (non-overlapping) shapes supported by Anoto's FDK, our solution also supports the concept of multi-layered active areas to control the link granularity. Note that this flexibility in the design of active areas becomes important in the design of interactive paper solutions with a high link density. Furthermore, none of our active areas are based on the "copy/paste" that is used by Anoto pidgets as described in the previous section as this may result in layout problems since pidgets always require a few millimetres distance between them.

The specific Anoto driver also deals with the mapping of an Anoto license to the corresponding iPaper coordinates. Again we are flexible in the way that our approach is not based on the concept of pages as defined in the Anoto license model. By using our own mapping algorithm, we can for example use parts of the pattern space of a single Anoto A0 page to cover multiple A4 pages defined by the iPaper framework.

In addition to the automatic authoring of interactive paper applications, described in the next section, we support the definition of links in XML format as well as based on the iServer cross-media authoring tool. Thereby, special attention has been paid to the definition of active areas that have to be repeated on multiple pages (e.g. page header and footer functionality). With the FDK, these elements have to be manually repeated on each page. Our iPaper framework supports the concept of *templates*. A template contains a set of shapes and may be applied to a set of pages or to entire documents. By defining the shapes only once (in the template) it becomes easier to make changes to elements that appear on multiple pages. At the same time, by eliminating any redundancy, we can reduce the space that is required to store this information in iServer. Note that, in the authoring process, active paper areas may be linked to any media supported by an iServer resource plug-in. At the moment we have plug-ins for web pages, movie clips, Flash movies and other resources.

In addition to these links to rather "static content", iServer introduces the concept of *active content* represented by active components that can be used as link source or target. An active component is basically a piece of program code that gets executed when the corresponding link has been selected. After an active component has been activated, its specific program code is loaded on the client and on the server side and the active component becomes the handler for any information, for example coming from a digital pen, until it is terminated. The active component concept has proven to be very effective since a developer can focus on the functionality to be handled by a single active component resulting in a component-based architecture where specific functionality is encapsulated in small active components. For the iPaper plug-in we have for example developed active components representing paper-buttons, paper-based captured areas, paper-sliders and many others. Active components can be reused across different applications and the growing set of active components tremendously supports the rapid prototyping of new interactive paper applications since a developer may choose from a rich set of existing active components.

4. PUBLISHING INFRASTRUCTURE

Our iDoc publishing framework brings together three different types of authoring: *database-driven authoring*, *automatic authoring* based on the analysis of a given document and *manual authoring* as provided by the Anoto FDT. These different types of authoring are integrated into iDoc via a plug-in mechanism of the Semantic Mapper component shown in Figure 2.

iDoc is based on three main components: the *Semantic Mapper*, which is responsible for mapping a position within a paper document back to its digital representation, the *Printer Driver*, which enables flexible printing of interactive paper documents and the *Document Database*, which stores all the information about the printed documents, such as the pattern used and the position of the different document elements. The Semantic Mapper plug-ins enable a flexible definition of the paper to digital mapping.

By using the iDoc publishing framework provided, some limitations of the Anoto FDT and Paper SDK can be removed. Since the FDT is a plug-in for Adobe Acrobat, it can be used only within that application.

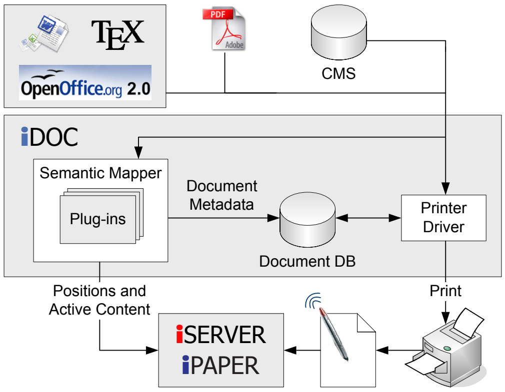

Figure 2: iDoc publishing framework

Furthermore, Adobe plug-ins are only available in Acrobat Professional and the FDT is tightly coupled with a GhostScript library for Windows. As a result, the authoring process is typically split into two separate steps based on two different tools: developers may use their favourite authoring tools (e.g. MS Word, Adobe Illustrator or CorelDRAW) for the document design, but they must switch to Adobe Acrobat to enable the Anoto functionality. iDoc addresses this problem by providing plug-ins for different authoring tools. In order to automatically track the position of single document elements and enable a mapping from the paper version back to the corresponding digital component, we are currently investigating plug-ins for MS Word, OpenOffice Writer and CAD systems. If an Anoto document becomes very complex in terms of the quantity and layout of user areas, authoring based on the Anoto FDT may become difficult. Since the PAD file is an XML file, developers may directly edit this XML document to overcome these problems. However no tools are provided for the automatic authoring of complex documents such as the interactive event brochure and map that we used in the EdFest project [2]. The database-driven authoring of the EdFest brochure was based on the *iPublish* plug-in. The position of all active areas was automatically calculated based on a PDF version of the brochure created by our content management system (CMS). It was therefore possible to automatically create a PDF from the CMS and, at the same time, to publish information about the position of active areas and the active components to iServer. Furthermore, we have plug-ins that automatically detect and calculate the position of document elements based on specific patterns. An example of this class of services is the Print-n-Link plug-in mentioned earlier.

While Anoto defines licenses for different page sizes, all pages within a segment have the same size. Practically, this means that in order to have pages of different sizes, different licenses have to be used. As the dimensions of the pages increase, the number of available pages within a single license decreases, limiting the amount of pages which can be generated with a single license. Moreover, the space is partitioned into streaming and non-streaming pattern. The streaming pattern allows some of the new Anoto pens to transmit real-time information from the pen to the computer via Bluetooth. In order to use the streaming functionality, a special streaming license is required. The PPGM library provided by Anoto tries to overcome some of these problems. The functionality which is available does not go much further than the one found in the FDT and the dependency on GhostScript libraries remains an issue. Since the PPGM offers rather low-level Anoto functionality, a tool offering a high-level interface is required. Nevertheless, because of its compactness, it is convenient to use the PPGM library as a starting point for an authoring and publishing tool with a more flexible and complete interface. Our printer driver is based on the Anoto PPGM and, acting as a virtual printer, enables the printing of documents of different sizes, the merging of multiple Anoto licenses, the definition of printing profiles and the use of black colour reduction. Together with the document database, it manages the Anoto pattern space, keeping track of the pattern already used. Furthermore, our printer driver may run best-coverage algorithms in order to cover for example a single A0 license page with up to 24 A4 pages as defined in the iPaper framework. The use of our virtual printer reduces the printing of interactive documents to one single step and provides direct access to Anoto-enabled printing functionality from any application.

5. CONCLUSIONS

We have presented the state of the art of existing Anoto tools for developing interactive paper applications. While most of these tools mainly focus on supporting the development of form filling applications, we introduced our general framework for interactive paper applications and compared it to Anoto's solution. We have outlined how our publishing infrastructure supports the automatic authoring of interactive paper documents and introduced the concept of active components enabling the rapid component-based development of interactive paper applications.

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Casual Interfaces for Ubiquitous Community Assistance

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ABSTRACT
One target of a ubiquitous computing environment is to create and activate communities in which people interact in a lively manner based on their interests and situations. To achieve that goal, we have been developing a "ubiquitous community assistance (UbiCoAssist)" for event spaces which have rich contents and interactions among certain interest groups and myriad sub-communities. We have been developing the UbiCoAssist by elaborately fusing web systems based on cyber world interaction and onsite systems based on real-world interaction. The UbiCoAssist has been demonstrated for attendees of UbiComp2005 and UbiComp2006. We further improved the UbiCoAssist for various conferences attempting to assist information technology researches widely. This paper briefly describes the characteristics of each sub-system and shows the intuitively usable interfaces such as digital pen or tabletop interfaces.

Categories and Subject Descriptors
H.5.2 [**User Interfaces**]: Input devices and strategies, User-centered design, Haptic

General Terms
Design, Economics, Experimentation, Human Factors

Keywords
Ubiquitous, Community assist, Event space, Social network, Web intelligence, Experience Sharing

1. INTRODUCTION
Increasingly, people enjoy information services while moving in the real world. Among aspects of "ubiquitous" [1] and "context-aware"[2] computing, the most important may be the realization of a context-aware information service [3]. This study develops a system for event spaces. The event space includes conferences, museums, expositions, concerts, parties, and so on with rich on-site contents that can benefit from investments of installing a ubiquitous environment. It is noteworthy that contents in event spaces include not only exhibits and demonstrations, but also the attendees themselves.

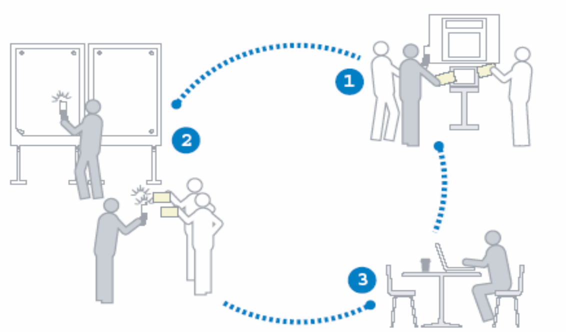

Figure 1 UbiCoAssist overview ①**UbiBoard**: Using digital pen, users can write messages and pin them onto UbiBoard. Users can view those messages via cell phone or PC. **Information Kiosk**: Users can login to Web assistance by placing an RFID card on a card reader. **Tabletop Community**: Placing RFID cards, users can take photos and find the past images taken with other people. ② **Information Clip**: By scanning QR codes using cell phone, users can "Clip" interesting objects onsite. QR codes are printed in posters, exhibitions, presentations in programs, user name plates, and so on. ③ Users can access web assistance using their own PC onsite or at home.

We are developing a UbiCoAssist that create and foster communities of attendees and event operators. In this paper, we briefly describe the characteristics of each sub-system and show the intuitively usable interfaces such as digital pen or tabletop interfaces, which is a revision of the system demonstrated at the Japanese Society of Artificial Intelligence (2003-2006) and UbiComp2005 and UbiComp2006 [4][5].

2. UbiCoAssist
An attendee will be able to use onsite assist systems during the conference period and web assist services from about one month before the conference. Figure 1 shows usage scenarios. Attendees can access to the Web assistance called POLYPHONET CONFERENCE before the conference. At the conference site, attendees can obtain RF-ID cards and log in to the Web system at the information kiosks. A log management server shares all the user interaction information of the Web system and onsite system.

UbiCoAssist can be connected with other systems with common interfaces very easily.

We developed four sub-systems for onsite assistance. Those systems are carefully designed to be used easily and intuitively. Users must be used to operate user devices and should be easy to carry. We call those interfaces “casual interfaces” which are enhanced or supported by environmental systems. Digital pen, RFID card and cell phone with a camera are employed for UbiCoAssist so far. In the following subsections, POLYPHONET and four onsite systems are briefly explained.

3. POLYPHONET CONFERENCE

My page of POLYPHONET is shown in Figure 2. The POLYPHONET makes it possible to display a **social network** through a collection of research works and publication data posted on the entire world-wide web [6]. It also provides functions to register acquaintances, which increases the reliability of the social network. Simultaneous interaction to Information kiosks is also acquired for social network modification. Thus the social network is created by Web mining initially and developed by interaction of Web services and on-site services [7].

Moreover, **connection search** is possible by inputting two researcher’s names based on the interrelationship between them. The additional information of research activities are extracted in the form of **researchers' keywords** [8]. Through these capabilities, it becomes possible to search for researchers in different disciplinary areas.

The system provides information **recommendation** and **social matching** services using user's **bookmark** and acquaintances list. User can find interesting papers and persons not only by recommendation. A social matching service helps users to introduce their friends to others easily.

4. Onsite Assistance

As shown in Fig.1, There are four onsite sub-systems. All the systems utilize RFID card. The RFID card of Ubicomp2005 version is shown in Figure 3.

4.1 UbiBoard

UbiBoard is a bulletin board system using a digital pen that converts handwritten messages into digital data. Participants can easily communicate with each other and share messages by applying a pen to a simulated bulletin board. Furthermore, participants can read messages with online mobile terminals because handwritten messages are also posted to the boards on the web site.

Figure 2 My page of POLYPHONET CONFERENCE

Figure 3 RFID card for users. The system name was changed from Ubiquitous Community Support System to UbiCoAssist afterwards.

First of all, users write into the message sheet using a digital pen as shown in Figure4. When entry completes, the system operates to converts handwritten analog information to the digital data - Flash animation data, and post to the bulletin board on the Web. This time simultaneously, it gets the user ID from users’ RFID card and the sheet ID from the bar-code on the message sheet. By enter the original sheet ID, users can reply to the message and link it from that message automatically.

You can see your own message and its associated reaction, or new arrival message for someone from the PC or the portable terminal anywhere at any time.

Figure 5 shows the hardware and the bulletin board on the web. The top left image is the terminal to post the messages. The bottom left images are the message sheet and the digital pen. The digital pen is the product of Anoto Corporation. The top right image is the UbiBoard web cite. You can also see the same message by the mobile terminal if you clip with the Information Clip system.

By using the UbiBoard system, you can easily communicate with each other and share the variety of information. For example, you can introduce your presentation or the demonstration. You can call for participation in informal discussion like BOF. You can share the information near the conference place, etc...

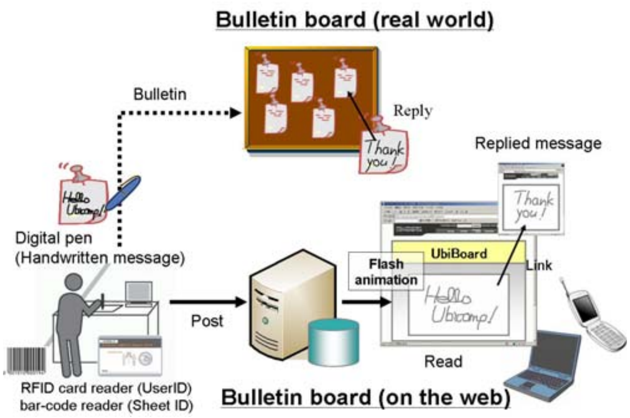

Figure 4 UbiBoard usage scenario

Figure 5 UbiBoard devices

4.2 Information Clip

By scanning QR codes using cell phone, users can "Clip" interesting objects onsite. QR codes are printed in posters, exhibitions, presentations in programs, user name plates, and so on as shown in Figure 6. The procedure of "Clip" is illustrated in Figure 7.

Figure 6 QR codes are printed to program, demo and name cards.

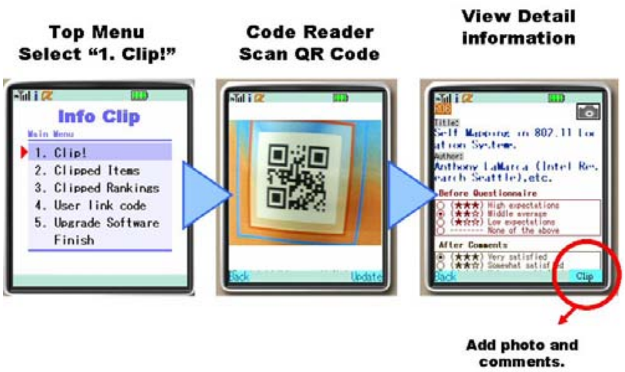

Figure 7 How to clip and add photo and comments.

Figure 8 How to view messages

Users can view and communicate one another by sharing clipped information on the cell phone as well as POLYPHONET. Figure 8 illustrates the method to view messages.

4.3 Tabletop Community

When a user puts a RFID card onto a reader of Tabletop Community as shown in Figure 10, it detects that individual's rough location (direction of the user from the camera) and identification of users in the picture, which is taken by an omni-directional camera every time when a user places/withdraws a personal RFID card. Each picture has additional information such as the time and date when it was taken, a unique ID number of the table and the ID information of the RFID card.

Figure 10 Tabletop Community demonstration at UbiComp2005

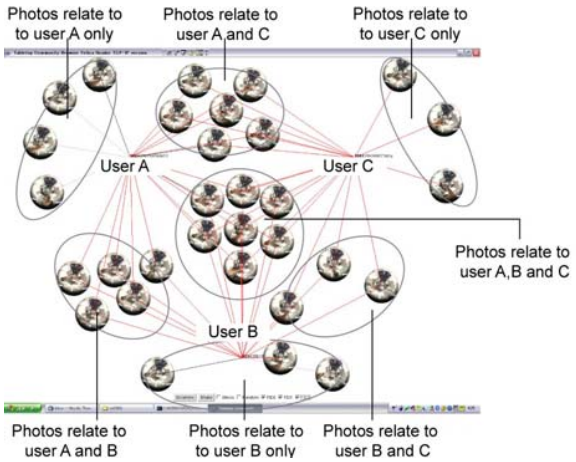

Figure 11 Snapshot of image network associated to users

Figure 11 illustrates three card readers on the table for three users. Unlike the static screenshot, this network of images reacts to a change of the network as well as users' interaction through a mouse pointer as if it were living. Images that include all three users move to the center of the screen. Images of one users move towards the edges of the screen. This motion is created by calculation based on basic physical simulation. We applied two physical simulation models onto the screen. One is repulsion force among each image. The other one is spring force between the user node and the image node.

4.4 Information Kiosk

When a single participant puts an RFID card on a card reader, that participant can log in directly to the POLYPHONET. If two or three participants put RFID cards together, they can see social networks among them as shown in Figure 12. Then the social-tie "We meet and see social networks together" is added automatically. These actions in the real word mean additions of know-edges to the social network.

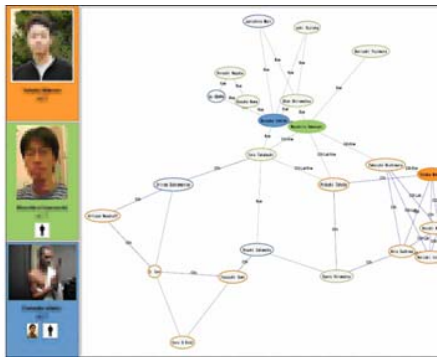

Figure 12 Shared social network appears at information kiosk

5. CONCLUSIONS

We explained especially onsite casual interfaces of the UbiCoAssist. Physical interaction using papers, digital pen, cell phones and information kiosks should be examined further to designing roles targeting user categories. Other future work is to integrate other systems such as wearable systems, mobile robots and web services.

6. ACKNOWLEDGMENTS

Information kiosk and PHOLYPHONET have been partially supported by New Energy and Industrial Technology Development Organization (NEDO) as the project ID of 04A11502a.

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Impacts of analogue and digital documents on collaborative episodes in professional education and training

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EXPRESSION OF INTEREST

The subject matter is very close to our recent and current interests and there is one of the very few events explicitly dealing with this theme. We contributed to the CSCW 2002 workshop on displays [8]; that reflected an earlier strand of work which has been greatly extended in this most recent paper.

1. EPISODES

We report on an international collaborative study into the implications of analogue and digital documents within professional education and training. Although the co-authors include very early adopters in the application of digital information technology in professional learning, the origins of the paper grew out of discussions between the co-authors on why analogue media continued to play such a significant role in such learning. Of particular interest were the collaborative processes which represent such a significant dimension of professional learning.

Table 1: The episodes

	Medium		Artefact
#1	Poster H	S	Dialogue Sheets
#2	Cards	UK	Learning game: Jigsaw
#3	Cards	UK	Index cards: Collection
#4	Poster V	UK	Knowledge Promenade
#5	Poster H	UK	Office design: team drawing
#6	Art Paper	UK	Sketchbook portfolios
#7	Magnets V	UK	Domain mapping - jigsaw
#8	Poster V	USA	Proposed Investment Poster
#9	Cards	USA	Quick Idea Capture
#10	Art Paper	USA	Collective Learning Journal
#11	Cards	UK	Executive Card/Board Game
#12	Art Paper	IE	Requirements Specification

H= Horizontal; V=Vertical

We constructed 12 learning episodes in different international locations, with different types of professional, which explicitly set out to apply innovative or unusual analogue learning methods, typically alongside continuing heavy use of parallel digital methods. The first phase of the research is now complete and has led to reviewing the collective findings from the 12 activities. We have taken a broad view of "paper" to include not simply A4 80gsm sheets, but also card, posters and magnets. The 12 episodes are summarised in Table 1, and we use the shorthand for them of #1-#12 throughout this paper. Most typically the episodes involve practicing managers in their 30's to 50's. Some of the episodes have been repeated.

The co-authors diverse backgrounds include theatre, science, accountancy, IT, graphic design and poetry. There is no doubt that in aggregate the authors were in search of educational innovation and willing and able to make personal investments and take some personal risks in order to bring out such innovation. There was also a context where the collaboration between the authors has helped accelerate the learnings about the innovations.

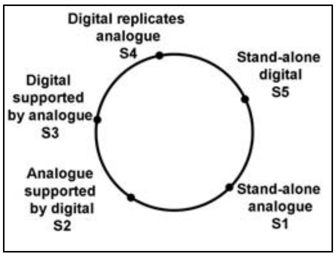

Figure 1: Five states

As we reviewed the episodes, we evolved a broad categorisation which simplifies the deployment of analogue and digital artefacts into five "states" set out in table 2. These states are rarely wholly clear-cut, but do offer useful reference points. Logically, S4 is a sub-set of S5, but since it represents a specific goal of some who seek to eliminate analogue media, we felt is it worth being separated out. The idea of a hierarchy of states, leading upwards to S4 and S5, could be seen as consistent with a "techno-romantic" [3] view of digital technology, but it is not assumed here that any one state provides "better" functionality than another.

Half of the episodes were S2 (#1, #2, #4, #5, #7, #11), the remaining S1. The purposes of the collaborations were respectively Design (#5, #8, #12); Jigsaw: developing a larger picture from individually produced components (#1, #3, #7, #9); Critiquing the work of others (#6, #10); and High-engagement simulation/game (#2, #4, #11).

2. COLLABORATION IN LEARNING

There are many different roles for collaboration in learning. In the specific context of face-to-face classes for professional learners, the central theories considered here relate to conversation and dialogue. Key authors include: [1] [2] [4] [14] [11] [18] [23]. Seven types of collaborative activity are identified by [15], drawing on [10] and [16]:

Explicit communication; Implicit communication; Coordination of action; Planning activities; Monitoring; Help; Protection

In terms of collaborative learning, these seven have some bias towards the traditional face-to-face team which collaborates over a case study or problem solving situation. Our episodes involved very little of such traditional learning collaboration, and in this context we would certainly wish to add the following four activities:

Reflection, Integration of individual knowledge into a larger whole, Constructive Critique; Unfreezing/playfulness

3. LEARNING DESIGN

Although originally designed for informal adult learning [20], we have found the concepts of Episodes and Projects particularly useful in conceptualising collaborative learning. When confronted with the design of collaborative learning episodes, it is not sufficient to examine the contribution of digital and analogue learning artefacts. After all, at the most fundamental level of S1, it is possible to create learning episodes which solely rely on oral approaches, making the most minimal demands on physical resources (most typically just physical space). This minimalist approach can be supplemented with very basic educational artefacts such as presentation technology, readings and case studies. Centrally, our concern has been with the deployment of artefacts which are integral components of learning episodes designed to promote conversation and dialogue.

One of the most profound approaches to collaborative learning is jigsaw learning [9], [10], [19], and this has strongly influenced the design of four of our episodes. This involves each team member only having one component of the larger picture, and it being necessary to work collaboratively with a larger group for all members then to develop that bigger picture together. Jigsaw, albeit artificially, creates a strong interdependence between learners, and works well with a whole range of analogue media.

4. ROLES OF ARTEFACTS IN COLLABORATIVE LEARNING

Examples of those who have studied artifacts in professional learning include [5] and [7]. More conceptually, [21] developed the concepts of the transitional object and transitional phenomena as part of infant learning. His initial focus was on physical artefacts (eg: a cot blanket or teddy bear) that epitomised for a child the sense of security provided by its mother and, being portable, enabled the child to feel safe while tentatively exploring its wider environment. However, this was evolved beyond tangible objects to include also beliefs and mental images. There is little doubt that many of the sketchbooks (#6) did take on this characteristic of a transitional object.

Both the overall learning episode design, and the specific use of artefacts within that episode can facilitate or, more actively, provide an accelerated stimulus to learning. We conceive of learning as ultimately only individual, but by working in groups collaboratively, that learning may be enhanced or quite different in nature from a purely individually-oriented stimulus.

5. DISCUSSION OF THE EPISODES

5.1 OVERALL

Looking across all twelve episodes, there are three types of collaborative situation. In the first there is a facilitator working with a single "large" group (in excess of 10 participants). In the second, a large group is divided into small groups which then work largely independently. In the third, there is an interplay involving working collaboratively both in small groups and in the larger group.

Overall, the work has reconfirmed the work of inter alia [6] on why distinct affordances of analogue documents imply their continued significance. But we have also studied the subtle interactions, interplay and interdependence between analogue and digital documents and devices in the context of collaborative professional learning.

5.2 BENEFITS OF DIGITAL

It is clear that the S5 stand-alone digital technologies offer collaborative learning capabilities that extend beyond what is possible with the purely analogue S1. Our own experiences over more than a decade have particularly involved group decision support systems and classroom response systems. There is now additionally great collaborative potential from mobile technologies [12] as well as physical objects connectable physically or logically to digital devices [13]. But it is also the case, which we argue below, that S1 states themselves have distinctive and beneficial features for collaboration.

5.3 EXPECTATIONS

We did not find significant differences between nations in attitudes towards analogue or digital technology. One concern in many of the episodes, which did not materialize on any scale, was whether the participants see it as regression to primary school, as being too "playful". We did perhaps surprisingly find that some of the most highly IT literate participants were the most eager to exploit analogue approaches, and three factors appeared to influence this. The first is that their daily routines are dominated by low-level digital technologies, so they perceive use of technology as an essential chore. Secondly there is actually a novelty factor in using an unknown analogue learning artefact (#1, #6, #7, #11, #12). Thirdly, analogue artefacts are perceived of as ephemeral and disposable, hence less public, unlike everyday electronic data which is stored and searchable for many years (#1, #5, #10, #11).

5.4 PHYSICALITY AND PLAGIARISM

Some major drivers of inauthenticity (en route to plagiarism) are the technical ease of cut and paste, and the universal electronic search for materials which appear plausible. Both have fuelled the cut and paste mentality. However, in relation to a physical (as opposed to an electronic) portfolio (#6) there turned out to be a distinct advantage of writing up notes for a course in a bound paper handbook using handwriting (not word processed printouts stuck in), in that the facilitator can actually see that the work was written in sequence by a single individual.

5.5 RISK & PHYSICAL ENVIRONMENT

Particular in the episodes with a strong element taking place outside the classroom or learning centre (#3, #6, #9) there were significant issues relating to security of the input devices, as well as the extent to which users were prevented from using digital technology by legal or social norms. On a plane journey there are increasingly significant periods when use of electronic devices is forbidden or difficult. We were provided (#6) with the example of using an analogue sketchbook while in a line for security checks. One other participant also listed the locales they had made analogue inputs, including “buses, metro, trains, tram, bus stops, cafes, lines, speeches, museums, stand-up conversations and a salt mine” and noted their reluctance to be seen to be using any digital technology on public transport in the inner city.

5.6 SPEED AND CONVENIENCE

It was very noticeable that several of the episodes involved substantial initial advanced preparation time, in order to provide a quite short learning experience, perhaps 20 minutes or less (#2, #9, #11). Most crucially however, the analogue experience involved minimal set up time on the day. In other cases, the analogue approach was very much more flexible. The precursor of the dialogue sheet (#1), the world café [2] simply uses blank paper tablecloths as the key analogue collaborative artefact.

5.7 STIMULUS TO CONVERSATION AND DIALOGUE

Episodes #1, #2, #4, #5, #10, #11, #12 were all designed to stimulate very substantial if not highly animated oral dialogue, and overall certainly did achieve this.

5.8 NOTATION

As we studied an increasingly large number of episodes, we began to develop an interest in how to notate them. One that we have trialled is a variant on a music stave, with the five states (or more usefully 4 if the special case of S4 is excluded) running horizontally and then symbols being used to represent the intensity and duration of events. We have also explored the use of the circle as in Figure 1 as a basis for representing the unfolding dynamics. Although our initial interest was in recording for research purposes, we see possibilities of using such notation in the development of academics and trainers in the choreography of collaborative learning activities.

5.9 COGNATE WORK

We have been particularly interested in the recent work of Angela Rogers [17]. Rogers’ research is into the use of collaborative drawing as a conversational tool, including with strangers. She is primarily working with analogue drawing tools, but also works with graphic tablet inputs.

6. STATES

We have not during our 12 episodes sought to gain particular insight into S3 or S5 deployment of digital technologies. But we have been interested in S4. Although we can readily conceive of digital artefacts replicating some the affordances of the analogue artefacts deployed in the learning episodes above, in most cases such replication would either be quite difficult, or uneconomic. Indeed one key issue arising from this paper is that there is still enormous potential to exploit low cost State 1 analogue artefacts such as magnets, cards and posters. Additionally, one of the key roles of digital technology in the episodes above, turns out to act as relatively invisible support to (rather than replacement of) analogue artefacts as exemplified in the S2 cases. In episodes #1, #2, #4 and #11 in particular, the ability digitally to originate analogue material with very high production values were vital to the credibility of the exercise with executive audiences (see Figure 2). Finally, major historic collaborative weaknesses of analogue documents (reproducibility and communication) have now been readily overcome with ubiquitous availability of fast scanners and digital cameras.

Figure 2: Dialogue Sheet (#1)

So we conclude that at the moment using a varied combination of S5, where the distinctive features of digital technology are drawn on, together with flexible and improvised use of S1, S2 and S3, is likely to be more pedagogically valid and economic than a search simply to replace S1 with S4.

7. TECHNOLOGY

Visualisers (document cameras) should urgently replace overhead projectors as they are substantially more effective at dealing with a wider variety of analogue materials, including 3D resources. Wall space needs to be much more seen as an educational resource both within classrooms and more generally. As a result of this study, we have collectively discovered a huge range of analogue resources available at modest cost, primarily aimed at primary school teachers. There have also been significant reductions in the price of analogue tools that formerly were limited to specialists eg laminators and binding machines. There have also been technological innovations such as the Xyron 510 cold laminator.

In general academics and corporate trainers are often treated very little differently in terms of their information processing needs than a clerk in an insurance company. They have a standard set of office software tools. They have printing facilities that are good enough for insurance clerks. The catalogues from which they can order paper etc supplies are usually those aimed at any type of office, as opposed to the catalogues for primary and secondary schools. Learning leaders needs a much wider range of software than an insurance clerk, eg mind-mapping, brainstorming, “script writing”/lesson planning, personal time management, presentations way beyond PowerPoint.

Hardware, especially networked printing and scanning needs to take account of sophisticated analogue needs eg the ability to deal with a full range of materials and sizes. Internal print units may need to provide specialist facilities such as poster printing up to at least A0 size; large size has been crucial for visibility in collaborative small and large groups.

One of the most useful technologies which has recently emerged and which may accelerate moves towards S4 is the UMPC (Ultra Mobile PC). Though currently significantly overpriced, this compact but useful format, makes excellent use of the Tablet PC interface. It appears to offer a potential offered neither by larger laptops, due to portability, or the larger PDA-style mobile phones, due to screen size. We have also been impressed with products such as Tidebreak Teamspot [22] which enables a team to meet and collaborate quickly electronically in a suitably equipped meeting room.

8. CONCLUSION

There has already been observed in some cases the beginnings of a reaction against digital documents and devices in professional learning. But the much more significant element, in our view, which is emerging relates to academics and trainers who are now much more versatile in working across both digital and analogue documents. This has particular implications for the personal development of academics and trainers. Some of the materials developed to support the reskilling of these groups in the above episodes have been used in such development events.

There is also a need for greater awareness by those funding professional learning, to support investment in methods involving both types of documents, not only in digital media which have dominated many recent large-scale learning investment decisions. Yet there seems to be little voice for investment in analogue technologies relative to digital. The continuing innovation in analogue media is rarely highlighted, nor is the scope for applying analogue tools developed for e.g. handicrafts and primary schools, to higher and professional education.

There is above all a need to support research into the emerging interplays between the analogue and the digital in the context of collaborative learning, with less emphasis being placed on S5 and S4 per se, and more on the S2 and S3 states.

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Study for Bridging between Paper and Digital Representations in the Flight Deck

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1. INTRODUCTION

Flight deck is a pilots' office which has special features [10]. For example, flight deck work is high-stakes and high-tempo activity. The flight deck is more isolated from its surroundings than its terrestrial counterparts. It is a small space and operators cannot move about. This means that display space is very limited. Because it moves, every extra gram of weight carried in an airplane must be paid for in extra fuel consumption. Consequently there are economic pressures to eliminate or reduce the amount of paper carried in the flight deck [1, 3] and concerns about the consequences of its elimination or reduction have been voiced [12].

Commercial aviation is currently at a crossroads with respect to the use of paper in the flight deck. Emerging computer-based technologies promise to provide flight crews with additional support. Among the proposed systems are devices that go by the name, "Electronic Flight Bag" (EFB). The name suggests computer-based versions of paper document collections. There is no doubt that EFBs, and other similar systems will play an important role in flight decks of the future. Manufacturers and operators are already exploring the space of possibilities for this sort of technology. However, in the design process of the EFBs, few research findings based on ethnographic observation describing how pilots use paper in flight operations have been reported. We believe that a careful documentation of pilots' actual paper-use practices in the flight deck should inform decisions about what should remain on paper, and what could be migrated to digital devices.

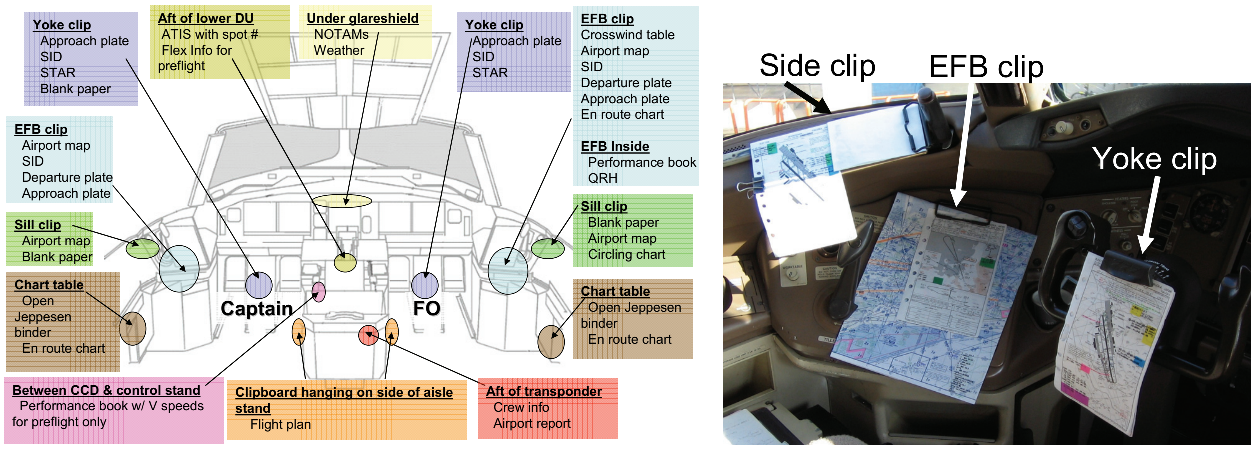
In this paper, our ethnographic study on the work in the flight deck, which is held in Japan and New Zealand in 2005, reveals several significant characteristics of the routine interactions among crews with paperwork. We suggest that these practices have a range of implications for the design of computer-based media to support pilots as they work in collaboration with the elements of the social and material world [5, 6].

2. PAPER USE IN THE FLIGHT DECK

2.1 Layout of Papers in the Flight Deck

Pilots brought several pages of paper into the flight deck. These are provided by company dispatch and are carried on board by the pilots, or are given to the pilots by maintenance personnel prior to pushback. They also carry their own heavy flight bags on board. Each flight bag contains aircraft operating manuals, airway route manuals (including aeronautical charts such as route maps, approach and departure charts), and Quick Reference Handbooks (QRH) which contains performance information and a set of procedures to follow in case of non-normal condition. These papers are distributed throughout the flight deck during the flight.

Figure 1a) illustrates the observed locations of various papers in a Boeing 777 during a short flight. In the flight deck, the captain sits in the left seat and the first officer sits in the right seat, and they have redundant arrangement of information source in both sides. This redundancy supports coordinated interpretation and action by the pilots. Basically, pilots place documents from their flight bags in front of them and beside them by the windows (See Figure 1 b)). On the other hand, papers from company dispatch (such as 'crew information', 'dispatch release', 'passenger list', 'airport information', 'special load', and 'NOTAM' (Notice to Airman)) are located near the center console in between pilots, so



a) Spatial layout of papers in the flight deck during the flight **b) Paper setup at the captain's seat in approach-taxi phase**

Figure 1: Spatial layout of papers in the flight deck.

that these can be easily accessed from both of the pilots.

In the flight deck, there is a small printer, called the ACARS (Aeronautical Communication Addressing and Reporting System) printer, located in the center console. ACARS is a digital data link system that allows airline flight operations departments to communicate with the various aircraft in flight. During the course of a flight the crew requests and receives messages and prints them out on small slips of paper. On a routine one hour flight, pilots print from 6 to 15 messages depending on how quickly the information is expected to change. The ACARS brings many kinds of information into the flight deck. Since there is only one screen for the display of information received via ACARS, the printer acts as a sort of display multiplier by making it possible to print and display many ATIS (Airport Terminal Information Service) messages simultaneously.

The latest printout is typically placed in a location that easy to access by both pilots, for example, between the pilots, on the center console, in front of the thrust levers, or impaled on a switch on the instrument panel (in the 737), depending on the airline and airplane type. Pilots handwrite the arrival gate number on the arrival airport information ACARS printout. When pilots replace an ACARS printout with an updated version, the old one is archived by moving it aft on the aisle stand, or a small pocket on the side console to archive them.

2.2 Interactions over the Papers

Throughout the flight, paper plays important roles in crew coordination, message confirmation, note-taking, and information affordance.

2.2.1 Reflection of the Social Organization

Each flight begins in the operations office. Here pilots receive and review the dispatch papers for the flight. In one Japanese airline, the dispatch paperwork is presented to the two pilots by a dispatcher who has compiled and annotated the documents. The flight crew stand on one side of a table and the dispatcher stands on the opposite side facing the crew. The paperwork is placed on the table in front of the captain oriented so it is right side up for him, and upside down for the dispatcher. The crew then discusses the papers with the dispatcher. This discussion is enhanced by a sequence of pages (graphical depiction of en route weather, for example) presented on a computer display located at the end of the table. The dispatcher uses talk, gesture, and previously-made annotations and highlighting to direct the captain's attention to important elements in the paper documents. The appropriate application of annotation provides the dispatcher a way to demonstrate professional competence. The captain signs a copy of the dispatch paperwork to confirm his approval of the dispatch work. The other dispatch documents that the crew must bring to the aircraft are collected by the first officer. The tangible nature of paper documents allows the crew to enact micro-rituals that express the social organization of the crew while handling documents. Paper also plays a role in the establishment of identity of the user.

2.2.2 Cross-Reference of Paper Work

Pilots must confirm the accuracy of certain types of information through multiple data sources and representations. For example, on takeoff, pilots must know the speed at which it is no longer possible to stop the airplane on the runway (V1), the speed at which the nose wheel should be lifted off the runway (Vr) and the speed at which the main landing gear should leave the runway (V2). Once the basic performance data have been entered, the flight management computer (FMC) can and does compute these V-speeds. However, the computed speeds are not immediately made active for the other systems (displays, for example) that use them in flight. The pilots are required by the FMC interface design to review and select these speeds one at a time. This design reflects a tradeoff between speed of execution and the depth of cognitive processing for the pilots. Many airlines require their pilots to interact even more closely with these critical speeds. In one airline in Japan, pilots check V-speeds (takeoff speeds) by comparing three sources of information. Pilots have V-speeds computed by the FMC and displayed on the CDU, V-speeds computed by company dispatch printed out via ACARS, and V-speeds as they appear in the flight operations manual.

Figure 1 b) is an example of paper distribution at the captain's seat during an approach. These documents were arranged like this prior to commencing the approach. Pilots are required to plan and prepare the access to information in advance so that they can stay 'ahead of the airplane' [7] as its position and operational context change. An en route chart is on the EFB clip at the captain's lower left. The chart for the approach to be flown is positioned on top of the en route chart. The destination airport map is on the yoke clip, and the taxiway map (with gate numbers) and a notepad are placed on a side clip below the left window. A Jeppesen binder opened to a page containing hand-written annotations is on the chart table to the pilot's left. During an approach, pilots must imagine and plan the path of the airplane from many miles out down to the runway, and then to the arrival gate. Pilots scan across these multiscale representations in order to imagine the location of their aircraft during this high-workload phase of flight. As the aircraft draws near to the airport, the crew performs the approach briefing. Both pilots refer to the approach chart while they review and confirm the runway number, approach course, glide path, navigation radio frequencies, missed approach procedures, landing visibility requirements and so forth.

2.2.3 Reading vs. Listening to the Speech

Many Japanese find written English easier to understand than spoken English.

When two pilots do a procedure together, the pilot monitoring (PM) [1] reads the procedure while the pilot flying (PF) executes the actions described. Some airplanes are equipped with an electronic checklist (ECL), which is presented on a display in the center of the flight deck. The checklist steps are presented in English and they are read in English by the Japanese crews. We observed many cases in revenue flight and in the simulator in which both pilots read the ECL together. When Japanese pilots used a paper checklist, the pilot reading the checklist leaned toward the other pilot and placed the paper checklist in the line of sight of the other pilot. Both of these practices make the written representation available in addition to the spoken representation (See Figure 2). Among other effects, this practice provides the second pilot with a

[1] The flight crew is composed of a Captain and a First Officer in two crew airplanes. Either pilot may assume the role of pilot flying (PF) or pilot monitoring (PM). The PF manipulates the flight control and flies the aircraft. The PM supports and monitors the PF.

representation of the procedure that is less foreign than the spoken representation. This pattern of behavior is also observed in mono-lingual English flight decks where it seems to facilitate the establishment of common-ground understandings [2].

Figure 2: Written English is easier to understand than spoken English.

2.2.4 Document Personalization

Many pilots annotate their own charts and flight manuals using highlighter pens and colorful sticky notes. Highlights draw pilots' attention to the specific numbers and letters on charts, and also help pilots to find particular charts in the Jeppesen binder which contains hundreds of similar looking pages. Colorful sticky notes are used for temporary messages and/or very important messages which should catch pilot's eyes very easily (See Figure 1 b)).

While this practice is present in all of the pilot populations we have observed so far, it seems to be especially important for pilots who are not native speakers of English. The charts are composed of graphics and numbers and text, and the language is English.

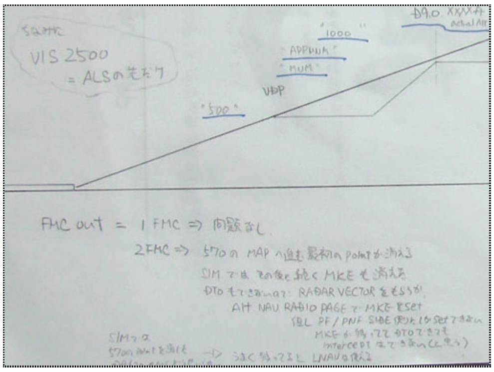


Figure 3: Document customization using color and pilot's native language.

Figure 3 is a heavily annotated hand-drawn representation of a complex instrument approach that was prepared by a young Japanese first officer to be reviewed just prior to flying the approach. Japanese pilots, especially young first officers, often review the flights of the day after work. They bring all paperwork created in the flight back home and run through the events of the day.

The document shown in Figure 3 is a microcosm of the language ecology of the Japanese flight deck. The annotations are a complex mix of English and the pilot's native language. Character strings that appear in English on navigation charts or flight deck displays while flying this approach are rendered in English. Required callouts and expected communications with ATC that must be produced in English while flying the approach also appear in English on this document. Commentaries, interpretations, techniques, and discussions of tricks and traps are represented in Japanese.

3. DISCUSSIONS

As is the case for other work settings [11], pilots use paperwork throughout the working day and beyond. The special characteristics of the flight deck also make it different from most other settings. The complex, high-stakes, high-tempo nature of the pilots' work requires careful planning of information access and the management of attention.

According to our analysis, we argue that paper should not be eliminated simply because of its weight and 'oldness'. There is no doubt that the electronic flight bags (EFBs) and other computer-based tools can enhance the efficiency of certain flight deck procedures. But paper is not just an independent resource that somehow has continued to survive despite attempts to remove it, but rather is an integral feature of using new technologies [8]. It may be possible to eliminate some classes of paper from the commercial airline flight deck, but it is probably neither possible nor desirable to attempt to eliminate all paper from the flight deck.

3.1 Requirements for New Technologies

When we design new computer-based tools (such as EFBs), we need to reflect on how technological innovation might find a place in the flight deck. We also need to keep in mind that the target of design activity should be the cognitive functions performed in the flight deck. This is because properly designed interfaces to digital tools can provide enhanced functionality for information access, the management of attention, control of depth of processing and the negotiation of shared understandings. According to our observation results, we suggest the following requirements for the design of computer-based technologies.

Shared understandings between pilots are essential to safe flight. This means that whatever the representations are, they must not only be available to both pilots, but available to the pilots jointly in interaction with one another. For example, when pilots do a paper-based checklist or a briefing, a pilot who reads aloud the document moves his hand toward his co-pilot so that they can share the document. During the takeoff briefing, pilots use multiple representations to coordinate with one another; both pilots see their own navigation displays, the CDU displays, airport maps, and departure charts on each side. Since displays and all paper charts are located near each other, a pilot can see artifacts which his co-pilot is looking at without changing the orientation of his face. Other multiple representations also support constructing common ground understandings between pilots in this context, such as speech, facial expression and eye contact. So the computer displays should be located where two pilots easily achieve common ground understandings over them.

Paper's flexible nature also needs be taken into account. That is, computer-based media should have multiscale and flexible interface. This is obvious from the practice which pilots display many ACARS printouts simultaneously. While engaging in a briefing preceding a high-workload maneuver such as an approach, pilots want to locate themselves bodily in an environment that is rich in tangible representations of the parameters relevant to upcoming events. Currently they do this by reading across many disparate documents and displays. They spread out different kind of maps around them and simulate the path of the airplane from many miles out down to the runway, and then to the arrival gate. Although the limitation of display space in the flight deck makes difficult to achieve what exactly pilots do with paper documents (access to several scales almost simultaneously) with current computer-based technologies, this factor should seriously considered.

Pilots annotate paper documents both in side of and out side of the flight deck. These annotations enhance pilots' cognitive functions. Taking notes during the radio communication assures a pilot to maintain the accuracy of the exchanging information. Writing down the captain's flight strategies during the flight develops young pilots' expertise. Especially for non-native English speaking pilots, annotations in their native language facilitate their professional understandings. The personal document creation at home increases the pilots' depth of processing of the information on the document, not only controls the allocation of attention to the document. So, direct manipulation and document personalization functions are required for the new digital media interface.

3.2 Challenges to New Technologies

There are also challenges on transfer of technologies.

Time consuming data entry to the FMC actually facilitates the depth of cognitive processing of pilots. Introduction of 'fly-by-wire system' which is highly computer-controlled flight deck decreased pilots' load (and eliminated a flight engineer) and increased safety. They, however, are decreasing pilots' depth of processing at the same time. One Japanese senior captain said to us, "New airplanes are very safe but not so fun to fly. We don't know who operates who; the airplane operates us or we operate the airplane? I am also concerned about the aviation expertise level of young pilots." Pilots need to understand deeply about the airplane's behavior in any flight contexts. Too much automation, however, makes pilots stay away from getting involved in deep tasks. So, we think that simply automating the data entry system should be avoided.

Another challenge is how digital media might participate in the establishment and maintenance of social relations [9] and personal identity as paper does. The way of handling paper between the captain and the first officer, the orientation of dispatch documents on a table during the dispatch briefing (right side up for the captain, and upside down for a dispatcher) obviously establishes and maintains their social organizations. So the challenge for design of the flight decks of the future will be to imagine not just tasks, but whole activity systems that integrate enhanced functionality with practices that are meaningful to pilots and that satisfy their social as well as their information processing needs.

3.3 Bridging between Paper and Digital Representations

We discussed the requirements and challenges for the introduction of computer-based new technologies in the flight deck. Now we want to think about how to take advantage of features of paper and computer-based media respectively, and how to integrate these media to satisfy social and technical needs of pilots in their work settings. By way of example, digital pen technology [4] has a possibility to provide useful functions for blurring the boundary between paper and digital representations.

Let us close this paper by providing a possible future scenario of dispatch paperwork as an example.

The dispatch documents have been already annotated and highlighted by a dispatcher with a digital pen. At the dispatch briefing, pilots and the dispatcher review the material in the operations office and add some annotation over discussion. The captain officially receives the dispatch papers, and the same data is moved in digital form to the flight deck. During the CDU set, pilots search data on digital document by annotation content. At the takeoff briefing, paper documents are used to assure the data accuracy. The computation of the fuel amount at each waypoint is updated through a link between airplane's GPS and other systems.

This idea could be applied to paper charts and manuals: easy to annotate by digital pens, easy to search specific information by digitized annotation contents and to browse zoomable figures with personal annotations on a computer display. A system like this would keep pilots involved, but would also eliminate some peripheral works of them.

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iJITinLab: Information Handling Environment Enabling Integration of Paper and Electronic Documents

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ABSTRACT
An information handling environment called “iJITinLab” is discussed. This environment enables users to integrate paper and electronic document information in both PC-based and paper-based work in ordinary offices. iJITinLab consists of two components. One is a desktop environment called “iJITinOffice.” Annotated information written on the printout can be accessible via the original electronic file, and can be shared and retrieved. The other is a digital notebook system called “iJITNote.” By cooperating with iJITinOffice, iJITNote provides notebook contents archiving function with preserving traditional pen and paper interface. iJITinLab prototype system was implemented using Anoto technology and now in trial operation in our lab.

Categories and Subject Descriptors
H5.2 [Information interfaces and presentation]: User Interfaces. - Graphical user interfaces.

General Terms
Documentation, Design, Human Factors.

Keywords
Annotation, handwriting, document management, digital pen.

1. INTRODUCTION

In current offices, the number of the electronic documents is increasing, because office workers write documents using PC and download documents from the internet. For example, most of papers and technical reports which researchers write are electronic files. On the other hand, the paper consumption in offices is increasing[4]. It is because paper is convenient for browsing documents, and for writing down the ideas in brain-storming. Actually, meeting materials which are created on PC are distributed as paper documents in many meetings in Japanese offices, and paper notebooks are used for writing down ideas when we stumble on them.

Even in the company cited as a successful case of paperless office in the literature, paper documents are often used in the collaborative task such as design review process in development[4]. That is, paper is more suitable for expressing the ideas during the discussion than an electronic document.

Handwriting on meeting materials or the notebooks is the record of the collaboration process itself, and is regarded as the organizational memory. This kind of knowledge should be crucial management resources for the enterprises. But it is left un-used in the filling cabinet.

Our motivation in this research is to enable us to utilize the information left unused on paper documents by digitizing handwritten annotations, and by linking them to the corresponding electronic documents.

We contribute iJITinLab, an information handling environment which enables users to integrate paper document information with electronic document information. When we annotate printed documents created on PC, handwriting information on the printouts can be accessible via the original electronic file, and can be shared among the persons the printouts were distributed to. When we edit documents by writing or pasting printouts on notebooks, information expressed on the notebooks is fully digitized. That is, we can browse, retrieve, and handle both handwriting and the electronic file printed on the pasted paper. “iJIT” stands for the concept “Information Just-in-Time.” Our prototype is embodiment of this concept [3].

2. iJITinLab ARCHITECTURE

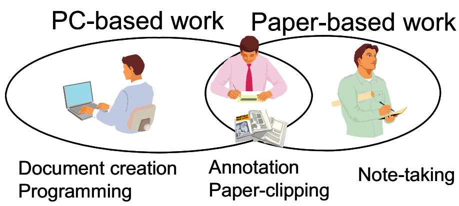


Figure 1. PC-based and Paper-based work in offices

In current offices, both PC-based work and paper-based work are conducted. Document creation on PC, and programming are PC-based work. Note-taking is a typical example of the paper-based work. But these two kinds of work can not be clearly separated. In creating a technical report, for example, we edit the primary version of the document on PC, print it out and annotate the printout version for proofreading, and modify the original version

on PC based on the annotation. On the other hand, in note-taking for recording a experimentation in lab, we write down the abstract of the experimentation and the experimental condition on the notebook, while we paste graphs, or pictures on the notebook by printing out the files stored in PC.
This means that two points of view in integration of paper and electronic documents need to be considered. One is for the PC-based work, that is, handwriting on printouts should be integrated with the original digital documents. The other is for the paper-based work, that is, handwriting on the notebook should be digitized associated with the electronic file printed out to the pasted paper document.

In this paper, a desktop environment which integrates handwritten information on printouts with the original electronic file is proposed for the former point of view. This is called "iJITinOffice." And a digital notebook "iJITNote" which can digitize not only handwriting on the page but also the contents of the paper pasted on the page for the latter. iJITinLab, an information handling environment which enables to integrate paper and electronic documents are to be realized by cooperation of iJITinOffice and iJITNote.

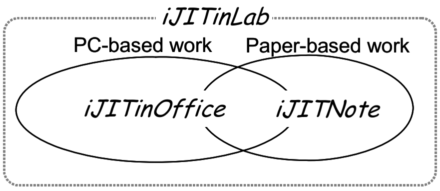


Figure 2. Architecture for digital/paper integration

3. RELATED WORKS

Guimbretière proposed Paper Augmented Digital Document (PADD), which is the digital document that can be manipulated either in the digital world or in the paper world [2]. PADD focuses on how to bring the handwriting information on the paper document back to the digital document. That is, the paper document and the electronic file are just the expression of the digital document, and they should be always synchronized.
In case of document management in PC, it is not always effective that the handwriting information on the paper document is reflected on the digital document automatically. We think paper document and electronic document should be just linked with each other not synchronized for PC desktop environment. Users don't want the electronic file in their PC to be modified forcibly by the handwritten annotation on the printout of the file.

Liao proposed a paper-based command system called "PapierCraft[7]," and Yeh proposed "ButterflyNet[8], " a digital notebook for field biology researchers. Both systems realize a kind of integration of paper document and electronic document. When a user tries to associate a photo with one page of the notebook, he/she needs to write specific command strokes on both pasted paper which the photo is printed and the target paper in "PapierCraft," or he/she needs to capture the photo by the special device and write specific command strokes on the target paper in "ButterflyNet."

In both systems, a user can view the integrated image of the document only on the PC monitor, not on the target paper. But in paper-based work such as note-taking, users want to view the integrated image of the document both on the paper and the display.

4. iJITinOffice DESKTOP ENVIRONMENT

4.1 Integration of paper document & electronic document

A paper document is generated by printing an electronic document on PC. The electronic document could be modified and another paper document could be printed out. In this case, printed contents on each paper document should be different. But two paper documents information is need to be linked because both are printed from the single electronic document. We designed the document information as combination of electronic document and paper document information which corresponds to each paper document.

4.2 Data structure for expressing document information

Based on the consideration above, the data structure of a paper document is designed as shown in Figure 3.
(1) Electronic document on printing
In case the user tries to re-print the paper document or to edit the printed version of the electronic document, the electronic document on printing should be stored.
(2) Paper document metadata
Physical layout information such as n pages in one piece of paper should be necessary for assigning handwritten strokes to the appropriate position on the paper document. Information like when the paper document was printed, or who printed should be kept for retrieving the document.
(3) Annotation information
This should be stored in vector format, not image format.
(4) Annotation Metadata
Information such as who annotated, or when annotated is also useful for retrieving the document.

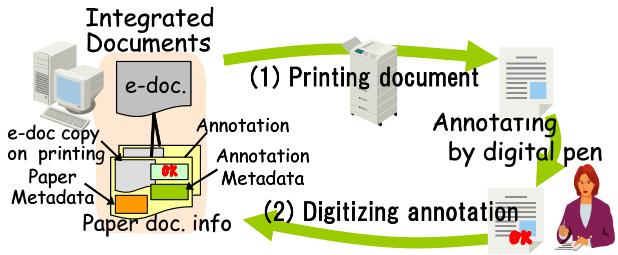


Figure 3. Data Structure of Integrated Documents

4.3 Overall architecture

We have implemented iJITinOffice prototype. For digitizing handwriting and for printing documents in order for annotation to be digitized, Anoto technology [1] is used. This prototype enables us to print paper documents with dotted pattern from any application format file without any special manipulation, to digitize handwriting by digital pen, and to store the digitized handwriting associated with the application file. The prototype is on server-client architecture. Anoto's Paper Lookup Service is running on the server. DBMS for the printed documents with annotations is also running on the server. User accesses the server through the client program for printing, digitizing handwriting, and browsing the documents.

4.4 Client functions

4.4.1 Viewing the linkage between paper and e-docs

Users can view the correspondence between electronic documents and the printed paper documents in the expanded Explorer window (Figure 4 (a)).

4.4.2 Browsing documents

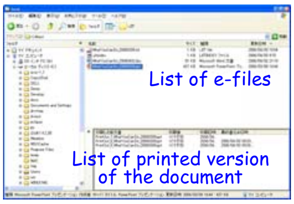
Paper document with annotations can be displayed as a PDF file (Figure 4(b)).

4.4.3 Retrieving documents

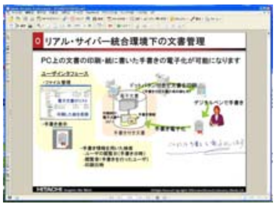
Electronic documents and printed paper documents can be retrieved by the metadata of the paper document and the annotations (Figure 4(c)). This retrieval is regarded based on the human memory about that person's action like writing comments during some meeting.

4.4.4 Sharing documents and security policy

Paper documents with annotation can be shared by creating a special file called "iJIT file," and send the file via e-mail. Users who are provided with the physical paper are allowed to access the paper document information.



(a) Paper, e-doc link browser



(b) Paper image browser

(c) Document retrieval interface

Figure 4. User Interface of iJITinOffice

5. iJITNote: DIGITAL NOTEBOOK

iJITNote is a digital notebook system which are to be used in the paper-based work. In many cases, it is difficult for users to use keyboard and display for input and preview during the paper-based work. Therefore, iJITNote should be a WYSIWYG system. That is, users edit documents only through the notebook, without keyboard and display. All the information expressed on the notebook, such as handwriting, pasted paper, should be previewed on notebooks. At the same time, it should be digitized and displayed on the monitor as it is on the notebook. This is the crucial factor for our proposed concept. On this primary factor, some utility functions are provided. iJITNote has a workflow control function. For example, whether the appropriate person signs for approval in the designated field or not can be verified by referring the time/writer information. It also provide notebook-data-retrieval function which enables users to search the desired page data easily(Figure 5).

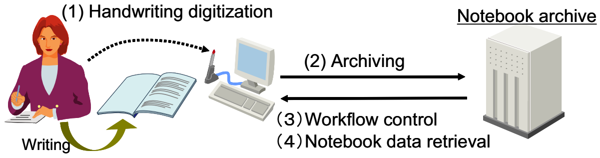


Figure 5. iJITNote function

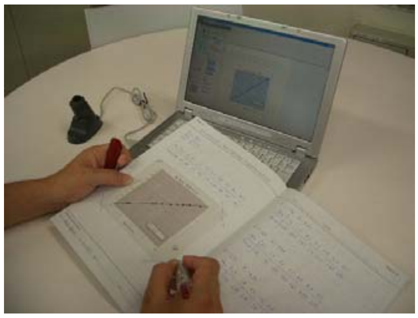


Figure 6. iJITNote: notebook and digitized image

5.1 Paper cut-and-paste on notebook

In order to realize above concept, paper cut-and-paste function is necessary. Printed information such as experimental data and graphs can be electronically linked to the notebook by printing on paper with a unique dot pattern, pasting it to the notebook, and marking the corner of the pasted paper and the background page in one stroke by digital pen(Figure 7).

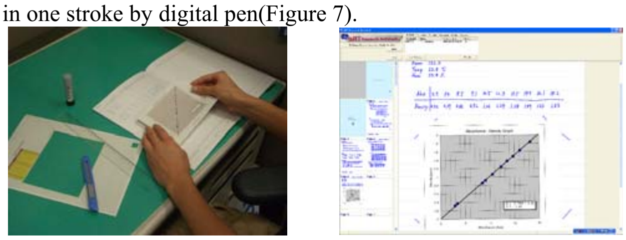


Figure 7. Digitization of cut-and-pasted paper

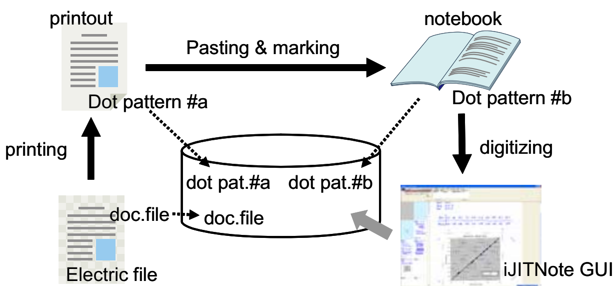


Figure 8. Data management for cut & paste

iJITinOffice system should be used for printing. An electronic file is assigned to specific dot pattern on printing. The dot patterns of the printout and the notebook are linked by pasting the printout on the notebook and marking by digital pen. Then iJITNote system can render the image of the content of the electronic file(Figure 8).

5.2 Information access via pasted paper contents

The image on the pasted paper is superposed on the page image on the PC display. In addition to this, users can retrieve the electronic version of the contents printed on the pasted paper. This can be achieved by tracking back the *electronic file-dot pattern –dot pattern* relation shown in Figure 8. This enables users to acquire the more detail data or the basic data from a piece of printout, such as raw data of an experiment from the result graph(Figure 9).

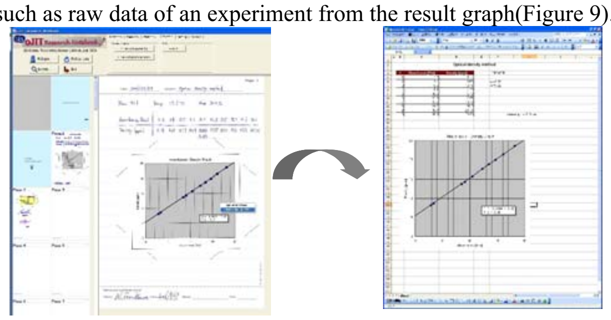


Figure 9. Accessing digital document from the pasted paper

5.3 Prototype implementation

iJITNote system is also implemented based on the Anoto technology for identification of the each page of documents. To realize the cut-and-paste function, both iJITinOffice system and iJITNote system need to refer the same Pattern Lookup Service(PLS) shown in Figure 10.

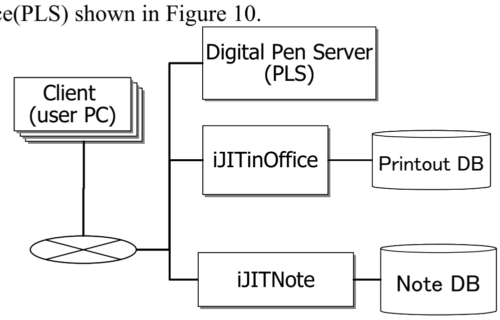


Figure 10. iJITinLab system architecture

iJITinLab prototype was implemented in server-client architecture. All the data users edit are managed and stored in iJITinOffice and iJITNote server and DB.

6. DISCUSSION

This iJITinOffice prototype started the trial operation inside our lab in the spring of 2006. More than 150 users participate in this trial at the moment. Participants' reaction is pretty good, especially in that they can share the paper document information with handwritten annotations without scanning sheets of paper. Some of them often use this prototype for proofreading of technical paper.

The iJITNote prototype also started the trial operation in our lab in the summer of 2006 as the research notebook application. In order for record management of each researcher's work, paper notebook has been used over the years. Comparing with the traditional paper-type notebook, iJITinLab has following merits;

(1) almost the same way of recording their work except using digital pen,

(2) effective information sharing among the research group members by accessing the digital notebook archives,

(3) fast access to the past research record.

7. CONCLUSION AND FUTURE WORK

An information handling environment called iJITinLab is proposed. This environment enables us to integrate paper and electronic document information in both PC-based and paper-based work in ordinary offices. iJITinLab consists of two components. One is a desktop environment called "iJITinOffice." Annotated information written on the printout can be accessible via the original electronic file, and can be shared and retrieved. The other is a digital notebook system called "iJITNote." By cooperating with iJITinOffice, iJITNote provides notebook contents archiving function with preserving traditional pen and paper interface. Currently, iJITinLab system is in trial operation in our laboratory for the research notebook application, and other information sharing purposes. Further analysis of users' behavior would be conducted in our lab.

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Modelling Computer-related Disengagement from Collaboration in Meetings

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ABSTRACT

We have noted that participants in meetings disengage from the conversation when they perform tasks with information resources such as laptop computers or pen and paper. A detailed study of five meetings has revealed a preference among participants to limit their disengagements to ten seconds. The preference is particularly evident when tasks are performed with pen and paper; also evident is the incidence of short disengagements punctuating long tasks. On the basis of these two features, we have outlined a model of paper-based task performance during meetings. We have then looked at how well participants are able to adhere to the model when performing tasks with computers, and find some areas of non-compliance. We discuss what this means for those setting requirements for technologies to be used in meetings.

1. INTRODUCTION

A fundamental concern of HCI has always been to improve the support that people gain directly from computer technologies. This concern motivated the pioneering work of Card, Moran and Newell (Card, Moran et al. 1983), and also that of Suchman (Suchman 1987). Suchman's work is especially relevant to this workshop, for it was instrumental in drawing attention to people's collaboration and the need to support it better. This in turn led to establishing the field of CSCW.

However, the improvement of support has not been the only concern of HCI researchers: another has been to track the emerging technologies of interaction and learn how they can be applied successfully to meeting users' needs. This kind of research can help reduce the risk of serious system failures, which can in turn have disastrous effects on collaboration (U.S.Congress 1988; LAS 1993; Scott, Rundall et al. 2005).

In this paper we discuss the negative impact of the laptop computer, a technology that is being used increasingly in meetings and other collaborative settings. In this instance there has been no lack of attention paid to improving support to users. But a guiding principle of laptop design has, from its inception, been to provide the full capabilities and tools of the desktop computer on an easily portable hardware platform; this is a major source of the laptop's wide appeal. The problem lies in designers' assumptions that these users would be working on their own and interacting solely with their laptops, rather than collaborating and interacting with other people face-to-face.

There is extensive evidence, most of it anecdotal, that laptop use interferes with collaboration during meetings. Our own studies of meetings, while not aimed at describing these effects at the macro level, have provided many examples of them, e.g.:

> difficulty in resuming full participation in a meeting after a long interaction with a laptop;
>
> insistence on conducting a laptop-based web search to answer a question after being told it doesn't matter;
>
> conducting a 'filler' conversation on an irrelevant topic (e.g., child care problems) while using a laptop, thus preventing the main conversation from continuing;
>
> breaking into an ongoing discussion to announce the results of a lengthy web search, now no longer relevant.

Our overall interest lies in these types of interference with collaboration, and in how to reduce them. We believe this is best done by following the lead of HCI pioneers, and seeking to make incremental improvements, in this instance to the support that laptops currently provide in meetings. Our adoption of this approach has led us to focus on two particular research goals. The first is how to measure improvements to meetings support, without which it becomes hard to track progress. The second is how to model the behaviour that is being supported, so as to guide the design of improvements. We report here on recent progress we have made in these two areas.

2. THE STUDIES

The primary focus of our research has been on small workplace meetings of up to a dozen people, and on their use of paper-based and computer-based information resources. We report here on a study conducted during the first half of 2005, in which a number of meetings were videotaped and analysed. This study was strongly influenced by an earlier study of medical consultations, and we therefore start by summarizing that study's results.

2.1 Prior study of medical consultations

In 1998-9 a study was undertaken by Xerox Research Centre, Cambridge UK, of consultations in two primary healthcare centres in London. At that time, computer use was already widespread in primary healthcare, but doctors were still using paper records extensively. The data thus support some interesting comparisons of the two types of resource, which might not be feasible in today's heavily computerized health centres.

In this study we noted that the use of information resources of either kind typically led to a pause in conversation, and that this pause rarely lasted longer than 10 seconds (Newman and Taylor 1999). Further analysis of the video data indicated that this feature of consultations was particularly pronounced when doctors used pen and paper (see Figure 1). When they used computers the effect was less apparent. Also, more than three times as many pauses exceeded 10 seconds when computers were used.

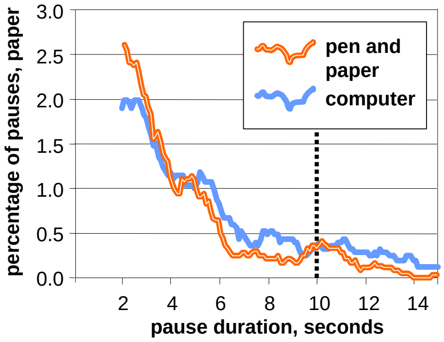

Figure 1. Distribution of pause durations in medical consultations when information resources were used. Moving averages of durations, measured to the nearest 0.1 seconds.

2.2 Recording and analysis of meetings

The study of medical consultations motivated us to collect video recordings of meetings, as a means of understanding the effects of laptop use in these settings. It also suggested a line of study and analysis. We hypothesized that, if there were temporal constraints on the use of documents in two-person conversations, there might be similar constraints in larger meetings. Also, there might again be differences between the effects of using paper and of using computers.

We therefore videotaped eight meetings, 35 to 75 minutes each in duration, in several different organizations. From these we selected five meetings, representing roughly equal participation by paper and computer users overall. These are shown in Table 1.

What interested us in these meetings was not silences, of which there were very few, but *disengagements* from the conversation when participants used paper or computer resources. Staying engaged is an important aspect of face-to-face collaboration: as Goodwin points out, a display of engagement "treats someone who is physically present as also relevantly present, and a locus for joint collaborative activity" (Goodwin 1981). Conversely, displaying disengagement may be regarded as an indication of unavailability for collaboration.

We therefore measured the durations of every detectable display of disengagement in the five meetings, of which there were nearly six hundred. Typically the start of each such display was marked by a turn of attention to an information resource or, if the person was speaking while turning, by an end to their conversational turn. The end of the disengagement display was indicated by turning attention to another attendee, or rejoining the conversation before turning. This method corresponds closely to that suggested by Stiefelhagen, with its reliance on head orientation (Stiefelhagen 2002).

Table 1. Data on the five meetings recorded. The *mins* column shows the videotape duration; *participants*, how many (male and female) took part; *info tools*, the number of users of pen and paper (*P*), laptops (*L*) and Tablet PCs (*T*).

	description	*mins*	*participants*			*info tools*		
			m	***f***	***tot***	***P***	***L***	***T***
A	sales team verbal presentations	58	3	3	6	1	4	1
B	tech support team weekly status	35	4	0	4	4	0	0
C	researchers' information exchange	35	0	3	3	0	3	0
D	student charity monthly status	57	4	3	7	7	0	0
E	software design	56	5	1	6	1	3	0
	Totals	**241**	**16**	**10**	**26**	**13**	**10**	**1**

Figure 2 shows how the frequency of disengagements varied as their duration increased, for both pen-and-paper and computer users. Disengagements by pen-and-paper users form a marked peak at around 9 seconds' duration. Where computers are used there is a less pronounced peak at around 10 seconds.

2.3 Brief reengagements

In our study of medical consultations we had noted doctors' use, during lengthy tasks, of brief reengagements with the patient in the form of *intermediate remarks*. These were usually neutral remarks whose effect was "reset the clock" for the doctor's next pause, thus allowing the current task to proceed in silence for up to another 10 seconds:

Doctor: You're ask, you're saying [*picks up letters*] about the results from what's been happening in the hospital?
Patient: Yes, they discharged me from there.
[*D starts reading letter*]
(6.6 seconds' silence)
D: Right.
(3.2)
D: They really pass the buck don't they?
P: [*laughing*] Heh heh.

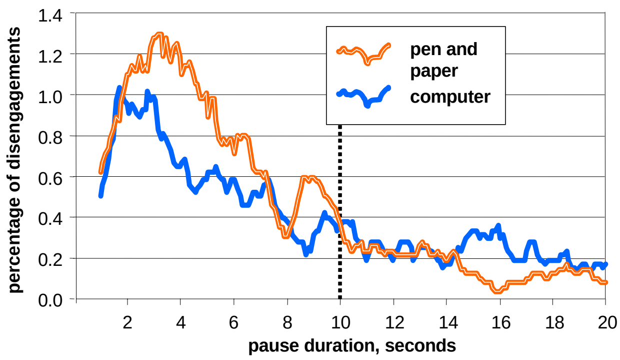

Figure 2. Durations of disengagements during meetings, when tasks are performed with pen and paper and with computers.

(2.7)

D: [*looking up at P*] So this is regarding getting some IVF treatment?

In the meetings we have studied there are also brief reengagement displays, lasting around 2 seconds, that appear to achieve a similar purpose. The disengaged person rarely speaks during the reengagement, instead typically lifting their gaze briefly to the current speaker and then returning to the information resource. Again, the purpose of these displays appears to be linked to performing a lengthy task. During some of these tasks, a whole series of brief reengagements may take place. For example, we have seen ten successive reengagement displays, each of 2 seconds or less, during the performance of a 55-second computer task; none of the intervening disengagements lasted longer than 9 seconds.

3. TASK PERFORMANCE IN MEETINGS

We are beginning to perceive a structure to the outwardly simple action of withdrawing from conversation to interact with an information resource. We are not yet in a position to define this structure with confidence, but we can sketch out its form and suggest how it can inform the design of technologies for collaboration. On this basis, we can propose a *model of task performance in meetings*.

The current version of the model is based on our analyses of tasks involving pen and paper. This is not to say that computer-based tasks conflict with the model, for they are largely in agreement. Rather, we believe the data on pen-and-paper tasks on their own provide strong enough evidence of the features we have described above. A model based on this evidence can, we suggest, support comparisons between task performance with pen-and-paper and with computers.

The main feature of our model is the strong preference, shown whenever pen and paper are used, to keep disengagements to 10 seconds or less. There is clear evidence of this in the data from medical consultations, in which both patients and doctors are seen to act so as to resume suspended conversations at or before the 10-second point. In the meetings data we see a similar preference by those who disengage, but we rarely see other participants take action to draw the person back into the meeting. It is harder, therefore, to demonstrate that they, too, prefer this to happen within 10 seconds. The strongest evidence we have found of this lies in the reduced attention that a participant will receive from others if they remain disengaged beyond the 10-second point. An example of this can be found in (Newman and Smith 2006).

3.1 The Model

The model can be stated in terms of the *tasks* that participants perform with information resources, and of the *disengagements* that accompany these tasks, as follows:

A. Participants who perform tasks normally display disengagement for their full duration, but with some exceptions, see C below;

B. Participants prefer that their own disengagements should last no more than 10 seconds;

C. A participant whose task is tending to exceed 10 seconds will make a brief display of engagement before the 10-second point is reached.

It may be possible to add further features to this model, but we are not yet in a position to do this confidently. We would like, for example, to be able to include in B the preference of others for sub-10-second disengagements, mentioned in section 2.3. We would also like our model to be more precise, in C, about when brief engagement displays are made during longer tasks. Our data suggest that they usually occur within 6 seconds of disengagement during paper-based tasks, and this may account for the minor peaks visible at around this point in Figures 1 and 2.

As it stands, the model offers a basis for analysing variations in how the use of information resources affects face-to-face conversation. Our data suggest that, as a resource, pen and paper enables people to conform quite closely to the model while performing tasks. Users of computers appear to be less successful, however. To understand why this is, and what could be done about it, we have looked at how well our data on computer-based tasks comfirms to the model.

3.2 Modelling computer-based tasks

As we pointed out earlier, computer users showed less evidence than paper users of a preference for disengagements of 10 seconds or less, and in this respect they complied less closely with part B of the model. The clearest evidence of this was the greater proportion of disengagements exceeding the 10-second time-frame: 46% of computer users' disengagements overran, compared with 31% of those using pen and paper. We believe such overruns must be apparent to others present, and that they are likely to hinder collaboration.

We see a second difference in people's compliance with part C of the model, the brief display of engagement before reaching the 10-second point. As yet we have only preliminary data on this, which we show in Figure 3; it shows durations of disengagements that occur during lengthy tasks, and that are followed by a brief reengagement. The chart suggests that these reengagements, too, are sometimes occurring too late when computers are used. The same is true of paper users' brief reengagement displays, but to a much lesser degree. It is also evident that computer users have greater difficulty in reengaging early, i.e., at or before the 6-second point we mention above.

Thus when computers are used there is less conformance with the model of disengagement, in ways that are likely to reduce attention to the meeting, or at the very least to be seen by others as lack of attention. We conclude with some thoughts on what is

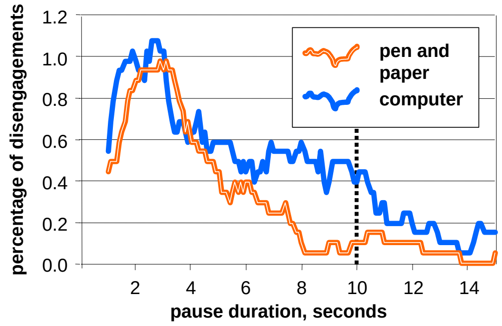

Figure 3. Durations of disengagements during lengthy tasks in meetings, occuring immediately prior to brief reengagements.

required of collaborative tools to ensure better conformance and shorter disengagements.

4. DISCUSSION

We are suggesting here that there is a common time-frame of 10 seconds to which people in meetings orient when they disengage in order to use information resources. In other words, attendees at meetings do not simply prefer to use these resources as quickly as possible; they also prefer to limit each such use to 10 seconds, and they prefer that others do the same.

We are finding that computer use in meetings hinders people from attaining these preferred outcomes, in ways that use of pen and paper does not. Of course, pen and paper cannot match computers for functionality; this is a case of balancing trade-offs. The question we would pose is whether the incidence of lengthy disengagements can be reduced without depriving users of the functonality they need.

In approaching this question ourselves, we kept in view the ways paper is used in meetings, and have found this helpful in two ways. First, paper has been used in meetings for centuries, and its survival for so long suggests that it may be appropriate to use it as a *baseline* for measuring the effectiveness of other technologies. Second, paper has *affordances* that contribute to its versatility, and a better understanding of these affordances may help us improve computer tools (Sellen and Harper 1997).

As a baseline, use of paper achieves a high degree of compliance with our model of task performance. We suggest to designers that a medium-term goal might be to adapt laptop tools so that they reach a similar level of compliance. We would expect this to result in less disruption. An obvious area in which to focus attention is the checking of email. Here it seems likely that filtering messages on the basis of their length could be helpful, for a participant could then choose to display only short messages in his or her inbox, and might be able to examine individual messages in under 10 seconds.

As a design resource, the affordances of laptops may point to ways in which a range of tasks can be performed in units of 10 seconds or less. The challenge here is to provide the user with resources for *designing* the method for performing the task. Instances of this design can be seen in paper use, e.g., when a quick handwritten note is taken by abbreviating its contents. Examples of recent designs that provide such affordances include the *Stuff I've Seen* and *Phlat* systems of Dumais, Cutrell et al. (Dumais, Cutrell et al. 2003; Cutrell, Robbins et al. 2006).

We are exploring technical strategies such as these, and plan to test whether they make a positive difference to users' ability to conform to our model of task performance. Meanwhile we hope to conduct further studies with a view to extending the model and dealing with some of its weaknesses. As mobile devices become increasingly common, we expect they will cause increasing numbers of disengagements from conversations, not just in meetings but in all kinds of social interaction. Consequently research in this area will, we believe, become increasingly important.

5. ACKNOWLEDGMENTS

We wish to thank the participants in the five meetings for agreeing to be videotaped. We are also grateful to Ken Wood and Arnie Lund of Microsoft for their support of this research.

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Bridging Personal and Collaborative Work through Contextual Use of Paper Documents

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ABSTRACT
In this paper, we propose a notion of bridging personal and collaborative work through the use of paper documents which expands the notion of bridging paper and digital document. Based on ethnographic field researches, we found out that paper documents are taken to the collaborative working scene as a cohesive package of work, and they are handled as a symbol of work. By tracking the use of paper documents between the sequence of private and collaborative working situation, we think that we could seamlessly support the large area of working contexts by paper documents.

We also report on an early implementation of our prototype system which seamlessly combine the use of paper and digital document in the personal and collaborative situation. While the user handles digital documents at the personal working situation, he or she could transfer into paper documents in collaborative working situation.

1. INTRODUCTION
People working collaboratively still prefer to use physical paper documents instead of digital documents while we greatly benefit from information technologies[8, 9]. Many researches investigated the advantages of papers in the affordance of paper and paper use[5].

Therefore, it is a natural way to support collaborative work by augmenting physical paper documents with information technology keeping affordance of paper. Former researches like Paper User Interface[4], Paper++ project[5], and Palette[6] seamlessly connects digital information with paper documents by printing computer readable bar-code on the sheets of papers providing applications like a paper-based workflow system, an educational system, or a meeting or presentation support system.

In actual business working situation, a collaborative work is just a part of whole the sequence of works. If we are to divide working styles of the people into personal work and collaborative work, the entire work might be achieved through the continual combination of personal and collaborative works.

While many commercial computing devices and software applications have been developed for supporting personal work, collaborative situation is relatively undeveloped. From the technological point of view, this imbalance between the support for personal and collaborative situation separates the entire sequence of works.

In this paper, we propose a notion of bridging personal and collaborative work through the use of paper documents which expands the notion of bridging paper and digital document. We also report on an early implementation of our prototype system which seamlessly combine the use of paper and digital document in the personal and collaborative situation.

2. BRIDGING PERSONAL AND COLLABORATIVE WORK THROUGH CONTEXTUAL USE OF PAPER DOCUMENTS

2.1 Copier as a Ubiquitous Multi-functional Appliances
As Weiser noted, "The most profound technologies are those that disappear. They weave themselves into the fabric of everyday life until they are indistinguishable from it."[10], to realize this invisible and transparent characteristic of the technologies[7], the technologies have to be aware of the users' situation and context[1]. Context-aware computing is to make information appliances and environments more user-friendly, flexible, and adaptable for the users by capturing, representing, and processing context information (e.g. location, time, and other persons nearby)[2].

Our company, as office equipment producer, offers information appliances, for example, copiers, printers, and digital cameras. Information technology capabilities of these appliances are gradually extending. Taking a copier as an example, it is no more just a copier (e.g. a machine that makes copies of printed or graphic matter). It has ability to connect to the network, and it involves much sophisticated services like a document management system, a user

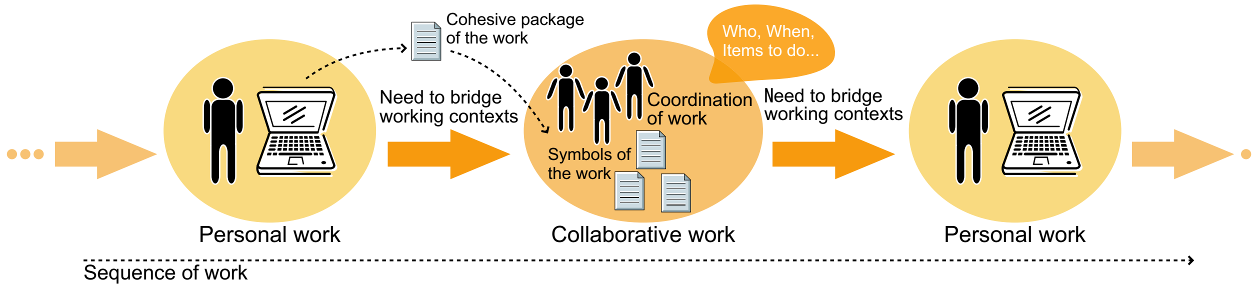

Figure 1: Sequence of personal and collaborative work: Paper documents act as a cohesive package of the work which bridges between personal and collaborative working situations.

logging system, and so on. Integration and combination of various functions of information appliances would develop information services both qualitatively and quantitatively. These multi-functional information appliances might be located everywhere in diverse ways in upcoming ubiquitous computing situation[3]. Increased mobility of the users, devices, and applications suggests that information services should adapt themselves to the activities of the users based on knowledge of both location and the task contexts of the users.

2.2 Role of Paper in Personal and Collaborative Work

Some kind of coordinating activities constantly happens in collaborative work in business situations. In the coordination process, paper documents are remain usable We inquired certain media company which frequently utilize paper documents at regular and informal meeting. This study is based on conventional ethnographic methods, containing ethnographic fieldwork, video recordings of interaction around documents, and collection and analysis of documents used in the interaction. Followings are what we observed from this study.

- Paper documents are printed out as a cohesive package of work for project team. In the case of the media company, crews often prints out a document that lists a broadcast schedule, a document that lists the different stories or items that the days broadcast can be composed of, and some documents related to the stories or items. Those former two types of documents are formalized in the work, in a way that the participants can know what should be done with it.
- Project members handle paper documents as a symbol of work at the meeting. Paper is used as a prop, generally indexing work. In our case, the editor-in-chieffs gaze at the paper or the paper with hand motion often functions as she changes the subject.
- Follow-on work would be arranged for each participant and nonparticipant member as a result of the regular meeting.
- Coordinating work would be described in factors like “Who, When, and Items to do”. In the case of the media company, the participants write down information like “who” is going to do “what items” on the sheet of paper called “Broadcast schedule document”.
- “Who, When, and Items to do” are written into the certain relevant position on the sheet of paper by each project member, however, they just describe the abstract information of the results.
- Each member performs his or her task according to the work arranged, and in that case paper documents used at the meeting are sometimes referred.

Pulling these activities together, paper documents are taken to the collaborative working scene as a cohesive package of work, and then they are handled as a symbol of work, and finally each project member take all the results back to their desk and personal work would be performed according to the results from the meeting(Figure 1).

The result of coordination of work during the collaborative work might be lost before performing the personal work in some situations. Therefore, bridging task context between collaborative work and personal work with the paper documents as the cohesive symbol of work would be a new approach for the seamless connection of paper and digital documents.

3. PROTOTYPE SYSTEM

We implemented a simple prototype system which connects personal work with collaborative work through the paper documents. The hardware system consists of a digital copier equipped with a network service, and a RFID system which makes the physical environment location-aware. The software system consists of a database management system and a schedule(task) management system. By using networked digital copier machine, cross-linking of the personal and collaborative work through paper documents can be seamlessly achieved.

Figure 2 shows the potential user scenario of our prototype system. The user is performing their personal work preparing some materials for the meeting (collaborative work). The user uploads his/her materials to the server through our system, and the materials could be associated with the schedule of the user. When the user walk up to the networked digital copier machine installed at the meeting space, the machine automatically recognizes the nearest user by the location of the RFID tag which the user is wearing, and the system could easily authenticate the particular user. Schedule information of the user are shown on the touch panel display of the digital copier machine, and when the user selects certain schedule information, digital documents which are associated with that schedule could be browsed and the user could printed out for the meeting. After the meeting, the user could scan his/her paper documents referred during the meeting at the user interface of digital copier, and the scanned information are associated with the schedule of that meeting. The documents which are referred during the meeting sometimes have important writings on them that the user could browse them at his/her desk with the context of his/her personal work.

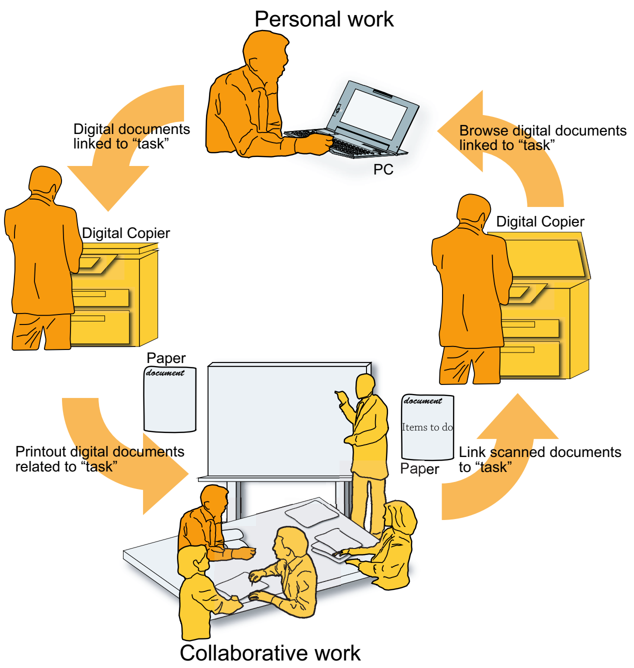

Figure 2: Simple user scenario for our prototype system

Figure 3 shows the prototype system working on the user interface of the digital copier. The system works on digital copiers and on the conventional web browsers of PCs that the user could access to the particular information through various ways.

Figure 3: Prototype system in use

The purpose of this prototype is not to show the possibility of augmenting the physical activities or paper documents with information technology itself. In our system, paper documents and digital documents are almost independently existed in collaborative and personal working situation respectively, however, they are connected flexibly and indirectly through the task context information like schedule and location. We naturally connected a sequence of personal and collaborative work through the contextual use of paper documents from the results of our ethnographic observations that paper documents are printed out as a cohesive package of work and handled as a symbol of work in collaborative working situation.

4. CONCLUSIONS

We proposed a notion of bridging personal and collaborative work through the use of paper documents which expands the notion of bridging paper and digital document. From our research observation, we found out that the paper documents are taken to the collaborative working scene as a cohesive package of work, and then they are handled as a symbol of work. Each project member we observed take all the results back to their desk by paper documents and personal work would be performed according to the results from the meeting which means that the paper documents might bridging both personal and collaborative working situations.

We described on an early implementation of our prototype system which seamlessly combine the use of paper and digital document in the personal and collaborative situation. While the user handles digital documents at the personal working situation, he or she could transfer into paper documents in collaborative working situation.

This research is ongoing and at this stage only an initial survey has been conducted, and early prototype system has been demonstrated. Further work will continue to refine our systems and to carry out precise field tests.

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RFID: enhancing paper documents with electronic properties

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ABSTRACT

RFID (Radio Frequency Identification) tags are getting small and robust enough to be printed on paper documents. This opens the way for enhancing paper with electronic properties by providing a connection between the paper document and an electronic database, as well as providing a tracking mechanism for paper documents. This paper describes a prototype application which was designed to do just this in a document intensive environment – the patent department of a large multinational company. The paper also discusses the affordances of paper vs. digital documents in a patent department.

1. Introduction

RFID (Radio Frequency Identification) tags are getting small and robust enough to be printed on a document or on other paper artifacts like books. This opens the way for enhancing paper with electronic properties by providing a connection between the paper document and an electronic database, as well as providing a tracking mechanism for paper documents. The examples are many, one out of them is described in [2]. This paper describes a prototype application which was designed to do just this in a document intensive environment – the patent department of a large multinational company.

The patent department is a document intensive environment where much of the work is still done using paper and there is a large overlap between work done with paper and electronic documents [3]. There are similarities between the work of the patent department and that of other legal departments, as well as to mortgage and insurance work. The work in such departments is case based, typically each individual case is independent of the others and has a logical trajectory through which it progresses. It is common for all the documents in each case to be assigned their own folder, nowadays, both electronic and paper folders may exist, however where only one folder is complete, it is usually the paper one. Typically in such departments there are large number of dormant folders that wait for letters, expertise or various other type of documents. Incoming documents can trigger actions that need to be taken, in addition, where documents do not arrive in a timely manner, action may need to be taken, such as the sending of letters, the assignment of tasks to new people or changing global deadlines. Parts of this process may be done remotely, documents may have to travel and be duplicated, as well as new documents being created, and so on. RFID tracking would seem to offer a number of possible advantages such as: tracking of physical documents, and associating processes with them, e.g. instigating actions when a document is or is not received and so on, as well as providing a means to manage physical/electronic duality.

RFID systems consist of transponders, readers, a host platform (e.g. PC) and system software. The RFID system described here, was developed as a demonstration prototype at XRCE. The technical features have been outlined in more detail by Arregui et al. [1]. In this paper we focus on the affordances of paper which led to the application development, along with a brief assessment of how the application might play out if installed in the patent department.

In the following sections the work of the patent department is described, then a prototype application is outlined, followed by a brief discussion of its applicability to the environment.

2. Patent Department overview

The work of the patent department is to take the invention disclosures (ID's) submitted by the companies inventors and to turn them into patents, to be filed in one or several of the patent offices around the world, primarily at the USPTO. This process involves: collecting together a variety of information; writing the patent - taking the inventors ID as a basis then formulating the contents in such a manner as to fit the legal criteria for a patent; then a correspondence is entered into with the USPTO (or other patent office) around the legitimacy of the patent. The whole process may take a number of years, during which there are various deadlines and legal criteria to be fulfilled. The work is ordered around cases, a case being an individual ID and patent application. Each case has a unique number and folder, in which all the documents pertaining to that case are placed. Work can be triggered by deadlines approaching, but also by the arrival of documents, such as correspondence from the patent office. Folders may become complete after the arrival of some document and missing documents can trigger actions, such as sending an email. Currently, although the patent office would like to move to a more electronic process they are constrained the USPTO's requirements for how patent applications are submitted. Staff in the patent department work in one of four main areas – ID's; dockets; legal (the attorneys) and legal administration.

It is an environment in which issues around the paper/digital divide are prominent. The process involves both electronic and paper documents and much duplication of effort around data entry and re-entry as the patent department uses a variety of legacy systems which do not or only partially interact with one another.

We will give a very brief overview of the process before examining how paper and digital systems are used. The patent department runs two main processes which are serial. The ID process and the docket file process (known as the D-file process).

- The ID process consists of receiving the ID from inventors (both hard and electronic copy), cataloguing it into the system, assigning it an ID number in the database and making up ID folder. The ID's are then assigned to another group where they are reviewed by the TAP panel; those getting a high enough review go on to a second review panel, the PMC (Patent Management Committee) review. ID's that get a high enough score will be filed as patents. They then proceed to the D-file process. Those that do not are inactivated.
- The D-file process consists of creating a patent from an ID. The ID's are assigned a docket number and a docket folder is made up: the ID's are now docket files. The dockets go into a pool (both hard and electronic copy), where the attorneys can select which ones they want to work on and remove them from the pool onto what is known as their docket. The attorney then works on the D-file until it is filed as a patent, when the D-file is stored in the docket department, to be activated again when correspondence comes from the patent office. The attorney then acts on this and the D-file returns to dockets to await further correspondence, until it is either accepted or rejected as a patent.

3. The affordances of paper vs. digital documents in the patent department

The field study of the patent department revealed a number of instances where the affordances of paper and digital documents reveal themselves through their usage. These include the physicality of paper documents and document tracking, as well as qualities of marking up and searchability.

3.1 Document and process tracking and the physicality of paper

The ID and D-files move around the patent department (and outside of it, for review) according to what stage of the process they are at. Thus the physical location of the document can be used to infer where a file is in the process and knowing where something is in the process provides people with an idea of where to look for it. Thus the physical instantiation of the paper documents can provide information on the state of the file. For example; ID's and un-assigned dockets are (or should be) in the ID room, ID files on table of ID room are awaiting PMC, D-files filed in dockets are awaiting USPTO action, D-files in patent attorneys or administrators offices means 'work in progress'. Work in progress files themselves could be in a number of places (according to current state and personal habit);

- Attorney's Desk (immediate work)
- Attorney's File cabinets for (working on but not immediate)
- Piles on the floor of attorneys office (as above)
- Administrators trolleys (various trolleys for different work)
- Attorney's or administrators in-tray (document exchange)

Currently various paper and electronic processes are in place to record where files are, many of these being duplications of one another. To take just once example, both paper and electronic ID files may be used and their location is recorded both electronically (on a Patent Information Management system (PIMS)) and on a paper log. Paper ID's removed from the ID room must be signed out on the paper log, the electronic log is not altered until they are either inactivated or they are assigned to an attorney. The ID manager keeps a hawk-like watch on these files, because of their propensity to go missing at least for short periods of time. They then must be tracked down (usually by working out the most likely patent attorney or their administrator, according to the subject area of the ID). Indeed, she tries not to let anyone into the ID room because otherwise files go missing or get disorganised, however the room is not kept locked. The procedure is that the attorneys can look at the electronic files or can sign out the paper files for three days prior to them taking them onto their docket. When an attorney requests that a D-file be assigned to her, the ID manager fills out a Change of Status (COS), an electronic record which goes to dockets who then enter the assignment of the docket on PIMS. Dockets also have a process in place for tracking the location of the D-files, involving PIMS and paper records.

As well as the systems for tracking of the location of ID and D-files, additional systems are in place for tracking the status of the D-files, in particular when the attorneys are working on them. Incoming mail often signals an action that needs to be taken on a file, for example, correspondence from the USPTO, known as Office Actions (OA) require work on the file and are time constrained (for example, there is usually three months to reply to a first OA). When OA arrive the following process is set into action: the OA is logged into the incoming and outgoing mail log book; the details of the OA are entered into PIMS, including the due date; the file is signed out of dockets (on the paper system); the incoming mail is attached to the physical D-file with elastic band; the file is placed in the appropriate attorneys mail box in the mail room, from which it is picked up by the attoneys administrator. A number of systems are used in parallel to ensure actions are carried out in good time; docket reminders are generated from PIMS by dockets on a weekly basis for domestic filings, these are sent to each attorney and their administrator. Fortnightly a report is run by dockets showing what is due from each patent attorney, according to the updates sent by the administrators on what has been actioned. Individual attorneys (and their administrators) also have their own reminder systems, such as Outlook tasks, PDA reminders, the piles of files in different places in the room, etc..

We can see then that the physicality of the document itself can be used as a tracking and reminder mechanism – it's presence in the attorneys room, or on the administrators trolley, indicating the need to work through that file, or that this file is awaiting something or other. However, this is not adequate on it's own and so is supplemented by other paper and digital tracking systems, used in combination. These however involve much work to maintain, duplication and are not foolproof – as evidenced by the tight control the ID manager now keeps (or attempts to keep) over access to the ID room. Digital reminders can be set to occur at a certain point, designed to give enough time for the work to be carried out to meet the deadline, however they involve an overhead above and beyond the process of working the file, and the current system has much duplication of effort and data entry – in different formats and on different systems. Because of the legacy systems used the current systems do not talk to one another. Currently lots of additional work is done to track the document process and to prevent loss of documents.

3.2 Searchability and marking-up

An interesting example of how attorneys use the affordances of paper and electronic documents to achieve their work effectively came to light during the process of writing the patent application itself. The attorney was engaged in addressing a final OA from the USPTO. The OA argued that the patent being filed was not different from a previously filed patent. The patent attorney now needed to make a clear argument that it did not, which involved understanding exactly what both patents were claiming so that he could make a clear distinction between the two. This work involved comparing the prior patent with the current patent to address the OA. The patent attorney used a number of documents: the paper OA; paper versions of the current and prior patent (both patents had been submitted by this patent department), plus the two electronic versions of the current and prior patents. The patent attorney used the paper documents, comparing them side by side and marking them up by folding the corners over; marking with sticky (post-it style) markers; underlining and circling text and saving a page by lying his pen in it whilst flicking further through the document. In addition, he used the electronic document to search for terms using the 'find' facility, then, located that section in the paper document and marked it up. Thus we can see that the patent attorney is using the affordances of both the paper and the electronic documents to complete his task. The paper documents offer an easy mechanism for side-by-side comparison, as they can be manipulated according to need, plus they offer a myriad of ways in which they can easily be marked up, either permanently or temporarily. Whereas the electronic documents have a quick and easy search mechanism, making locating specific terms much simpler than with paper documents. Thus the use of these two technologies in parallel enables the attorney to complete a complex task requiring much thought and concentration.

4. The RFID Solution

The overhead involved in multiple tracking systems suggests that a mechanism for tracking paper documents by linking them with electronic information might be of use in this situation. The application we envisage is one where RFID tags are embedded in paper documents and folders, whilst cabinets, desks, etc. are equipped with RFID readers. The RFID tags are associated with electronic records relating to the documents at the time of printing. Rules are used to associate processes and actions to the documents. The solution involves a number of features; tracking of the physical document; associating processes to documents and managing electronic/physical duality. A demonstration prototype was built.

4.1 Document and process tracking

As described above much effort is currently put into tracking the location of the physical folders. By fitting documents and folders with RFID tags, when the folders are inserted in the cabinet containing a reader, at the ID phase of the process, the RFIDs are detected by the ID cabinet. Simultaneous detections and recording about previously stored documents provides association between documents and their folders as they are put into the cabinet, so that the folders themselves do not require readers. Other readers in the 'inactivated ID' cabinet, on the table in the ID room, on desks and in-trays in the patent attorney's offices, on their administrators trolleys, in dockets, in the mail room and so on detect movements of the ID and the

D-files. In addition, if required people can be tagged too and cabinets can detect the person that is collocated with it and by comparison with the documents/folders before and after the collocation we can deduce what are the folders/documents that are inserted/removed and by whom. Information is transmitted via WLAN to the electronic database which can update the records as necessary (see Fig 1). This system has a number of benefits, for example, it could remove the need for the signing out of the ID- and D-files currently undertaken. In addition, the status of the file, in relation to the patent process, could be deduced from it's physical location, e.g. on the PMC table - up for PMC review - and the movement between locations could trigger actions. For example, a D-file moving from the ID room to a patent attorney desk or in-tray could trigger a request for to the administrator for information to be updated, e.g. is it a three day sign out or is it now assigned to that attorney. Assignment could trigger the relevant actions in docket.

Thus the system can keep track of the physical movements of the documents:

- When folders are inserted/removed from the cabinet
- What are the documents associated to a folder
- What are the documents that have been added/removed
- When the documents have been added/removed
- When documents are used (out of the cabinet)
- Who is manipulating the documents

In addition, processes may be associated to a folder and triggered by:

- Change in folder location
- Document added to folder
- Document needed to be added to a folder (deadline reached)
- Document has been superseded by a new version

Reminders could be electronic (e-mail, SMS, PDA popup, etc.) or physical (light/sound on cabinet, etc.)

4.2 Managing electronic/physical document duality

We have seen how both electronic and paper document have an important role to play in the patent writing process and how they live alongside one another. This system offers the opportunity to take advantage of this feature. Meta information added to the physical document can associate it with its electronic counterpart: as versions of the document are altered electronically and printed off they can be added to the physical folder and versioning rules could be put into place to provide an easy record of the most up-to-date version, both electronically and on paper, as well as of different versions, for example, for foreign filing. Not all actions on the document involve movement of the document around physically, for example in redlining (a process of removing information for foreign filings) the attorney 'red lines' (i.e. marks up) the hard copy of the patent application; the administrator makes these changes on the electronic copy and creates an e-cover sheet the e-cover sheet is emailed to dockets, who retrieve the electronic version of the patent from the shared drive and they print off the cover sheet and two copies of red-lined application: for foreign filing and the D-file. By associating the paper and electronic versions, this process can easily be handled by the system.

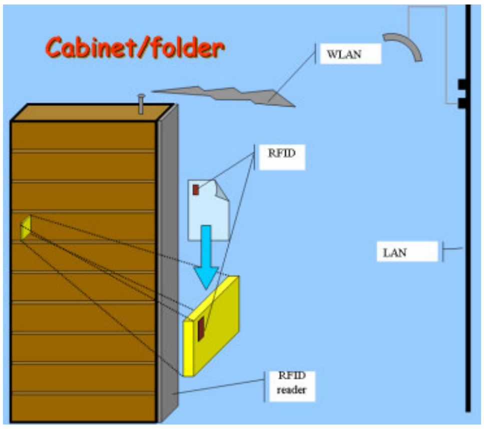

Figure 1 : Cabinet/Folder RFID Detection

5. Discussion

A major constraint with the prototype system developed was that it was necessary to have a time delay when filing the folders in the cabinet. That is, the identification by RFID reader of the tags requires that there be a three second delay between one folder and the next being (re)placed in the cabinet to associate the documents to the folders. This would not be a problem, for example, when filing single files, it might not be a problem when filing sheets in existing docket folders in dockets or when filing folders in the existing dockets shelves, since in dockets there are so many files they are not likely to be the same shelf (where an RFID reader might sit). However, it is likely to be a problem for many of the ID filing tasks, because of the nature of filing. Filing is mundane work, or as the ID manager put it 'Monday work'; it tends to be done for efficiency and saved up until a pile has been collected, then all done together. Having to wait three seconds between each filing action would seriously change the nature of the task. Also tasks such as filing the new ID files are currently done by putting all the new ID files in the cabinet together, as they are in numerical order, all at the end of the row. Advances in RFID technology are likely to be able to address this problem.

Other aspects of ordering the work still need to be defined, such as keeping track of versions, both electronic and printed – with the same tag ID or different tag ID's etc. Plus what is the most effective use of the tags, should all documents be tagged or just the ID or Docket itself, plus perhaps incoming mail and so on.

Additional benefit to the system would occur if it was propagated throughout the patent process. For example, within the company, if the writers of ID's had standard electronic forms, with standard fields for title, authors, and so on, plus the ability to print the final paper copy ready with its embedded RFID tag, this information could be automatically entered into the electronic system when the ID's arrived at the patent office and associated with the relevant RFID tag. Of course, the full benefit of such a system would come from its global adoption by the USPTO and other patent offices. If we could imagine such a situation, then the OAs from the patent office could be emailed and printed out in the patent department, with standard fields enabling automatic data entry for due dates, reminders and such like. Prompting the question: why not take the process completely electronic, as the managers at the patent department (and rumours have it those at the USPTO) might desire? The answer, of course, is the importance of paper in this process. Harper and Sellen [3] outlined its affordances for reading, comparing, marking up etc. and these were demonstrated again in this study. So however much there might be a management push to go electronic it is likely that throughout the process paper will be used. Indeed, at the moment it is likely that the paper folders actually reduce the amount of printing out required (as these are passed around the department rather than each person printing out their own version of the electronic file). Thus by enhancing this dual paper and electronic process by providing a link between the paper and electronic data and versions, we can reduce the current duplication of effort and complexity of multiple parallel systems and thus would hope to improve the process.

6. REFERENCES

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