Implications for the Design of Email Management Software

by

Aleksandra Jovicic

A thesis submitted in conformity with the requirements for the degree of Master of Science.
Graduate Department of Computer Science
University of Toronto

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Implications for the Design of Email Management Software
M.Sc. Degree (2000)
Aleksandra Jovicic
Department of Computer Science
University of Toronto

Abstract

Email management is very time-consuming. Also, hierarchies of files and folders become harder to use as they grow in size. This thesis explores an alternative approach to email organization in which time is the main organizational principle and no filing is required. The user interface was designed to support and utilize the human ability to reconstruct dates. Also, from literature on human memory we developed a set of implications for the design of user interfaces for email management. As in the earlier prototype of the Timestore email management software, the user interface consists of a grid with time along the horizontal axis and a list of senders along the vertical axis. However, the timeline now incorporates temporal schemata used in information retrieval. The user tests show that four out of five users would use Timestore on a regular basis to handle their email.
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Za uspomenu na baku i dedu...
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USER 1 (PILOT USER)

SESSION 1. DURATION: 28 MINUTES
SESSION 2. DURATION: 17 MINUTES
SESSION 3. DURATION: 27 MINUTES

USER 2

SESSION 1. DURATION: 22 MINUTES.
SESSION 2. DURATION: 17 MINUTES.
SESSION 3. DURATION: 20 MINUTES.

USER 3

SESSION 1. DURATION: 17 MINUTES.
SESSION 2. DURATION: 24 MINUTES.
SESSION 3. DURATION: 33 MINUTES.

USER 4

SESSION 1. DURATION: 1 HOUR 7 MINUTES
SESSION 2. DURATION: 17 MINUTES
SESSION 3. DURATION: 34 MINUTES

USER 5

SESSION 1. DURATION: 31 MINUTES
SESSION 2. DURATION: 11 MINUTES
SESSION 3. DURATION: 34 MINUTES

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One of the most popular forms of information sharing in recent years has been electronic mail, or email. Emergence of email marked a breakthrough in communication among people. It has allowed collaboration among people spread around the globe, and has led to emergence of online communities. However, the success and popularity of email have also led to high volumes of messages being exchanged daily. Email is therefore a mixed blessing. On one hand, it is a fast and reliable form of communication, cheaper and less obtrusive than telephone, and faster than regular mail. On the other hand, its popularity has introduced an additional demand on its users, who now need to devote increasing amounts of time to the upkeep of their email.

This thesis focuses on email overload. We define email overload as the situation in which a person receives more email messages than s/he can comfortably manage.

Chapter 2 discusses the causes and implications of email overload. Particular attention is paid to the question of why semantic hierarchies of files and folders are not as useful for managing email. This knowledge is tied in with an overview, in Chapter 3, of previous attempts to address the issue of email overload.

Chapter 4 summarizes some important points in the relevant literature on human memory research, while paying attention to information relevant to email and its inherent properties. The objective of the literature review is to gain an understanding of the process of recall of autobiographical events. More specifically, we want to learn how the effort associated with retrieval of email messages could be minimized, and how different aspects of the time reconstruction process may be supported.
Chapter 5 presents a set of implications for a design of the user interface for an email management system, developed from important points in Chapter 4. These implications are used to revise and expand an earlier prototype of Timestore email management software (Yiu, Baecker, Silver & Long, 1997). Timestore was envisioned as an email system in which the user would not have to do any filing. Instead, email messages are displayed in a two-dimensional grid, with time along the horizontal axis and a list of senders along the vertical axis. In this thesis, the two axes were revised to incorporate the set of implications developed.

Timestore’s user interface was implemented as a separate component that offers an additional view of Eudora’s mailboxes. Eudora is responsible for most of message handling functionality. Chapter 6 gives more details about the implementation of this version of Timestore.

Chapter 7 presents the user testing methodology: its objective, the components of the study and the rationale for the choices within the experiment. The chapter concludes with a summary of the study results and a discussion of the lessons learned about the methodology.

Chapter 8 outlines the contribution of this work to the field. Finally, Chapter 9 presents some directions for future work, while concluding remarks are given in Chapter 10.

1.1. History of the Timestore project

Timestore project is an ongoing project. It started in 1994 with a study of how people organize their computer desktops (Fitzmaurice et al, 1994). They found that people frequently use time stamps when naming their files and folders (e.g. tutorial notes - January 28.doc)

This finding lead to the first Timestore prototype (Figure 1.1.) implemented by Long (1994). The software functioned as an add-on to Eudora. Its objective was to study time-based visualization of email messages as an alternative to hierarchies of files and folders. Its user interface consisted of a two-dimensional view of messages, with the horizontal axis displaying time, and the vertical axis displaying senders.
The above prototype was extended and refined by Silver (1996). Silver carried out a Eudora user study, as well as a Timestore user study. She found that the users preferred the time-based visualization to their current one.

In the next version, Yiu (1997) reimplemented Timestore as a standalone application, fixing many interaction problems reported by Silver. The results of his user study were particularly encouraging: 4 out of the total of 5 of his users said that they would use Timestore provided that it included the common functionality such as attachment handling.

In this version of Timestore, we take a step back to examine how the retrieval of messages could be improved. To that end, we review relevant literature on memory, and provide a set of design implications. Also, we reimplement Timestore to function as an add-on to Eudora, in order to utilize its email handling functionality. Lack of such functionality was one of the major impediments during an earlier user study (Yiu, 1997). We also implement, in Java, a user interface that incorporates the above design suggestions. The modularity of this code will make future experimentation with the interface significantly easier.
This chapter considers the origin of email overload and examines the pitfalls of the currently prevalent approach to email organization. It should be noted that studying these issues poses several challenges. In particular, only three significant studies have considered email overload in recent years. They are Whittaker & Sidner's (1996) "Email overload: Exploring personal information management of email", Balter's (1998) Ph.D. thesis titled "Electronic mail in working context" and Lantz's (1998) "Heavy users of electronic mail." The first study analyzes organization of email messages with clients at the corporate setting. Its findings indicate that many users do not successfully file and retrieve email messages. The study also identifies several issues that lead to email overload. The second study lists a wide number of results pertaining to email. Among others, the study extends the results by Whittaker & Sidner by considering several user categories and email clients and explaining what kind of organizational systems the users construct when they file their email. Lantz (1998) confirms independently from Balter and Whittaker & Sidner that file and folders are frequently not successfully used. She also discusses users' attitudes towards email and email overload based on the interviews she carried out in her study.

This thesis focuses on development of the software solution to address the problem of email overload and relies strongly on key results of these studies, with occasional use of other work on email, some of which dates back to 1990. In a field that has developed significantly in the past two years, it is important to note that while one of the main studies used in this thesis (Whittaker and Sidner) is four years old and some are still older, the main findings of the studies are still credible for our purposes. Namely, though email applications have evolved significantly over the
past decade, adding numerous features for filtering and manipulating email, the method of representing email messages has not changed: messages are still represented in the same list-based view and organized in hierarchical structures of files and folders. The volume of email exchanged, however, has been steadily increasing since the studies were carried out, and so it is possible that the degree of difficulty users encounter in managing their email has increased as well. This increase makes the findings of the studies cited here potentially more credible, as the same problem is amplified over time, as the user population grows and the volume of email messages increases.

2.1. Abundance of email

A number of research studies suggest that the abundance of email poses some serious problems for users, especially in the workplace. The amount of time spent filing email messages, searching through mailboxes, or reorganizing messages is continually increasing due to constant increase in email use. Not only is handling email time-consuming, it is also a source of frequent interruptions: A study by Lantz (1998) showed that 37 out of 58 respondents read mail continually, as it arrives, and another 18 read it several times a day. Balter (1998) reported similar results: 93% of his subjects read their email several times a day.

Email was designed to be a form of asynchronous communication, but now it is also used for functions that were not initially anticipated, such as time management, task management and personal archiving (Mackay, 1988a; Whittaker & Sidner, 1996; Balter, 1998). Task management involves task delegation, as well as ensuring that information related to the current tasks is readily available. Personal archiving pertains to the long-term information organization, i.e. information that might not be relevant to the current task but which might be needed in the future.

Since messages are kept around for many reasons, it is hardly surprising that some users’ inboxes have grown to contain hundreds, and sometimes thousands of messages (Whittaker & Sidner, 1996). The size of the inbox was found to be directly correlated with the number of email handling problems (Lantz, 1998). Some of these messages serve as reminders for outstanding tasks, while others are kept to provide context in conversational threads. In addition, inboxes often contain partially read documents that might be needed at some point in the future (Whittaker & Sidner, 1996).
2.2. Difficulties with hierarchies of files and folders

Filing and retrieving messages are the greatest problems associated with email (e.g. Whittaker & Sidner, 1996; Lantz, 1998). Jones et al. (1990) found that users had great difficulty organizing email messages and retrieving information from stored email, and that they were uncertain of the organizational structure of folders they had created. Lantz (1998) in particular states the following:

"Regardless of the number of messages in the inbox and whether employees felt a time shortage, employees had difficulty organizing stored messages within folders and catalogues."

Along the similar lines, Whittaker & Sidner (1996) remarked that "users' attempts to rationalise their inboxes by filing are often unsuccessful, with the consequence that the important messages get overlooked, or 'lost' in the archives."

That filing does not work as well as it should is confirmed by results showing that more email messages are kept in the inbox than are filed. In one study, the ratio of items in the inbox to filed items was found to be 3:1, a clear indication that folders were not successfully used (Whittaker & Sidner, 1996). Although results from some other studies show markedly different ratios, the same conclusion can be deduced. For example, the ratio of inbox items to filed items of 1:6 in Lantz’s study (1998) is still few: "given that 85% of employees received 30 or fewer (M=15) messages over the course of couple of days (...), the number of messages stored within folders (M=284) compared with the number of messages received over the course of 20 days must also be regarded as few." Other studies reported that ratios of filed to non-filed messages were somewhere in between these two results (e.g. Balter, 1998).

**Requires considerable effort**

Why does filing fail so frequently? Literature indicates that the main reason for this is the effort that is required to generate and maintain folders of files. To be more precise, filing is not only a time-consuming, but also a cognitively difficult task (e.g. Balter, 1997).

**Difficult to envision**

Successful filing implies foreseeing a folder structure that will be needed in the future – a task that is certainly daunting. Finding names that adequately describe content of folders is difficult as
well. As a consequence, a folder might not be used for the kind of files it was originally intended for, which makes subsequent retrievals even more difficult.

Another reason is that users are reluctant to create archives of information that might turn out to be useless or irrelevant (Whittaker & Sidner, 1996).

**Difficult to organize**

An ideal hierarchy of files and folders would be *straightforward* – straightforward to file, and straightforward to retrieve, with manageable number of files and/or subfolders at each level of the hierarchy. However, in reality, the situation is markedly different, both in case of email and general file and folder hierarchies. In the latter case, Fertig et al. (1996) reported that users of common desktop systems have difficulty organizing and finding information within hierarchical systems, and they even resort to deletion of archived information so that they are not overwhelmed by it (Fertig et al. 1996). These results of course apply to classification of email messages into files and folders as well. Moreover, it may be hypothesized that classification of email messages would pose more problems than classification of desktop documents, since email messages often arrive independently of recipient’s activities. Indeed, Balter (1997) found that an overwhelming majority of respondents who reported having problems with handling email cited problems related to the difficulties of classifying messages in files and folders (Table 2.1.).

Whittaker and Sidner also noted that users have difficulties when filing messages (1996). In their study, 35% of their users’ folders contained only one or two items on average. Clearly, in such instances filing was not successful – these folders cannot be said to be any more useful that the files themselves would be.

<table>
<thead>
<tr>
<th>Problem</th>
<th>Number of respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Message belongs to several folders</td>
<td>9</td>
</tr>
<tr>
<td>Finding the appropriate folder</td>
<td>5</td>
</tr>
<tr>
<td>No/unclear strategy for classification</td>
<td>4</td>
</tr>
<tr>
<td>Disk space shortage</td>
<td>2</td>
</tr>
<tr>
<td>Sub-folders not visible</td>
<td>1</td>
</tr>
</tbody>
</table>

*Table 2.1. Problems with classification of email messages. Gray text denotes the problems not related to message filing. (Adapted from Balter, 1997).*
Inflexible

In addition, hierarchies of files and folders are highly inflexible structures. A document cannot realistically be in two or more subfolders at the same time (unless it is duplicated, but the duplication would probably prove to be too cumbersome). Should different subfolders become semantically related, the user would need to spend time reorganizing the entire hierarchy. Such a process would be very time consuming and difficult, so the users are not willing to do it even though they are not satisfied with their folder hierarchy. (Lantz, 1998). Over time, most semantic hierarchies would grow to be too large and/or cumbersome to be useful in practice.

2.3. Problems with email retrieval

In Balter’s study (1998), 7 out of 28 participants cited difficulties in retrieving stored email messages as their most common problem in handling email.

Finding information in hierarchies of files and folders is fairly difficult and relates to problems with filing described above. Classification of messages into folders may lead to retrieval difficulties in the future; for example, it might not be possible to recreate the location of a message in the folder hierarchy. Problems may also be software-specific: certain software packages only allow searching of one folder at a time. Also, difficulties with retrieval reflect the initial difficulties with filing: failed folders, too many folders or few folders with many messages can all negatively reflect on the ability to retrieve messages (Whittaker & Sidner, 1996).

Keeping all messages in one folder, usually the inbox, does not improve the situation either. Such folders can grow large in size, and this usually translates into difficulties with email handling (Lantz, 1998). Large inboxes can have other implications as well, such as important messages being overlooked (Whittaker & Sidner, 1996).

2.4. Impact of email overload

Not only is email management time consuming, it also pressures users. For example, Jones et. al (1990) reported that the users feel increasingly overwhelmed with the amount of email they receive. This finding needs to be considered in the context of present level of email use. Although precise statistics are not available, according to a U.S. Census Bureau report, "access to the
Internet is one reason for the big increase in computer use in the last decade” (United States Department of Commerce News, 1999). Furthermore, the level of computer availability in U.S. households and, by extension the volume of email messages exchanged, has been steadily increasing every year since 1984 (U.S. Department of Commerce, 1999). Therefore, we may safely assume that level of email use has been steadily increasing since 1990 and that it will increase even further in the future.

In a 1998 study, 63% of users at a university site reported having or having had problems with handling email, and 15% described these problems as either “borderline” or “severe” (Balter, 1998). Moreover, the problems of handling email correlate with the size of the inbox (Lantz, 1998). Since this number is usually quite large (e.g. Whittaker & Sidner (1996) reported that mean number of inbox items is close to 2500 messages), it follows that problems with handling email are fairly common.

The question of how people cope with email overload is a difficult one and the answers must be considered in the context of existing conventions for the organization of electronic information. In particular, the approach that users adopt depends heavily on the email tools that they use (Balter, 1997) and the environment in which they work. Since these issues are often beyond one’s control, (i.e. most institutions purchase software on users’ behalf and dictate what the environment is like), we should not assume that these strategies are necessarily the ones that work the best for a particular user. Instead, we can assume only that they work sufficiently well within the given email tool and environment in which they are used.

What gives us some basis for comparison, however, is that most popular email tools currently available are based on the similar organizational principles, in that they all place incoming messages in a list, called the inbox, and allow the users to create folders to store messages (e.g. Eudora, Netscape Communicator, Microsoft Outlook, pine, elm). The inbox is a list of messages, which can typically be searched and sorted alphabetically or by time, size or subject. With that in mind, we can proceed to examine the different email management strategies people use.

**Users’ email handling strategies**

Whittaker & Sidner (1996) distinguished among no filers, frequent filers and spring cleaners according to whether or not the users maintained folders and how often they systematically
purged their inboxes from unwanted messages. Properties of these categories of users are summarized in the Table 2.2.

<table>
<thead>
<tr>
<th>Type of user</th>
<th>Characteristics</th>
<th>Proportion of users</th>
</tr>
</thead>
<tbody>
<tr>
<td>No filer</td>
<td>Don't use folders any more (previous attempts had failed), use full-text search</td>
<td>6/17</td>
</tr>
<tr>
<td></td>
<td>to find information, have huge inboxes</td>
<td></td>
</tr>
<tr>
<td>Frequent filer</td>
<td>Use folders successfully, try to clean up their inbox daily, have small</td>
<td>5/17</td>
</tr>
<tr>
<td></td>
<td>inboxes containing mostly new messages</td>
<td></td>
</tr>
<tr>
<td>Spring cleaner</td>
<td>Use folders unsuccessfully, try to clean up their inbox every 1-3 months, have</td>
<td>6/17</td>
</tr>
<tr>
<td></td>
<td>small inboxes containing mostly new messages</td>
<td></td>
</tr>
</tbody>
</table>

Table 2.2. Types of users according to folder usage and frequency of inbox “cleanup”. (Adapted from data in Whittaker & Sidner, 1996).

According to their study, 12 out of 17 users did not successfully use folders. As expected, they also found that users' email management habits were, to a great extent, influenced by the environment in which they work. In particular, employees who, due to nature of their jobs, spent a lot of time away from their desk, fell either under 'no filer' or 'spring cleaner' categories. On the other hand, people who stayed at their desk for large portions of their workday were more successful in keeping the sizes of their inboxes at a manageable level.

The above certainly implies that handling email has become a task that takes away a significant chunk of a worker's daily tasks. What is particularly telling is also the authors' observation that "spring cleaners have very strong feelings about the disorder of their inboxes (...)”. Hence, not only is email management a time-consuming task, it is also a stress-inducing one. That, coupled with the fact that 50% of people in their study have given up on filing (Table 2.3), gives us some indication of the extent of this problem.

Balter (1998) provides details on filing strategies adopted by users who did manage to file their email. He finds that 50% of users store all their email in one folder, similar to the above study. Also, 36% of users classified mail in subject-related folders, while 18% named folders according to sender (Table 2.3). Up to 28% of users had folders for each month, or folders organized otherwise chronologically. As discussed earlier, this information must be considered in context of the email tool and the management strategy it allows. Therefore, although it is not clear that a folder hierarchy organized to reflect this information is the best strategy for email management, the categories do give us some insight into what kind of information people want to preserve.
### Table 2.3. Email handling strategies. The percentages add up to more than 100% since users were allowed to choose several alternatives. (Adapted from Balter, 1998)

<table>
<thead>
<tr>
<th>Strategy</th>
<th>Percentage of users</th>
</tr>
</thead>
<tbody>
<tr>
<td>All messages in the same folder</td>
<td>50%</td>
</tr>
<tr>
<td>Filing according to subject</td>
<td>36%</td>
</tr>
<tr>
<td>Filing according to sender</td>
<td>18%</td>
</tr>
<tr>
<td>A folder for each month</td>
<td>14%</td>
</tr>
<tr>
<td>Other chronological strategy</td>
<td>14%</td>
</tr>
<tr>
<td>Delete most of the messages</td>
<td>21%</td>
</tr>
</tbody>
</table>

The above research clearly indicates that email management is a pervasive problem at the modern workplace, with far-reaching implications for productivity and overall quality of work.

Furthermore, the prevalent email management strategy, filing email in hierarchical structures of files and folders, is plagued with a number of problems.
Some approaches to reducing information overload

This section briefly examines selected approaches aimed at assisting users in dealing with information overload. Some of these studies concentrate on the problem of email overload, while others deal with management of other kinds of electronic information as well.

The studies summarized below may be divided in three general groups:

- The first group of studies tries to address the problem of email overload through tools that would aid users in classification of email into folder hierarchies and its subsequent retrieval. The researchers assume that the hierarchy of files and folders will necessarily be used and that the users need assistance in constructing more useful folder hierarchies.
- The second group of studies relies heavily on autobiographical memory, and in particular on providing context which should aid users in reconstructing the information he or she is looking for, or at least indicate where the desired information can be found.
- Finally, the third group of studies explores time as the basic principle for organization of electronic documents.
3.1. Email management tools

Suggestions for more efficient classification of email into folder hierarchies and its subsequent retrieval range from simple suggestions to complex new software. On one end is the suggestion by Lantz (1998) that the users simply keep the number of messages low and clean the mail regularly, with the aim of making subsequent retrieval easier. Similarly, Balter (1997) suggests that aliases be used, so that email messages can be filed in several folders without duplicating the required storage. However, users still needs to file the messages, but now they have to deal with the additional challenge of constructing a list of folders that may be appropriate for a particular message. Also, additional difficulties may arise from the increase in the number of items per folder.

On the other end of the scale are tools that employ intelligent agents that try to learn the patterns in users’ email management habits and subsequently apply them to automatically filter incoming mail (e.g. Sheth & Maes, 1993). Somewhere in between the two are various filtering or querying tools (e.g. Jeffries & Rosenberg, 1987; Tajima et al., 1998). Such tools have been suggested by some researchers as a means of alleviating information overload (e.g. Mackay, 1988). However, several problems with the filtering approach have been subsequently noticed by researches (e.g. Lantz 1998; Balter 1997). In particular, they noticed that formulating such criteria may not always be possible, as the requirements vary from one task to another, and that different users want different amounts of control over the filtering process. Some want incoming messages to be stored automatically into appropriate folders, while the others simply want a suggestion of where to store the message after reading it (Lantz, 1998).

All of the above approaches implicitly assume that email is stored in a hierarchy of files and folders, and that the messages are organized in one of the currently predominant ways, either alphabetically or by time. One markedly different suggestion came from Whittaker and Sidner (1998), who propose a system in which intelligent agents would filter incoming mail into folders organized by senders, who are in turn grouped into “social networks.” Since their interface offers a visualization of the mailbox rather than the list-based view, it represents a big step in the representation of email messages.
3.2. Tools relying on autobiographical memory

A different set of suggestions stems from the researchers who consider human memory, and autobiographical memory in particular, to at least some extent. We will discuss autobiographical memory to a greater extent in the next chapter. We note here however an important lesson from literature on autobiographical memory: the more cues about a certain event that are available, the more things about the event will be remembered. This is the basic premise of the research presented below.

- Newman et al (1991) have developed Pepys, a system which collects information on user’s activities. The intention was to automatically collect information about tasks that could later serve as cues for retrieval of information related to the tasks. For example, if the user is searching for notes from a particular meeting, then the date of the meeting and the list of participants might serve as cues for finding the information about the meeting.

- “Forget-me-not”, developed by Lamming and Flynn (1994) is another system recording data about users’ activities. The system is intended to serve as a portable episodic memory aid. However, reduction of the raw data down to human-recognizable episodes posed a major challenge in this study.

- In a similar study, Eldridge et al (1992) used videotaping to record information about users’ activities. They found that a video diary provides a better context for retrieval than a written diary, so that the retrieval process is more successful. This result is to be expected since videotaping captures more contextual information.

- The MEMOIRS system (Lansdale et al, 1989) attempts to take advantage of the memory events to support users in managing large information systems. It treats users’ personal filing system as a history of events, and focuses on users’ recall for those events. The recall process is supported by a mnemonic system.
3.3. Tools relying on time

Recognition that hierarchies of files and folders pose many problems for management of electronic documents has led researchers to experiment with different organizational categories. This work is still fairly recent. Of possible alternative organizational approaches, so far only the suitability of organization by time has been explored to some extent.

- In the Lifestreams project (Fertig et al, 1996), hierarchy of files and folders is replaced by a chronologically ordered stream of electronic documents (Figure 3.1.). The stream is intended to function as a diary of one's electronic life - every time an electronic document of any kind is created, updated, or received by fax or email, it is placed in a stream of documents. Unlike common desktop organization system, Lifestreams does not rely on file and folder hierarchies for document organization.

![Figure 3.1. Lifestreams user interface, showing the stream of electronic documents.](image)

- LifeLines (Plaisant et al, 1996) on the other hand, utilize time to simplify the display of complex, well-structured information, such as medical or juvenile records. (Figure 3.2.).
Finally, the TimeStore project (Long, 1994; Silver, 1996; Yiu 1997, Yiu et al., 1997) uses time to simplify management of email, as presented in Section 1.1. above.

3.4. About this work

It is clear from the above overview of related literature that only a few studies have concentrated on alternative ways of managing of electronic documents, and even fewer have been concerned with the management of email. This thesis attempts to offer some understanding of issues that should be considered when such a system is designed. Silver (1996) and Yiu (1997) carried out user studies on earlier prototypes that have shown that the idea of implementing time as an organizational metaphor was a suitable one.

Other work on management of electronic information has pinpointed literature on human memory as a useful resource that might help us in understanding this issue. In the next chapter, we will concentrate on discovering points in memory literature that could assist us in improving the
design of software for email management. This knowledge is used to develop a set of design implications presented in the following chapter. A user study that examines if a system based on these design implications is useful and usable is presented in Chapter 7.
CHAPTER 4

Research on Human Memory

The literature review in this chapter concentrates on those aspects of human memory that might guide us in designing an interface that assists users in email retrieval. Overview of the structure of human memory and its basic characteristics are presented below. The bulk of this information is adapted from the following sources: Squire et al. (1993), Thompson et al. (1996) and Larsen et al. (1996). These sources were chosen because they provide a thorough overview of the area and summarize a large number of findings. Using such resources was necessary because of the large volume of works in the field; otherwise, the synthesis and interpretation of these works would not have been possible within the scope of this thesis.

4.1. Human memory: A short overview

Two basic kinds of memory are short-term and long-term memory, or STM and LTM respectively. The prevailing view in the contemporary memory research is that STM grades into LTM, and that STM is essential for the formation of LTM. Although there is no clear indication in the literature of the exact time period assumed by the concept of short-term memory, it is generally understood that it spans a period that could last anywhere from seconds to hours after a certain event. On the other hand, the concept of long-term memory spans a time period as long as one’s lifetime.

LTM is composed of several components, mediated by different brain systems. The major distinction lies between declarative (conscious) and non-declarative (non-conscious) memory. In

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1 This section relies mostly on Squire et al. (1993). Other sources have been cited as appropriate.
the former, recollection is carried out explicitly, and the subjects are aware that the information is being accessed. In the latter, memory is expressed through performance, rather than recollection.

Declarative memory is further divided into episodic and semantic memory. *Episodic* memory refers to autobiographical memory for events that occupy a particular spatial and temporal context, while the *semantic* refers to general knowledge about the world.

![Diagram of human memory]

*Figure 4.1. Structure of human memory. The relationships among different kinds of memory are not represented in this figure. (Adapted from Squire et al., 1993).*

It should be noted that the effectiveness of episodic memory drops with age, and that the age-related differences are much higher for recall tests than for recognition tests (Fergus et al.). Further, a substantial age decrement exists in the ability to recall event context - where and when a fact was learned or an event occurred (e.g. McIntyre & Craik, 1987). This study focuses on retrieval issues for general users.
4.2. Autobiographical memory

This section takes a closer look at a specific kind of episodic memory called *autobiographical memory*. This kind of memory is used in retrieval of email messages, and is further discussed in the next chapter.

Autobiographical memory is concerned with memories of events that a person has experienced during his or her lifetime. The aspect of autobiographical memory of greatest interest to us is that concerned with time; namely, how accurate people are in dating of events, on which bases events are placed in time, and what the nature of information used in the process of dating is.

**Dating accuracy**

A number of studies have been carried out with the aim of establishing how well people are able to reconstruct time of events (e.g. Larsen et al., 1996; Rubin & Baddeley, 1996; Thompson et al., 1996; Friedman, 1993; Wright et al. 1997, etc.). In all studies, somewhat unexpected results have been found: for events that happened up to six years earlier, datings are almost exactly correct on average, with forward and backward estimates symmetrical around the date of the event (Larsen et al. 1996). However, absolute errors tend to increase with the passage of time, about 1 day for each week that has passed since an event occurred, for up to six years (Larsen et al. 1996). This characteristics are specific to autobiographical events.

Other studies identified some sources of dating biases. Rubin & Baddeley (1996) noticed that some biasing occurs when subjects know the bounds of the interval from which events are drawn. In that case, a *telescoping effect* occurs: estimates of dates of the events near the ends of the interval are slightly away from the boundaries. This is to be expected, as knowledge of the ends of the interval prevents the subjects from overestimating the date of the event in one direction. The effect is less represented as one moves away from the boundaries towards the middle of the interval.

It is interesting to note that this accuracy of dating holds only for autobiographical events. Dating errors for news events, for example, are much larger (Thompson et al., 1996). Similarly, vividly remembered events are dated as more recent than the less vivid ones, but this kind of bias has not been established for autobiographical memory (Rubin & Baddeley, 1989).
Theories on time estimation

There are many theories that try to explain how time of events is remembered. In a thorough review, Friedman (1993) classified them into the following categories:

1. **Distance-based theories:** These theories hold that certain processes occurring between times of encoding and retrieval produce cues that can be used to estimate the time since the event. For example, one suggests that this time is proportional to the strength of the event's trace in memory. These theories fail for personal events however, as time estimates of high-strength personal events are fairly accurate in practice (Thompson et al., 1996).

2. **Location-based/time-tag theories:** These theories rely on information stored at the time of event encoding. The simplest assumes that location of events in time is represented explicitly in memory, similar to a photograph with a date imprint on it. More complex *reconstructive theories* suggest that time of events can be estimated from temporal cues afforded by the event, knowledge of time patterns, and knowledge of the exact times for a few points of reference, called landmarks. Finally, encoding perturbation theory shares with the reconstructive view the idea that general context rather than a 'time-tag' is stored with the event, but assumes that some data are lost over time. (Friedman, 1993).

3. **Theories based on relative times of occurrence:** *Associative chaining theories* propose that the events are associated with their location in the sequence of experienced events. These theories do not explain the granularity of encodings, for if the sequences were encoded at a level of minutes, a long traversal of events should be made (Friedman, 1993). *Order code theories* assume that temporal information is added to stored items even after they occur, e.g. when the next event in the sequence is added to the memory. These theories also fail to address that the time for at least one event needs to be known for the before-after relationship to be used to estimate time (Friedman, 1993).

Friedman (1993) concluded that there is very limited support for the distance-based theories, time-tagging and associative chaining. In addition, Wright et al. (1997) cite a number of studies demonstrating evidence contrary to what distance-based theories suggest and presents their own similar findings: they found no systematic differences in the memory quality ratings between people who forward and backward telescoped the dates of test events.
However, Friedman (1993) noticed that many results are consistent with the reconstructive model, and most of them with the encoding perturbation model. In particular, he noted that the empirical data supported the idea that the memory for time of a past event should be more accurate when more event details are remembered, and similarly, that the events that are poorly remembered would not be easily placed in time. Further support for the reconstructive view comes from the study by Larsen et al (1996), who reported that think-aloud protocols show that subjects extensively use time patterns and reference events to arrive at temporal estimates. In the remainder of the thesis we will assume that time is estimated as described by the reconstructive theories.

**Components of time reconstruction**

We will take a closer look at the components of the time reconstruction process as described by the reconstructive theories. This knowledge will be useful for the discussion of the design in the next chapter.

Conway and Rubin (1993) distinguished among three basic categories of autobiographical memory:
- Lifetime periods, typically spanning years;
- General events, typically spanning days, weeks or months; and,
- Event specific knowledge, typically measured in seconds, minutes or hours.

There may exist many lifetime periods, each with many general and specific events. A lifetime period usually carries a specific theme – for example, it may be related to one’s relationship history or work history – and therefore there may exist several overlapping lifetime periods in one specific instance of time.

Friedman’s study (1987) supports the notion that recurring lifetime periods are often used in dating of events. He asked subjects to estimate the year, the month, the day of month, the day of week and the hour of an earthquake that occurred nine months earlier. For the hour, the day of week and the month, subjects claimed to relate information recalled about the experience to knowledge of temporal patterns or to the time of contiguous events. On the other hand, day of the month was difficult to reconstruct, supporting the notion that such schema is unlikely to exist (Larsen et al., 1996). The next most commonly used strategy was landmark reference (20-30% of the time, depending on the temporal level). Possible explanation is that cultural and societal
noms have made days, days of week and years common denominators of all temporal schemata, as they appear in clearly distinguishable cycles: night and days, weekends and weekdays, different seasons all succeed each other etc. (Larsen et al., 1996). By the same token, a day-of-month schema is unlikely to exist as hardly any difference can be noticed in the succession of months.

The importance of lifetime periods and landmarks is corroborated by studies by Skowronski et al. (1995) and Thompson et al. (1993). As shown in Table 4.1., these dating strategies are the most commonly used ones. The 1993 study covers the range of periods of 2 to 105 days, while the 1995 study covers recent, middle and old events. Since the results for the recent events and the events in the 1993 study are similar, the results are sufficiently reliable. (Thompson et al., 1996).

<table>
<thead>
<tr>
<th>Estimation Strategy</th>
<th>1993 study (2-105 days)</th>
<th>Recent Events (1-100 days)</th>
<th>Middle Events (100-365 days)</th>
<th>Old Events (more than 1 year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Period (cyclic or linear)</td>
<td>29</td>
<td>37</td>
<td>58</td>
<td>56</td>
</tr>
<tr>
<td>Linear landmark</td>
<td>22</td>
<td>19</td>
<td>16</td>
<td>9</td>
</tr>
<tr>
<td>Exact date recalled</td>
<td>18</td>
<td>21</td>
<td>7</td>
<td>3</td>
</tr>
<tr>
<td>Cyclic landmark</td>
<td>13</td>
<td>9</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Guess</td>
<td>10</td>
<td>5</td>
<td>12</td>
<td>21</td>
</tr>
<tr>
<td>Clarity of memory</td>
<td>5</td>
<td>8</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td># of intervening events</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Other</td>
<td>-</td>
<td>2</td>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>

Table 4.1. Percentage of time each dating strategy was adopted during reconstruction of dates of events between 1 day and more than 365 days old. (Adapted from Thompson et al., 1996).

A brief explanation of the terminology follows. Cyclic landmarks are important events that recur with some frequency, e.g. birthdays and anniversaries. Similarly, linear landmarks are important non-recurring events, e.g. weddings and births. Clarity of memory is used to test the accessibility theory, which holds that events remembered in plenty of detail are more accurately dated. Lifetime periods, as the name suggests, may be any significant periods for which end dates are known, such as the duration of the undergraduate studies, the period lived in a certain city, etc.

The two studies included dating strategies that Friedman used (the exact date, guess and landmark relation, here divided in cyclic and linear) and some new ones (lifetime period, clarity of memory and the number of intervening events). The inclusion of the lifetime period strategy made a substantial difference between Friedman's results and these, for it was by far the most commonly reported strategy. It was especially important in estimation of events older than 100 days, where it was used more than 50% of the time (Table 4.1). The table data suggest that most common
strategies are reference to lifetime periods, landmark relation, exact date recall and guessing. All other strategies are used only sporadically.

- **Recent events**: For events less than 100 days old time estimates are generally good: exact dates are known about 20% of the time, while landmarks and lifetime periods are used about 65% of time. That time is remembered well can be seen from low percentage of guesses as well (5-10%).

- **Middle events**: Knowledge of exact dates drops to 7%, so other strategies need to be used. Knowledge of lifetime periods is the most commonly used strategy, used 58% the time, and landmark relation 20% of the time. It is interesting that the percentage of guesses is still relatively low (12%).

- **Old events**: It is not surprising that in this case memory is poorest, as evidenced by the high percentage of guesses (21%) and low percentage of exact dates known (3%). Knowledge of lifetime periods is still most common strategy (56% of the time), while all other strategies, including landmark relation, are used only sporadically.

**Nelson’s theory**

One slightly different approach to dating of autobiographical events is the Nelson’s (1993) theory. She suggested that the approach to autobiographical memory needs to be reconsidered in light of some new research and offered an alternative theory. According to this theory, the following three sources of memory are used in time reconstruction: generic event memory (memory of events that recur during a certain time period or with certain frequency; e.g. everyday tasks, holidays, birthdays etc.), autobiographical memory (significant personal events) and episodic memory (events that are neither recurring, nor related to one’s personal history).

Thompson et al. (1996) explain how this theory ties in with the schematic approach:
- Generic events provide cyclic schemata at different levels, and recurrent dates may be used as landmarks;
- Episodic memory provides cues for placing the event in a certain timeframe, with reference to the landmarks; and,
- Autobiographical memory provides information about a person’s life periods.
Temporal schemata and the week schema

One of the most interesting results from memory literature concerns usage of temporal schemata in time estimation. As noted earlier, hours of day, days of week and years are thought to be the schemata people use (Larsen et al. 1996). Thompson et al. (1996) also noticed that the pattern of subjects’ dating errors implied their use of the day-of-week schema; their day-of-week estimates were often correct, even when the actual week was not estimated correctly. This phenomenon is represented at figure 4.2. below.

An important characteristic of the week schema is that it is resilient to the time passed, at least for events that took place up to a year earlier. Larsen et al. (1996) studied time estimates for events that happened two days and five months earlier, and found no differences in distributions of the day-of-week estimates.

Despite being fairly good at estimating time of the week, people often have trouble finding the correct week, as demonstrated by the graph of errors which has peaks at 7-day intervals.

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Figure 4.2. The graph of dating errors. The errors peak at seven-day intervals, indicating that the day of the week is well-remembered even when the actual week is not. (Adapted from Thompson et al., 1996).
Based on this graph, Thomas et al. (1996) concluded that there is no temporal level of a month, for if it existed, errors would not be greater than 4 weeks.

Cues and context

It is not surprising that people’s retention rates drop with time. However, describing exactly how people forget is not simple, since there is no consensus on what constitutes forgetting. In addition, forgetting rates differ from person to person, and can follow very different patterns (e.g. Thompson et al., 1996, fig. 7.6.). However, Thompson et al. (1996) argue that most crucial cues are remembered as time passes by, and that side details are gradually lost. What is almost always preserved, according to them is time, event, location and people involved. It is interesting that this information, as well as memory of what happened before and after the event have also been cited as strong cues for recall (Lamming & Flynn, 1994). Access to partial information about an event is also crucial for successful recall as it may prompt a memory of the entire event. Brown & Schopflocher (1998) claim that events are organized based on these principles into sets of causally and thematically related events called event clusters. More precisely, clustered events often occur close together in time (mean of two days), refer to the same people, take place at the same location and involve the same activity.

Similarly, although people are fairly poor in remembering the precise date of an episode, they are often quite good at remembering temporal relationships between episodes (Lemming, Brown et al. 1994). It is theorized that in general people have access to memories of recent, mundane events and older, more important events, and that task demands and nature of the prompting event affect the probability that a recent event will be retrieved (Brown & Schopflocher, 1998). Exact dating rapidly decreases in recent retention intervals and slowly decreases over the long intervals. (Thompson et al., 1996).

Burt et al. (1998) examined how well sequences of events are remembered. In their study, they considered events that occur during one day. Their results show that memory for the sequence rapidly diminishes over time – for the first few days event order is fairly well retained but by one week comparatively few details can be placed in correct order. This finding supports the Event Component Ordering Model (ECOM), which predicts fairly rapid loss of connections between specific details of an event (Burt et al., 1998).
4.3. **News Events**

*News events* are types of events that are predominantly informational. These events are autobiographical in nature to the extent that a person has been informed of them, but has not participated in them. For example, a situation whereby a person watches a coverage of an accident on television (but the person was not involved in the accident) would be an instance of a news event.

In general, the results of time estimation studies may be predicted from the review of autobiographical memory presented in the previous section. In particular, scarcity of retrieval cues and the lack of temporal framework within which the event may be placed clearly imply that news events will not be well remembered. Therefore, the event may be vividly remembered, but it will lack contextual information that would allow date estimation. In case of the autobiographical memory, these cues were crucial for time estimation.

In case of news events, as in the case of autobiographical memory, time reconstruction theory is corroborated by experimental results (Friedman, 1987). However, Thompson et al. (1996) found that time estimations are much poorer for these events. One of the reasons for this difference could be that the day of week estimates for news events are less accurate than those for autobiographical events (Wright et al., 1997).

Overall, news events may not be well since there is an abundance of information in today’s society. In such situations, it could be expected that most pieces of information will fall in the background, and only few most significant ones will stand out. It should be noted that it is usually such significant news events that were used in tests of recall; for example, in the study by Wright et al. (1997), carried out in England, subjects were asked to estimate the dates of Thatcher’s resignation and the Hillsborough disaster. The first event took place in 1990 and the second in 1989. Even in these two cases, where events were clearly of high significance to the local population, only a small percentage of respondents were able to estimate the month of events correctly (15.1% and 9.3% respectively). In the first case, the percentage of respondents who made absolute errors greater than 6 months or could not answer was 41.5%, which is certainly very high. In the second, estimations were even poorer: as many as 75.6% of respondents could

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2 A tragedy in which 96 people were crushed to death at the beginning of a football match at the Hillsborough Stadium in Sheffield, England.
not place the event within a 6-month interval or could not answer. Given such large margins of error, we can expect that the estimation errors for less significant events will be even larger.
Filing and retrieval problems were identified in the literature as major obstacles to effective email handling. As noted earlier, filing is a difficult process that must be continually attended to. While in the case of electronic documents the user has control over how many of them are created and where they are stored, email messages arrive independently of user's activities and hence it is more difficult to attend to their organization. Previous work on email overload summarized in Chapter 3 suggested certain strategies for handling email overload. Although these approaches may indeed make the process of filing and retrieving messages easier, they are bound to preserve same inadequacies of file and folder hierarchies as they still rely on them. In order to move away from these problems, we need to introduce a different management methodology.

Literature in the previous chapter provides us with some pointers on which directions we could take. As discussed in Section 3.4., the focus is on determining which aspects of autobiographical memory can be applied to our user interface design.

Using time for organization of electronic documents is a fairly novel approach that has so far been published in a very few works (e.g. Lifestreams and LifeLines projects, as well as the Timestore project). At the same time, we are not aware of any study that explores both time-based organization of email messages and autobiographical memory.
5.1. Properties of email messages

Before we continue, we need to determine what type of information is entailed in email messages and which aspect of memory is responsible for remembering information about each type.

As shown above (Section 4.1.), short-term memory is responsible for most of incoming, new mail, and the long-term memory for email that is a few hours old or older. Further, recollection of email is clearly a conscious process, hence email retrieval depends on declarative memory, and the episodic memory in particular, since it is fairly autobiographical in nature.

However, thinking of all email messages as purely autobiographical just because the user has read them would be misleading. Instead, the messages need to be considered within the context to which they refer. Some may be related to events that the user has personally experienced, while others may be predominantly informational. For example, correspondence about a dinner with friends would fall in the first category, while an announcement of a seminar that was not attended would fall in the second. The difference between the two is that in the former case, information about the event is handled by a part of memory called autobiographical memory, while in the latter case, information would fall into a sub-category of semantic memory called news events. In the work context, however, most email messages would be both autobiographical and news events to some degree. For example, if a person was involved in a certain project, then all email related to that project may be considered autobiographical to some degree; more so if the person was involved in the actual event referred to in an email, and less so if he or she was not. The reason for this is that, in this particular case, the email may always be associated with a personal event of involvement in the project.

Section 4.3. discussed why news events in general are poorly remembered. In the context of email, the situation is even more difficult – the abundance of email dictates that very few messages will stand out in user’s mind. Making it possible to retrieve these kinds of messages presents a challenge that will be addressed in the design section.
5.2. Design Implications

This section reformulates the points from the chapter on autobiographical memory that are relevant to the design of the email management software. They are organized in several categories: utilizing context, compensation for the lack of context, support for reliance on temporal schemata, support for knowledge of exact dates and compensation for dating errors.

Utilizing context

Context is of key importance for retrieval, since the presence of cues prompts recall of more information about an event.

Implication 1. Incorporate as much contextual information as possible into the interface.
The ability to retrieve information depends very much on the presence of context. If retrieval cues are present, more of the context can be reconstructed and the event can be better remembered. Hence, as much information about events that might serve as retrieval cues should be incorporated into the interface (e.g. activities, places visited, notes of meetings etc).

Implication 2. Show people, activity, place and time in the interface.
These four components are the most well remembered aspects of autobiographical events (Thompson et al, 1996). Since recollection depends on the number and kind of cues available, it has to be ensured that the most valuable cues will be represented.

Implication 3: Show together all people related to a certain activity.
It is important to note that activities may be related to a group of people, rather than an individual. A sender's name alone might not always be a sufficient cue for recall. A person might be associated with an event, place, organization, or a group of other people and could be meaningful only in that context. It is therefore important not to rely on names only in representation of senders, but to provide as much other contextual information as possible. Such information is, naturally, user-specific and therefore very difficult to model. Any such groupings or information would need to be provided by the user, and it is important to establish whether in fact people are willing to invest time to organize senders in such categories. In ideal circumstances, it would be possible to distinguish among well-defined, non-overlapping categories of senders (e.g. 'coworkers from project A', 'people I know from MIT', 'people from my bridge club' etc.) which would allow meaningful groups of senders to be clustered together.

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Compensation for lack of context

Older autobiographical events and news events carry less context than recent events. In the former case, contextual information is gradually lost over time. In the latter case, fewer contextual information was present since the beginning.

Implication 4: Assist the user in finding old autobiographical events.
Since fewer temporal cues are available for older messages, finer grained time cycles, such as days, become increasingly less important. In particular, absolute error of event date estimates increases approximately by one day for each week since the event (Larsen et al. 1996). Given such results, time cycle representation for old events should represent less fine-grained cycles, such as weeks or months.

Implication 5: Assist the user in finding ‘news events’.
‘News events’ represent the other kind of events involved with email. Since they are not autobiographical, they cannot be placed in temporal frames the way that autobiographical events can. Furthermore, they can rarely be associated with any other kind of personal event, hence they carry virtually no contextual information. As a consequence, any information that is available must be used to narrow down the number of messages. A possible solution for finding such information could be a search tool that would make optimal use of known information.

Support for reliance on temporal schemata
Temporal schemata such as days, weeks and years are commonly used in event retrieval. Importance of weeks is especially noted in memory literature, since day-of-week schema is largely resilient to the time passed. In other words, people are able to locate exact date of the week even if they are not able to locate the exact week of the event.

Implication 6: Emphasize days, weeks and years in the timeline.
One of the most important implications from memory research is related to importance of temporal cycles for time estimation. In particular, researchers found that people rely on days, weeks, months and years when estimating time, and that time can be successfully reconstructed for 85% of events up to a year old. On the other hand, the day of month was rarely successfully
recalled even for fairly recent events. For these reasons, it is important that the interface clearly reflects temporal cycles of days and weeks for email messages that are up to a year old.

**Implication 7: Present the days of the week.**
Day-of-the-week schema was found to be resilient to the lapsed time, at least for events that happened up to a year earlier.

**Support for knowledge of important dates**
Exact dates are often known for recent events. Landmarks are also commonly used in time estimation.

**Implication 8: Include exact dates in the timeline.**
Of events up to a hundred days old, 21% are remembered exactly. Figures for events up to a few weeks old are not available, but from the fact that the errors increase with time, we can deduce that a higher percentage of those dates would be exactly remembered. Since users most commonly handle recent mail, exact dates should be included in the timeline.

**Implication 9: Include salient events (landmarks) into the interface.**
Salient events or landmarks are frequently used as references when estimating time of an event. Such events may include cyclic events such as birthdays, anniversaries, and non-cyclic ones, such as the beginning of undergraduate or graduate studies, weddings and so on.

**Compensation for dating errors**
Dating errors increase roughly linearly, by about a day for each week lapsed since the event (Larsen et al, 1996). Also, dating errors are symmetrical around the correct date.

**Implication 10: Provide an option of having coarse granularities of time.**
For messages older than a year, exact dates are remembered only 9% of the time. Also, absolute dating errors increase by approximately one day for each week since the event. Since dating is more rough, we postulate that rougher granularity of time would leverage this increase in errors. However, the timeline itself should not be directly scaled, for reasons described in Implication 11. Rather, an option should be given to the user to view the entire timeline at a different level of granularity.
Implication 11: Do not combine several granularities in one timeline.
Absolute error for remembered dates is symmetrical around the correct date. Hence, the timeline should represent equal periods of time around each particular date, rather than be scaled linearly or logarithmically (e.g. fisheye views, by Yamaashi et al., 1993). For example, it is not recommended to represent the timeline at a level of day in one section and at a level of month in another. Rather, the entire timeline should be uniformly scaled.

Implication 12: Include more messages for older dates.
More messages need to be included for older dates, so that the increase in dating errors may be leveraged.

5.3. Design of the Timestore user interface

A lot of contextual information needs to be incorporated into the user interface (Implication 1). Since available cues prompt other cues, we should incorporate well-remembered characteristics of email messages into the user interface. In general, well-remembered components of any autobiographical event are the activity, the people involved and the place and time of the event (Implication 2). Assuming that the user will access his email from one or at most few locations, the ‘place’ component is not going to be sufficiently distinct from one message to another to serve as a cue for recall. On the other hand, ‘time’, ‘people’ and ‘activity’ have a straightforward mapping onto the email attributes:
- ‘people’ in email communication are the sender and the recipients
- ‘activity’ is the main topic of the message, which is typically but not necessarily the subject of the message, and,
- ‘time’ can be the time that the message was sent, received or handled in some manner (e.g. read for the first time).

Since availability of cues for recall is crucial for recognizing information, we will focus on the above attributes of email messages in the design of the interface for our email tool.

It is very interesting that the above attributes are commonly used by email tools to represent a message. That is quite fortunate, since our email system will be consistent with other tools in that respect and will reduce training time in our user study.
Time
Several systems developed for visualization of large data sets (e.g. Fertig, 1996; Alonso, 1998) also rely on time as the basic organizational principle. In the case of email, earlier work on Timestore shows that users find time-based organization compelling and desirable, at least after using the system for several weeks (Silver 1996; Yiu, 1997). These results go hand in hand with the study by Balter (1997) which shows that up to 28% of users file their messages by month or according to some other chronological order (Table 2.3.), and with findings from the literature review which indicates that time is one of the most important attributes of an email message (Implication 2). Hence, it is reasonable to preserve time as the principal organizational metaphor.

Sender
Two other attributes of events that are well-remembered are ‘sender’ and ‘subject’ (Implication 2). This finding is consistent with findings from field studies of email usage. A study by Balter (1997) showed that most users file their mail in more than one way. In particular, the most common organization of email was a hierarchy of folders labelled by subject, sender and time.

Organization according to sender is very straightforward, since every message has to have both the sender and the recipient. An additional advantage over the organization by subject is that the sender of the message is unique and remains consistent during email discussion, whereas the topic of the discussion, may evolve over time but subject might remain the same. Furthermore, if the name of a sender is recognized by the user, it can also serve as a prompt for recall of the user’s relationship with the sender, thereby introducing additional contextual information that may aid in email retrieval.

Subject
The idea of having email organized by subject is echoed by Whittaker & Sidner’s (1996) recommendation that messages “similar in content” be grouped together. In practice, however, this is difficult to achieve, for a number of reasons. Ideally, the subject of the message should accurately describe its content. In practice however, the situation is very different. Users often do not bother to construct subject lines that adequately reflect the content of the message. Also, a discussion of one topic may turn into a discussion of another, but the subject does not get updated. Some messages may also contain more than one topic.
Trying to come up with an appropriate description of the content is not any easier. The problem of determining computationally what the message is about is an extremely challenging one. Some researchers have been very successful in creating keyword extraction software (e.g. Turney, 1999) but such systems have mostly been designed for cases when the text deals with only one topic, for which the system needs to be previously “trained” on a set of documents. Since email messages might refer to a number of topics, results typically cannot be predicted.

An alternative to having the subject explicitly displayed is to allow the user to view subjects of the messages upon request. For example, the user could specify one or more keywords and initiate a search that would check the entire contents of the message, and then look through the list of messages returned by the search. In that case, the subject of the message does not need to be precisely formulated.

5.4. Organization of the display

With the above information in mind, we can proceed to organize the display. Our objective is to present as much useful contextual information as possible (Implication 1), and most importantly information about senders, subject and time pertaining to email messages (Implication 2). Presentation of time and sender in a two-dimensional display was shown in earlier work on Timestore to be helpful in message retrieval (Silver 1996; Yiu, 1997). In such a display, time is shown running along the horizontal, and senders along the vertical axis. Users liked this organization and found it more useful than the other email systems they used (Yiu, 1997).

The two-dimensional representation described above has the additional advantage of providing contextual information about communication patterns with each person that can help the user locate the desired message.

An issue that was not addressed in earlier studies, however, is the significance of social networks between the sender and the recipient (Implication 3). As discussed above, the ability to associate people with a place, event, organization etc. is a very strong contextual cue. The hypothesis in Timestore is that allowing people to organize senders in such groups will be useful for email retrieval (Figure 5.1.).
Figure 5.1. TimeStore interface. Groups of senders are clustered according to user-defined categories.

Furthermore, such two-dimensional organization allows us to exploit fully the ability to distinctly see both the sender and the date. In particular, the ability to point at the sender can be used to provide the user with more information about the sender. Similarly, the ability to select a date or a range of dates can be used to present to the user messages from those dates only in a compact list rather than the full view, which can be rather sparse if not many messages were received on those dates. In summary, the interface layout can be utilized to provide information to the user about a person, or to present different subsets of the mailbox to the user, with the goal of reducing the number of the messages dealt with to a manageable level.

5.5. Implications from memory research on time organization

In this section, we discuss how the horizontal axis, representing time, should be organized to reflect the corresponding processes in human brain that occur during information retrieval. We will discuss these issues in context of the two kinds of memory that are involved in handling email: autobiographical memory and memory of news events.
People are usually able to reconstruct time of autobiographical events, by relating lifetime periods, landmark events and other known information. The strategies that users would rely on in everyday situations will vary depending on the nature of their retrieval task and the availability of cues that make time reconstruction possible. As Table 4 suggests, time can be reconstructed for 85% of events up to a year old and 60% of events older than a year. On the other hand, time-estimates of news events are rather poor and need special support (Implication 5). Similarly, some contextual cues are lost with lapsed time, hence older autobiographical messages need special support too (Implication 4). Such a wide range of abilities warrants two different kinds of retrieval strategies:

- Relating messages to a timeline would help in retrieval of messages related to recent, autobiographical events, and
- A search tool would be useful in locating messages related to news events, for which few, if any, time cues are available, or for locating old messages, for which most of temporal cues may be lost. It would also be useful for searching by content of the message.

**Locating a message**

In a two-dimensional grid discussed above, the intersection of the sender and the date is a natural choice for representation of messages received from that sender on that date. When looking for a message information about the message content has to be made as easily accessible. Furthermore, the time to scan over messages and view messages represented by the dot should be kept at the minimum. The second requirement can be achieved by striving to keep the number of keystrokes required to access a message should be as low as possible. In our software, when a user clicks on a dot, a small window will appear, showing the subject lines of the messages the dot represents (Figure 5.2.). The choice of subject over other information reflects our earlier discussion about attributes of email that are most well remembered (Implication 2).
There are some differences in the way messages should be displayed, depending on how old they are. Recent days are well remembered, so in this case, each dot should represent messages from that day. Since the users mostly handle new messages (e.g., transcripts of user sessions from Yiu, 1997), this has been implemented in the current version of the interface. However, some errors are expected to occur for older messages, so more messages should be included for these days (Implication 12).

**Granularity**

Literature on memory strongly suggests that a week is the most important temporal frame. We hypothesize that it should therefore be the basic unit of temporal organization of our timeline. Consequently, the display needs to be designed so as to allow the user to implicitly know where the limits of the week are. In this display, weeks are separated by a darker band, representing the weekend. Besides Implication 6, this kind of representation also satisfies Implication 7, according to which days of the week need to be emphasized. We hypothesize that having this kind of visual representation allows the user to quickly tell which day of the week a certain message arrived.
Days need to be incorporated into the interface as well, since they are another significant temporal frame (Implication 6). But rather than only displaying them visually, they need to be associated with the actual calendar dates as well (Implication 8). However, week should be preserved as the most important temporal frame. To reconcile these two requirements, the display was designed so that the exact dates may be looked up if needed, but otherwise they are not emphasized. Rather, they visually "blend in" the week representation (Figure 5.2.).

**Searching**

As discussed earlier, email messages that are mostly informational are particularly difficult to locate, since they lack the context that aid in dating of autobiographical events. The situation with 'old' personal events is similar: over time, contextual information is gradually lost, so that dating errors for such events are very large. Hence, special support is needed for these events, since the organization outlined above is not very useful for message retrieval. What is needed in such cases is a way of making most of any information that may be remembered about the event. In particular, an appropriate tool in such cases seems to be a search tool, which would then single out the messages with the required information.

It is interesting that in a study that examined email usage, it was found that there is a correlation between the number of stored messages and the number of searches among these messages (Balter, 1998). In particular, the users with 940 or more messages searched through their messages weekly or daily (Figure 5.3.).

![Figure 5.3. Relationship among search strategies and the number of stored messages (Adapted from Balter, 1998). The more messages users have in their mailbox, the more often they use the search tool.](image-url)
In the study in question, the users were limited to a list-based display that is certainly more difficult to manage the larger the number of messages in the inbox. We therefore have to be careful before we assume that the same will be true in our case, since our interface is very different. However, based on the memory literature, we can hypothesize that a search tool will be required to locate those messages that are either very dated or for which little contextual information is available. What we will try to do in our user study is to estimate the frequency of searches in our interface and see how it compares to the above result. Our assumption is that the number of searches in our case will be lower, since the user will be able to retrieve more messages by utilizing the contextual information presented in the interface.

However, the purpose of the search tool is not simply to find messages with a certain keyword. Rather, it allows the user to search for the subject or topic of the message; in other words, it allows exploration of messages via the third characteristic of email messages, the subject or topic. Since the results of the search are displayed in the same time-based view, the users can still rely on other message characteristics (namely, time and sender) in their search.

In the context of email overload, the search tool can also serve as a filtering tool that will remove from view those messages that the user does not want to consider.

5.6. Further discussion on the user interface design

Message representation

At the intersection of time and sender, a dot is placed if messages were received from that sender on that date. The choice is partially due to the fact that the space where at the intersection of the sender and date is very small, hence the representation needs to be as simple as possible. In particular, representing a message by an icon, as suggested by Yiu (1997), would result in visual clutter if several icons were placed close together. Further, if more than one kind of icon were used, it would be hard to tell them apart, again, due to their inherently small size. The need for simpler representation led to choosing among simple geometric shapes. Of those, circle was chosen since it was aesthetically most pleasing to the eye (E.g. Aaron Marcus paper – include full ref.). Blue has been chosen for the read messages, since it is used by the Eudora commercial software, with which this system is integrated (more on that in the next chapter). Unread
messages are represented by lighter blue and a bright yellow star, which is, again, consistent with Eudora software. High priority messages are shown in red.

Some issues with the display organization

Earlier prototypes of TimeStore did not address some important downsides of the two-dimensional organization of the user interface. Firstly, this kind of display consumes a lot of screen real estate. In particular, as soon as the length of the list of senders exceeds screen height, the likelihood that users will miss some messages increases, as they will need to scroll to find the appropriate sender. In this version, we provided users with the ability to cluster senders together. We will need to establish, through the user testing, whether the ability to dock a cluster of senders from view (thereby also excluding a range of messages from the display) would reduce the screen size to a manageable level in most cases.

Figure 5.4. Timestore display. The current date has a thick red border, similar to borders used to frame the current date in the calendar. Placing the cursor over the dots shows the tooltip with the number of messages the person sent on that date. Unread messages are denoted by a yellow star. High priority messages are denoted in red. For consistency, name formatting is the same as in Eudora.
We also address the problem of screen space usage by maximizing the amount of screen real estate dedicated to the main view. In particular, in each view, we only show those senders from whom mail was received. An earlier prototype by Yiu (1997) showed all senders, which resulted in a number of empty lines. This approach carries a certain risk with respect to consistency and also the possible loss of contextual information coming from seeing a line containing no messages, so we will need to establish through user testing whether the saving in screen real estate is valuable. This prototype also introduces another reduction in screen real estate over an earlier prototype. In the earlier prototype, several lines at the bottom of the screen were reserved for display of message subjects, regardless of how many messages actually need to be shown (Yiu, 1997). In this version, we alleviate the problem by eliminating the lines at the bottom of the interface and overlapping the main screen with a new window that contains subject lines. Since not all information displayed on the screen is relevant to the sought message, we can assume that the loss of contextual information will be minimal in this case.

Another possibility for reducing the size of the screen real estate involves re-examining the two-dimensional approach. This discussion remains outside of the scope of this thesis. However, it is touched on again in the Chapter 9 on the Future Work.

**Incorporating more of the design implications**

There are certainly other ways to incorporate the set of design implications listed in this chapter. This thesis offers just one possible interpretation. Also, it is possible to implement other design implications to a greater degree as well:

- Implication 1 – including as much contextual information as possible in the user interface – has not been developed fully in this work. In the future, the user interface could be extended to include more information about users’ activities (see Chapter 9 for more discussion).
- Implication 9 – incorporating landmark events to a greater degree – should also be explored further in the future. In this version, inclusion of any such components would be hard to test because of the short duration of the user study.
- Also, according to Implications 10 and 11, different levels of granularity should be provided, but the timeline should not be scaled. A possible way to meet these two requirements would be to give users the option of zooming in and out of the interface as the need arises. This option was not implemented in this version because of the time constraints.
• Implication 12 – including more messages for older dates – needs to be refined further as well. This problem was also encountered during a user study with an earlier prototype: users often do not remember the exact date of the message, so they need to click on a number of dots in order to find the desired message (Yiu, 1997). Now, the memory literature indicates that dating errors are symmetrical around the correct date and that they increase linearly over time. Therefore, including subjects of messages from equal number of days before and after the represented date seems reasonable. How many days should be included is not clear, however. Clearly, the older the message, the greater the dating error and hence more messages should be included, but it is not clear how many days should be included per each period, nor even what these periods should be. On the other hand, it might be more useful to give users an option of selecting a certain range of days to be viewed, rather than pre-selecting these numbers for the users. All these options would need to be verified through future user testing.
The current version of the TimeStore prototype functions as an add-on to Eudora email client. Eudora is an email system with a significant market share, giving us a chance to access a wide range of users. There are a number of other advantages to this system. First and foremost, the implementation can leverage a number of Eudora's email handling functions, making the prototype construction significantly easier. The lack of such functionality in an earlier Timestore prototype was one of the major reasons why users did not use it much after the first few sessions (Yiu, 1997). Another problem was that during user testing, users had to switch email systems, which caused the mail downloaded using Timestore to be permanently stored in its folders. However, with Timestore functioning as a part of Eudora, users do not have to switch email systems nor worry about losing their email.

Relying on Eudora has some advantages with respect to user testing as well. User testing is more realistic, since users can handle their own email without having to worry whether they can entrust their entire email history to a new application. Otherwise, a complete reliable and robust email system would have to be built, which could consume person-years of effort. Furthermore, since the users have the option of using both Timestore and Eudora for their tasks, it will be very easy to see whether and to what extent would users choose the list-based view over the visualization view given the two-process model of email.
Yet another advantage of relying on Eudora’s mail is the possibility of porting Timestore to other platforms. Since Eudora folders are identical on both PCs and Macintoshes, and since the bulk of Timestore is implemented in Java, porting the software to the PC would be straightforward.

Furthermore, Eudora’s folders are similar to Netscape’s, so that Timestore can be extended easily to work with Netscape as well. Ease of adaptation to other applications means that we can carry out more comprehensive user studies in the future.

Using Eudora has some disadvantages though. From the developer’s perspective, interfacing to Eudora poses a number of challenges. Eudora’s internal data structures, including important
information about messages (e.g. message status), are not available to outside applications. This poses problems for the update of the Timestore display since Timestore has to wait until Eudora has written out the new status to the disk. (This happens with a delay of several seconds.) Also, Timestore cannot know whether any message information has changed once the focus has been transferred to another application, so that essentially the entire display needs to be reconstructed every time the user switches back to Timestore. Although a significant delay was not encountered during the period of Timestore’s use in trials, this operation is very costly and might slow down Timestore’s performance in the future, for example if new functionality is added. Another disadvantage is that we have no influence over Eudora’s functionality nor its user interface, which limits the possibilities for experimentation with the user interface of the combined system. For example, it would be useful to add a button to Eudora that would display the messages in Timestore view. However, Eudora’s interface to other applications does not allow such extensions. Similarly, we may wish to include the text of the message in the pop up box containing subjects of messages in order to minimize the number of keystrokes required to view a message. But then, we would need to include shortcuts to Eudora’s message handling functionality (e.g. reply, forward, delete functions), which would seemingly duplicate the functionality of the combined system and could pose interaction problems.

An earlier version of the TimeStore interface was implemented in Tcl/Tk, with the back-end functionality written in C (Yiu, 1997). In 1998, Tcl/Tk was abandoned by Sun Microsystems in favour of Java, so we could no longer rely on Tcl/Tk for our user interface. A decision to use Java instead was made because of its rich library of UI components, and the fact that Java code is portable across platforms. Implementation in Java offers a number of advantages. The core functionality of Timestore is implemented in Java and hence is platform independent. This includes components of the interface to Eudora as well as the GUI, which takes up most of the Timestore code. Furthermore, due to Java’s object-oriented design, the code is modular and may be easily changed. This is very important for any future experimentation with the interface. In particular, changing properties of table columns, table headers and cells is straightforward now that the appropriate renderers have been written. Also, code that handles numbers of clicks on components of the interface is modular as well, so that new functionality may be easily added.
6.1. Overview of the system

As shown in Figure 6.1, Timestore consists of several components: the user interface, search engine, and the integration code. The integration code is responsible for interfacing between the Java front-end (GUI) and Eudora’s mail files, as well as for interfacing between the front-end and the search engine.

The main user interface is implemented in Java, using the Swing libraries of interface components. This allows for an easy portability of the user interface across platforms. More details about the implementation of the user interface will be given later in this chapter.

Although Eudora provides an API for other applications to use, the set of functions offered is very limited. Therefore, Timestore has to rely on Eudora’s mailbox files to construct its display. Eudora manages these files in a slightly platform specific way, so the code that reads them needs to be platform specific as well. Consequently, C was used for this purpose. Fortunately, Java’s JNI library provides a way of using native C code in Java’s applications. Through this library, we were able to access data structures created in C, which contain essential information about each message.

![Figure 6.2. Overview of the TimeStore code.](image)

A major advantage of using C for handling the integration is its great speed. The integration code contains complex functionality, so fast performance is essential. The downside of using C is that
porting TimeStore to other platforms will require slightly more effort. However, the code that does this conversion does not use any platform-specific functions, and hence the port should be straightforward.

The search engine included in the software is written in C, again for performance reasons. As before, the code should be easily portable to other platforms since the version of C used is a standard one, and no platform specific functionality is used. More details on this component will be provided in a later section of this chapter.

**Communication between TimeStore and Eudora**

At startup, messages are loaded from Eudora's TOC files\(^3\) sorted and displayed in the main user interface. An important issue was ensuring that email messages in TimeStore are synchronized with these files.

![Diagram of communication between TimeStore and Eudora](image)

**Figure 6.3. Overview of the code integrating TimeStore and Eudora.**

\(^3\) TOC files contain basic information about email messages in one folder, such as the subject, time, location in file, length, status of the message, etc. Actual email messages, including the header and the entire body text, are located in a different file.
Eudora loads its TOC files during startup, or creates them if no such files exist⁴. They are frequently updated during the period when Eudora is in use. In particular, new TOC files are constructed whenever the user resorts messages, downloads new messages or deletes old ones.

In order to use the information in the TOC files, Timestore constructs a "parallel" list of objects, where each object points to a specific entry in the TOC file. This list is constructed so that it is independent of the ordering of the TOC file. Now, for each mailbox file, Eudora creates one TOC file, and Timestore creates its corresponding list of objects containing information about each entry in the TOC file (Figure 6.3.) In order to keep track of the entire mailbox, one additional list, containing pointers to Timestore's list of pointers to TOC files, is constructed. (Figure 6.3.). This list is sorted by chronologically, and handed to the Java code to be displayed in the user interface.

**User Interface**

User interface consists of Swing components, extended and customized to create the desired look. In particular, the table showing senders and time is an instance of a JTable class. Special renderers were written to customize the table cells and table headers. A separate class serves to encapsulate properties of senders, such as their email addresses, phone and fax numbers, etc, as well as the list of messages associated with each sender.

The main display depends on the final list of pointers to TOC files, as described in the previous section. For simplicity, we can assume at this point that we have a simple array of pointers to Eudora messages. This array is then sorted in the manner depicted in Figure 6.4, in order to facilitate the display of information in the Timestore view.

Briefly, the main array in the user interface contains a list of senders. Each sender in the array contains an array of messages. Each entry in the array of messages contains messages from one day. Since there may be more messages from one sender on one day, the arrays of messages actually contain another array (Figure 6.4.).

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⁴ New version of Eudora does not use TOC files by default, but allows their use for backward compatibility. Since Timestore is intended for visualization of large amounts of email messages (e.g. email archives), it is adapted to use TOC files. This means that if the newest version of Eudora is used, the option to use old TOC formats must be selected from the 'Preferences' menu.
To allow clustering of senders, an additional class, called SenderGroup, was created. Each instance of this class contains pointers to senders in the sender list. Also, each sender stores a pointer to the SenderGroup it belongs to.

**Search Engine**

TimeStore implements its own search engine since the results of Eudora’s search are not available to outside applications. TimeStore’s search engine allows full-text searching of Eudora’s email files, including the entire contents of messages. It allows searching for a single word or a phrase, as well as boolean combinations of words and phrases.

The search engine is implemented in C. This was necessary for performance reasons: the process of indexing of mail is very computationally intensive, and requires a lot of writing and reading.
from hard disk. If the search engine was implementing it in Java, it would certainly be much slower.

The data used in full-text search is structured as per the above figure. All words in all email messages are sorted alphabetically, and stored together with token ID of each word. These IDs are converted to the actual file offset through the conversion table (Figure 6.5.). The list containing all words is partitioned in blocks containing 128K of bytes each. A separate list, called 'the map', keeps pointers to the beginning of each block, as well as some information about the first entry in the block.

When a search is initiated, the map is searched to locate the block within which the particular string is located. Then the block is accessed and searched. Thanks to the ordering of blocks, the
search returns a list of token IDs, that is then converted to the file offsets. To actually determine to which messages these offsets belong to, information about the array pointing to the TOC files needs to be consulted (Figure 6.3., 6.4.). However this array is ordered by time, and cannot be resorted since it is still needed for the main display. To work around this, a new set of pointers is created. They still point to the TOC files, but they are sorted by offset of messages in the file. A search of this array then gives us the location of the actual message.

As mentioned before, building indices is very costly, since lists of tokens need to be sorted, written to files and then merged again, and reading and writing to files are very costly operations. To optimize the use of indexes, they are initially created for each mailbox file and stored for subsequent uses. The index is rebuild only if the file is changed. However, for mailboxes that are updated frequently, such as the inbox, creating the index for full-text search is not suitable, as the indexes would need to be frequently rebuilt. Clearly, if users face long delays when trying to use the search, they will resist using it. Hence, we have also written a function that performs linear search, and does that at a speed comparable to Eudora’s (tested with 30,000 messages).
7.1. Objective

The objective of this study is to determine whether the email software described in the earlier chapters of the thesis makes management of email messages easier. A comparison is made between Eudora alone and the combination of Timestore and Eudora software. The assumption is that the users of the email tool will have a large number of email messages in their mailbox.

7.2. Overview of the user study

Participants

The study was carried out with 5 participants. All but one of the participants for the study were drawn from the undergraduate/graduate students and employees of the University of Toronto. All participant use Eudora software for reading their email along with other email applications such as Netscape and MS Outlook. All participants except the pilot user (User 1) have more than 1000 messages in their inbox. All participants are friends or acquaintances of the author.

Protocol

The user study took place over 3 sessions held 5-7 days apart. Users worked with their own email.
Obtaining consent
Before the first session, the purpose and method of the study are explained to the participants in plain language. They were assured of the complete confidentiality of the data collected. They are also informed that they may terminate the session at any point during the study, and ask questions at any point before, during or after the study. The participants are told that they would be videotaped while using the software, or that, alternatively, the session would be recorded using a tape recorder. At this point, those participants willing to proceed with the study are given a copy of the consent form. All participants agreed to proceed with the study. None of the participants objected to being videotaped.

Preliminary interview
The participants are first asked to answer some questions in a preliminary interview. In the first part of the interview, they are asked for some basic demographic information about themselves. In the second part, they are asked about their computer experience and the nature of their interaction with email.

First session
The first session starts with a short training period, during which the system interface is presented to the participants. The participants are then asked to use the software to handle their email as they normally would. They are also asked to think aloud while using the software. Their interaction with the software is observed, and notes of the interesting user comments or actions recorded. Unexpected interactions with the software are followed up by questions intended to find out what kind of response did the participant expect to get.

Second session
The second session is held approximately 5-7 days after the first one. In the meantime, some changes proposed by users are implemented. In this session, participants are given a list of short tasks to carry out. They are allowed to use both Timestore and Eudora software, whichever they found more useful. The objective of this session is to note when the users rely on Timestore, and when on Eudora. The participants are asked to think aloud while carrying out the tasks. Their interaction with the software is observed, and notes of the interesting user comments or actions are recorded. Also, questions about the email software that did not assist in completing the task are answered (there were no situations in which the participants required assistance in that regard).
Third session
The third session was held 5-7 days after the second one. The intention was to let enough time to lapse so that the participants may forget any strategies that developed or learned by carrying out the tasks in the previous session. We also wanted to have sufficient time to implement any additional suggestions the participants may have.

In this session, the participants are instructed to freely interact with their email messages. They are also asked to describe the actions they were taking. Their interaction with the software is observed, and note taken of any interesting comments or observations.

After the third session, the participants are asked for feedback on utility of the software. They are also asked to share any other comments or suggestions for improvements they might have.

Initial Interview
This interview serves to establish some basic characteristics of users, such as their level of education and the level of their computer experience. Also, we want to find out how they organize their email messages, and if such organization is suitable for subsequent retrieval. To that end, they are asked questions aimed at discovering any problems that they might have when trying to find messages. The interview is exploratory in nature, since not all problems can be foreseen, and not all questions are applicable to all users. Some questions are same as the ones used by Yiu (1997) and Silver (1996). The list of questions is presented below.

Demographic information
1. Age range (21 or younger, 21-35, 36-50, 51 or older)
2. Gender
3. Highest level of education (high school or less, some post-secondary education, university or college degree, post-graduate education)
4. Occupation
5. How many years have you been using computers?
6. How many years have you been using email?

Questions about email usage
1. Which systems, besides Eudora, do you use?
2. Of those, which do you use the most? Why?
3. How many messages do you typically receive every day?
4. Of those, approximately what percentage do you a) save for future reference, b) delete immediately?
5. Which messages do you save?
6. Which do you delete?
7. How do you organize the messages that you save? (e.g. most messages kept in the inbox, filed by subject, time, sender etc.).
8. How many messages, approximately, do you have in your inbox?
9. How about in the other folders (except 'Trash' and 'Sent')?
10. How many of these folders do you have?
11. How much time, approximately, do you spend every day handling email?

Questions on Email Retrieval:
1. Do you ever delete stored messages. If yes, which messages do you delete? How often do you delete them?
2. How often do you need to find a stored message?
3. Can you give me an example or two of stored messages that you retrieved?
4. How do you find these messages?
5. When do you use a search engine?
6. Have you encountered difficulties when looking for an older message? If yes, what kinds of problems did you have?
7. Were you ever in a situation where you knew which information you wanted to find, but could not formulate the search? If yes, please explain.
8. When you encountered problems in retrieval, were you able to find the message? How long did it take you to find it?

Answers to these questions are given in the Appendix A.

Tasks
These tasks were designed with the goal of determining how the users find older messages. The reason for including these tasks is the fact that when users handle their messages freely, they typically only access very recent mail (e.g. transcripts of user sessions in Yiu, 1997). In order to examine how the users would use Timestore to locate old mail, we have two options:
1. Give the software to people to freely use over a long period of time, log the sessions, and analyze them later.

2. Try to emulate the real usage situations through specific tasks.

The first study would certainly provide more reliable results than the second one. However, there are many difficulties with this approach. First, the study would need to be carried out over a long period of time, as users have indicated, and transcripts of user sessions confirm this, that old messages are accessed very irregularly. In the context a M.Sc. thesis, such a study is simply not feasible. Second, the users would need to use the software in the way they normally do, which poses many problems as far as logging of user sessions is concerned. If all messages are logged, and it would be hard to create a logging tool that would stop recording once a message is opened, than this raises many concerns about privacy, especially in the workplace. On the other hand, if the study is carried out with users' personal (home) mail, than results may well be inconclusive, since presumably these messages are treated differently than those at work. In particular, one may rarely want to locate an old personal message; indeed, when asked for an example of an old message they retrieved, users typically referred to a message they needed for work. Furthermore, logging of users interaction lacks a significant piece of information: knowledge of what it is that the user is looking for, and what information he/she has in mind when trying to initiate the search. This is a major obstacle, since knowing which information the user wants to locate is crucial in constructing a useful retrieval tool.

Using tasks, of course, has some shortcomings too. The search process is simulated, and may not be the same in practice. Tasks may not capture the real usage situations. However, the tasks may be designed so as to include a wide range of search situations, which may not arise during a real-usage study, because they are inherently limited in time. Tasks are used in this thesis since they are particularly suitable for short-term user studies such as this one.

The list of tasks used in this study is below. They were designed so as to be applicable in a large majority of cases. In other words, the situations described below are presumed to be very common. They also ask for messages that were received between 3-4 days ago and one year ago. The messages specify a time frame that reflects the increase in dating errors as described in the Chapter on autobiographical memory. For example, one message refers to “a week or two ago”, and another “6 to 12 months ago.” The tasks were purposely arranged so that the time period
required appears random. We did not want the tasks ordered so as to progress from say, most recent to the oldest or vice versa, since we did not want the users to progressively move in one direction.

Also, some tasks ask for a specific person, while others refer to a message in general. Clearly, Timestore has an advantage over list-based systems in that messages are automatically sorted by both sender and date. On the down side, accessing subjects of messages is not as straightforward. By sometimes asking for the name of the sender and other times not, we should be able to gain some insight into how people generally approach the process of finding messages.

One of the tasks asks the user to specifically look for a message that they actually need to find. We wanted to see how the participants go about finding such messages, and also what kind of messages will they want to find. To make this process easier, they are asked to think allowed as they carry out the task.

1. Was there someone who wrote to you a week or two ago, but you didn’t get a chance to reply to him/her? Find the message that you need to reply to.
2. Think of a message that you actually need to find. (Some suggestions: a message with a certain URL, information about a project, a job posting, someone’s contact information…). Find the message.
3. Think of an interesting message that you received in the past few days. Find the message.
4. Find a message announcing a meeting or a seminar that was to be held between 6 and 12 months ago.
5. Think of a person that often sends you mail. Find a message from that person that you received 3 or 4 months ago.

The transcripts of these tasks may be found in the Appendix B.

Since the intention is to compare when the users would rely on Timestore and when on Eudora, both were located on the screen before the beginning of the session. Also, the list of tasks given to the user explained that they could use either software for task completion. The same was reiterated verbally before the beginning of the session.
Final Interview

Final interview serves to gather users’ impressions of the software after they have used it to handle their email and carry out tasks. The list of questions follows below. Some of these questions are the same as those used by Yiu (1997) and Silver (1996).

1. For what types of tasks did you use Timestore? Was Timestore useful for those tasks?
2. For what types of tasks did you assume Timestore would not be useful, so you didn’t use it?
3. What are the things you most liked about Timestore?
4. What are the things you least liked about it?
5. Did you find the time-based organization useful? Why?
6. What about the sender-based organization… Did you find it useful? Why?
7. Do you think the ability to group senders would be useful to you? If yes, how would you group them? If not, why not?
8. Overall, do you think you would use Timestore on a regular basis?
9. Do you have any other comments about the interface, or suggestions for improvements?

Answers to these questions may be found in the Appendix C.

7.3. Initial interview results

General user characteristics

All participants are highly educated (all have at least a university degree) and are in the 21-35 age range. All use Eudora for reading their email, although none of them use it as their primary email software. All of them have been using computers and email for three or more years. All but one have more than 1000 messages in their inbox. Some of these users are friends of the investigator.

The size of users’ mailboxes ranged from 78 to 1700 messages. Users received between 4-5 and 100 messages per day. Four users saved most of their email (70% or more), while one user deleted 90% of her email. A possible reason for this difference is that the latter user is the only student in the group, and by her own admission, “does not receive a lot of important mail.” Other users save most of their email, and this email is typically work-related.
Users’ interaction with email

Users’ email organization strategies were very diverse. The user who received few messages and deleted most of them did not have any folders. The three users who had approximately 1100 messages reported relying on a project and sender-based folder hierarchy to organize their mail. And the user who had most of the mail (1700 messages) reported that she gave up filing because it became too difficult to organize all the messages in the appropriate folders. She still has some old folders, but most of her mail is in the inbox.

The users spend anywhere between 1 and 4 hours per day handling their email.

They also reported significant number of problems during message retrieval. Two users said that they cannot use search tools, because the number of returned results would be too large. Two users reported that they were sometimes not able to find messages they were looking for. Another two reported that they typically spend a lot of time searching for messages.

7.4. Results of the user testing sessions

This section summarizes the results of the three user testing sessions. In response to the user feedback, several changes to the interface were made. In particular:

After the first session:
- The red border was added around the current day in order to make it more apparent.
- The number of clicks on a dot required to open the pop-up box was changed from two to one, in order to be consistent with the number of clicks required to open messages.
- The icon representing a new message was slightly changed. One user thought that the original “sparkle” on the icon looked too much like an asterisk.

After the second session:
- Additional window update functionality was added. In particular, after this change, the Timed toast view would get updated for checking whether a status of a message changed while the message was handled in Eudora.
- The colour of the background for the list of senders was changed to differ from the white background of the message list.
First session

Users were not prompted for any immediate feedback. All comments summarized below were volunteered by the participants.

Users' first impression of the software were positive. Four out of five participants commented that they like the interface and that they think the software would be useful for finding their email. One user commented that she liked the fact that Timestore will "organize" her messages by two criteria rather than the standard one.

Some comments were interesting. Two users said they liked the software because it reminded them of a particular computer game. Three users used the term "calendar" to refer to the interface. This is particularly interesting since one of the users in the study by Yiu (1997) said that she wished the interface "seemed more like a calendar."

Timestore also received some critiques. One person commented that she would not use Timestore as primary email software, as she thought that not enough detail about messages is provided for recent mail. However, she said that she would use it to find archived mail. Another user opened an unread message using Eudora, and commented that there was a problem with Timestore since message status was not changed in Timestore. (Eudora takes a few moments before it writes the data to disk). Two users also admitted being confused as to the extent of integration of Timestore and Eudora. They thought of the two applications as separate, not integrated. One commented that she would expect to see a button or a menu option in Eudora that would take her to the "Timestore view".

Second session

In the second session, the users carried out tasks provided by the author. All users carried out the tasks without any problems or delays. They mostly used Timestore to locate messages. One user relied on Eudora when she wanted to find a message by subject. Another did so after being reminded that she can also use Eudora to carry out the tasks, but she closed Eudora and switched back to Timestore as soon as she completed the task in question.
Task 1
This task asked if there was a person that needed to be replied to. As expected, all users except one quickly came up with the name of the sender, and found the message almost instantly. One user thought that she replied to everyone, but did think of the person in the end. After that, she quickly found the message. All users relied on Timestore for this task.

Task 2
This task asked the users to locate the message they actually need to find. The result of this task were very diverse. One user wanted to find an announcement, another wanted to find a certain email message and the third wanted to find a contact information about the person. Of the remaining two senders, one wanted to look up a message sent that day, and one wanted to locate a message sent the previous month.

What was particularly interesting is that four users relied on Timestore for this task. The user who wanted to find the announcement could not remember who the message came from, and used Eudora. The remaining four users knew who the sender was and were able to locate the desired message fairly quickly. Of these four, one used the search engine and the other three relied on the user interface.

Task 3
This tasks asks users to find an interesting message received in the previous few days. As expected, the users knew who the sender was and relied on Timestore to locate the message. Two users, however used the search to filter out the messages first.

Task 4
All but one users relied on Timestore for this task. The one who used Eudora did so after she was reminded that she may use Eudora for some of the tasks. In all cases, the users used the interface to scroll back to the desired period. One user changed his mind and tried searching for a keyword instead.

Task 5
All users relied on Timestore for this task; four navigated through the interface, and one searched for the name of the person. After he realized that he got more messages that way, he closed the search window and used the interface to find the person. They scrolled to the period in question
and found the name of the person they often get email from. This task was completed very quickly in all cases.

**Third session**

The third session was reserved for free handling of email, followed up by a final, post-study interview. During the user session, some users reiterated some of their earlier objections regarding interaction. Some users shared some more ideas, but in general, there were fewer such ideas than in the first session. The focus of this session was the post-study interview, the results of which are summarized below.

**7.5. Final interview results**

The most important result is that four out of five users said that they would use Timestore on a regular basis to handle email messages. The remaining user said that she would use Timestore provided some requirements are met: she wants to be able to click on a URL and view attachments (both are Eudora’s functionality).

Of the four participants who liked Timestore, one repeatedly stated throughout the study that she wished she had this software available at her last job, when she had to manage large amount of email. Another asked for a copy of the software.

Overall, the users relied on Timestore for a number of tasks. They mostly read and answered recent messages. All users said that Timestore was useful for those tasks. One said that Timestore lets her view larger amount of email at a quick glance, whereas in Netscape or Eudora she would have to scan a long list of messages to view the similar number of messages.

The users liked the visualization very much, as well as the colours and icons. They like being able to skim their mailbox very quickly and access a large number of messages directly. Two users were confused about the way Eudora and Timestore are integrated. Two also did not like the way the pop up box was implemented. During the study, many users failed to close the pop up boxes.
7.6. Discussion of results

The current version of Timestore was very well received by the users. The users praised the visualization and found it useful for the tasks they carried out during the periods of free email use. This was slightly surprising, since in these sessions the users mostly handled recent email, and Timestore does not provide a compact view of recent messages. However, it seems that the number of messages people receive daily has grown so large that even a list-based view has become too cumbersome.

All users liked the ability to organize the senders into groups. As expected, they thought that it was a good way to reduce visual clutter in the user interface. They did not have a chance to use Timestore for prolonged periods of time, but even so during the periods of free email use the users created sender groups to categorize people. When asked which sender groups they would have, four users listed at least four groups. One said that she would have all senders categorized in these groups.

Some results were not as clear as we had hoped for. In particular, the search functionality was not used very much, except by two users who frequently search for messages, and another who simply tried it out. Of those who did not use it, one said that she would not need to search because she thinks that she would be able to find the messages using the Timestore interface. The other was convinced, as per her earlier experience with the search engine, that the search would not yield useful information since most of the keywords and people are the same from project to project. However, the user who relied on the search engine to complete all of his tasks was very satisfied with how it works. Another, who frequently searches for messages, said that the way it was implemented was very suitable for her, since she normally types in a keyword to filter messages and then scans anyway. She liked the fact that she did not need to type any information apart from what she is looking for.

It is important to note that several factors may have influenced the results. First, the fact that the author knows all participants may have skewed the results towards more positive. Second, the novelty of the software might have caused users to use it more than they would in practice. On the other hand, the fact that the users do not use Eudora as their main email software was probably not a factor, for several reasons. First, all other email clients the participants use offer the same, list-based view of messages and the same basic email handling functionality. In fact,
most users demonstrated, when handling email messages freely, that they were comfortable with using Eudora. They replied and forwarded the messages, changed the message status etc. Also, Eudora was not needed in the study except in the second session where only the usage of the list was anticipated. In that case, before the participants were given a list of tasks to carry out, both Eudora's list of messages and the Timestore view were shown at the screen, and the users were told clearly that they had a free choice of the view which they wanted to use. The same was written on the handout containing the list of tasks to be completed.

Overall, four out of five users said that they would use Timestore on a regular basis. This result is certainly encouraging.

7.7. Lessons learned about methodology

Videotaping
During the study, users’ interaction with the software are observed and the users are videotaped. This strategy has its advantages and disadvantages. On the positive side, the investigator is able to ask users to explain what kind of response they expected when they performed a certain action. A lot of valuable feedback about the interface – especially information about user interface standards – was obtained in this manner. On the negative side, most participants are fairly self-conscious in front of the video camera and hesitate to keep their email opened for more than a few seconds. One user in particular turned to the video camera at one moment to explain why the text she was typing was underlined in red (it was in a language other than English). Users also hesitated to type responses that are longer than just a few lines, even when it is clear that the message they are responding to requires a longer response. It is possible that conducting the user testing in a location other than the one where the users typically access their email contributed to the users’ discomfort, as the users who handled email at their workplace generally seemed more relaxed. Moving to another location was necessary in case of three users: one had a very slow Macintosh with an old operating system that did not support Java (User 1). Users 2 and 3 had PCs at home, and their Eudora files had to be transferred onto Macintosh so that the software could be used.

Location of the testing sessions
As noted above, when testing was done in a location other than one where they typically handle their email, the users seemed more ill at ease. Ideally, the studies would be carried out at the
users’ natural setting (work or home), but this poses some problems. First, gaining access to one’s workplace is difficult. One user in particular was not willing to use the email he keeps at work for user testing, since this mail is considered “proprietary information”. He was unwilling to transfer the mail onto his computer at home, since he was worried that “administrators at the company would think something strange is going on” if he starting downloading all of his email (he has about 35,000 messages at work taking up over 300 megabytes of space). Consequently, the testing was done with the email he has at home. Second, a lot of companies have a policy in place whereby any software that is to be used must first be approved by the appropriate department, which poses additional difficulties for conducting user testing at the participants’ workplace. If possible, future user studies should be carried out in the users’ natural setting, so that more real usage situations are incorporated into the study.

**Work-related or personal email?**

As noted in the preliminary interview results, there are large differences in the way personal and work-related email is handled. In the future, it should be ensured that the type of email that is being used is consistent across users. Under the assumption that more email messages are stored for the intended future use in the work setting, subsequent user studies should ideally rely on user’s work-related email.

**Adapting design to users’ feedback**

This study was also somewhat unusual in that the test sessions were held approximately 5-7 days apart. The reason for this is that we wanted to implement some suggestions from the users before the following session would take place. This kind of study was successfully used by Rubick (2000).

Incorporating users’ suggestions had a very positive impact on the kind of feedback provided. In particular, users were a lot more willing to share their comments and suggestions when told that previous users’ suggestions were incorporated into the system. Users seemed pleased when told that a certain characteristic of the program would be changed in response to their comments.
7.8. Summary

Overall, the users like the email visualization offered by Timestore and 4 out of 5 would use it to handle their email on a regular basis. However, some users were confused about the interaction between Eudora and Timestore.

The software evaluation strategy used here is useful for obtaining qualitative feedback about the interface. Also, the users liked to see their suggestions incorporated into the design. Knowing that other users' suggestions were incorporated also encouraged users to offer more suggestions of their own. Some shortcomings to the evaluation process were identified as well. In the future, it should be ensured that the kind of email used in testing is consistent across users. Whenever possible, the testing should be carried out at a location where the users typically handle their email, so that more realistic usage situations may arise and so that users' discomfort is minimized.
8.1. Literature review

This thesis provides a summary of literature on autobiographical memory related to retrieval of events. Although it is primarily concerned with a design of an email system that assists in email retrieval, the overview of relevant literature provided herein and a discussion of its implications for retrieval of messages may prove useful to others as well. In particular, those who wish to utilize properties of autobiographical memory in the design of retrieval systems may find useful information in this thesis.

8.2. User interface design

The set of design implications that stemmed from the literature review should prove useful in future work on Timestore and other email management software. Also, the current version of the Timestore prototype illustrates how these implications may be incorporated into such user interfaces. The current prototype has practical value as well; the participants in the user study have indicated that it helps them in management of email.
8.3. Implementation

This version of Timestore is one step along the way in building software that would allow users to find a message among a large number of messages, and was designed to make any future refinements easier.

Previous work on Timestore has included a prototype built by Long, which was subsequently refined and evaluated by Silver (1996). This work showed that the time-based and sender-based organization is useful for message retrieval. Next, Yiu (1997) created a new version of Timestore prototype, incorporating suggestions from Silver (1996). Unlike the earlier prototype, which functioned as an add-on to Eudora, Yiu’s system was a self-contained email client. However, as time passed, users used Timestore less frequently. As one user noted, missing features caused him to alter his normal way of using email, and at times he was less motivated to use Timestore (Yiu, 1997).

Integration with Eudora

As a result, this version of Timestore was designed so as to utilize the features supported by Eudora, popular email software. Results of this decision were clear: none of the user commented that Timestore was missing any of the features that they typically used in email management. Another problem highlighted by Yiu (1997) is the one of synchronization of data. The messages downloaded in Timestore were not immediately transference to the other application, nor vice versa. In this version, no data needs to be transferred between applications, since Timestore simply reads Eudora folders and displays them in a different view.

Portability

Moreover, the core functionality of Timestore is platform independent. This includes the GUI, which takes up most of the code, and components of the interface to Eudora. Moreover, Eudora TOC files, which contain information about each particular message, are identical for Macintosh and PC platforms. Hence, we have created a prototype that may be easily ported to other platforms. Furthermore, given the fact that the code is modular and that message information is similar for most email applications, Timestore may be adjusted to handle email by various applications as well, if the need for that arises. In particular, if a more extensive study needs to be carried out at any point, involving more users and different email applications, Timestore may be easily adjusted to satisfy these requirements.
Modularity

Another advantage of using Java needs to be stressed. Due to Java's object-oriented design, the code is modular and may be easily changed. This is very important for any future experimentation with the interface. In particular, changing properties of table columns, table headers and cells is straightforward now that the appropriate renderers have been written. Also, code that handles numbers of clicks on components of the interface is modular as well, so that the existing functionality may be easily changed, or new functionality added.

8.4. User testing

The study carried out as a component of this user testing extends the earlier work to examine, through tasks, strategies that people use to locate older messages. As interviews and transcripts of earlier user sessions show, when people freely use email, they tend to focus on the most recent messages. In this study, we have asked users to describe examples of older messages they needed to retrieve, and also to carry out a set of tasks that ask them to locate messages between 3-4 days and one year old.

Another fairly novel user testing strategy, used previously by Rubick (2000), was incorporated into the user testing. Improvements to the software were made between user testing sessions, so that user could see the effects of their recommendations. Although, due to resource constraints, only those recommendations that did not require a substantial number of person-hours could be implemented, the results were clear. Users appreciated seeing their suggestions incorporated into the interface. Also, when told that certain features were included because other users have suggested them, they were more likely to provide suggestions of their own.
The work outlined in this thesis can be extended in many directions.

9.1. The current prototype

Some possibilities for future work on the current TimeStore prototype are listed below.

A long-term user study

In order to better understand usage patterns and the nature of users’ interaction with the time-based view, it is necessary to carry out a long-term user study. The reason for this is that a short-term user study will examine only a small number of real usage situations, and will identify fewer areas for improvement than a long-term study. For example, allowing users to mark a message as important might be sufficient for the success of its subsequent retrievals during a short-term user study, but only a longer study might show if the same would hold over the long-term, or were the users, for example, able to find the message only because it was still fairly fresh in their minds. Carrying out a long-term study can therefore provide us with better understanding of the software’s strengths and weaknesses.

An exploration of the full-text search approach

Since the TimeStore interface was shown to be a useful one, a user study re-examining the current implementation of search process might be very valuable. As discussed earlier, a usable search interface is crucial for finding messages for which little contextual information is
available. Now, formulating a search query in such situations might still be difficult if little is remembered about the message sought: the user might not be able to formulate exactly what she or he is looking for, or worse, might try searching by a key that is a synonym of the word that appears in the text. In such situations, providing the search engine with some “intelligence” might result in an interface that’s a lot more usable. Certainly, this extension has potential for some multidisciplinary work.

A study of user preferences

Another possible study that would improve the current interface would involve users in a discussion of aspects of the email message they deem important. This information could be useful for any refinements of the current interface design. In addition to basic properties such as subject, sender, time and the recipient list, possible properties could include information such as whether the user has replied to the message, what the next message in the thread is, was there a particular context for this message (e.g. was it a part of a conversational thread). This kind of study would also point out any components of the interface that should be excluded or included, as well as if an existing component of the should be made more apparent.

Relationship between search and browsing

Relationship between searching and browsing could be explored in further detail. Right now, a search is performed on the entire mailbox, regardless of where in the interface the user is located when the search is initiated, and the results obtained are the same. However, it might be possible to interweave in searching and browsing, so that the user’s location in the interface and actions that preceded the search gives additional information to the search engine, which can then formulate the results of the query in an appropriate way. Such communication between searching and browsing can perhaps be taken further to make the retrieval process simpler.

Determining which subsets of messages are useful

There is some room for exploration of alternative viewing options. For example, an option of seeing a subset of messages in a compact list might be a better solution in some cases. For example, if the user does not have many messages in the mailbox, he or she would have to scan a large, possibly very sparse list in order to locate the desired message, in which case a compact list of messages may be more appropriate. Also, some users might wish to be able to see all messages sent on a particular day or during a certain time period in a compact list. Others may wish to look
at messages from several senders only... In general, carrying out a user study with a goal of determining which viewing options are most commonly desired would provide very valuable information for improvement of this prototype. Any such study would have to be long-term, so that real usage situations dictate these suggestions.

**Minimizing real estate use**

A major drawback of the present two-dimensional user interface is that it consumes a significant amount of screen real estate. The list of senders exceeds the length of the screen when the number of senders reaches about 30. Clearly, reducing row height or the font size can only go so far. What is needed is a way to reorganize the display so that meaningful information is shown, but the real-estate is still preserved. A starting point could be the realization that when the user is looking for a message is sought, he or she will only find a small subset of the messages actually useful in their search.

One possibility is to take clustering of senders one step further, and allow the user to hide *other* information from view when examining messages from an expanded group of senders. At the moment, clusters may be collapsed and expanded, but all other senders are still displayed. For this approach to be useful, we need to show that hiding of other information will not result in loss of important contextual information, and also that the sought message can reasonably be expected to appear among those shown together.

Since only as subset of the senders is displayed, less real-estate is consumed. The leftover may be used to attach notes or other information that may provide context in the future.

**9.2. Work beyond this prototype**

Some possibilities for future work on some of the issues beyond this study are listed below.

**Re-examining the two-dimensional grid**

A possible extension of this work involves examining the possibility of moving away from a two-dimensional grid into a different organization. Several versions of TimeStore have used the same essential interface layout. While time and sender are certainly both useful and helpful, it is not clear that it is necessary, or even useful, to have both be displayed at the same time. A two-step
process, whereby the user would first specify/choose one and then the other criteria might be more useful and less consuming of the screen real estate. For example, the user could select a sender or a group of senders only from the set of all senders. The messages from that person or group could be displayed along a timeline, as in Timestore. In that case, a user study that would compare the present approach with the approach described above should prove to be very informative.

**Introducing a place component**

Another possible extension of this work involves an exploration of the possibility for an introduction of a 'place' component. As discussed in the memory literature, people involved, the main activity, and the location and time of the event are event components that are well remembered. Since we are assuming that the user will access his/her email from one location (or a small number of locations), the 'place' component of the event could not have been utilized in this version of Timestore. However, having the software on a mobile device could provide additional retrieval cues. This could be tested by extending Timestore to work on a mobile device such as a PalmPilot, and finding out if this would provide some additional retrieval context.

Another option is to extend the desktop version of the software to incorporate contextual cues in the user interface. For example, information about the user's activities and their location might provide additional retrieval context.

**Re-examining the approach to search and retrieval**

It is also possible to look at the issue of search and retrieval from a different angle. In particular, examining what kind of information people most commonly look for when they are trying to locate a message could be very informative. A study of this type would need to take into account the email client people use and what options in the search engine interface are available in this client. Our approach has been to present information that is well remembered, and assume that this would allow user to easily recognize the messages they are looking for. A study of the kind outlined above would provide the other side of the issue.
The work on this version of Timestore provides more information about the design of the system that can be used in the future. In particular, the review of literature on autobiographical memory and the discussion of the implications for design will be a useful reference in future extensions of the system.

In terms of implementation, this version eliminates most of the crucial problems identified in the previous version. In particular, reliance on a popular software system gave us the opportunity to rely on most of its functionality and concentrate on interface design. This is a considerable advantage, since convenient features that users expect to be present (such “cut and paste” functionality, or support for attachments (Yiu, 1997)) can be either overlooked as the designer focuses on building crucial features, or simply not possible to implement due to time and resource constraints. As a result of this integration, most of the user feedback we obtained was concerned with the look and feel of the system, which is what our objective was.

Results of the user study are mostly positive, but some important shortcomings have been identified as well. All users liked the visualization of their mailbox, and most said that they would use the system on the regular basis. All liked the ability to group senders, and said that they would use the functionality to form several groups. On the other hand, users complained that sometimes the list of senders was too long to scroll, and suggested adding functionality that would let them see messages sent on a certain day in a compact list. Two of five users were confused about how Timestore was integrated with Eudora.
This thesis is one step along the way in creating a useful system for management of large amounts of email. Although the software, as developed, is not perfect, user feedback indicates that the approach to the visualization of email management adopted here has the potential to be developed into a valuable and effective email management tool.
Bibliography


Appendix A – Initial Interview Results

Demographic Information:

1. Age range (21 or younger, 21-35, 36-50, 51 or older)

<table>
<thead>
<tr>
<th>User 1</th>
<th>21-35</th>
</tr>
</thead>
<tbody>
<tr>
<td>User 2</td>
<td>21-35</td>
</tr>
<tr>
<td>User 3</td>
<td>21-35</td>
</tr>
<tr>
<td>User 4</td>
<td>21-35</td>
</tr>
<tr>
<td>User 5</td>
<td>21-35</td>
</tr>
</tbody>
</table>

2. Gender

<table>
<thead>
<tr>
<th>User 1</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>User 2</td>
<td>Male</td>
</tr>
<tr>
<td>User 3</td>
<td>Female</td>
</tr>
<tr>
<td>User 4</td>
<td>Female</td>
</tr>
<tr>
<td>User 5</td>
<td>Female</td>
</tr>
</tbody>
</table>

3. Highest level of education (high school or less, some post-secondary education, university or college degree, post-graduate education)

<table>
<thead>
<tr>
<th>User 1</th>
<th>Post-graduate</th>
</tr>
</thead>
<tbody>
<tr>
<td>User 2</td>
<td>University degree</td>
</tr>
<tr>
<td>User 3</td>
<td>University degree</td>
</tr>
<tr>
<td>User 4</td>
<td>University degree</td>
</tr>
<tr>
<td>User 5</td>
<td>University degree</td>
</tr>
</tbody>
</table>

4. Occupation

<table>
<thead>
<tr>
<th>User 1</th>
<th>Ph.D. student</th>
</tr>
</thead>
<tbody>
<tr>
<td>User 2</td>
<td>Software tester</td>
</tr>
<tr>
<td>User 3</td>
<td>Doctor of Medicine</td>
</tr>
<tr>
<td>User 4</td>
<td>Marketing manager</td>
</tr>
<tr>
<td>User 5</td>
<td>Webmaster / software quality assurance</td>
</tr>
</tbody>
</table>
5. How many years have you been using computers?

<table>
<thead>
<tr>
<th>User 1.</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>User 2.</td>
<td>3</td>
</tr>
<tr>
<td>User 3.</td>
<td>3</td>
</tr>
<tr>
<td>User 4.</td>
<td>10</td>
</tr>
<tr>
<td>User 5.</td>
<td>15</td>
</tr>
</tbody>
</table>

6. How many years have you been using email?

<table>
<thead>
<tr>
<th>User 1.</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>User 2.</td>
<td>3</td>
</tr>
<tr>
<td>User 3.</td>
<td>3</td>
</tr>
<tr>
<td>User 4.</td>
<td>10</td>
</tr>
<tr>
<td>User 5.</td>
<td>7</td>
</tr>
</tbody>
</table>

Questions about email usage

7. Which systems, besides Eudora, do you use?

<table>
<thead>
<tr>
<th>Answers and comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Netscape Communicator, and web-based email systems (e.g. Hotmail).</td>
</tr>
<tr>
<td>2. MS Outlook/Outlook Express, Netscape Messenger.</td>
</tr>
<tr>
<td>3. MS Outlook, Netscape Messenger.</td>
</tr>
</tbody>
</table>

8. Of those, which do you use the most? Why?

<table>
<thead>
<tr>
<th>Answers and comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. She uses Netscape the most, since it is fastest and can handle large messages.</td>
</tr>
<tr>
<td>2. He uses Outlook the most, because it is the email software of choice where he works.</td>
</tr>
<tr>
<td>3. At first she used Netscape, for about a year. Then she used Outlook the most, for 2 years, since it was the software that her company used. Now she uses Eudora, web-based mail and Netscape.</td>
</tr>
<tr>
<td>4. She uses Netscape the most, since it is consistent across platforms (she has PC at home and Macintosh at work). She also finds it easy to use.</td>
</tr>
<tr>
<td>5. Netscape. Because she uses the browser a lot, so its email program is the most convenient. It’s already opened.</td>
</tr>
</tbody>
</table>
9. How many messages do you typically receive every day?

<table>
<thead>
<tr>
<th>Answers and comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. 4-5.</td>
</tr>
<tr>
<td>2. Approximately 100.</td>
</tr>
<tr>
<td>3. 50-60.</td>
</tr>
<tr>
<td>5. 20.</td>
</tr>
</tbody>
</table>

10. Of those, approximately what percentage do you a) save for future reference, b) delete immediately?

<table>
<thead>
<tr>
<th>Answers and comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. She saves about 10%, deletes 90%.</td>
</tr>
<tr>
<td>2. He saves 90% and deletes 10%</td>
</tr>
<tr>
<td>3. She saves about 70%, deletes 30%.</td>
</tr>
<tr>
<td>4. She saves about 70%, deletes 30%.</td>
</tr>
<tr>
<td>5. She saves about 90%, deletes 10%.</td>
</tr>
</tbody>
</table>

11. Which messages do you save?

<table>
<thead>
<tr>
<th>Answers and comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. She saves personal messages.</td>
</tr>
<tr>
<td>2. He saves business-related mail.</td>
</tr>
<tr>
<td>3. She saves all professional and work-related mail.</td>
</tr>
<tr>
<td>4. She saves personal mail and work-related mail (which is most of her email: company communications, support issues, customer mail etc.)</td>
</tr>
<tr>
<td>5. Business and personal.</td>
</tr>
</tbody>
</table>

12. Which do you delete?

<table>
<thead>
<tr>
<th>Answers and comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Most of her messages are seminar announcements, information about recreational activities etc, which she deletes once that the even has taken place. She does not receive</td>
</tr>
</tbody>
</table>
many important messages. If she does receive such a message, she prints it out. The reason why she deletes so many messages is that other lab members have access to her mail folder, so she doesn’t leave many messages there.

2. He deletes personal mail.
3. She deletes most of her personal mail.
4. She deletes messages she receives from mailing lists, various ads and “general spam.”
5. Spam.

13. How do you organize the messages that you save? (e.g. most messages kept in the inbox, filed by subject, time, sender etc.).

<table>
<thead>
<tr>
<th></th>
<th>Answers and comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>She keeps all her messages in the inbox.</td>
</tr>
<tr>
<td>2.</td>
<td>He stores messages in folders, by sender and project.</td>
</tr>
<tr>
<td>3.</td>
<td>She files mail in folders, by person or by project.</td>
</tr>
<tr>
<td>4.</td>
<td>She used to file her email, but couldn’t keep up with the volume. Now she keeps everything in the inbox. Earlier, she organized mail into folders. She had a folder for every person until the number of people grew over 500, she grouped them into a “people” folder etc.</td>
</tr>
<tr>
<td>5.</td>
<td>She keeps most messages in the inbox. She has lots of folders, but only one level of them. She organizes some by person, but most by project.</td>
</tr>
</tbody>
</table>

14. How many messages, approximately, do you have in your inbox?

<table>
<thead>
<tr>
<th></th>
<th>Answers and comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>She has 78 messages in her inbox.</td>
</tr>
<tr>
<td>2.</td>
<td>1061.</td>
</tr>
<tr>
<td>3.</td>
<td>1211.</td>
</tr>
<tr>
<td>4.</td>
<td>1693.</td>
</tr>
<tr>
<td>5.</td>
<td>1250.</td>
</tr>
</tbody>
</table>

15. How about in the other folders (except ‘Trash’ and ‘Sent’)?

<table>
<thead>
<tr>
<th></th>
<th>Answers and comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>0</td>
</tr>
<tr>
<td>2.</td>
<td>11,000</td>
</tr>
</tbody>
</table>
16. How many other folders do you have?

<table>
<thead>
<tr>
<th>Answers and comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. She has no other folders.</td>
</tr>
<tr>
<td>2. 53.</td>
</tr>
<tr>
<td>3. 10.</td>
</tr>
<tr>
<td>4. She has no other folders at the moment.</td>
</tr>
<tr>
<td>5. 10.</td>
</tr>
</tbody>
</table>

17. How much time, approximately, do you spend every day handling email?

<table>
<thead>
<tr>
<th>Answers and comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. About 1 hour.</td>
</tr>
<tr>
<td>2. 3 hours.</td>
</tr>
<tr>
<td>3. 2 hours.</td>
</tr>
<tr>
<td>4. 2-4 hours, depending on the amount of other work she needs to do. However, email is crucial for her work.</td>
</tr>
<tr>
<td>5. About 1 hour. She quickly skims incoming mail.</td>
</tr>
</tbody>
</table>

Questions on Email Retrieval:

18. Do you ever delete stored messages. If yes, which messages do you delete? How often do you delete them?

<table>
<thead>
<tr>
<th>Answers and comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Yes. She deletes things that are no longer relevant, such as old seminar announcements and the like. She deletes them approximately once per month.</td>
</tr>
<tr>
<td>2. No. He immediately deletes messages he doesn’t need. He mostly deletes personal messages that are in the ‘Sent’ folder, not to take up space. He deletes them approximately once per week.</td>
</tr>
<tr>
<td>3. Yes. If a project is finished, and she’s sure that messages will never again be needed, she deletes them. She does so approximately every two weeks.</td>
</tr>
</tbody>
</table>
4. Yes. Probably once a week she goes through them and does some cleaning. Goes by date and looks for stuff she no longer needs. There's also mail that is not important but she didn't delete it earlier.

5. Yes. She deletes those she no longer needs, and large ones. She deletes them approximately once a month, or whenever she exceeds her mailbox quota.

19. How often do you need to find a stored message?

<table>
<thead>
<tr>
<th></th>
<th>Answers and comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Up to 2-3 times per week.</td>
</tr>
<tr>
<td>2.</td>
<td>Very often. As many as 2-3 times per day.</td>
</tr>
<tr>
<td>3.</td>
<td>She often needs to refer back to an earlier message while working on a particular project. A few times per week for short (one month) projects, and every 10 days or so for longer (3-month) projects. Sometimes she had many concurrent projects. That's why Timestore would be very useful.</td>
</tr>
<tr>
<td>4.</td>
<td>At least 20 times a week.</td>
</tr>
<tr>
<td>5.</td>
<td>Some of the time. Maybe 10 times per week. Or about 20% of the time.</td>
</tr>
</tbody>
</table>

20. Can you give me an example or two of stored messages that you retrieved?

<table>
<thead>
<tr>
<th></th>
<th>Answers and comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>There was a message about a conference to be held next weekend that she received a while ago. Another example: she was looking for a message announcing repairs in her building, because the door she uses was to be shut. She wanted to know when she could resume using it.</td>
</tr>
<tr>
<td>2.</td>
<td>He was looking for certain information, characteristics of some software he got from a person. Or a document that someone sent him.</td>
</tr>
<tr>
<td>3.</td>
<td>After three months, she needed to look up an early suggestion from her boss. She often needs to refer to an older project message.</td>
</tr>
<tr>
<td>4.</td>
<td>A request from a user, and at the time she was not able to answer it, so she put it on hold until she had something to say. Or someone requesting a new version of the software, and she put him on hold, and she had to look back for the email address.</td>
</tr>
<tr>
<td>5.</td>
<td>She usually looks for reference material. For example, she often needs to go back to the list of things she needs to do to see what she needs to do next, or what she still needs to do.</td>
</tr>
</tbody>
</table>
21. How do you find these messages?

<table>
<thead>
<tr>
<th><strong>Answers and comments</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>1. She usually scrolls through the inbox, looks for subject of the message. The inbox is sorted by time.</td>
</tr>
<tr>
<td>2. He uses the search tool most of the time. He specifies the name, subject or time, or a combination. In the case of the document, he searched for the name of the document. In the other case, he looked up the message by sender.</td>
</tr>
<tr>
<td>3. She looks in the project folder, or sometimes in the several folders if the project is divided up in that way. She then scans the messages. She doesn’t sort because sorting is not always useful. For example, if she sorts by sender, and one person sends her a lot of mail, then she still has to scroll up a long way to go from, say last week’s message to this week’s message.</td>
</tr>
<tr>
<td>4. The list is organized by date, she looks up the name. She usually finds the message like that, but if that fails, she uses the search. She usually searches the body of the text.</td>
</tr>
<tr>
<td>5. She goes to the appropriate folder, looks at the subject, than the date. Messages [in the folder] are all from one or two people, so she doesn’t need to refer to the sender a lot.</td>
</tr>
</tbody>
</table>

22. When do you use a search engine?

<table>
<thead>
<tr>
<th><strong>Answers and comments</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>1. She never used the search, because she didn’t know Eudora or Netscape had a search tool.</td>
</tr>
<tr>
<td>2. Most of the time, except for message up to two weeks old. For these, he scrolls in the mailbox. All older messages are automatically archived, and he uses the search engine to find these message.</td>
</tr>
<tr>
<td>3. She used it once or twice. She can’t use it because in case of the projects she works on, most keywords are the same.</td>
</tr>
<tr>
<td>4. When she cannot find the message by scanning.</td>
</tr>
<tr>
<td>5. She never uses it. She didn’t know that she could search in any email software.</td>
</tr>
</tbody>
</table>

23. Have you encountered difficulties when looking for an older message? If yes, what kinds of problems did you have?

<table>
<thead>
<tr>
<th><strong>Answers and comments</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Yes. She looked for some messages and couldn’t find them. She thinks that maybe she…</td>
</tr>
</tbody>
</table>
deleted them, but isn't sure.

2. He had lots of problems. Typically, the search gives too many results (several hundred) that he can't do anything with. Other times, he couldn't remember who it was from, or what keyword he should use.

3. People who send her mail are the same from project to project, and the project keywords are the same as well, so she can't search. She has to think of a highly unique keyword, such as the name of the school they worked with or a name of a street, to find the message.

4. Sure. It is hard to scan through many messages. In the search, you can misspell the name or the email address... Also, Netscape performs a search only at one mailbox at the time by default, so sometimes you cannot find the message.

5. Yes. She has so much email, that sometimes it's very hard to find things. She usually goes by sender, but the problem arises when the sender has sent lots of email. She than has to look through messages one by one, which she finds really irritating.

24. Were you ever in a situation where you knew which information you wanted to find, but could not formulate the search? If yes, please explain.

<table>
<thead>
<tr>
<th>Answers and comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. She can't remember.</td>
</tr>
<tr>
<td>2. He could remember a keyword, but he would get too many results. Other times he couldn't remember the exact word. In those cases, he tries the wildcard search, which returns a few thousand messages.</td>
</tr>
<tr>
<td>3. She knew the keywords but couldn't make use of them, because the search would give too many results.</td>
</tr>
<tr>
<td>4. Sure. You don’t have the name of the person or email, you just remember it happened around the certain time, but you cannot assess what time it was.</td>
</tr>
<tr>
<td>5. She doesn't know.</td>
</tr>
</tbody>
</table>

25. When you encountered problems in retrieval, were you able to find the message in the end? How much time did it take you?

<table>
<thead>
<tr>
<th>Answers and comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. N/A</td>
</tr>
<tr>
<td>2. No. He had to call some people in the end and asked them to resend the document.</td>
</tr>
<tr>
<td>3. She was mostly successful, because she had to be. One search took her almost three hours, a good chunk of the day. She was not in the position to give up, because she needed the document. If she called the sender and asked him to send it again, her office would seem unprofessional.</td>
</tr>
<tr>
<td>4. Usually. It never takes more than 3 minutes. If it takes more than that, she gives up. It probably means she erased it.</td>
</tr>
</tbody>
</table>
| 5. Yes, she can always finds things in the end, but sometimes it takes a long time. Say, 10
minutes. She can skim quickly, speed reads her email, so 10 minutes is a long time for her.
Appendix B - User Testing Summary

User 1 (Pilot user).

Session 1. Duration: 28 minutes

The user scrolled several months back. She double-clicked on a dot, and deleted the message, adding that she deletes most of her old email because her email folder is accessible by other people in her lab. The user then scrolled forward to the current month. She double-clicked on a dot representing an unread message, and then double-clicked to read it (only a single click is required). She closed the message, and then the message window. Then, she single-clicked on another dot, marked as 'read', then opened the message and marked it as 'high priority'. She closed the message, and then the message window. She scrolled to another dot, opened a message by double-clicking. She commented that she keeps double-clicking instead of single-clicking. Next, she replied to the sender and closed the message. After that, the user played with the window size, making it larger and smaller, until she settled on the view of width of one month and length of the screen. She then double-clicked on another dot, opened a different message, wrote some comments and forwarded it. The user then browsed Eudora functionality for a few moments and wondered about a difference between Eudora’s functions “forward” and “redirect”. The user then played with the forward and back buttons, exploring the limits of the interface. She commented that she was impressed that the she could scroll backward or forward by any amount.

Observations:

- The user kept on double-clicking on the dot for the first 5-6 times, but then got used to the single-click.
User comments:
- The user commented that the double-click followed by a single-click was inconsistent. When asked if she would prefer to have two-single clicks or two-double clicks, she chose the first, even though she initially tried to double-click on the dots.
- The user expected an unread message to be marked as read after opening it in Eudora (The message status was being updated when Timestore was restarted. This has been corrected before the software was tested with other users).
- The user comments that she likes the dots on the display, and thinks they are ‘cute’.
- She also suggests making it possible to close the window by pressing together the apple symbol and W. (This is the standard for closing windows on the Macintosh platform).
- The user commented that she expected to see time when the message was sent in the pop-up box as well, but added that this might be specific to her, since most of her mail is a few days old.
- The user comments that having weekends highlighted is “very useful. as it gives you an idea about weeks”.
- After terminating the session, the user comments that she thinks the software was “very good” and that she “likes it”.

Session 2. Duration: 17 minutes

<table>
<thead>
<tr>
<th>Task</th>
<th>Strategy and comments</th>
<th>Software</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>The user looked up the name of the person, looked for messages in the appropriate week, and found a message that she did not follow up to after a several clicks.</td>
<td>Timestore</td>
</tr>
<tr>
<td>2.</td>
<td>The user opens Eudora, commenting that she is trying to look up the message by subject, since she cannot remember the name of the person.</td>
<td>Eudora</td>
</tr>
<tr>
<td>3.</td>
<td>She is trying to find a message with a certain picture. She knows who sent it and looks it up by the person. She comments that Timestore is more useful for this task since she does not have to look at the long list of names. She estimates the time of the message and clicks on the dot in that time period.</td>
<td>Timestore</td>
</tr>
<tr>
<td>4.</td>
<td>The user comments that she would “definitely” use Timestore for this task. She scrolls a year back, looks up the name and clicks on several dots before she finds a correct one.</td>
<td>Timestore</td>
</tr>
<tr>
<td>5.</td>
<td>The user scrolled back to 3-4 months ago, looked up a sender and opened a message.</td>
<td>Timestore</td>
</tr>
</tbody>
</table>
Session 3. Duration: 27 minutes

The user tried out the search engine, “just to see how it works”. She than scrolled back a year, than forward a year to the current date. She replied to some recent messages. She noticed that the single clicks were implemented [as per her earlier feedback], and commented that she likes the fact they work now. When clicking on dots, she noticed that the highlighter moves [a bug in JTable code]. She than moved back one month, and looked for messages that she didn’t reply to. She also looked for people with whom she hasn’t corresponded. She composed a few messages and sent them. She then checked new mail, and read the few messages that have arrived, by accessing them through Eudora’s inbox list. She made a group ‘Friends’ and moved four people in it. She moved back a year, then forward, month by month. She opened some messages and read them. When she returned to the current month, she said she was done.

User comments

- The user said that she would expect the search to return her a list of find messages, but she liked the view-based results as well.
- She liked the fact that Timestore responded to single clicks now.
User 2

Session 1. Duration: 22 minutes.

The user scrolled back a year, then back. He double-clicked on a dot and scrolled through the messages. He opened and read two messages. He scrolled to previous month, then to the next month. He opened another message. He tried clicking on the header of the sender column, and commented that he thought that would sort the senders. The user opened several messages in succession, by clicking on several dots.

Observations:
- This user was reluctant to think aloud. Most comments were given in response to investigator's inquiry.
- The user kept on double-clicking on the dots. (The system was changed to respond to single clicks in response to the user 1). When asked about that, he commented that double-clicks were more natural to him since he used Windows at work, which requires double-clicking.

User comments:
- The user asked if the system was independent from Eudora. He noted that it is not clear that Eudora is working in the background, and commented that to the user, these two systems seem independent.
- The user expected that clicking on the “Senders” header would cause messages to be sorted in reverse-alphabetical order.
- He commented that he thought the idea of presenting the mailbox as a “spreadsheet” was interesting.
- The user suggested that the click on the date header opens a list of messages sent on that date, “so that you don’t have to scroll all the way down the sender list.” The user said that this is something that he would use.
- This user also suggested a “preview feature” - adding a first few lines of message text to the window that shows subject lines.
Session 2. Duration: 17 minutes.

<table>
<thead>
<tr>
<th>Task</th>
<th>Strategy and comments</th>
<th>Software</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>He scrolls down the message list. He got an email two weeks ago asking him to do something. He now did it, and he wants to reply. He looks at the area denoting two weeks ago. He knows the sender. There is only one message in that period, so he finds it immediately.</td>
<td>Timestore</td>
</tr>
<tr>
<td>2.</td>
<td>He wants to find a message with &quot;top ten jokes&quot; he received from someone. He uses the search, enters &quot;jokes&quot; as the keyword. Only two dots appear as the result, one recent, one several months old. He clicks on the recent one, that's the correct message.</td>
<td>Timestore</td>
</tr>
<tr>
<td>3.</td>
<td>He wants to find a message about the Raptors game. He searches for 'raptors'. Clicks on the result for March, showing the desired message.</td>
<td>Timestore</td>
</tr>
<tr>
<td>4.</td>
<td>He goes back a year, then forward to the first month with messages. Scrolls through the list of senders, than back and forth, looking around, but not opening any messages. He then searches by keyword, looks at the period one year back and finds the message immediately.</td>
<td>Timestore</td>
</tr>
<tr>
<td>5.</td>
<td>He tries to find the message by nickname, then by part of the name. The search returns several hits in addition to the actual person he wants to find. He changes his mind, closes the search window and locates the person in the list of senders instead.</td>
<td>Timestore</td>
</tr>
</tbody>
</table>

Session 3. Duration: 20 minutes.

The user looked at the messages sent during the current week. He clicked on several dots. He closed immediately some pop up boxes. He read three messages, and replied to one. He then created a group for ‘Friends’ and moved 6 people to the group. He then docked it from view. He scrolled back, month by month, opening and reading messages. He said he was looking for messages he needed to reply to. He replied to three messages in total. He then returned to the current month. He scrolled through the list of senders changed some names. He also created a group with the title being the title of his project, and moved 4 people to the group. He then docked the group from view and expanded it again, playing with it, and finally closed it.

User comments:
- At the beginning of the session, the user said that he answered most of his email already and that he does not have much more to do. He said that for the purposes of the study, he will look for people that he did not contact in a while.
- The user wondered if there is a way to see messages in the ‘Sent’ folder [at the moment there was not]. He added that he would really need to have that functionality, since he often needs to refer to the ‘Sent’ mail to see to whom he still needs to reply.
- The user asked if the number of clicks was changed in response to his comments, that he would like to see double-clicks instead of single-clicks. [They were not, since other 3 users tested to that point preferred single clicks.]
- He suggested extending the group functionality by allowing it to function as a filter as well, so that users could specify which messages they want to have in a certain folder.
User 3

Session 1. Duration: 17 minutes.

The user had a careful look at the interface, inquiring about the axes, labels for read and unread messages and messages with high priority. She used tool tips to locate a dot with many messages. Next, she opened a high-priority message and read through it. She then found a message that she didn't reply to and sent a message. She also composed a new message and sent it. She browsed through messages some more. She opened several messages sent in the previous month and replied to them.

Observations:

- This user also seemed slightly uncomfortable because the video equipment was set up all around her.
- This user was very careful with using the software. She spent a lot of time simply examining the interface. A possible reason could be that she was being videotaped, and that she did not want to make a mistake on camera.

User comments:

- The user commented that she "really needs something to organize her email."
- She asked how can she find out if she has more than one message from a certain person on that day [by checking the tool tip, or by clicking at the dot].
- When examining the interface, the user admitted being slightly confused by the new message icon. She said that the icon on top of the dot reminded her of an asterisk.
- The user commented that the application would be really helpful for work, in cases when she needs to find a message from a certain person. She added that the addition of time makes it even easier to find messages than having only email filed by the sender.
- The user said that she is happy that her email will finally be organized. She thought Timestore would save her time both during filing and retrieval.
Session 2. Duration: 24 minutes.

User comments:

- The user suggested using a different colour to visually separate the list of senders from the rest of the display.

<table>
<thead>
<tr>
<th>Task</th>
<th>Strategy and comments</th>
<th>Software</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Yes, there was someone [knows the name]. She looks at the past two weeks, sees a dot at the March 1st. Says, yes, it was exactly March 1st. Opens the message immediately, replies to it.</td>
<td>Timestore</td>
</tr>
<tr>
<td>2.</td>
<td>Contact information of a person. She knows the name, opens the first message by the person that she finds. She also replies to it.</td>
<td>Timestore</td>
</tr>
<tr>
<td>3.</td>
<td>She looks up a message by a particular person that was sent the same day.</td>
<td>Timestore</td>
</tr>
<tr>
<td>4.</td>
<td>She moves back a year, than forward to the first month that contained messages. She knows who the person is, so, she looks for the first message from that person. She closes it, opens the next one.</td>
<td>Timestore</td>
</tr>
<tr>
<td>5.</td>
<td>From the previous task, she moves forward to December 1999. She knows the sender. She opens the message and replies to it.</td>
<td>Timestore</td>
</tr>
</tbody>
</table>

Session 3. Duration: 33 minutes.

The user first looked for the messages she needs to respond to. She started with the messages received the same day. She scrolled through the list, opening the pop up boxes from the surrounding dates and reading some of the messages. She replied to five messages from the past week. She then created a sender group called ‘Friends’, and moved 5 people to the group. She docked the group from view. She also looked for messages that she could delete. She looked up the messages that were “taking up space”, that is, the cases where only one dot was displayed per line. She opened several such messages, and deleted all by one. She scrolled through the list some more, presumably looking for more such messages to delete. When she came to the bottom of the list, she moved to the previous month, and started reading some messages. Again, she replied to several messages, and deleted two. She then quickly moved four months back, and started examining old messages by opening subject lists in the pop-up window. She then worked her way
toward the current month, examining messages, and replying to an occasional message. When she reached the current month, she said that she was finished.

Observations:
- This user was still a little uncomfortable in front of the camera. This could be a reason why she was very careful with the interface, although less so than the first time.
- The user spent most of the time seemingly “cleaning up”, e.g. moving senders to groups, deleting old messages etc. She replied to some messages as well, but this did not seem to be her focus.

User comments:
- The user was pleased that her suggestion to change the background colour in the list of senders to visually separate it from the rest of the display was implemented.
- She wondered why it now takes a longer time to open up a message in Eudora [because the Eudora itself had to start up first].
- The user said that she thinks that the interface made navigating through messages a lot easier. She also said that having “something like this” would have helped during her last job, when she had to handle a lot of email every day.
User 4

Session 1. Duration: 1 hour 7 minutes

Observations:
- This user spent a lot of time thinking about the software and how it could be improved. In particular, she spent a lot of time wondering how the flow of tasks between Timestore and Eudora could be made more seamless.

User comments:
- After using Timestore to answer several messages, the user commented that she thinks it would be very useful for finding archived messages, but less useful for day-to-day work. She would use Eudora or Netscape for that since the list with subjects and senders serves as a prompt to respond to email or do certain tasks. She thinks that not enough information is provided for the recent messages. On the other hand, she believes that Eudora provides too much information for old messages. As a consequence, she would not use Timestore as a primary, day-to-day tool, but she would use it as a supplementary tool when she is trying to retrieve an old message.
- The user would like to be able to get a list of messages sent on a particular date, for example, by clicking on the date.
- She also commented that the idea of adding an application onto Eudora was somewhat confusing, since the two applications are fairly different, in both display and functionality. When asked why, she responded that one has Timestore written across the top, and the other Eudora, that you can use either one for most tasks, and that some functionality is very different. She would prefer it if Timestore was either more closely integrated or completely separate. In the first case, for example, she would like if Eudora interface had a button that would bring up messages in a "Timestore-view."
- She would like if opening a message using Timestore would cause the corresponding message in Eudora to be highlighted.
- The user also suggested reducing the number of windows needed to access a message.
Session 2. Duration: 17 minutes

Observations:

- From user’s comments about the pattern of email messages from a particular sender, it became apparent that the user was able to determine the day of the week from the approximate position of the dot.

User comments:

- The user commented that she would expect the search to “light up” found messages in the same window, and that the system would bring her to the last found message, from where she would track the messages back.
- She likes that the results of the search are displayed in the similar fashion, because “you might find another message (other than the one you’re looking for) because you are browsing”.
- She also commented that she didn’t have a strong preference for the email software for any of the tasks. She said she would use either Eudora or Timestore, whichever was on hand.
- The user suggested adding date to the pop-up window, or identifying pressed dot in some way, such as depressing it or highlighting it.
- The user also suggested adding shortcuts; for example that pressing “apple” and ‘a’ together brings you to the first sender whose name begins with ‘a’.
- The user commented that she would try all ways of finding a message, and that she would use the search engine only when she is desperate. She would even try reading subjects of all messages, even though she “knows that’s silly.”

<table>
<thead>
<tr>
<th>Task</th>
<th>Strategy and comments</th>
<th>Software</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Yes, there was someone last week. She wants to check what she needs to send him. She knows the name, looks up the list of senders to find the name. She knows that the message arrived sometime last week or so (actually, it was two weeks earlier). There is only one message from that person in this period. She clicks on the dot, opens the message, reads it and replies.</td>
<td>Timestore</td>
</tr>
<tr>
<td>2.</td>
<td>She got a message the message the same day. She knows who sent it, looks up the person’s name and clicks on the dot for this day. She volunteers to find another message since finding the first was very easy. She chooses the search tool, types an email address. She looks up messages in the last month, and clicks on two dots before she finds the correct message.</td>
<td>Timestore</td>
</tr>
</tbody>
</table>
3. She searches for a word in a title of the attachment. She who the sender is, and that the message was sent in the last few days. She finds the dot (there is only one in this period) and opens the message.

4. The user switched to Eudora after being reminded that she can use Eudora to complete the tasks as well. She sorts the messages by date, scrolls quickly by moving the scrollbar to August 1999. She scans the subject list until she finds the message. She commented that she might also try to search for keywords "apple seminar," but that she would do that only when desperate. The user then closed Eudora and switched back to Timestore.

5. She immediately comes up with a name of such a person. She moves back 3 months, scans the list of senders and finds a message.

<table>
<thead>
<tr>
<th>Session 3. Duration: 34 minutes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Observations:</td>
</tr>
<tr>
<td>- During this session, the user has been accessing only mail sent in the current week (The session was carried out on a Friday).</td>
</tr>
<tr>
<td>User comments:</td>
</tr>
<tr>
<td>- She suggests adding a button that would bring you forward to the current month.</td>
</tr>
<tr>
<td>- She comments that she never sets message status to 'high priority' and that she doesn't like it when people do that (&quot;who do they think they are?&quot;).</td>
</tr>
<tr>
<td>- Suggests adding a way to identify which messages are high priority once you click on the dot and get a pop-up box.</td>
</tr>
<tr>
<td>- The user asks about viewing sent mail (not currently supported). She commented that she uses 'Sent' mailbox a lot to track who she replied to.</td>
</tr>
<tr>
<td>- She doesn't like having to close the pop-up window. Comments that she has an impulse to click on the main screen, not on the pop-up box [once she closes the message in Eudora].</td>
</tr>
</tbody>
</table>
User 5

Session 1. Duration: 31 minutes

The user opened several messages in the initial display, showing current month. She then moved back one month, and opened several messages. She merged several occurrences of a person into one. She moved back three months, one by one. She opened and deleted some messages. She then moved forward by one month. She clicked on one dot, which displayed subject lines of five messages. She opened them one by one, and deleted each one.

Observations:

- The user recognized what the gray lines represented. Also, she understood that the red square around a date represented the current date.
- She was able to relate blank areas of space to periods when the company was closed (e.g. Christmas), so there was not much activity. She also related areas with many dots to high-activity periods (e.g. just before Christmas), and recognized communication patterns in sequences of dots.

User comments:

- She likes that weekends are separated.
- She thinks that using red for both high priority messages and the current date is slightly confusing, because it makes the two seem related.
- She suggests numbering messages in the pop up window.
- She also suggests adding a little legend to explain what each icon represents.
- She thinks that having the option of fixing the size of the window would be useful.
- She suggests allowing highlighting of columns, in addition to highlighting of rows.
- She comments that the software is “pretty handy”.
- Notices that a particular person sent her messages every day.
- She suggests putting buttons for moving by month on the inside, and the buttons for moving by a year on the outside.
- She comments that she likes the information in the tooltip.
- She thinks that “it is easy to navigate by sender.”
Session 2. Duration: 11 minutes

Observations:

- The user was not closing all dialog boxes as they opened. At the end of the session, there were many that were left open.
- She never tried to search for messages.
- She used Timestore for all tasks.

User comments:

- She doesn’t think that search engines are useful, because she can’t always remember exact word. She thinks for Timestore she probably won’t need it, because messages are very visible.
- She thinks that Timestore helps her find messages quickly. The list would take a lot more time, and there’s a lot more information that she needs to scan to find a message.

<table>
<thead>
<tr>
<th>Task</th>
<th>Strategy and comments</th>
<th>Software</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>She tries to come up with the name, scrolls through the list. She thinks she replied to everyone. Finally, thinks of a person who wrote to her this week. She finds the message immediately, replies.</td>
<td>Timestore</td>
</tr>
<tr>
<td>2.</td>
<td>Says the name of the person who sent her something about the Web site last month. She goes back to previous month. Clicks on dots one by one, starting with the most recent one that month, reads subject lines, closes dialog boxes. The last dot she opens (e.g. first that month), contains the subject she is looking for. She opens the message. The user commented that she actually wanted to user Timestore today to find this very message.</td>
<td>Timestore</td>
</tr>
<tr>
<td>3.</td>
<td>There was a message today. She knows who sent it, scrolls to the name, looks up to the date, opens it.</td>
<td>Timestore</td>
</tr>
<tr>
<td>4.</td>
<td>She goes back month by month, to 6 months ago. She looks for her boss, who often sends meeting announcements. Opens pop-ups one by one. The fifth one contains a confirmation of a meeting.</td>
<td>Timestore</td>
</tr>
<tr>
<td>5.</td>
<td>She moves forward three months, to three months before the current date. She says the name of the person, finds a message.</td>
<td>Timestore</td>
</tr>
</tbody>
</table>
Session 3. Duration: 34 minutes

The user created a group for her company, and started moving people into the group. She moved 5 people in total. She merged four occurrences for one person into one, and three occurrences of another into one. She then opened a message and deleted it. She creates another group, scrolls down to it. She opens another message. She moves back a year, then forward to four months before the current date. She opens some messages along the way. She then adds another few members to the group. [At this point, her computer crashed. She waits until it reboots. She is now back at the current month.] She merges a few more people. Opens a few more messages, all in the current month [at this point, only messages from the first two weeks]. She moves to previous month, opens some messages, replies.

Observations:

- The user sometimes double-clicks on the message, and other times single clicks. She spent a lot of time organizing senders into groups and merging several occurrences of a sender into one.

User comments:

- The user commented that the grouping and merging really help clean up all the people.
- She likes the fact that when she scrolls to merge people, the rest of the screen does not scroll (only the list of senders). If the whole screen moved, that would be too distracting.
- Should would like to be able to delete all messages from one person. Thinks that would be very useful for “spam”.
- She likes that as she moves back and forward, the sender groups stay.
- The user asked which mail folders are presented [all incoming folders, i.e. all except Out and Trash]. She would like to have an option of viewing only one folder at the time, or all folders combined.
- She comments that she really likes the icons.
- At the end, she comments that the application is “really handy”.

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Appendix C – Final interview results

For what types of tasks did you use Timestore?
Was Timestore useful for those tasks?

<table>
<thead>
<tr>
<th></th>
<th>Answers and comments</th>
</tr>
</thead>
</table>
| 1. | She used to find messages from several months ago and to answer recent mail.  
  - Yes, it was useful. |
| 2. | Mostly for search. Also to read email.  
  - Yes, it was useful. |
| 3. | To find recent personal messages. Also to find important old messages and to locate a particular message.  
  - Yes, it was very useful. |
| 4. | To read recent mail. Also, to search for messages.  
  - Timestore was useful because she could see the dates better. 90% of time she searches by date, for messages up to a week old. For older messages, she searches by subject. Timestore is good since it combines these two strategies. |
| 5. | To read new mail, organize senders into groups, to find old mail that she could delete. Also to read mail from previous year.  
  - Yes, it was very useful. It’s a lot easier to use Timestore than to do the same thing in Netscape or Eudora. |

For what types of tasks did you assume Timestore would not be useful, so you didn’t use it?
What were your assumptions based on?

<table>
<thead>
<tr>
<th></th>
<th>Answers and comments</th>
</tr>
</thead>
</table>
| 1. | She didn’t think it would be useful to find messages whose sender she didn’t know.  
  She wanted to browse by subject, and Timestore does not display subjects. |
| 2. | For no tasks. |
| 3. | It wouldn’t be useful for a search, since she would get too many responses for the same keyword [the same problem she described earlier]. |
| 4. | It wouldn’t be useful for scanning individual messages. She has to click to see the subject, but it’s not that bad since she can see the number of messages. Suggests adding subjects to tool tips so that no clicking is necessary.  
  - She also can’t use it to read attachments and click URLs. She thinks that the fact that you can’t click on a URL in Eudora is ridiculous. |
| 5. | She did not assume it would not be useful. |
What are the things you most liked about Timestore?

<table>
<thead>
<tr>
<th>Answers and comments</th>
</tr>
</thead>
</table>
| 1. - She likes the visualization, since she is a “visual type.”
  - She likes the dots, colors.
  - She likes the fact that weekends are highlighted.
  - Also, the ability to group several people in one line. |
| 2. - The user interface. He thinks it is original.
  - He likes the icons.
  - Also, the fact that messages are visible and easily accessible. |
| 3. - Efficiency – the fact that she can find things quickly. Timestore saves time, and that’s very important in the business world.
  - She also likes the visual design.
  - She likes the way messages are sorted. |
| 4. - She likes visual scanning, that you can see your mailbox in a quick glance. For example, if she sends an email to a list of people one day and the following day she sees a solid line [in the column of dots], she knows that her email was successful and she can plan the day around answering the mail.
  - She likes that you can find messages in 1-2 weeks to maybe up to 4 weeks by scanning the display, versus up to about 1 week in Netscape.
  - She also likes that surrounding messages tell her little bit about a week, e.g. whether she sent out a particular question, got an assignment etc.
  - She likes that she can type only one word for search and not specify whether to search in subject etc, because most of the time she types a word to narrow down the list and then scans the messages anyway. |
| 5. - She likes it because of the layout, the fact that she has people on the side. They typically send one type of information. It’s nice to have it organized by people, and then you can look up the date, instead of going through the list. It’s easy to go right to the message. And there is no extra details. Eudora list is hard to look at. She can get rid of some information, e.g. hide the subject, but she still has to scan messages linearly. Timestore is not linear so she likes it a lot better. |

What are the things you least liked about it?

<table>
<thead>
<tr>
<th>Answers and comments</th>
</tr>
</thead>
</table>
| 1. - She did not like having to double-click to open a message.
  - She didn’t like that the status of a message did not get updated if it was changed in Eudora. She expected that to be automatic. |
| 2. - Limited set of features. For example, he would like to see more criteria in the search engine. |
3. She doesn’t like the black colours in the sender list. Also does not like the gray panel on the top. She suggests using dark blue for the sender list and a livelier gray for the top.

4. - Responsiveness of the pop-up box. She thinks that’s a big aspect of functionality.
   - She thinks that the pop-up box is slightly ambiguous, i.e. it is not clear which dot it represents. Suggests using a drop-down menu. Also suggests that if a message is selected, the dot gets depressed, highlighted or marked in some other way.

5. - The fact that it doesn’t refresh.
   - Also, that she can’t tell which message in the pop up box is the newest one.

Did you find the time-based organization useful? Why?

<table>
<thead>
<tr>
<th>Answers and comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Yes, she thinks it is useful. One-month view and highlighted weeks remind her of a calendar, and dots remind her of marks one would put on a calendar.</td>
</tr>
<tr>
<td>2. Yes. Everything is very clear. It is easy to find messages.</td>
</tr>
<tr>
<td>3. Very useful. It helps in finding even old messages very quickly, that would otherwise take a while to find. It is good for new messages too, especially if she receives several messages from one person in a day. In a list, that would take up a lot of space.</td>
</tr>
<tr>
<td>4. Definitely, especially for quick scanning purposes. The fact that she doesn’t have to read all the text in a moving list saves her eyes.</td>
</tr>
<tr>
<td>5. Yes. Because it helps her delete old mail. She can quickly go back, look at the list of people. She knows who useless email is most likely to come from, and she can just start deleting.</td>
</tr>
</tbody>
</table>

What about the sender-based organization... Did you find it useful? Why?

<table>
<thead>
<tr>
<th>Answers and comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Yes. She likes the ability to group people into “business”, “personal” etc. She thinks that alphabetical ordering is clear. However, she would prefer to have all senders displayed, to be consistent across months.</td>
</tr>
<tr>
<td>2. Neutral. It’s alphabetical, standard for all email software.</td>
</tr>
<tr>
<td>3. Yes, it’s very useful. Especially in combination with time. It’s easy to find a particular sender.</td>
</tr>
<tr>
<td>4. Yes. Alphabetical order is intuitive, helps in combination with time-based order, as mentioned before.</td>
</tr>
<tr>
<td>5. Yes, for the same reason as above. Also because certain people are connected to certain projects.</td>
</tr>
</tbody>
</table>

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Do you think the ability to group senders would be useful to you? If yes, how would you group them? If not, why not?

<table>
<thead>
<tr>
<th>Answers and comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Yes, definitely. She would group them into &quot;personal&quot; or &quot;friends&quot;, &quot;coworkers&quot;, &quot;admin&quot;. She thinks that she would probably have all senders grouped, because this would resemble her hierarchy of files and folders.</td>
</tr>
<tr>
<td>2. Yes. He would even like to be able to filter messages into groups like that, so that they deal with the same topic. He would organize the people by project, and 'Personal'.</td>
</tr>
<tr>
<td>3. Yes. For example all people in one project would be grouped together. Also, parts of company: procurement, finances, sales, office of Chief of Staff, budget...</td>
</tr>
<tr>
<td>4. Yes. She would definitely group people. She would group spam, announcements, things that she doesn’t have to act on. She would have a group for DGP, feedback, customers, 318 group, company.</td>
</tr>
<tr>
<td>5. Yes. She would have a group for her company, by project, teachers / users of the software, friends. She thinks that being able to combine people helps reduce clutter.</td>
</tr>
</tbody>
</table>

Overall, do you think you would use Timestore on a regular basis?

<table>
<thead>
<tr>
<th>Answers and comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Yes. In fact, she would like a copy.</td>
</tr>
<tr>
<td>2. Yes. He would use it because it is very clear, it’s easier to find email messages, and messages are sorted automatically.</td>
</tr>
<tr>
<td>3. Yes. It would be helpful.</td>
</tr>
<tr>
<td>4. If it was integrated more into an email program – she doesn’t like Eudora because she can’t click on URLs – if she could use it with a browser, if it was platform independent, she’d be more likely to adopt Timestore rather than Eudora, but she wouldn’t go back and forth.</td>
</tr>
<tr>
<td>5. Yes.</td>
</tr>
</tbody>
</table>

Do you have any other comments about the interface, or suggestions for improvements?

<table>
<thead>
<tr>
<th>Answers and comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. No.</td>
</tr>
<tr>
<td>2. No.</td>
</tr>
<tr>
<td>3. Suggests adding a way to customize the colour scheme. But she wouldn’t touch the &quot;bubbles&quot;, she likes those.</td>
</tr>
<tr>
<td>4. She finds it hard to scan horizontally over blank space, suggests adding thin horizontal</td>
</tr>
</tbody>
</table>
5. She would be more likely to use the search engine with other applications. With Timestore, she is 99% sure that she wouldn't need to use it.