VISUALIZING RHYTHMS OF INTIMACY IN EMAIL COMMUNICATION

A Thesis

by

MIRKO MANDIC

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

December 2004

Major Subject: Computer Science

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Approved as to style and content by:

Andruid Kerne (Chair of Committee)	John Leggett (Member)
Carol LaFayette (Member)	Valerie E. Taylor (Head of Department)

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ABSTRACT

Visualizing Rhythms of Intimacy in Email Communication. (December 2004)

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Email has developed into one of the most extensively used computer applications. Email interfaces, on the other hand, have gone through very few transformations since their inception. As the growing volumes of email data accumulate in users' email boxes, these interfaces fail to provide effective message handling and browsing support. Saved email messages provide not only a vast and pulsating record of one's electronic past, but also a potential source of valuable insights into the structure and dynamics of one's social network.

In this thesis, we introduce a visualization approach to email that draws upon email's inherently personal character and uses intimacy as a key parameter. We have developed faMailiar, a novel email interface that visualizes email in a chronological manner through two alternative, calendar-like views that present email activity on different time granularity scales. Visual mappings of email data and support for filtering help the user see rhythms and patterns in her social interactions. Zooming, panning and implicit semantic zooming facilitate navigation across large email collections.

This thesis also describes our iterative, human-centered design method. Two user studies have been performed at different stages of the process, and we explain their purpose, results and implications.

To all the familiar ones who are far away

ACKNOWLEDGMENTS

Taking the Recombinant Media Ecosystems course taught by Dr. Andruid Kerne during my first semester of graduate school entirely changed my perspective on computer science and my place in it. The multidisciplinary approach to interfaces and the focus on human experience excite me as much today as they did two years ago. I am thankful to Dr. Kerne for supporting and encouraging me to explore thesis research topics that are relevant and interesting to me, at the same time providing crucial, valuable insights and guidance. I have learned a lot from him during this process.

I thank Carol LaFayette, MFA, who was always positive and enthusiastic about this research. She provided extremely valuable insights during the design of the early interface mockups. I also thank Dr. John Leggett for his support and ideas related to the interface's interaction model.

Graduate school and the work on this thesis would not have been the same without my officemates and those countless cups of coffee we consumed together in 423B. I am grateful for all the constructive ideas, programming tips and great support that Ryan Saunders, Jacob Foshee and the others provided throughout the process.

I thank all the participants in the user studies that were performed during this research. Their input was of immeasurable value and it was instrumental in the design of faMailiar.

All the ones who are in Serbia, who have always loved me and believed in me, I love you. This thesis is dedicated to you.

Slava i hvala Gospodu Bogu.

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1 INTRODUCTION

Email has developed into one of the most extensively used computer applications and a pervasive medium of communication. At the beginning of the new millennium, almost every seventh human being (on average) owned an email account [Gross 2002]. In 1998 alone an estimated 3 billion email messages were sent daily just in the USA [Gwizdka 2002]. If there ever was an argument for describing a man as an island, the information age bore and nourished email as a tool to erase that argument. The popularity of email coincided with the rise of the Internet and branded it as one of the "killer apps" [Berghel 1997]. Its omnipresence in our daily digital lives promoted it into our primary electronic "habitat" [Ducheneaut and Belotti 2001]. However, the form of the medium hasn't developed in a manner commensurate with its rise in prominence, and email interfaces have gone through very few transformations since their inception.

Popular email applications, such as Microsoft Outlook, enable users to organize messages in folders. Yet, according to several studies [Becker and Ferreira 1996; Whittaker and Sidner 1996; Becker et al. 2000], email folder structures are not suitable for storage and management of the large amounts and types of data contained in email messages. Browsing through hundreds, or even thousands [Whittaker and Sidner 1996] of messages can be difficult. Organizing large volumes of email messages can also be immensely frustrating. Numerous problems that users encounter when dealing with email folders [Becker and Ferreira 1996] are evidenced by the fact that about half of

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This thesis follows the style of the *Journal of the ACM.*

email users do not sort their messages into folders, but instead, keep all of them in their inboxes [Whittaker and Sidner 1996].

Despite the fact that email has become the primary environment for and facilitator of online interaction between people, its current interfaces do not offer much insight into the structure and dynamics of one's online social network [Farnham 2002; Viegas et al. 2004], especially with regard to the communication patterns and rhythms [Tyler and Tang 2003; Venolia and Neustaedter 2003; Rohall et al. 2001]. According to Tyler and Tang [2003], users "display typical patterns of response behaviors" in email communication, and these patterns are closely related to relationships. Furthermore, Tyler and Tang indicate that users attempt to create and sustain a persistent email "responsiveness image" in concurrence with the way they feel about their relationships. By presenting messages as visually monotonous and increasingly long lists of subject lines and contact names, commonly used email interfaces, instead of making the communication patterns observable, tend to conceal them, thus hindering the user's ability to monitor her contacts', and maintain her own responsiveness image.

Participants in a study by Ducheneaut and Bellotti [2001] sent an average of 17 and received an average of 42 messages daily. Farnham [2002] reports that in the work context, an average user emails about 22 unique people every day. The large data sets created by the use of email make email an obvious field in which to apply information visualization methodologies. In approaching email visualization, as in other visualization domains, a crucial question is: what are the important parameters that can serve as the basis for visualization? Our desired goals were to facilitate browsing and to

make visible significant communication and social patterns within email usage that would otherwise remain hidden. In recognition of email's personal and social role, we answered the aforementioned question by focusing on intimacy, while visualizing it in a temporal context. In this thesis, we develop faMailiar, a novel email interface. Applying notions of intimacy, and techniques of information visualization to email, we are constructing an email application that facilitates handling of and navigation through large email collections, by enabling the user to discover communication rhythms and patterns. Furthermore, we argue that thousands of messages in one's inbox are more than just a large collection of "to-dos" and reminders, pictures and attached documents, and even bits of asynchronous communication. They are a vibrant, clear record of one's past, a diary we were never aware we were keeping. Therefore, a goal is to provide an experience framework that enables the user to get a better apprehension of her (electronic) history.

Section 2 provides a conceptual background for this work by addressing intimacy in contexts other than computing - namely, psychology, sociology and literature. An overview of the related work in the areas of design of email interfaces, temporal paradigms in computing and interactive experience design is also provided in Section 2.

Sections 3, 4 and 5 focus on our research contributions. Specifically, Section 3 describes our approach to intimacy in the context of computing, within the email domain. In Section 3 we describe in detail how intimacy is defined and visualized in faMailiar. Section 4, explains how visualized intimacy is made observable and available to the user in faMailiar, by providing a comprehensive description of the program's

interaction model and user experience. The application architecture was driven by the interaction model and in Section 5 we provide a high-level overview of it.

Two user studies have been performed during this research. The first one was used to evaluate the potential of three alternative intimacy-based email visualization prototypes. The second one was utilized to assess the usability of the developed application. A description of the design process, including an explanation of the early application prototypes and both of the user studies, is provided in Section 6.

In Section 7, we recapitulate the work performed in the thesis and examine possible future directions for this research.

2 BACKGROUND

In this section we provide an overview of prior work in the areas related to our research. Intimacy, a key abstraction in our work, is an intrinsic constituent of human experience. Here, we examine intimacy in the contexts of psychology, sociology and literature. We also discuss related work in computer science by focusing on email interfaces and visualizations, temporal data management systems, and interactive experience design.

2.1 Intimacy in Human Experience

Intimacy has traditionally been the subject of psychology research, and many definitions of intimacy have emerged from psychology. Significant dimensions of intimacy, as defined by that research, are included herein. Also, we examine intimacy from sociological and literary perspectives.

2.1.1 Intimacy Defined: Psychological and Sociological Perspectives

Jamieson states in [Jamieson 1998], "if intimacy is defined as any form of *close association* in which people acquire familiarity, that is *shared detailed knowledge* about each other, then it is impossible to conceive of a society without intimacy." By examining *stories* that deal with intimacy in families, parenting, friendships, couple relationships and sex, Jamieson points out that, in addition to close association and familiarity, caring, deep understanding and some form of love are required qualities of an intimate relationship.

Prager also establishes a multitiered definition of intimacy in [Prager 1995]. She states that intimacy, "as a concept, cannot be defined precisely enough for research purposes." Instead, according to her opinion, intimacy should be considered as a superordinate concept that can only be described in terms of its two subordinate concepts: intimate interactions (including intimate behaviors and intimate experiences) and intimate relationships. She states that intimate behavior is "any behavior in which partners share that which is personal and/or private with each other," and that "intimate experience is the positive effect and perceived understanding that partners experience along with or as a result of their intimate behavior." Especially relevant to our work is Prager's definition of intimate relationships. In her opinion, intimate relationships are characterized by continuing, recurrent intimate interactions between familiar people who feel affection and trust for each other. In order to support her multitiered definition of intimacy, Prager examines intimacy through the life span, recognizing its morphing forms in numerous relationships during that span.

According to Bensman and Lilienfeld, intimate, private and public are traditional social roles one can assume [Bensman and Lilienfeld 1979]. Within this social framework, they recognize numerous forms of intimacy and pseudo-intimacy (pointing that the pseudo-intimacy can be manifested as "devaluated privacy," "intimacy of suspended [rigid] social rules" or socially deviant sexual behaviors). According to their opinion, these numerous forms can be identified in a varied set of contexts, ranging from the intimacy of marriage bed and parental home to pseudo-intimacy of army barracks, prisons, hospitals and brothels.

The point Bensman and Lilienfeld make that is of special interest to us is their declaration of intimacy as the basis of social networks and culture. They define social network as a "social linkage of friends or peers in which not all of the friends know each other," and state that intimacy is at the root of friendships, which, in turn, are the basis of social networks. Furthermore, they declare that "the totality of network gossip, as it seeps through a multitude of networks at uneven rates, constitutes the totality of the culture of a society."

It is easy to overlook the aforementioned multiple dimensions of intimacy in a society which often reduces intimacy to one of its physiological forms - sex [Bensman and Lilienfeld 1979; Bell et al. 2003]. We want to emphasize that intimacy in our work is treated as multi-faceted and diverse, reflecting a wide variety of interpersonal relationships. At the same time, as email communication manifests dyadic relationships between people, recognizing the mutuality of intimacy in that communication is crucial for our approach.

2.1.2 Intimacy in Literature: The Diary Form

Van Gogh stated, "There is something intimate about painting I cannot explain to you - but it is so delightful just for expressing one's feelings," [The Painter's Keys 2004]. If art is a medium through which an artist expresses her deep, personal feelings, then the diary, which is commonly considered as the most personal form of literature, is among the most explicit and deliberately revealing of all the art forms that are egocentrically focused on the artist's self.

There is a historical relationship between a diary as a literary form and letters as means of communication. According to Sjoblad, diaries emerged from letter writing [Sjoblad 1986]. Furthermore, there is a connection between diaries and letters as forms of self-expression. As Foucault points out, "disclosure of self" through "letters to friends" is one of the three Stoic techniques of self-knowing [Foucault 1988]. The others are "examination of self and conscience, including a review of what was done, of what should have been done, and comparison of the two," and remembering of the secret self. Kadar identifies all three of these techniques in instances of self-writing (diaries, journals, autobiographies, memoirs, testimonies and letters) in postmodern literature [Kadar 1992].

2.1.3 Experience: A Motivation for Design

This research has been motivated by my first person experience of intimacy over distance. After moving to a foreign country, I have been using email extensively, on a daily basis, to stay in touch with my family and my girlfriend who stayed in my home country. In my personal experience, email has been a significant facilitator of intimate relationships. However, the email interfaces that I use daily, confine communicated intimacy to texts of the messages I send and receive, and allow me to experience it only when I write and read those messages. In my inbox, intimate messages look the same as meeting schedules and assignment descriptions. My email experience of these important, intimate relationships is fragmented and restricted, and I can not see what I feel. I am not satisfied with this experience. I want to be enabled to see, understand and interact with intimacy of my email history in its totality, as well as in its fragments.

I respond to my own experience in the context of other research on experience design. In the late eighties, the design quality of everyday things was measured by their utility [Norman 1988]. Today, as we have started to recognize the human user as an emotional entity, we have also started to care about the appeal of our designs [Norman 2004]. Or, as McCarthy et al. point out, "our concerns have broadened from usability to include wider qualities of people's experiences with technology" [McCarthy et al. 2004].

Forlizzi and Battarbee define experience as "a totality, engaging self in relationship with [an] object in a situation" [Forlizzi and Battarbee 2004]. Based on a detailed review of work related to experience design in numerous disciplines (ranging from business to philosophy), they observe three categories of approaches to experience, and focus on the third:

- product-centered models, where the goal is to build products that evoke gripping experiences;
- user-centered models, where the goal is to understand peoples' experiences and expectations; and
- interaction-centered models, where the goal is to understand the interactions between people and products, as well as emotions and experiences that emerge out of those interactions in their social contexts.

As we pointed out, emotion ("some form of love" in [Jamieson 1998], "affection" in [Prager 1995]) is central to intimacy. At the same time, Forlizzi and Battarbee state that "emotion is at the heart of any human experience and an essential component of user-product interactions and user experience," and that, as such, it

"serves as a resource for understanding and communicating about what we experience" [Forlizzi and Battarbee 2004]. By making intimacy of email communications explicit and interactive, our goal is to provide a framework that would enable the user to recollect memories and experience emotions related to her past email communications and relationships.

McCarthy et al. recognize enchantment as an important aspect of interactive experience, defining enchantment as "an experience of being caught up and carried away, in which, although we are disoriented, perception and attention are heightened" [McCarthy et al. 2004]. According to McCarthy et al., in order for a system to provide an enchanting experience, its newness and unexpectedness should be sustained after the initial encounter with the user, and should not vanish with repeated uses. Kerne's combinFormation [Kerne 2004] is an example of such a system – it continually enchants the user by creating an interest-sensitive, yet unpredictable "aesthetic experience" [Kerne 1998]. By providing an insight into the user's email history from a new, intimacy-based perspective, and by enabling her to notice previously hidden communication rhythms and patterns, we want to provide a richer, enchanting interactive experience of her email communications and relationships.

Also, we must note that the aesthetic experiences gathered by McCarthy et al. [McCarthy et al. 2004] through their research on technologically enhanced body jewelry are pertinent to us on an additional level – they implicitly deal with intimacy in the milieu of ubiquitous computing. In the next section, we further talk about this research.

2.2 Intimacy in Ubiquitous Computing

Lamming and Flynn introduce intimate computing in a ubiquitous computing context, referring to a computer's "intimate knowledge" of the user [Lamming and Flynn 1994]. As Galloway points out in her account of intimacy between a human and technology, "of interest here is the repeating notion of being together in close connection, and of being actualized through particular associations in space and time" [Galloway 2003]. Especially interesting to us is the notion of ubiquitous intimacy in [Bell et al. 2003], where in addition to technologies that are familiar *with* their users, also recognized is a potential for technologies that promote intimacy *between* people.

Forget-me-not is a wearable, ubiquitous memory device designed to support human memory in retrieving the forgotten information [Lamming and Flynn 1994]. While providing several references to relevant research in the field of psychology, Lamming and Flynn point out that such an "intimate" computer could be crucial in supporting the user's autobiographical memory. By using a data capture mechanism, *Forget-me-not* keeps track of the user's social interactions, workstation activities and locations, constructing an iconic, *private biography* of the user. The biography is subsequently used to provide important contextual hints and refresh the user's memory.

Relevant to our research on several levels is a recent project [Kaye and Goulding 2004] that addresses intimacy in the contexts of interpersonal relationships and ubiquitous computing. Through a participatory design study, Kaye and Goulding focus on intimate objects, devices specially conceived for maintaining intimacy between couples at a distance. Moreover, the devices are not only *for* couples, but are also

designed *by* couples - four couples in long distance relationships. Two of the designs attempt to provide for the sensation of handholding at a distance and one provides a way to send and receive dedicated, intimate voicemail messages. By looking at the specific intimate object designs that emerged out of the study, Kaye and Goulding pose relevant questions of customized technology and experience design in intimate computing.

2.3 Email Interfaces and Visualizations

As [Bellotti et al. 2002] point out, more than a few recent projects attempted to redesign email's interface. Broadly, with respect to how it is related to our work, this email research can be categorized into three clusters: social networks oriented, conversation (thread) oriented and time oriented. Below is an overview of each of these three groups.

2.3.1 Social Networks Oriented

PostHistory [Viegas et al. 2004] is an email visualization that focuses on dyadic relationships on a day-to-day basis. By analyzing message headers, *PostHistory* visualizes the strength of these relationships by showing daily volumes of email interchange, directedness of the interchange and frequency in communication between the user and each of her contacts. *Social Network Fragments* [Viegas et al. 2004] is another email visualization program by the same group. Like *PostHistory*, *Social Network Fragments* treats people and time as the major dimensions of one's email past, obtaining data from email headers. Based on different types of relationship ties between the members of the user's social network, a spring system is formed and visualized as a connected graph of the network members. Ego (i.e. the user) is shown at the center, and

distances between individuals in her network show how closely related they are to her and to each other (if any connections exist between them).

Personal Map [Farnham 2002] also presents an egocentric view of the user's email activity by placing the user at the center of the visualization and organizing her contacts into 'pie slice' segments around her. Relational ties between the user's email contacts influence how they are grouped into segments. These ties are determined according to how often contacts appear together in the user's emails.

eArchivarius [Leuski and Oard 2003] and EmVis [Heckel and Hamann 1997] are 3D email visualizations that facilitate analysis of email exchange within an organization. Both visualizations associate company-specific organizational hierarchy and frequency of email exchange between the members of that hierarchy. Additionally, eArchivarius enables the user to specify a similarity function (i.e. intended recipient or message content) according to which messages are visually clustered.

2.3.2 Thread (Conversation) Oriented

An emerging paradigm in email interfaces is use of threads (conversations) to organize messages. Based on the results of an analysis that involved 18 subjects, Whittaker and Sidner point out that their experiments indicate "the pervasiveness of inbox conversational threads" [Whittaker and Sidner 1996]. Another study [Kerr 2003] that surveyed a total of 42,000 messages showed that only 38% of them were "singles" (unthreaded). Clearly, a significant portion of email exchange is conducted via reply messages.

Gmail [Gmail 2004] and *Grand Central* [Venolia and Neustaedter 2003] are email interfaces that utilize conversation threads in a similar manner. Both interfaces feature summaries of both the incoming and outgoing messages that are part of a thread in a chronological, vertical sequence. However, *Grand Central* is more interesting, since it features an overview+detail approach. In addition to the aforementioned, detailed *mixed-model* conversation view (sent and received messages are interleaved, positioned in the chronological order), it also provides a small, schematic view of the entire conversation tree, as well as a brief textual summary of the conversation. Both interfaces enable the user to label the conversations and thus provide a simple annotation mechanism in place of message folders.

ReMail, an ongoing project at IBM Research, also provides a view of message threads in a mixed-model visualization [Kerr 2003; Rohall et al. 2001]. Using arcs to indicate relationships between messages, *ReMail* provides clear, chronological thread representations that are more compact and stable than the visualizations based on the tree structures. *ReMail*, in addition to its thread visualization, also provides contextual information about all the participants in the thread (contributors and recipients) and a list of all the messages contained in the thread with author and subject.

Even though communication provided by the public discussion groups is distinctly different from the communication afforded by email and even though public discussion threads are unlike email threads in numerous ways [Kerr 2003], we mention here two interesting Usenet group visualizations that inspired our work. Both, *Conversation Map* [Sack 2000] and *PeopleGarden* [Xiong and Donath 1999] treat

conversations in visually appealing ways - *Conversation Map* by its remarkable scalability and *PeopleGarden* by introducing the *data portrait*, a visual metaphor showing a person as a flower whose appearance is based on its interaction with the group (garden).

2.3.3 Time Oriented

Several general information management systems organize information along a temporal axis, creating "a diary of one's electronic life" [Gelernter 2004]. *Lifestreams* [Freeman and Fertig 1995], *TimeScape* [Rekimoto 1999], *Stuff I've Seen* [Ringel et al. 2003] and the already mentioned, *Forget-me-not* [Lamming and Flynn 1994], are some of these systems. All of these systems utilize psychological research on *episodic memory* [Tulving 1972; Tulving 2002], and attempt to maximize the effectiveness of such memory by providing important contextual clues.

Time is also a crucial dimension in the discussed conversation oriented email interfaces since threads provide meaningful context only when they are chronologically accurate. Likewise, temporal ordering of messages is vital in several of the social networks oriented email visualizations that were mentioned previously (*PostHistory*, *Social Fragments*). Additionally, few other email interfaces use the notions of time and episodic memory in the same manner as the listed information management systems. Both the timeline visualization proposed by Jovicic [Jovicic 2000] and *TimeStore* interface [Yiu et al. 1997] show time along the x-axis and contacts along the y-axis. *TimeStore-TaskView*, an extension of the *TaskView* project, visualizes messages "with

future references containing pending tasks" by listing pending tasks along the y-axis and, again, using time as the x-axis [Gwizdka 2002].

3 RESEARCH CONTRIBUTION

Prior research in intimate computing, such as *Forget-me-not* [Lamming and Flynn 1994], has utilized interactive devices. It treats intimacy as familiarity between technology and the user. Even research with the goal of facilitating intimacy between people has relied on physical forms of technology. We recognize email's inherently personal character and so we use it to develop a new, intangible form of intimate computing. This intimacy is based on information. We pursue a multi-dimensional definition of intimacy, one that is consistent with traditional psychology, and develop a framework that enables the user to define, quantify, see, filter and understand intimacy of her relationships. By providing a new experience of one's email communication that is based on intimacy, we want to improve people's lives by enabling them to recognize personal relationships that they need to devote more or less time to. This process is based on an interactive information visualization representation.

faMailiar offers a *time-centric* [Rekimoto 1999] experience of intimacy in the user's email. Email is visualized chronologically for two reasons:

- We are interested in providing the user with an insight into the structure and transformation of her social network by visualizing the chronological rhythms and patterns in communication that shapes up that network. A temporal view of communications enables the user to notice email habits of her contacts and maintain her own "responsiveness image" that is in reciprocity [Tyler and Tang 2003] with that of her contacts.

- We are interested in facilitating easier navigation and browsing through the user's email collection. Organizing email messages according to temporal intervals that they belong to (namely, days and weeks) in a calendar-like manner, with a labeling schema that visually differentiates distinct constituents of these intervals (day and night, weekdays and weekends, etc.), faMailiar provides temporal cues, which are essential in enhancing the user's episodic memory [Tulving 1972].

By applying the notion of intimacy to the email data and organizing the visualization in a calendar-like manner, we help the user to see the patterns in the data. Furthermore, by facilitating the interaction techniques of zooming, panning and *implicit semantic zooming*, we address the paramount visualization problem of showing a large amount of data on the small screen space [Tufte 1990] and enable navigation across the large email collections.

3.1 Defining Email Intimacy

We computationally define intimacy in the email domain as a combination of the following two metrics:

- *contact intimacy category,*
- *message intimacy weight.*

Contact intimacy category is a user-defined parameter that reflects how intimate the user feels about her email contacts. faMailiar enables the user to categorize her contacts into five intimacy categories ranging from the most to the least intimate. All the contacts are initially categorized as having the lowest intimacy category. We

acknowledge that relationships between people can change over time, and faMailiar enables the user to modify the intimacy rating for any of her contacts at any time.

On the other hand, *message intimacy weight* is a computed parameter, based on message data. Each message is procedurally assigned an intimacy weight rating between 0 and 1, using Lucene [Lucene 2003], as a result of information retrieval analysis of the presence of "intimate" and "anti-intimate" keywords. Additionally, forwarded messages and those having more than one recipient are assigned decreasing intimacy weight.

Semantic analysis of message text is a hard task and could be extended into a thesis of its own. However, the use of basic information retrieval techniques of term identification has been sufficient to provide initial valid results. The choice of the intimate and anti-intimate keywords, whose presence increases and decreases the message intimacy weight, respectively, reflects our desire to provide support for a diverse and flexible definition of intimacy. Below are some of the examples that demonstrate how message intimacy weight is determined in faMailiar:

- emotional vs. cold ("love, baby" is an intimate syntagma, while "to whom it may concern" is an anti-intimate),
- formality of language ("yo" and "what up" are intimate syntagmata, while "Dear Mr." and "Sincerely," are anti-intimate),
- casual vs. professional ("party" is an intimate syntagma, while "assignment" or "meeting" are anti-intimate),
- capitalization (messages in which all the sentences begin with lower case letters are more intimate than ones that are capitalized properly).

Psychological researchers almost unequivocally divide autobiographical memory into semantic memory and episodic memory [Levine 2004]. According to Levine, semantic memory is a time-independent collection of facts and knowledge about one's past (including the knowledge of specific events within that past); episodic memory, on the other hand, is a "conscious recollection of a temporally and spatially specific event from one's personal past."

The user's knowledge of a contact's intimacy category is a piece of concrete, time-independent semantic memory. On the other hand, each new message arrival or departure is a primary event in one's email experience. As Cahill and McGaugh [1998] point out, emotions that people tie to events are crucial in episodic memory and remembering. In faMailiar, message intimacy weight implies the emotional context for the episode, while message time provides the chronological context. Together with the semantic context afforded by the visualization of the contact intimacy category, we believe that mapping of these two episodic cues can enable the user to remember the event easier.

3.2 Visualizing Email Intimacy in Temporal Context

The space of email messages and their attributes over time is multi-dimensional. In designing the visualization, we assigned time itself to the x- and y-axis, then used shapes and attributes of color to convey dimensions of intimacy.

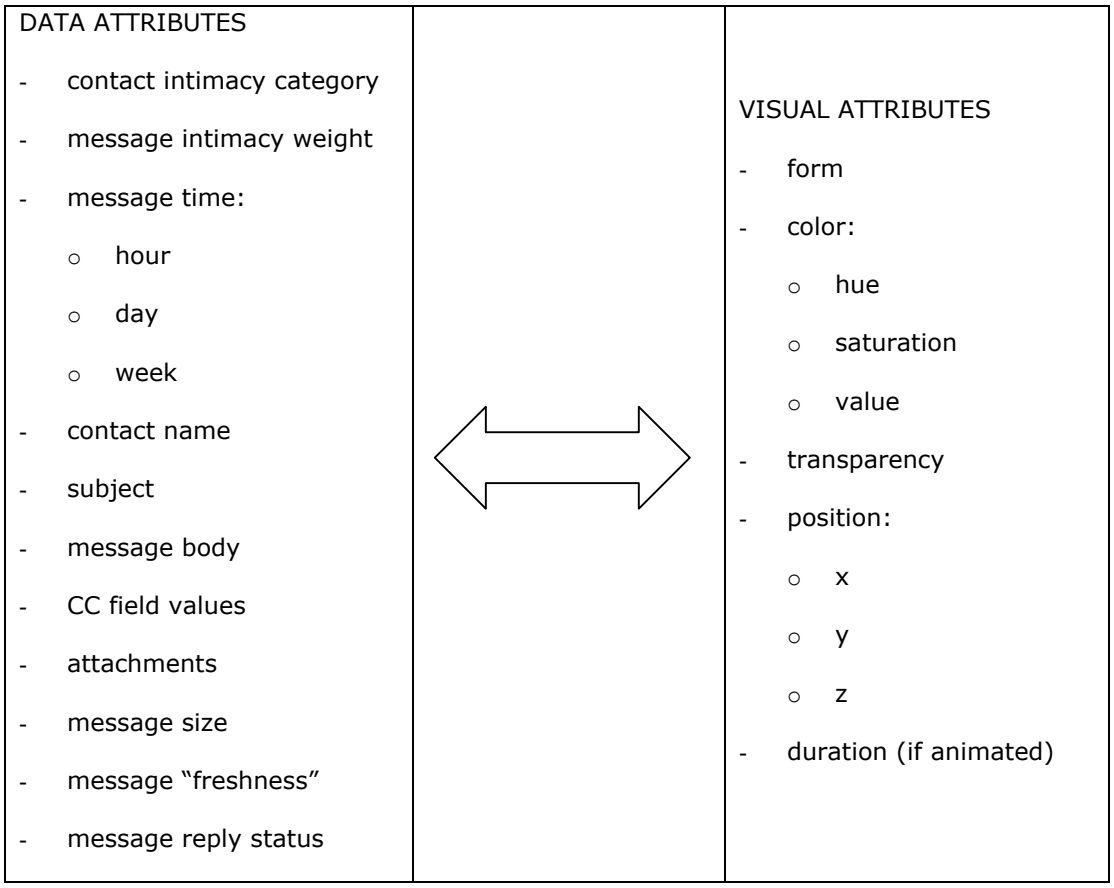

FIG. 1. The multi-dimensional spaces of possible mappings for the email/intimacy data to visual attributes (each attribute represents a dimension).

3.2.1 Mapping of Email Intimacy to Visual Attributes

Before we elaborate on how data is mapped to visual attributes in faMailiar and what other sets of mappings were considered in the early prototypes of the interface (Section 6), we provide a schematic view of the multi-dimensional design matrix (Figure 1) that was examined in the pursuit of clear and cognitively fitting mappings. Note that there are numerous possible correspondence combinations, especially when redundant

mappings (one data dimension is mapped to more than one visual attribute) are considered.

In essence, every visualization problem deals with a design space similar to the one introduced above: some set of data attributes is mapped to a set of visual attributes. Even though these spaces can be large (especially the data space, which is entirely domain specific), the number of possible mappings is not unlimited. Careful exploration of the potential mappings was a crucial step in the design of the intended experience framework. We took an ecological approach [Kerne 2002] and surveyed knowledge originating in a diverse set of disciplines, bringing them into one in our design. During this step, we drew upon:

- established, empirically proven information visualization principles (e.g. shape is irrelevant in visualizing ordinal data, length is effective for encoding quantitative information [Mackinlay 1986]) and the conclusions of autobiographical memory research (e.g. knowledge of an event is a piece of semantic autobiographical memory, while the temporal context for that event is a piece of episodic autobiographical memory), and
- domain-specific knowledge (e.g. psychological and sociological research into the manifestations of intimacy in interpersonal relationships, and the results of email-related studies).

Based on a cross-disciplinary approach (cognitive and art), faMailiar uses hue and iconography to represent contact intimacy categories (Figure 2). Mackinlay points out that color hue is effective encoding in nominal perceptual tasks [Mackinlay 1986].

We recognize that there is an inherent relationship between the nominal perceptual tasks and semantic autobiographical memory. According to Itten, "cold-warm contrast ... contains elements suggesting nearness and distance" [Itten 1973]. Consequently, faMailiar shows messages from the contacts that the user categorized as the most intimate, using a warm, yellow hue in contrast to the grey background. Even though symbolically, red might be treated as being warmer than yellow, yellow contrasts the background, grey hue better. Therefore, for the sake of consistency within the gradating approach we propose, yellow is used to represent the most intimate contacts. In the same schema, messages from the contacts in the fifth, default category are represented by a cold, grey hue, and by design, almost blend into the background. Messages from contacts in the categories between the two extrema are shown in red (second), green (third) and blue (fourth category).

Similarly, there is a gradation in the number of edges of the shapes that are used to represent incoming messages - messages from the most intimate contacts are visualized as triangles, while the messages from the least intimate ones are depicted as circles (Figure 2, bottom). We have decided to use simple shapes with sharp edges to describe clearly defined, more intimate relationships, and vice-versa.

While all the incoming messages are represented as gradually more complex icons, the messages that were sent by the user have a distinctly different shape (Figure 2, top). They are represented as stars. Like incoming messages, they are assigned an appropriate hue based on the recipient's contact intimacy ranking. Additionally, as [Whittaker and Sidner 1996] identify that email has been overloaded by many new,

unexpected functions it was not designed for, we represent messages that the user has sent to herself (i.e. reminders) as white stars, making them highly visible.

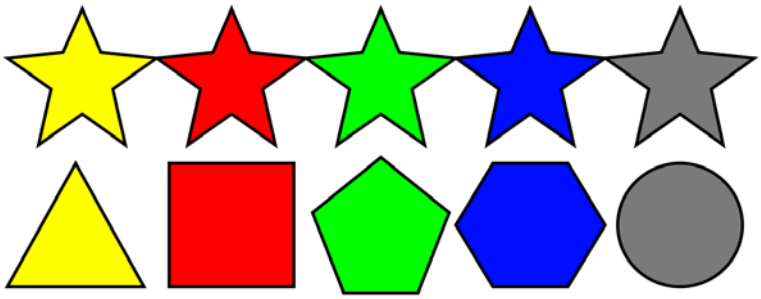

FIG. 2. Outgoing (top) and incoming message icons (bottom), ordered from left to right by decreasing contact intimacy category.

Message intimacy weights are visually differentiated through the use of color value. More intimate messages are brighter than the less intimate ones, thus making it easier to find a specific message within a subset representing email interchange with contacts from the same category, or with a single contact. As we pointed out earlier, numerically determined message intimacy weight can be any non-discrete value in the range between 0 and 1. Mapping these weights directly to the color values could produce results that are hard to differentiate, since the color value space that they would be mapped onto would be continuous. Therefore, we have decided to map the numerical intimacy weight values to four discrete color values within the aforementioned range. Each intimacy weight is mapped to the maximum value in the range quarter that it belongs to (.25, .5, .75 or 1). Figure 3 shows four messages from the same contact

intimacy category, but with different message intimacy weights. We realize that the user may need to learn these mappings.

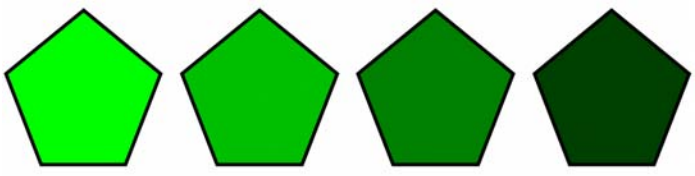

FIG. 3. Message icons belonging to a single contact intimacy category, ordered from left to right by decreasing message intimacy weight.

3.2.2 Calendar Metaphor

As we discussed earlier, the notion of time is essential in faMailiar for several reasons. faMailiar enables the user to experience her email past at two levels of temporal granularity through its daily and weekly views. Since position is the most effective encoding for ordinal data [Mackinlay 1986] and has traditionally been used in timeline paradigms to encode chronological change, we are using x and y position to visualize time in both daily and weekly views.

Daily view (Figure 4) is the most detailed view. It shows all the messages that the user has sent and received, drawing each one of them within the hourly visual segment that its time corresponds to. Days are shown along the x-axis, and hours are represented along the y-axis. Width of the visual daily segments and their labels' font sizes are determined dynamically, according to the maximum number of messages that the user has sent and received during a single hour. Within each hour, incoming and outgoing messages are laid out chronologically, in the order that they were sent or

received. Such ordering creates a meaningful temporal context. Even though our decision to visualize days as starting at 5 A.M. is inconsistent with the reality, it is consistent with our goal of creating an experience that is rhythmically aligned with the user's perception of time.

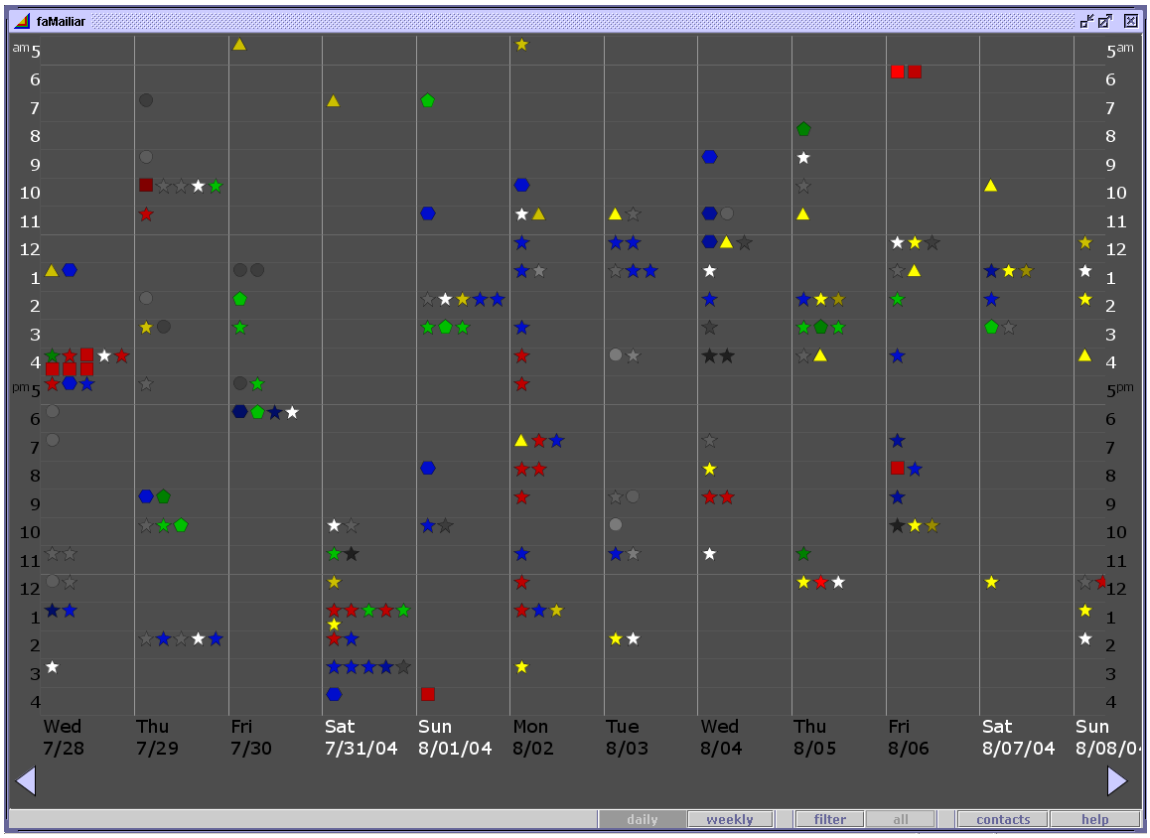

FIG. 4. Daily view of a user's email.

In order to enable the user to more easily perceive communication rhythms, horizontal and vertical labels are colored according to a descriptive scheme in the daily view. Vertically, labels for daytime hours are white, while the labels for nighttime hours are black; horizontally, labels for weekdays are black, in contrast to the white labels used

for the weekends. The disparity in label colors makes the patterns, such as "person A always emails me in the evenings" or "person B never responds during the weekend" more apparent. Additionally, the relative distance between the messages that belong to the same conversation affords insight into how quickly contacts respond, or how long it has been since the last time the user emailed a specific contact. Messages visualized in such a way make it easier for the user to develop responsiveness images for herself and her contacts. The user is thus enabled to keep up appropriate reciprocity in her email communication. Additionally, the user can identify relationships that she needs to devote more or less time to, or recognize periods of intense email exchange related to a specific activity in her life. In order to accentuate the visibility of these patterns, faMailiar supports zooming and filtering of message icons. We will discuss more about these interactive characteristics of the interface in Section 6.

In the weekly view (Figure 5), weeks are aligned along the x-axis and days are visualized along the y-axis. While in the daily view each icon represents a single message, in the weekly view, icons represent all the messages in the contact intimacy category they stand for within the specified day. Therefore, an icon can represent an arbitrary number of messages. We introduce scale as a new visual dimension to convey the notion of volume in the weekly view: each icon is scaled proportionally to the number of messages it represents. The numerical value used as the scaling factor is a result of a linear interpolation between the minimum and the maximum daily message volumes, over the entire collection. The shape and color hue used to represent contact intimacy categories are consistent with the daily view, while color value of each icon is

derived from the average of all the message intimacy weights for all the messages that it signifies.

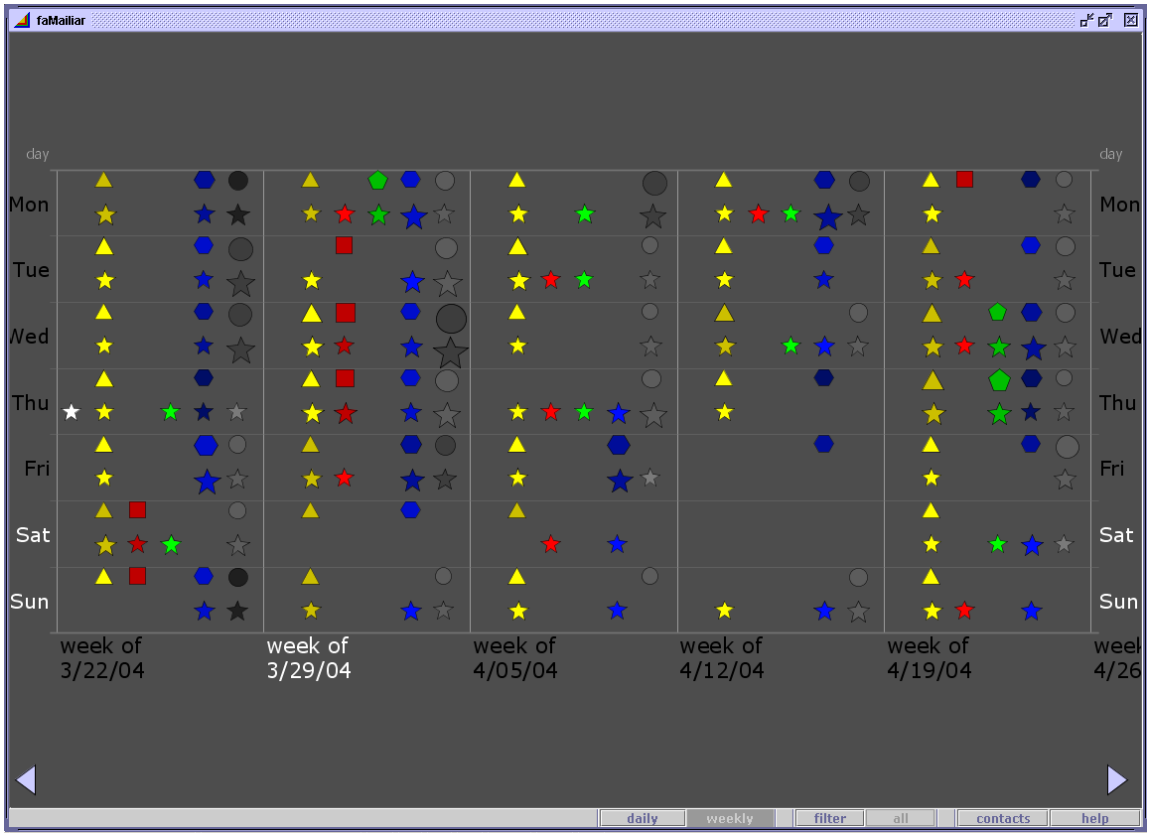

FIG. 5. Weekly view of a user's email.

Since, unlike in the daily view, each icon represents an arbitrary number of potentially non-consecutive messages, chronological ordering within the separate days constituting the weekly visual segments is impossible. Instead, to provide better support for pattern recognition, icons within each day are placed in two rows. The icons in the top row represent incoming messages and the ones in the bottom row signify outgoing

messages. Icons in both rows are ordered according to the decreasing contact intimacy category, from left to right.

Labeling schema used in the weekly view is uniform with the labeling schema of the daily view. Vertical labels for weekdays are different than the labels for weekends. Horizontally, the first week in each month is labeled with white letters, while all the other weeks are labeled with black letters providing additional contextual awareness.

4 INTERACTION MODEL AND USER EXPERIENCE

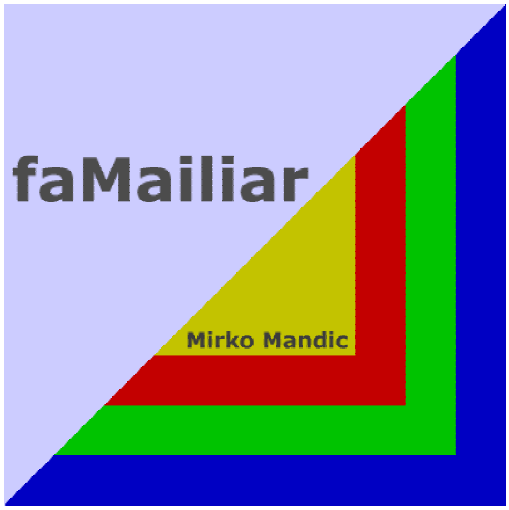

FIG. 6. Introductory splash screen.

In this section, we present faMailiar's interaction model and intended user experience. The user can interact with faMailiar through two main application windows - the contact window and the email window. Interactive experience provided by both of these windows is described here.

4.1 Contact Window Interface

At the application start-up, the introductory splash screen (Figure 6) is replaced with the contact window interface (Figure 7). The contact window interface contains a list of all the contacts, each of them preceded by five icons representing possible visual mappings of his/her contact intimacy category. The icon indicating a contact's current intimacy category is visually differentiated from the other possible intimacy category icons for that contact - its color has distinctly higher value and its border is colored differently. This makes the currently selected category assignments stand out and

enables the user to quickly associate the chosen contact intimacy rating with the appropriate contact.

At start-up, faMailiar synchronizes with Microsoft Outlook by extracting all the newly saved messages in the user's Outlook folders. If the user is interacting with faMailiar for the first time, her entire email history will be extracted from her Outlook folders. Otherwise, only the messages saved after the last time faMailiar was used will be extracted from Outlook. In order to make the system's state transparent during the message extraction process, a progress bar is provided at the top of the contact window (Figure 7). The progress bar is only visible when the message extraction is taking place.

As new messages are harvested, names of new, unidentifiable contacts found in those messages are added to the contact list, and a new contact indicator ("N") is placed in front of each one of them. In order to have the view automatically scroll to the bottom of the list when a new name is added to it, the user can click on the "auto-scroll" button. The "auto-scroll" button is placed in the lower right corner of the contact window interface.

When the user places mouse tip over a name, immediate visual feedback is provided – the name and the corresponding icon representing the chosen intimacy category for that contact are enlarged. At the same time, all the email aliases (more on this in Section 4.1.2) associated with the selected name are displayed in a semi-transparent tooltip, on the top of the name. Similarly, when the user moves mouse pointer over a contact intimacy category icon, both the icon and the name associated with it are scaled up.

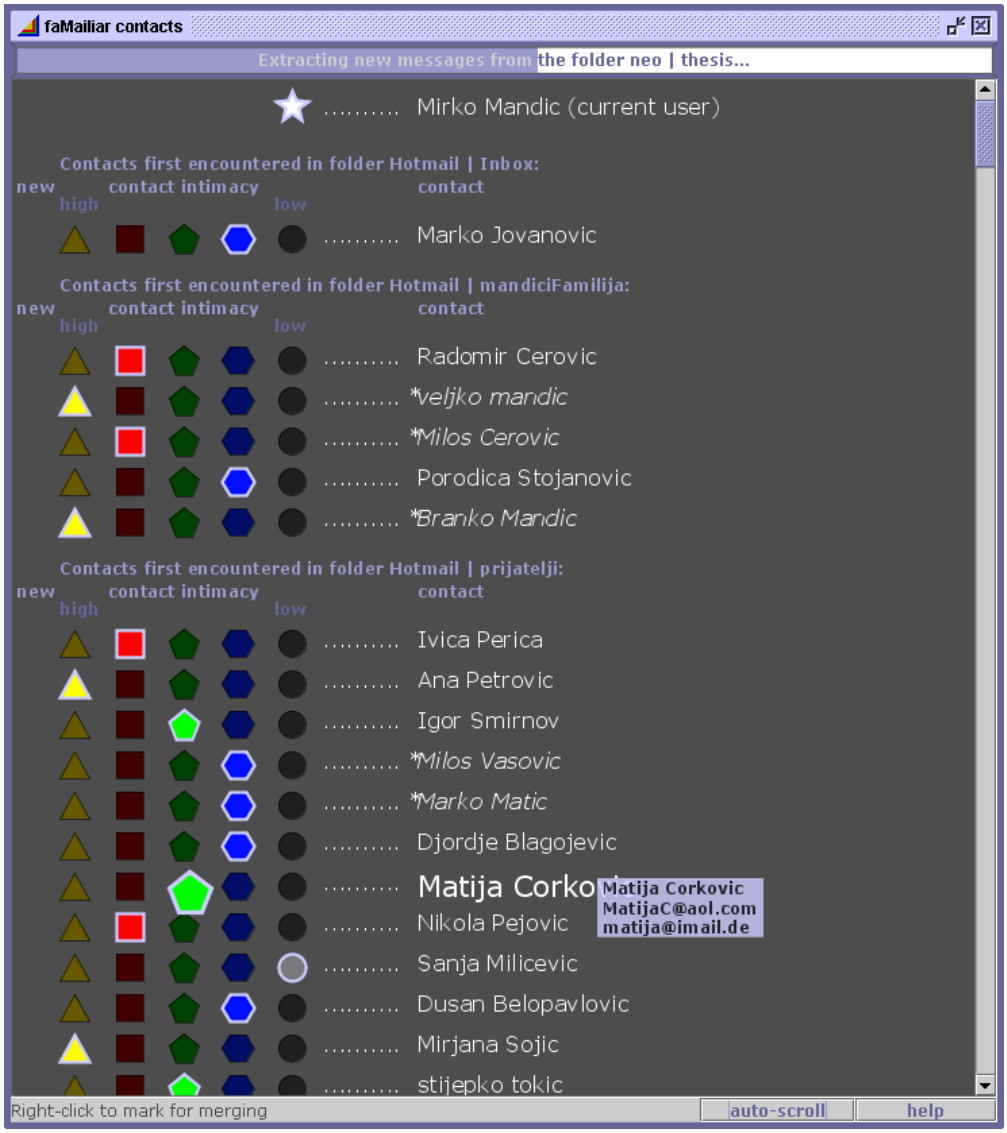

FIG. 7. Contact window.

4.1.1 Assigning Contact Intimacy Categories

As we indicated previously, each contact is initially assigned the lowest contact intimacy category. Contact intimacy assignment changes are immediately propagated

across the visualization. The user can assign a new intimacy category to a contact by clicking on any of the icons that are on the same line as the chosen contact. The user's action is immediately followed by a visual adjustment of the corresponding contact intimacy category icons - the newly chosen icon and the old one change their colors and the border colors. Both the shape color and the border color are changed in such a way that the new ones get brighter and visually more apparent, while the old ones get darker. The icons representing messages form the selected contact in the email window interface (if it has been opened) are also adjusted accordingly. If the user clicks on the icon representing a contact's current contact intimacy category, the ranking is undone and the contact is given the default, lowest contact intimacy category ranking.

4.1.2 Merging Contacts

Gross points out that many email users acquire different roles through distinct email accounts they use on a daily basis [Gross 2002] and Turkle proclaims, "[W]e are both single and multiple voices" [Turkle 1996]. The social role through which we know someone can influence how intimate we feel with that person. Furthermore, if we are in touch with a person in several unrelated contexts (i.e. "I am his boss at work, but when we get together in the evening to play the music, we are just bandmates"), we can feel different levels/kinds of intimacy depending on the context we are in. On the other hand, some (intimate) relationships are so solidly shaped by time and intensity that no change in context can affect the familiarity they embody. Similarly, one might choose a new email alias or open a new email account, but this alteration does not necessarily indicate a transformation in that person's online identity and his/her relationships.

Therefore, the user should be enabled to merge distinct email aliases associated with a single person into one. At the same time, if these email aliases signify distinct roles, with different relative intimacy levels, they should be represented differently.

As new contacts are added, if any new name completely matches any previously extracted name, they are merged into one. A complete match occurs when all the tokens in the names are identical, regardless of their order. Additionally, if there is a partial match (on any one of the tokens), the newly added name is marked with an asterisk preceding it. If a name is marked with an asterisk, the user can use the left mouse click to see a list of all the previously extracted similar aliases and choose any one of the listed names to merge the newly extracted name into (Figure 8). Only if the user selects a name from the list will she be enabled to click on the "ok" button.

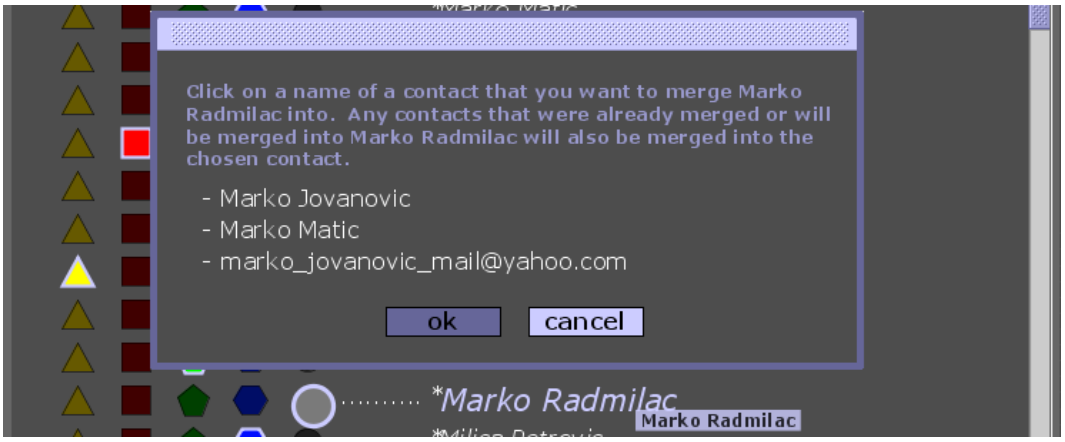

FIG. 8. Contact merging.

Even if there is no similarity in their names, the user can merge any two contacts by using two subsequent right clicks on contact names. The first chosen name is the

source of the merge action and the second marked name is the destination. After the merge is preformed, all the messages to/from the merge source are represented as the messages to/from the merge destination. Note that, in the current implementation, faMailiar doesn't allow the user to perform an action opposite of merging.

4.2 Email Window Interface

The email window interface is intended to be the primary interaction space in faMailiar. Here, the user can access zoomable daily and weekly views, which use iconography and color to represent experiences in the email habitat over time. The patterns in the visualized message data are made observable through the use of the mappings described in Section 3.2, such as mapping shape to contact intimacy category, color value to message intimacy weight and chronological message relationships to x / y position. In order to provide a better understanding of these patterns, the email window interface enables the user to vary the amount of data and level of detail presented in proportion to her moment-to-moment needs. If the user is interested in a particular message, she can interact with it, and access more detailed information. The user can read each message in one of the three messages views (brief, partial and complete) that differ in the amount of the message data (including the text, size, attachments, all the recipients besides the subject and sender/recipient info) they provide.

Similarly, if the user is browsing through her email collection, she can vary the overall amount of the data that is displayed in the email window by changing the zoom level. While zooming enables her to continuously adjust the view scale, *implicit semantic zooming* allows her to change the temporal granularity of the visualization by

altering the viewing mode she is in. She can move through the temporal segments and notice the regularities in the communication by panning the view. The regularities are also accentuated through the use of filters that are available in the email window interface. The filters permit the user to focus on a specific, queried subset of her email communications.

4.2.1 Messages - From Visualization Icons to Message Views

Iconographic message representations in the chronological views facilitate comparative perspective on the rhythm of email communication. They also enable viewing particular messages. As we stated previously (Section 3.2.2), each icon in the daily view represents a message. Based on the user's level of interest, expressed through her interaction with a message icon, faMailiar provides three views of a message's data that differ in the level of detail they provide:

- brief message view (Figure 9, top) is invoked by a mouse-over action and it shows the message subject and the contact-related data for the selected message representation. The contact-related data can be either the sender name (in the case of an incoming message) or a list of all the recipients (in the case of an outgoing message).
- partial message view (Figure 9, middle) is brought up by a left click on an icon and it replaces the brief message view. Partial message view is actually an expansion of the brief message view, and in addition to the data provided by the brief view, it shows the exact message time and a message preview - the first 75 characters of the message body.

- complete message view (Figure 9, bottom) is the most detailed of the three and it replaces the partial message view after the user clicks on the message icon for the second time. The entire message body is provided by this view, including the data already available in the partial view, along with the message size, number of attachments and all the other recipients (in the case of an incoming message sent to more than one recipient).

A causal relationship between a shape and the corresponding message view is indicated by instantaneous increase in the shape's scale and appearance of the message view, as a result of the user's interaction with the shape. A message view is positioned next to the icon that it is related to. It is dynamically placed in the direction of the screen quadrant that is diagonally opposite of the quadrant that the selected icon is placed in. If the text contained in a message view is too long to fit in the message view window (this is particularly likely in the complete message view), a scroll bar appears in the message view (Figure 9, bottom). A message view conveys appropriate intimacy information by having the same background color as the icon with which it is associated. In order to preserve the visual consistency of the interface, the message view's text color is either white or black, whichever maximizes contrast with the background (e.g. white on blue, black on yellow). A message view can be closed by a click anywhere on the screen (other than on the selected icon), and this action is accompanied by a decrease in the scale of the selected icon.

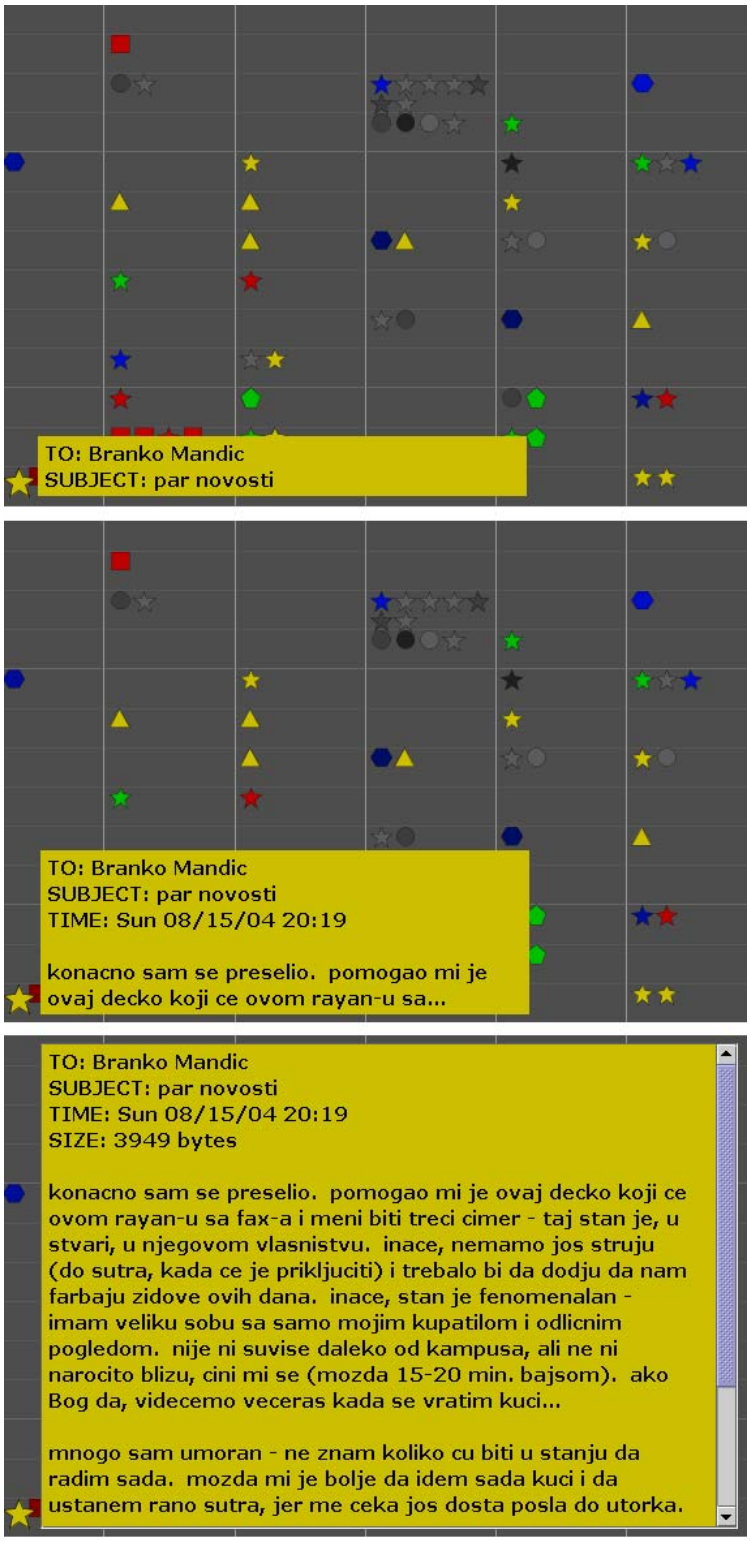

FIG. 9. Message views in the daily viewing mode – brief (top), partial (middle) and complete (bottom).

The interaction semantics and the visual attribute rationale associated with message views in the weekly view (Figure 10) are the same as in the daily view. However, the data that they show is different, since each of the shapes represents an accumulated daily average for all the messages belonging to the intimacy category it signifies. Therefore, the brief message view (Figure 10, top) shows the exact date for the chosen day along with the number of messages represented by the icon. The partial message view (Figure 10, bottom) provides a list including subjects of those messages as well as the associated contact data. The detailed message view is not provided in the weekly view.

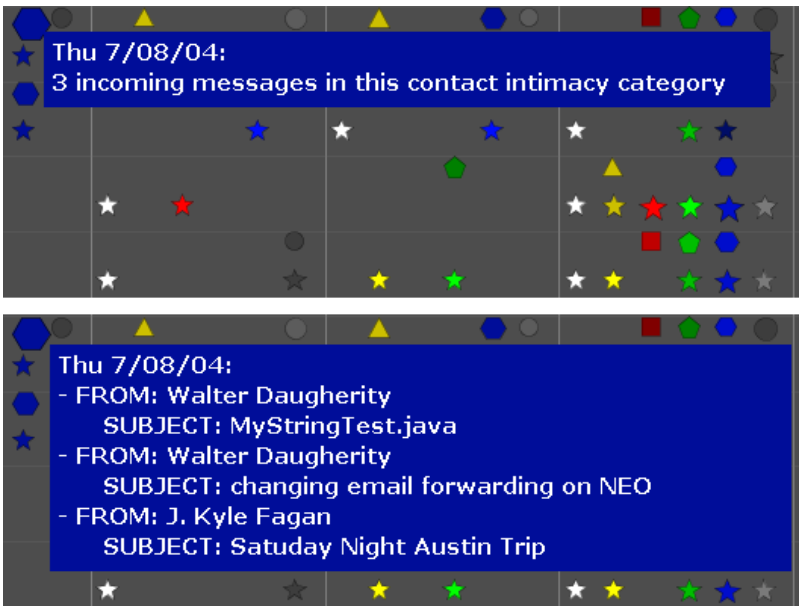

FIG. 10. Message views in the weekly viewing mode – brief (top) and partial (bottom).

4.2.2 Zooming to Navigate through an Email Collection

Patterns in a visualization can only be noticed if a large amount of data is displayed in a self-explanatory manner [Tufte 1990]. Zooming is a visualization technique that provides a "meaningful way (...) to vary the amount of detail presented in a scene" [Clark 1976] and a zoomable user interface (ZUI) "lets [a] user zoom in and out, or pan around, to view much more information than can normally fit on a single screen" [Combs and Bederson 1999].

Zoomable interfaces are present in a wide variety of applications, ranging from industrial CAD programs to word processors. In order to accentuate the communication rhythms and patterns in the user's email and so make them more observable, faMailiar supports zooming, panning and filtering of message icons. Zooming and panning functionalities were built using the Piccolo ZUI toolkit [Piccolo 2003]. The user can zoom continuously around any point on the screen by pressing the right mouse button, and while still holding the mouse button down, drag the mouse to the left (to zoom out) or to the right (to zoom in). When in the daily view, zooming enables the user to fill the screen with as little as one day, or as much as an entire month (Figure 11); when in the weekly view, between one week and four months. A filtered, zoomed-out view can afford a striking visual emergence of communication patterns. For example, the visualization in Figure 11 makes it clear that the user and the selected contact email each other intensely (almost every day), and almost always between 2 and 7 P.M. Also, observable is a daily micro-rhythm – almost every day, an incoming message from the selected contact precedes the outgoing message sent by the user to that contact.

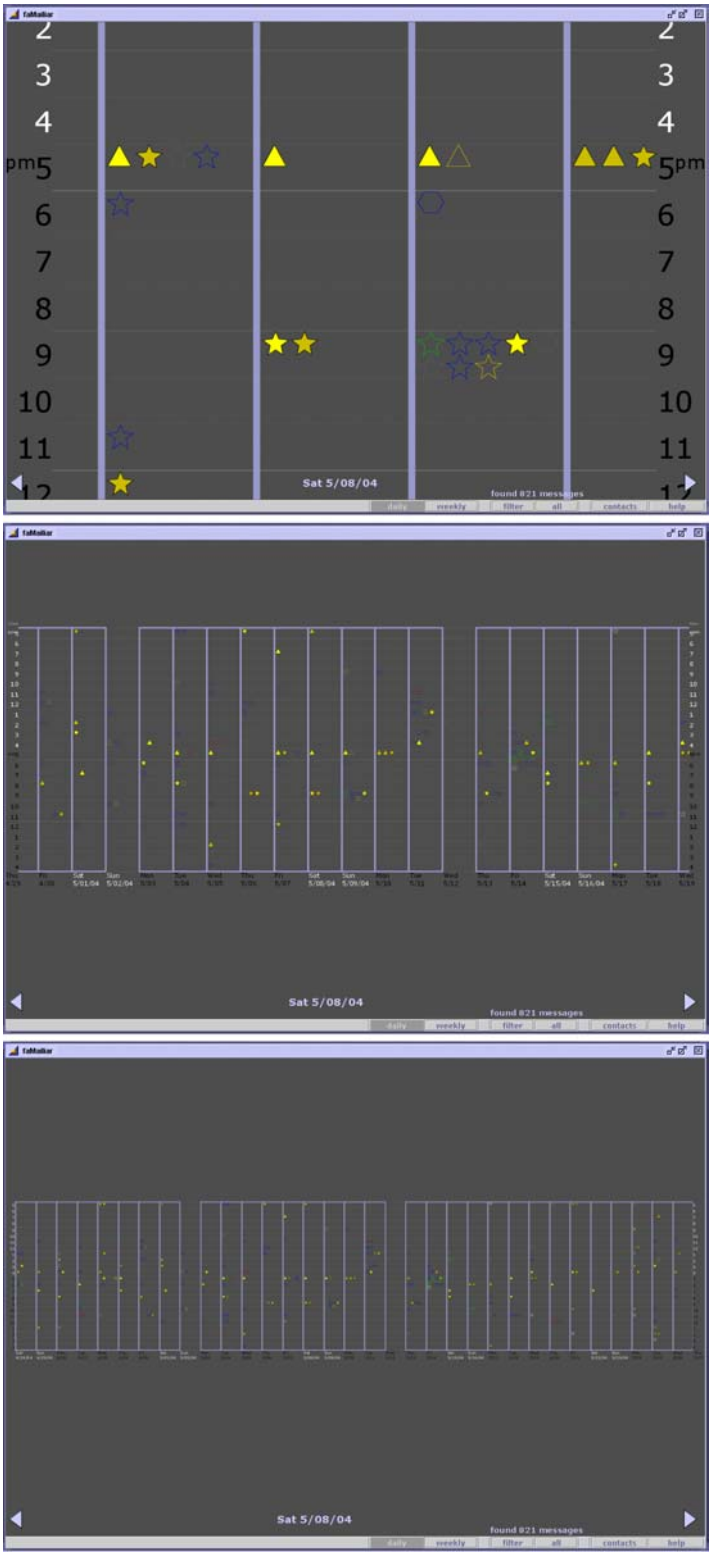

FIG. 11. Different zoom levels of a filtered email view.

The user can pan the view in two ways when using faMailiar. The first follows a traditionally accepted ZUI panning interaction model, achieved by holding the left mouse button down and moving the mouse in any desired direction. This action causes the view to move along with the mouse tip. The second way, in essence an auto-pan action, enables the user to scroll the view only horizontally, shifting the chronological framing. When the user places the mouse tip over an arrow (left and right bottom of the screen), the entire view starts continuous movement in the direction indicated by the arrow. The movement animates the chronological frames, enabling the user to recognize the communication rhythms without having to interact with the interface. When the user wants to stop the auto-pan, she just needs to move the mouse so that its tip is not above the arrow. The panning speed is proportional to the zoom level. A zoomed-in view indicates that the user is interested in detail and therefore, the panning speed is slower. On the other hand, a zoomed-out view implies overview browsing, so the panning speed is increased.

Zoom scale and the vertical view pan offset of the vertical labels (hour labels in the daily view and weekday name labels in the weekly view) are consistent and maintained with the zoom scale and the vertical view pan offset. However, the vertical labels are always attached to the screen edges (they can not be panned in any non-vertical direction). On the other hand, the horizontal labels (day/date labels in the daily view and week labels in the weekly view) are attached to the visual temporal segments that they provide information about (days in the daily, and weeks in the weekly view). Therefore, they can become entirely invisible if the view is highly zoomed-in (Figure 11,

top), or unintelligible, if the view is zoomed-out (Figure 11, bottom). To alleviate this problem, when the user moves the mouse pointer over a visual temporal segment, immediate system feedback is provided through the appearance of an appropriate temporal context indicator at the bottom of the screen, right below the segment that the user interacted with. The temporal context indicator's text is the same as the text that is in the label of the daily/weekly interval segment that the user interacted with. So, if the label is not visible, the user need only move the mouse tip over a temporal segment she is interested in. For example, in Figure 11 (all visualizations), the text at the bottom of the screen clearly indicates that the user is positioned with the mouse pointer over the daily email segment for Saturday, May 9 2004.

In semantic zooming, "as the magnification of an object changes, (...) different types of information about that object (are displayed)" [Perlin and Fox 1993]. faMailiar enables the user to switch between the daily and the weekly level in a manner that utilizes semantic zooming. If the user is in the daily view, she can click on the "weekly" button to change to the weekly view, and vice-versa. faMailiar responds by slowly fading the current view out and replacing it with the selected view. Consistency of their visualization parameters is maintained. If the view that is being faded out is filtered, the view replacing it will be filtered as well (according to the same filtering criteria). The views are also temporally aligned – when the switch is made form the daily to the weekly view, the weekly view will be centered on the week including the day that was at the center of the daily view; if the current view is weekly, the daily view, when it appears, will be centered on the middle of the week that was at the center of the weekly

view. We call this interaction technique *implicit semantic zooming*. Figure 12 shows the daily view being replaced by the weekly view.

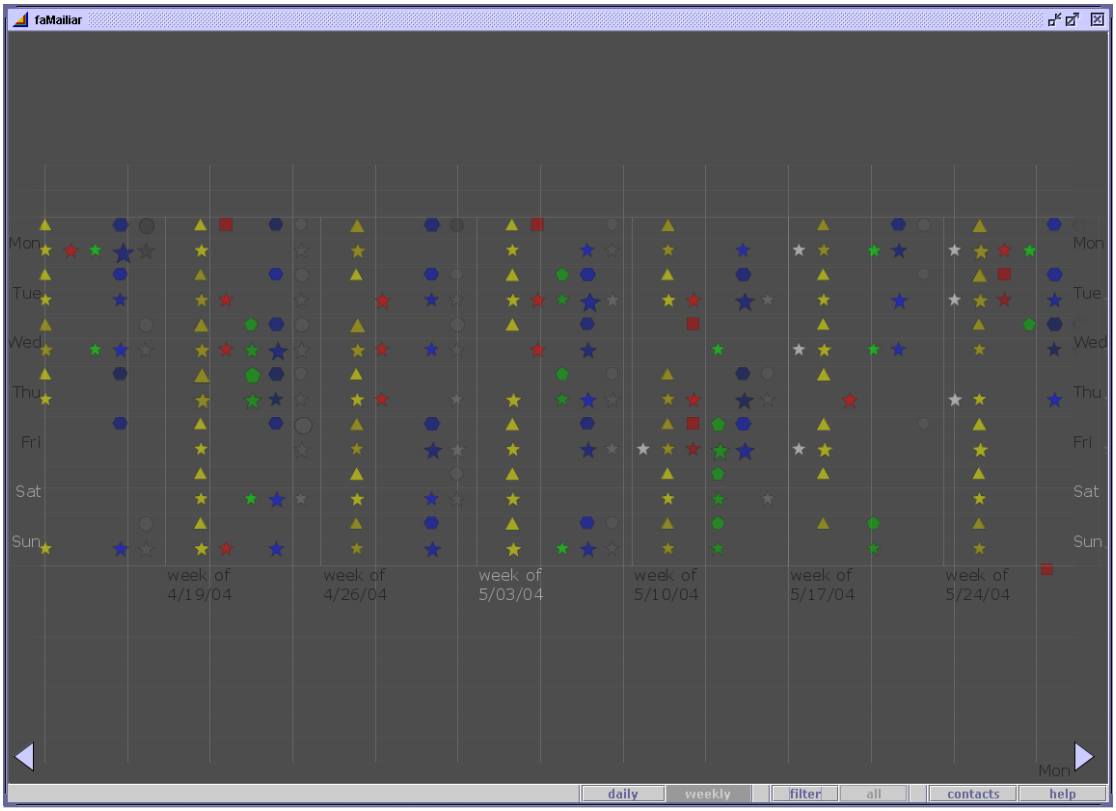

FIG. 12. Implicit semantic zooming – the weekly view replacing the daily view.

4.2.3 Filtering Messages

faMailiar enables the user to visually filter messages in her email collection. Figure 11 shows visualization with a filter (with the filtering settings shown in Figure 13) applied to it. In the daily view, all of the message representations that satisfy the results of the filter criteria are colored, while all the other ones are shown as silhouettes. In the weekly view, images that represent contact intimacy categories containing the

messages that are the results of the filter criteria are colored, while the rest are represented as silhouettes. As we have indicated in Section 3.2.2, filtering is extremely useful in enabling the user to notice communication rhythms and patterns since it enables the user to focus her attention on a significant subset of her email. For example, messages associated with a specific contact, or on a specific topic can be filtered out from the whole.

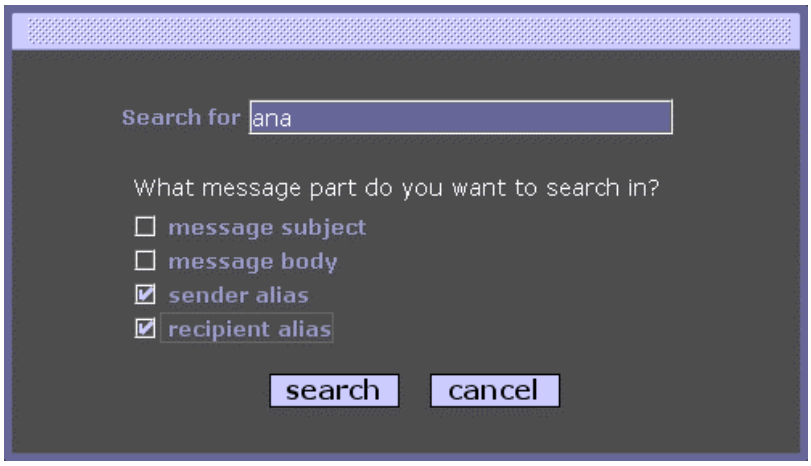

FIG. 13. Filter input box.

Messages can be filtered in two ways: using an input box to specify a search (on subject, body, sender and/or recipient), or by example, in a hypertextual manner, using the reply sequence (i.e. all the messages in the same thread, if the message is a part of a tread) or contact (associated with the selected message). The filter input box (Figure 13) can be invoked by a click on the "filter" button. Filtering by example, on the other hand, is performed through a message popup window invoked by a right click on a message icon. The message popup window (Figure 14) enables the user to filter all the messages

that are in the same thread as the selected message (if the message is a part of a thread) or all the messages to, or from, or to and from the contact associated with the selected message.

FIG. 14. Message popup window.

4.2.4 Communicating via faMailiar

Even though facilitating email communication is not our primary focus, communication is the primary purpose of email, and as such is supported in faMailiar. The user can email any of her contacts by using Outlook's compose window. The compose window is opened when the user clicks on either of the three email options offered in the already mentioned message popup window (Figure 14). These options enable the user to write either a reply, or a forward, or a new message. The message's fields are populated according to the option that the user selected.

5 APPLICATION ARCHITECTURE

The aforementioned interaction model drove the application architecture. The user's experience is the main focus of our approach and the application architecture reflects this tendency. In this section, we provide an architecture diagram (Figure 15) and a high-level description of the faMailiar's architecture.

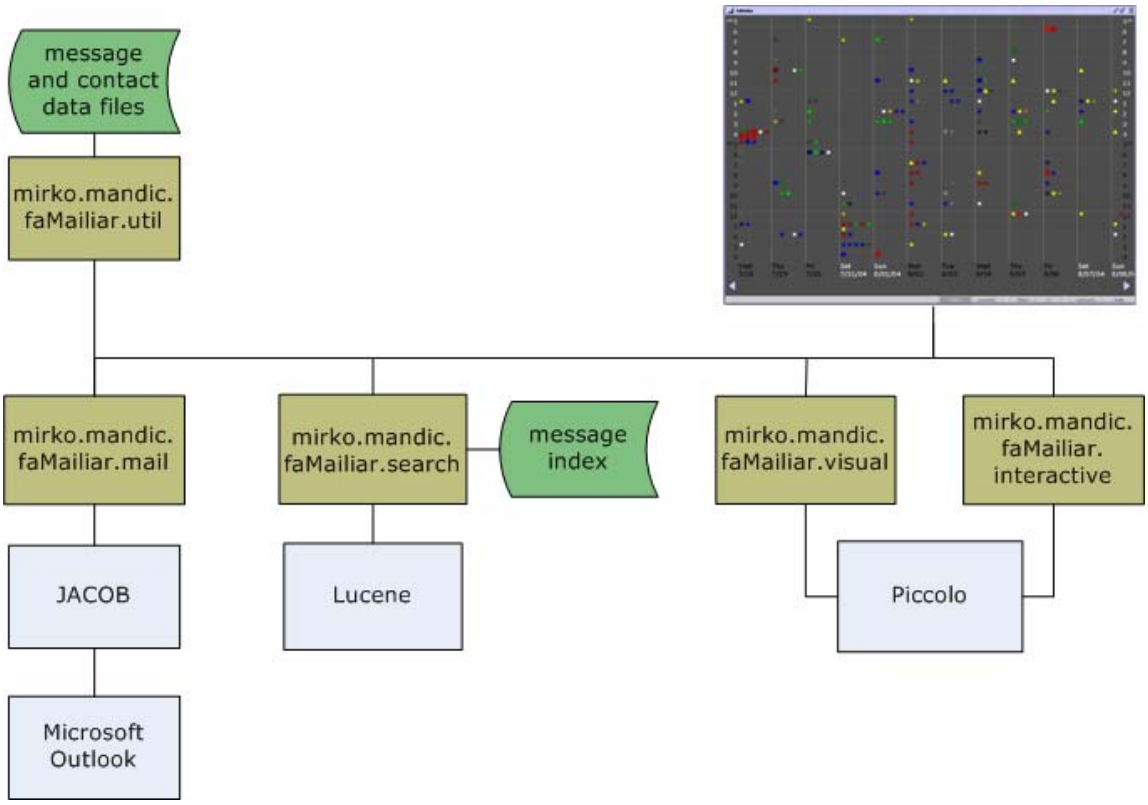

FIG. 15. Application architecture diagram.

According to a study conducted by Scheuett [2002], "the most commonly used email client [is] Microsoft Outlook (at a whooping 60%)". Similarly, Outlook was "by far the most common mail tool" among the interviewees of a research conducted by

Ducheneaut and Belotti [2001]. Additionally, Outlook allows for manipulation with messages associated with more than one email account, and so it can be used as a single source for all of the user's email. Therefore, to take advantage of Outlook's popularity and the great availability of the user's email messages it provides, we decided to support it in faMailiar. JACOB, a Java-COM Bridge [JACOB 2003], was used to interface Java and Outlook (through COM), and Piccolo, the already mentioned (Section 4.2.2) graphics toolkit was used for its zooming and panning capabilities, as well as for its flexibility in building appealing graphical representations.

On the top of these three open source libraries, we developed about 65 classes, organized into 5 packages:

- mirko.mandic.faMailiar.mail contains all the contact and message classes, as well as classes that extract messages from Outlook and delegate them to appropriate temporal intervals.
- mirko.mandic.faMailiar.search contains classes that build a searchable message index and enable searching of the indexed message data, as well as classes that are used to estimate message intimacy weights.
- mirko.mandic.faMailiar.visual is the most comprehensive package, containing classes representing the basic message shapes, all the visible temporal segments and grids that visually define them, and all the custom-made GUI components.
- mirko.mandic.faMailiar.interactive contains all the window event handler classes, along with pan and zoom handlers.

- mirko.mandic.faMailiar.util contains utility classes - file manipulators, html messages parser, faMailiar calendar and a class that uses Java's regular expression support to compare contact names for similarity.

6 DESIGN PROCESS AND EVALUATIONS

faMailiar was developed through a human-centered and iterative design process. Even though our vocabulary in this thesis is deliberately not consistent with the distinction (for the sake of clarity and uniformity with the traditional use), we primarily treat our "user" as a "human," and secondly as a user of the application. We believe that the distinction is crucial in creating an intimate experience framework that visualizes interpersonal communication. The user, as such, has been involved in the process from early on. We created several interface mockups and evaluated the most promising ones with the users' help. Consequently, faMailiar was built according to the results of those evaluations, and in turn, it was appraised through the second user study. In this section, we briefly describe the early mockups and discuss about both of the user studies.

6.1 Design and Evaluation of Early Interface Mockups

Multi-dimensional matrix of mappings from email/intimacy data to visual attributes introduced in Section 3.2 was used in the creation of the early interface mockups. At first, about ten interface mockups were produced with pencil and paper. Informal discussions with other computer science graduate students and several friends who are avid email users helped us choose three mockups that had the most potential to be developed into interesting and useful intimacy-based email visualizations. Using an image editing program, the three pencil and paper mockups were developed further to create three sets of interactive storyboards (Figure 16).

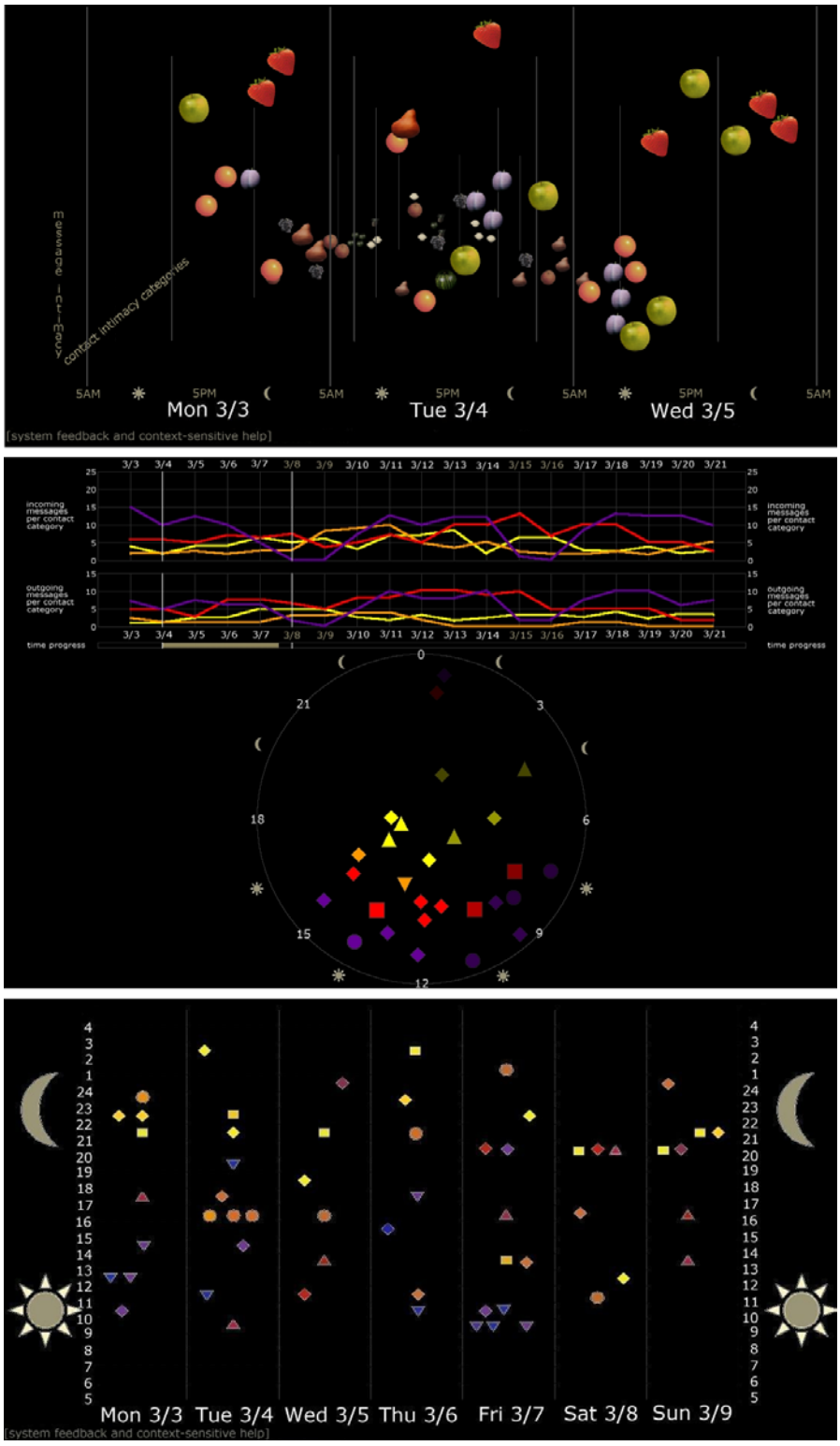

FIG. 16. Early interface mockups.

6.1.1 Early Interface Mockups Design

In mockup 1 (Figure 16, top), we used disjoint sets of fruit images to represent contact intimacy categories. Fruit was chosen because of its organic nature, visual simplicity and a wide variety of colors and tastes that it comes in. Initially, four intimacy categories were used, instead of five. After the user specified a contact's intimacy category, she would pick a specific fruit from the subset of images associated with the chosen category to represent the messages from that contact. In order to visually group messages belonging to the same contact intimacy category (especially if visualized as different fruit), y-axis (depth) was used. The level of interpersonal proximity was mapped to one of the four discrete levels of visual proximity, in a schema where more intimate categories meant closer visual representations. Message intimacy weight was mapped to the y position of the fruit icon (more intimate messages were higher than the less intimate ones). Additionally, while a date was mapped to the x position of the visual time interval segment representing it, specific message time within that date was mapped to the x position within the time interval segment (starting with 5 A.M.).

Baudisch et al. state, "In [overview+detail] interfaces, one window is the overview, which always displays the entire document. The other window, the detail view, shows a close-up portion of the document" [Baudisch et. al 2002]. In mockup 2 (Figure 16, middle), we used an overview+detail approach by visualizing the quantity of incoming and outgoing messages over a long time interval in the top portion of the mockup, and by showing a detailed view of email interchange in a specific temporal

segment that belongs to the specified interval in the bottom portion of the mockup. For example, it the user was in the daily view, she would be able to click on a day label in the top of the screen and message data for the chosen day would be shown in the bottom portion of the screen, organized temporally in a clock-like manner. The clock metaphor was slightly inconsistent with the real clock, since the visualization space that represented the clock was separated into 24 sequences, instead of 12. Shape and color hue of a message icon were used to represent the contact intimacy category, and its distance from the center to signify message intimacy weight. Shapes were chosen randomly, while the colors were specified according to the already mentioned warm-cold rationale. Animation was also featured in this mockup. If the user specified a time range by clicking on any two time interval segments in the top portion of the interface, all the emails sent and received during the selected time span would be shown in an animation, in the bottom portion of the screen. Each of the email representations would stay on the screen exactly for one clock revolution and would disappear by gradually fading out.

As Figure 16 (bottom), mockup 3 is similar to the interface developed in faMailiar. However, the moon and the sun icons (which indicate the difference between the daytime and nighttime in mockup 3) are not present in faMailiar. Also, unlike what we developed in faMailiar, in mockup 3, shapes that represent different contact intimacy categories were randomly chosen. Additionally, color hues chosen to represent message intimacy categories (yellow, orange, purple, blue) are different from the ones in faMailiar (yellow, red, green, blue, gray). Finally, instead of using color value, color

hue is altered to indicate the message intimacy weight. Numerical message intimacy weight was used to interpolate between the color hues representing the contact intimacy category associated with the selected contact and the next less intimate category.

6.1.2 Early Interface Mockups Evaluation

In this section, we describe the user study conducted in order to evaluate the mockups, and discuss about the results of the study, as well as their design implications.

6.1.2.1 Participants and Protocol

The user study involved 6 participants (2 female, 4 male), all computer science students (1 undergraduate, 5 graduate; 3 doing with HCI-related work). All of the participants were experienced email users (with more than 5 years of email experience). On the average, each one of them had 4 email accounts (ranging from unix command-line email utilities to different web email clients), and all of them assumed different roles when using different email accounts. They checked their email several times a day (within the range of 2-3 times per day to hourly) and spent about 1 hour daily using email applications. Approximately, each received about 25 and sent about 15 messages a day. The test subjects volunteered for the study and received no compensation for participating.

The study consisted of two parts. In the first part, the users filled out a questionnaire related to their use of computers and email. In the second stage, they were shown the three mockups and through an open-ended interview session, they evaluated each mockup separately and compared them to each other. We recorded answers that

the users provided, and also wrote down observations as they were interacting with the mockups.

6.1.2.2 Results and Implications

We list some of the most relevant results of the interview sessions here. All of the answers were provided on a 5-point likert-scale, where 1 meant "strongly disagree" and 5 meant "strongly agree". We also summarize the results by providing a set of interface design implications.

- prior to the interview, only 2 of the test subjects said that they could categorize their contacts according to how intimate they felt towards them. However, after the interview, they gave a 70% approval rate (3.5/5 on the likert-scale) to the use of intimacy as an important "axis" against which one's email could be organized successfully.
- mockup 3 outperformed prototypes 1 and 2 in the following categories that relate to the mappings between data and its visual representations:
  - clarity (4.5 vs. 3.2 and 4.3),
  - intuitiveness (4 vs. 3 and 3.3),
  - ability to show that some messages are more intimate than the others (4.2 vs. 3.2 and 3.7),
  - ability to distinctly differentiate messages from different contacts/groups of contacts (4.5 vs. 3.9 and 4), and
  - ability to provide useful temporal context (4 vs. 3.5 and 3.7).

- mockup 3 outperformed mockups 1 and 2 in the following categories that relate to the social interaction visualization potential:
  - showing communication rhythms and patterns (4.8 vs. 2.8 and 3.7),
  - allowing the user to learn about her contacts' communication habits (4.3 vs. 2.8 and 3.8), and
  - allowing the user to understand her email history better (4.5 vs. 3.3 and 4.2).
- mockup 3 was rated as having the most potential to be used as a diary (3.5 vs. 3.2 and 2.7).
- the subjects felt that it would be easiest to find a specific message if mockup 3 was used (3.3 vs. 2.5 and 2.7).
- the subjects didn't like how message intimacy weight was mapped to an offset in color hue in mockup 3 – several of them noticed that this type of interpolative approach could lead to a potentially infinite number of colors in a continuous color space.
- even though it was identified as "aesthetically superb", mockup 1 was described as being "too confusing" and "very uninformative".
- the subjects were not too enthusiastic about the animation in mockup 2, since it showed (in the bottom portion of the interface) detailed email data for only one temporal segment at a time. Also, most of them had trouble comparing different message intimacy weights in this mockup, since it was hard to compare the distances from the center for the shapes that were not near by in the circular space.

Based on the results of the study, we concluded that the mockup 3 had the highest overall potential. Considering the importance of temporal communication rhythms and patterns to our approach, the user study clearly pointed in the direction of a timeline-based solution. Additionally, given the large amounts of data that would potentially be visualized, the user study helped us understand that zooming capability is absolutely necessary if we wanted to produce a useful interface. Also, several subjects pointed out that the visualization should provide additional support through some filtering capabilities.

We realized that the message intimacy weight was not visualized effectively in mockup 3 and we concluded that a non-continuous domain must be used to show message intimacy weights. At the same time, the user study confirmed that color hue is an effective encoding for contact intimacy category. On the other hand, we became aware that even though shapes were used successfully to support color hues through their redundant mapping in mockup 3, in order to make the mapping even stronger, they should not have been chosen randomly, but rather, in a predictable and informative way.

Even though it was accepted by the participants as the most interesting, the 3D interface proposed in the mockup 1 was decidedly unsuccessful, especially with respect to its support of the communication rhythms and patterns. This was caused by the proportion deformation and visual overlap that are inherent to the interface's 3D character, as well as possible multiple mapping of a single contact intimacy category to several fruit shapes.

Based on the study results, we concluded that the animation would not be a good solution. In order to focus more on a specific time interval segment or a particular message, the user would have to slow the animation down (or even pause it), which would have the effect of distorting her perception of time and disabling her understanding of the communication rhythms and patterns. Based on these evaluations, we built the system described in Sections 3, 4 and 5.

6.2 Evaluation of faMailiar

After an initial working implementation of faMailiar had been constructed, we developed the second user study. We took an ecological approach in designing it. The study was to be experience-oriented, since our overall process and goals were experience-oriented. The purpose of the study was to evaluate how effective faMailiar is in facilitating browsing through email collections and providing a richer human experience of an individual's email history, especially with the respect to communication rhythms and patterns. The design of the study acknowledged email's personal and private nature. We didn't want to disrupt the participants' email habits. We didn't want to bring them into a "usability lab" or other artificial test environment. Instead, we asked them to use faMailiar in the same personal context(s) in which they were already reading and writing email. There were no specific tasks. We wanted to see how the perspective afforded by faMailiar might affect their overall experience with email. In this section, we describe the study and discuss its results and implications.

6.2.1 Participants and Protocol

The preliminary user study involved 4 participants (3 computer science students and industrial design student). All of the participants were avid and experienced email users – they all checked their email accounts several times a day and all had more than 5 years of email experience. On the average, each participant had 3 email accounts (ranging from unix command-line email utilities to different web email clients) and all of them assumed different roles when using different email accounts. They spent around 1.5 hours daily using email applications, on the average. Approximately, each received about 15 and sent about 15 messages a day. The participants volunteered for the study and were not compensated for participating.

The study participants were given the application and were instructed to use it at their own discretion during a period of seven days. They began with extremely limited knowledge of both the conceptual and the implementation characteristics of faMailiar. The participants were introduced to the main functionalities of the system through a 15-minute training session, which entailed an interactive demonstration. The email data that was visualized in the demonstration belonged to us.

During the week that they had a chance to interact with faMailiar, the participants reported using it on daily basis, several times during the day. On the average, the interaction lasted for about 20 minutes and overall, each participant spent about 3 hours using the application during the week. The number of visualized messages ranged between 100 and 1,000, with the average of 650. The visualizations

covered time intervals ranging between 3 weeks and 4 years, with the average of about 2 years.

At the end of the week, a two-part interview session was conducted with each participant. The pre-interview questionnaire was used to gather demographical information and to assess the user's general email tendencies. During the second part (an open-ended interview), we recorded the participants' answers and observations related to their experience with faMailiar. The recorded answers were either in the form of a rating on the 5-point likert-scale, where 1 meant "strongly disagree" and 5 meant "strongly agree," or a particular short answer related to the interface. The recorded observations that emerged out of the discussion with the participants were preserved in the form of a list of major ideas and comments made by the participants.

6.2.2 Results and Implications

The most relevant results gathered from the interviews are provided below. A summary of the results and conclusions about the evaluation are provided at the end of this section. We first present the results that relate to the faMailiar's ability to provide new, richer experience of the user's email past and to successfully visualize the social interactions expressed in the rhythms of the communication:

- participants felt that faMailiar enabled them to get a better understanding of their email history (average 4.25/5 on the likert-scale), as well as what activities they were spending their time on during specific visualized time periods (average 4/5 on the likert-scale). One of the participants was surprised by the amount of email he wrote and concluded that his sleep patterns were not healthy, based on the

erratic distribution of the messages he sent. Another participant noted, "I could see that in past four years I lost many of my personal relationships in favor of school." Yet another participant observed that he could understand better how he managed time and even evaluate his productivity.

- faMailiar enabled the participants to learn more about their contacts' communication habits (average 4.25/5 on the likert-scale) and notice communication patterns they were not aware of previously (average 4.25/5 on the likert-scale). They also felt that intimacy and its visual manifestations were helpful in allowing them to notice their communication rhythms and patterns (average 4/5 on the likert scale).
- compared to the email interfaces they used regularly, the participants felt that they could predict with more accuracy the exact time of the day/month that the specific contact will email them (average 4.25/5 on the likert-scale), as well as exactly how long it would take a specific contact to respond after receiving an email from them (average 4/5 on the likert scale).

The participants were also asked to evaluate and comment on the faMailiar's visual mappings and data presentation, in general. Following are the participants' assessments and observations related to the aforementioned questions:

- temporal relationships between messages and different temporal segments (hours, days, weeks) were clearly communicated (average 4.5/5 on the likert scale). Similarly, the participants agreed that the positioning of message

representations clearly communicated about their time (average 4.75/5 on the likert scale).

- three out of four participants stated that they used daily view most of the time, while the remaining, fourth, participant said that he used the daily and the weekly views about equally.
- two out of four participants found the partial message view to be the most useful, one felt that the brief message view was the best, while the fourth participant thought that they were all equally useful. Overall, the participants felt that the complete message view is the least useful. One of the participants stated that the complete message view provides "too much info, especially for browsing."
- the participants agreed strongly that the contact intimacy categories were visualized clearly (average 5/5 on the likert scale) and that the meanings of the shapes and color hues were unambiguous (average 4.75/5 on the likert scale). On the other hand, a neutral rating was assigned to the visual mapping of the message intimacy weights to the color value (average 3/5 on the likert scale).
- even though the participants felt strongly that the hue and shape mappings were transparent, two of them suggested that they would like these mappings to be customizable so that they can choose them.
- one of the participants observed that it would be useful if he could sort contacts.
- overall, the participants rated their skills in the activity medium high (average 3.75/5 on the likert scale) and observed that the interface was "easy to use"

(average 4.25/5 on the likert scale), while noting that they were satisfied how they were doing (average 4.25/5 on the likert scale).

We also discussed faMailiar's filtering capabilities with the study participants:

- all the participants noted that filtering was extremely useful in identifying communication rhythms and patterns.
- the participants agreed that the available query options were meaningful (average 4.5/5 on the likert scale).
- when the filter input box was utilized, queries on the message body were the most frequently used, while the ones on the recipient alias were the least frequently used.
- the participants pointed out that it was not easy to find a specific message after the results have been filtered. The participants disagreed (average 2.75/5 on the likert scale) that it was easier to find a particular message when using faMailar, compared to the email interfaces they used regularly.

According to the results of the preliminary user study, faMailiar is successful in visualizing communication rhythms and patterns. Furthermore, by using faMailiar, the participants were able to gain a new understanding of their past, both electronic and non-digital, and a better insight into their contacts' communication habits. They agreed that intimacy and its visual manifestations were helpful in enabling them to gain the aforementioned knowledge. Also, the facts that the partial message view was considered the most useful and that the participants most often queried on the message body

indicate that they were interested in browsing quickly through their email past and that the temporal and topical relationships between the messages were important to them.

The visual mappings of the contact intimacy category and message time were regarded as being effective, while the mapping of message intimacy weight received a neutral rating. We explain this discrepancy by the fact that the message intimacy weight mapping to the color value was not as noticeable as the redundant mappings for the contact intimacy category and message time, and was perhaps obscured by the visual intensity of the combination of the other two mappings.

Even though the participants found filtering extremely useful in recognizing regularities in email communications, they needed more support for it when trying to find a particular message. However, other, commercial email clients offer support for the retrieval of particular messages and providing this specific functionality was not an objective of our research.

Also, it was interesting to learn that the participants didn't filter their email collections on sent messages. Possibly, this is an indication of the fact that the participants were aware of their own email habits and felt comfortable with their own responsiveness images.

7 CONCLUSIONS AND FUTURE WORK

In this thesis, we introduced a novel approach to understanding rapidly growing amounts of data created by daily email use. We proposed use of intimacy as the main visualization parameter. In our approach, email intimacy is defined as a combination of the two metrics: contact intimacy category and message intimacy weight. Contact intimacy category is a user-specified parameter that indicates how intimate the user feels about her contacts. Message intimacy weight is a derived parameter that specifies how intimate each message body is. The two parameters not only reflect the inherently personal character of email, but also support the two components of autobiographical memory: semantic (contact intimacy category) and episodic (message intimacy weight) memory. We visualize email intimacy with the goals of providing a richer experience of the user's electronic past and presenting a diaristic view of the user's history, in general.

In the developed solution, email intimacy is presented in a chronological context. The temporal dimension is crucial in enabling the user to get a better understanding of the genesis and mutations of her relationships, as expressed in the sequential rhythms and patterns of communications that personify those relationships.

Intimacy and time in the user's email communications are visualized in faMailiar, a novel email interface that was developed as a part of this thesis. We conducted a preliminary user study to verify the efficacy of the visualization interface. The study was ecological and experience-oriented in order to support the overall focus on experience in our design and desired goals. It confirmed that the visual mappings and filtering capabilities of faMailiar enable the user to recognize regularities in her email

exchange more effectively. It also demonstrated that the interactive support in faMailiar (zooming, panning and implicit semantic zooming) facilitates easier navigation across large email data sets.

There are numerous directions at which intimacy visualization in email can further be expanded. Here, we list some of these possible directions for further research:

- enable the user to customize the visual appearance of the message representations. Multitiered, flexible definition of intimacy that we have adopted from psychology recognizes multiple faces of intimacy and these faces could be visualized by customizable, user-specified icons or avatars. However, the icons should be simple and distinct enough to preserve the qualities that the current mappings already have.
- enable the user to annotate email messages (textually and/or visually). This idea is consistent with the diaristic approach we are already taking, and if implemented, could enable the user to describe past, as well as future (reminders, schedules, etc.) events. It would be interesting to extend this idea even further and incorporate it into cell phone and/or PDA.
- integrate the interface with telephone/voice mail. This approach would enable the user to get an even more elaborate and complete picture of her communication rhythms and patterns and would help her understand the structure of her social network even better. Such research could also examine if some media increased more for more intimate communication.

- provide a more intelligent and more robust mechanism for determining message intimacy weights. Ideally, the solution would employ a machine learning approach and the system could be trained by sample messages that the user identified as “intimate” and “anti-intimate”.

Some findings identified our role as developers of research software systems. Even though faMailiar provides basic communication capabilities (described in Section 4.2.4), we could enhance its interface with the respect to some other features that are characteristic to traditional email systems:

- provide better support for a particular message search. The user study helped us identify that even with filtering, the user might be disoriented in the visualization, or might need to use the arrows and practically, perform a sub-search to find a particular message. The possible solution could feature an overview+detail approach. In addition to the main visualization space, faMailiar would show a minimized view of the timeline on which all the filtered results would be provided. The user could interact with any of the results in the overview window, and the interaction would in turn, show the selected message in the large, detail view.
- provide sorting capabilities for both the contact data (in the contact window) and for the results of the filtering action (in the email window). Dealing with a large list of contacts can be as frustrating as dealing with a long list of email messages. Therefore, the user should be enabled to sort the contacts according to several criteria. Additionally, providing sorting capabilities for a list of the filtered

message results could be used in conjunction with the above overview+detail solution. Simply, the user would be shown a list containing all the results of filtering and could sort it. By clicking on any of the messages in the result list, she could make the selected message appear in the large, detailed view.

- provide our own email client. Breaking away from Outlook would mean platform independence. Additionally, it would make faMailiar a stand-alone application.

The above features were not the focus of our research and this is what prior email systems do well. However, a usable product would need to incorporate them.

Kerne states, "In the Information Age, information and knowledge, themselves, form the basis of essential artifacts" [Kerne 2002]. Large amounts of data that are exchanged daily in email communication and people's dedication to this form of conversation have turned email into an essential artifact and promoted it into their "primary electronic habitat" [Ducheneaut and Belotti 2001]. As the Information Age matures, the volumes of email data grow and store impressive records of our everyday lives and histories of our relationships.

In ecology, habitats are integral constituents of ecosystems. Interface ecosystems, on the other hand, are "the fundamental units of Information Age ecology" and are characterized by "dynamic interactions of interrelationships between media, cultures, and disciplines" [Kerne 2002]. By recognizing interpersonal intimacy as a primary characteristic of information accumulated in email conversations, and visualizing its rhythms, faMailiar provides a revitalized, more organic interface to email.

This new visualization interface expands the dimensionality of the traditional email habitat by utilizing intimacy through an essentially ecosystems, cross-boundary approach. The dynamic interaction of disciplines (computer science, information visualization, experience design, psychology, sociology and literature) promotes intimacy, traditionally a non-computing concept, into a primary constituent of a computing paradigm that is based on information.

The data provided by our preliminary ecological evaluation shows that faMailiar enabled the users to experience their email collections and their pasts in new, meaningful ways. Comments, such as "I could see that in past four years I lost many of my personal relationships in favor of school," illustrate that the participants were gaining striking insights into their lives. They were recognizing new, important facets of how they conducted their personal relationships. We are encouraged by these findings. The study revealed faMailiar's potential to improve users' lives and their overall well-being by enabling them to recognize a personal need to improve intimate relationships [Prager 1995]. These salient qualities of experience go beyond task-centered measures.

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