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Development of an Improvised PIM-Integration Design Prototype for Organizational Efficiency

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ABSTRACT: Personal Information Management (PIM) describes the acquisition, organization, and retrieval of information by an individual computer user. Studies have shown that many users struggle to manage the volume and diversity of information that they accumulate. Much design activity has been aimed at improving integration between different PIM tools, such as file and email managers. However, in terms of making a systematic contribution to HCI knowledge, much of this cross-tool design can be criticized for a lack of empirical grounding and evaluation.

The research described in this thesis employs a user-centered design methodology to deepen understanding of PIM, and in particular to provide guidance for PIM-integration design. The research is grounded in an exploratory study of file, email and bookmark management, which is differentiated from previous studies by its cross-tool nature. The study offers several contributions including observations of participants' multiple organizing strategies – in both tool-specific and cross-tool contexts. Also, many participants had significant numbers of over-lapping folders that appeared in multiple tool contexts. This finding informs the design of Workspace Mirror, a novel PIM-integration prototype, which allows a user to mirror changes between their file, email and bookmark folders.

The final stage of the research is a dual-purpose field study, aimed evaluating Workspace Mirror, and investigating PIM behaviour over time. Participant feedback indicates that mirroring is more appropriate for top-level folders, and illuminates a trade-off between organizational consistency and organizational flexibility. The study also reveals the incremental nature of changes in organizing strategy, and highlights the supporting nature of PIM. These and other empirical findings are used to improve previous descriptive models of PIM behaviour. Furthermore, a number of design and methodological guidelines are developed. In particular, the authors emphasize the importance of assessing the strengths and weaknesses of PIM designs from both tool-specific and cross-tool perspectives.

Keywords: PIM Interfaces, PIM-Integration, Unified Search Interface, Collaborative Information Management, Information retrieval, Abstract PIM tool

Introduction

Personal Information Management (PIM) is an umbrella term used to describe the collection, storage, organization and retrieval of items of digital information (e.g. email, files, appointments, reminders, contacts, bookmarks) by an individual in their personal computing environment (Lansdale, 1988). Bergman et al. (2003) compare PIM with "general information management" in which a professional – such as a librarian – manages information for other people. In contrast, with PIM the onus is on an individual to manage his/her own information. PIM is a fundamental aspect of everyday computer-based activity in both work and home contexts (Barreau and Nardi , 1995), per for med by "millions of users many times a day" (Whittakeret al., 2000b).

Like managing one's possessions in the physical world, studies have reported that PIM is frequently a chore

(Malone, 1983; Lansdale, 1988; Barreau and Nardi, 1995; Whittaker and Sidner, 1996; Jones et al., 2001). These studies indicate that PIM is poorly supported by current technology, and that many users struggle to handle, classify and retrieve the information that they accumulate over time in tools such as the file system, the desktop and email. There is widespread concern that problems with PIM impact work productivity (Lansdale, 1988; Sellen and Harper, 2001; Jones, 2004) and user experience (Bellotti and Smith, 2000). Several current trends are exacerbating these problems. Firstly, computer users are being exposed to more and more information (Sellen and Harper, 2001), much of it personally managed. This is partially due to the success of email and the web in transferring previously "real-world" activities to the digital domain. Secondly, increased storage capacity on interactive devices means that users are able to collect more information (Gemmell et al., 2002), leading to more management overheads. Thirdly, users are managing information in more technological for mats in more software applications (Bellotti and Smith, 2000; Kaptelinin, 2003). Finally, many users are managing information in more places – for example on multiple desktop computers, laptops and on PDA devices and mobile phones.[2]

Improving the design of PIM tools is therefore a compelling challenge for inter face developers. Since this is an area in which millions of people encounter everyday problems, there is a huge potential market for improved PIM tools. However, it should be noted that this challenge is not new and many of the problems encountered by users today were observed more than a decade ago, e.g. (Malone, 1983; Lansdale, 1988). This is not surprising as Cooper (2003) observes that the designs in common usage have changed little over the two decades since the invention of the folder hierarchy and the Desktop metaphor in the 1960s and 1970s . Although many new designs have been proposed, few have been successful. However, much design effort, in both the commercial and open-source sectors, continues to be aimed in this direction, and a number of major software companies consider improving PIM support to be a key objective (Gates, 2003). There is a general acceptance that new tools are needed, but no consensus as to route for design.

The high level aim of this doctoral research is to improve HCI knowledge regarding PIM, and thus provide guidance for the designers of PIM-tools. In particular, the thesis focus is on investigating the potential to improve integration between PIM-tools. Researchers have high-lighted the particular problems caused by the fragmentation of an individual's information across a range of distinct tools such as files and email (Bellotti and Smith , 2000; Kaptelinin, 2003). Therefore, there is ongoing design effort in developing more integrated PIM technology. Many novel technologies have been proposed in both the commercial (Giampaolo, 1998), open-source (Fitzgerald, 2003), and research domains (Dourish et al., 1999; Bellotti et al., 2003; Kaptelinin, 2003). Further more, at the time of writing, the two major commercial personal operating system vendors, Microsoft and Apple, are planning enhanced PIM integration in the next versions of their operating systems (Fried, 2004).[1]

HCI Research on PIM

The literature review identifies two main areas of PIM-related research: (a) empirical studies of user behaviour, and (b) explorative design and prototyping. A brief over view is provided of previous research as follows. As discussed above, a number of studies have investigated PIM behaviour. These have offered many pertinent observations of user strategies and needs, and provided many design recommendations. However, Whittaker et al. (2000b) claim that PIM has been relatively under researched despite this existing body of work. They argue that considering the fundamental nature of PIM, a handful of studies does not constitute a body of systematic research. In particular, they highlight the need for consistent descriptive vocabulary, theoretical models and evaluation metrics.[1]

In this research paper, it is emphasized that particularly little research attention has been directed to the question of PIM integration. It is also necessary to know how most empirical studies have focused on specific tool contexts, such as email. Although it has been observed that people often employ multiple PIM tools in support of their high-level activities (Kaptelinin, 1996) [2], there has been little investigation of PIM as a cross-tool activity. Do individuals employ similar strategies in email as in files? How are PIM tools used together? Such questions must be addressed to provide a firm empirical foundation for design work aimed at improving PIM-tool integration.

The second area of research has focused on the exploratory prototyping of new PIM interfaces. As in the commercial domain, there has been extensive interest in the potential to improve integration between tools. Two main approaches can be identified in efforts to improve integration: (a) embedding support for managing multiple types of information within an existing tool. e.g. (Bellotti et al., 2003) and (b) unifying interaction with multiple types of information (e.g.files and email) within a consolidated interface. Examples of this second genre include Stuff-I've-Seen (Dumais et al., 2003) which provides a unified search interface, and UMEA (Kaptelinin,2003) which enables the organization of multiple types of information in terms of projects [3]. The term cross-tool is proposed to describe design that provides integration between PIM-tools. This body of cross-tool design research can be criticised for not making an effective contribution to HCI knowledge, for two key reasons:

1. Firstly, much of this cross-tool design work has been driven by technological innovation rather than founded on empirical user requirements. As noted above, empirical work to date has focused on the management of particular types of information within specific PIM tools (e.g. email).
2. Furthermore, most cross-tool systems have not been evaluated. Although, many systems have been highly innovative and offered much in the way of new technology, such "radical invention" (Whittaker et al., 2000b) can raise significant usability issues. This means that evaluation is particularly important to confirm the benefits claimed by designers. One factor which may contribute to the infrequency of evaluation, is the lack of agreed metrics for comparing different PIM designs (Whittaker et al., 2000b).

Objectives

The research objectives are outlined as follows:

1. To develop increased understanding of PIM practices and related user problems – In particular, the researcher set out to investigate user needs and issues relating to PIM integration, and thus provide a firm empirical foundation for design work in this area. A secondary aim was to develop theoretical models to describe and explain empirical observations.

2. To propose, implement and evaluate an empirically-grounded means of PIM- integration mechanism – The author embarked upon the research programme from a background in computer science, and had a keen interest in developing a new for m of PIM- integration. A key interest was to improve upon the limitations of previous prototyping in the area by emphasizing empirical grounding and evaluation.

3. To devise methodological recommendations for future research and design work in the area of PIM-integration – The final objective was to provide methodological guidance for future work, derived from the experience of pursuing this course of research. In particular, Whittaker et al. (2000b) note the need for the identification of evaluation metrics.

Approach

The selection of appropriate research methodology is a common HCI dilemma. As an interdisciplinary research field, HCI offers many competing research paradigms and methodologies, each with own way of contributing to the HCI knowledge base (Sasse, 1997). The methodology employed in this thesis is heavily influenced by the design-based research paradigm, as advocated in Carroll (2000). Carroll describes how design can be employed as a research method to achieve two complementary goals to understand the world in the process of gathering design requirements, and to improve the world through the process of design. He contrasts this applied research paradigm (literally "research through design") with traditional perspectives on design as a craft, or design as the object of research. Carroll argues how the designed artifact can be interpreted as a theory, a set of claims regarding how a particular situation of concern can be improved. Theory development, the validation of the designers' claims, is enabled through the subsequent evaluation of the design, a crucial stage of the research process.

This assessment of the strengths and weaknesses of a specific design may then be generalized to a wider design genre. The task-artifact cycle (Carroll et al. , 1991) forms a backdrop to the research approach: the study of a task context provides the requirements for the design of an artifact, which is then in turn evaluated in the context of the original task[4]. Evaluation also provides an opportunity for further empirical discover y (understanding of the world). The approach was seen to be highly compatible with the author's desire to produce a novel PIM- integration mechanism, whilst also facilitating the investigation of user behaviour and theoretical development. A final reason for selecting this approach, was that it allowed the researcher to experience design issues at first hand. A key concern in HCI is the so-called theory/practice gap (or research/practice gap) (Sutcliffe, 2000; Rogers, 2004), whereby the products of much HCI research can be irrelevant to designers' needs in the real-world.

Specifically, the research reported in subsequent chapters is centered on a 3-stage user-centered design methodology :

1. Requirements gathering – The research is empirically grounded in an exploratory study to develop understanding and establish requirements for subsequent design.
2. Design and prototyping – Findings from the exploratory study are used to motivate the design and implementation of a prototype PIM-integration mechanism. In order to facilitate systematic evaluation, and cause minimum disruption to users, the design route is incremental rather than revolutionary (Newman and Lamming, 1995).

3. Evaluation – The tool is evaluated through a longitudinal field study. Lansdale and Edmonds (1992) notes the importance of evaluating PIM technology over time. As well As evaluating the proposed design, the field study also enabled the investigation of long term user behaviour such as changes in strategy over time.

Conceptual Background

This research paper provides a conceptual grounding to the research in this thesis, and defines the key terminology used for the purpose of research. It also provides an over view of Personal Information Management (PIM) as a fundamental aspect of computer-based activity.

Lastly, our research work contrasts PIM with related terms such as information retrieval and information management.

The second part of the research area is concerned with the software tools that support PIM, termed PIM-tools in this thesis. Firstly, we define the term PIM-tool, and describes an abstract model of a canonical PIM-tool. In the next part of research, we consider the past, present, and future of PIM-tool technology. The research also discusses the history of PIM-tools, surveys the current generation of PIM-tools, and highlights a number of ongoing trends in PIM-tool design. Finally, our research discusses the concept of integration between PIM-tools which is a central theme to this innovative research work.

Personal Information Management

A fundamental characteristic of human nature is to collect. In both the physical and digital domains, our personal environment (e.g. desk, wallet, computer desktop) becomes populated with the objects we accumulate as our lives unfold.

Some of these objects are acquired intentionally. We choose to keep a subset of the objects that we encounter – those of some perceived value to us. The notion of value varies widely between the objects we keep. A brief perusal of the author's desk, the physical environment in which this thesis is being written, reveals a range of objects valued for varying reasons: postcards kept for sentimental reasons, documents containing information required in the writing process, a cycle helmet. All these objects are valued in relation to some aspect of the author's ongoing roles and activities. As well as valued material, our environments fill up with other less important objects. This "excess baggage" may include objects that were once valued, but for reasons that have been long-forgotten. Other objects we do not even choose to acquire – they just seem to appear as an implicit by-product of our lives – for example receipts and junk mail. Although we may wish to discard of such objects, the time and effort involved in dealing with them can be so high that we put off doing so, and they accumulate in our personal environment.

Our lives are filled with personal decisions relating to managing our possessions: what to ac-quire, whether and how to organize it, what to throw away, and how to go about finding things when we require them. Unless influenced by an external constraint such as a corporate clean-desk policy, this managing activity is inherently idiosyncratic.

Over the ages, many artifacts have been created to help people to manage the objects they collect in the physical domain. Today, many of these are taken for granted. For example, Norman (1993) discusses the invention in the late nineteenth century of the seemingly humble filing cabinet [5]. At the time, this device revolutionized the management of document archives. Norman discusses the cognitive scaffolding offered by such artifacts: they allow people to offload the over head of organizing – and remembering how things are organized when they need to find them – onto the environment.

The dramatic boom in personal computing technology over the past two decades means that people now manage personal collections of digital objects in addition to the physical objects they manage in the real-world. Today millions of personal computer users collect and manage a wide range of digital objects such as email messages, music files, contacts, and web bookmarks.

The term Personal Information Management, often abbreviated to PIM, is used as an umbrella term to describe the everyday process performed by individuals as they collect, store, organize and access their collections of digital objects. As in the physical world, a range of technologies have been developed to help people in this process, such as the folder hierarchy and search mechanisms. This thesis aims to contribute to the HCI knowledge base to better guide the designers of such technology.

Defining Personal Information Management Step by Step

This part builds up a step-by-step definition of PIM in three stages:

1. Firstly, a definition of information is presented.
2. This is specialized to for m a definition of personal information.
3. The final step is to define the term PIM. This definition in turn used to define the functionality provided by a PIM-tool used in this research work.

Defining "Information"

Information has been defined as "an assembly of data in a comprehensive form capable of communication and use" (Feather and Sturges , 2003) [6]. Here, information is defined more loosely as any assembly of data which carries some meaning for one or more people. This thesis focuses on information in the digital domain: arrangements of bits which carry meaning for one or more people, for example a paragraph of text or an image. Henceforth, the term information is used to designate information in a digital context. The next stage is to distinguish personal information from information in general.

Defining Personal Information

Personal information is an ambiguous term with a number of possible interpretations.

1. One interpretation is information about an individual (i.e. where that individual is the subject matter of the information). One common context for this usage is to

describe the information stored by an institution about an individual (e.g. date of birth, credit card number). In this case, the information is not directly managed by the individual concerned.

2. A second interpretation is the information managed and stored within personal organizer software (Rosenberg, 1999). In this sense digital personal information includes appoint-ments, contacts, and to-do items – but not information stored outside that specific tool,such as files stored in the file system.

In the context of this thesis, personal information is defined as information owned by an individual, and under their direct control. In other words, the owning individual is able to alter or delete the information without going through an intermediary. Note that this definition is independent of(1) the subject matter of the information, (2) the software application in which it is managed, and (3) the digital device on which it is stored. The units of analysis in this thesis are those of items and collections of personal information:

An item is a self-contained unit of information. In the digital domain, items of personal Information exist in a range of technological formats such as files, email, bookmarks, contacts, to-do item, and so on. Note that in this thesis, a sentence or paragraph is not considered to be a unit of personal information, but rather a sub-unit. Items may possess metadata attributes , further information describing the content of the item. Attributes may be system-defined (e.g. file size) or user-defined (e.g. title).

A collection of personal information is a self-contained set of items. Typically the members of a collection share a particular technological format and are accessed through a particular application3 . Each collection can be considered as a personal information space that is constructed by the user (Abrams et al., 1998). Example collections of personal information include electronic messages, managed with an email tool, and the set of contacts within an address book.

Defining "Personal Information Management"

The Oxford English Dictionary defines "management" as "the process of dealing with or controlling things (noun), to be in charge of an under taking, to administer, to regulate (verb)" . Therefore, based on the above definition of personal information, PIM can be defined as the management of personal information as per formed by the owning individual [7]. The conceptual framework offered by Barreau (1995) is adopted in this thesis to denote the sub-activities that constitute "management". However, a number of changes are made to Barreau's conceptualization as follows:

1. As noted above, Barreau included the updating of information in her definition of the maintenance sub-activity. Here the modification of items (e.g. editing of files) is considered outside the scope of PIM. Once an item of information is retrieved from a collection, it may be edited and re-saved (effectively re-acquired). However what happens between the retrieval and re-saving is not considered par t of PIM.

2. Barreau defines PIM as being carried out in a work context. Here it is defined as the managing of personal information in any context – work or leisure.

3. Barreau defined PIM in terms of the functions provided by a PIM-system: acquisition, organization, maintenance, retrieval and output. In this thesis, PIM is conceptualized as a user activity. The first four of Barreau's functions equate to PIM sub-activities performed by a user : the acquisition of items to for m a collection of personal information, the organization of items, the maintenance of the collection, and the subsequent retrieval of items.[8]

Barreau also highlights output as a key PIM-system function. Since this is performed automatically by the computer in current PIM tools, it is not included as a sub-activity. Furthermore, reminding is not considered to be a PIM sub-activity. Instead, the view is taken that items may be acquired and arranged (as par t of PIM) to enable reminding. Figure 2.1 illustrates the view of PIM taken in this research paper.

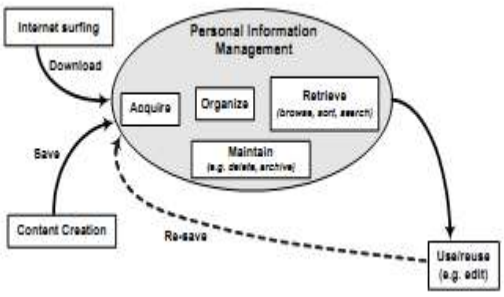

Figure 2.1: Actual View of PIM

The main exception is the file system which can contain items (files) in a range of technological formats, e.g. spreadsheets, images and text documents.

Figure 2.1: Four PIM sub-activities: acquisition, organization, maintenance and retrieval Barreau treats the computer as one monolithic PIM system, centred on the file system. This thesis builds up the case that the computer is best conceptualized as a set of PIM systems, each denoted by the software application thaalloto manage a collection of personal information in a particular technological format. Examples include the email collection, the bookmark collection, and the file collection. For now this framework is

offered as a description of the activities performed by an individual in each collection of personal information .

Comparison between PIM and Related Terms Information Management

Information Management (IM) has been described as "the application of management principles to the acquisition, organization, control, dissemination and use of information relevant to the effective operation of organizations of all kinds" (Wilson, 2002a). In other words, the term IM typically relates to an organizational context 4 . In contrast, with PIM, the scope of interest is limited to that of an individual user.

General Information Management

Bergman et al. (2003) compare PIM with what they term General Information Management in which a professional – such as a librarian - manages information for other people.[10] PIM is differentiated by its focus on an individual managing information for his or her own use. Managing information for other users is outside the research scope of this paper.

Collaborative Information Management

Another type of IM is Collaborative Information Management (CIM) when a collection of information is managed by multiple users. For example, a team may share information via a communally managed network drive. CIM raises numerous issues such as the need for a shared vocabulary for naming and categorizing items (Berlin et al., 1993). This research paper focuses on PIM performed by an individual for their own dedicated use. [11]

Information Retrieval

Information Retrieval (IR) has been defined as "the study of systems for indexing, searching, and recalling data, particularly text or other unstructured forms" (Weiss, 1997). IR is a discipline in its own right, served by a range of journals and conferences.

Here it is argued that PIM can be considered a high-level activity which involves IR in two of its sub-activities: acquisition and retrieval. Figure 2.2 illustrates the relationship between PIM and IR. Firstly, the acquisition of an item may involve the retrieval of the item from a remote information system such as a website. Secondly, the PIM sub-activity of retrieval is equivalent to IR within the context of an individual's personal collection.

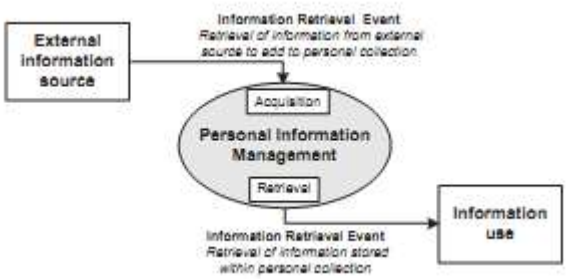

Figure 2.2: The relationship between PIM and Information Retrieval

Personal Information Management Tools

This section considers the software tools that allow users to manage personal information.

A Personal Information Management tool (abbreviated to PIM-tool henceforth) is defined as a software tool that allows a user to manage a collection of personal information items. The PIM-tool inter face defines how a user views and interacts with the collection.

1. Support for acquisition – a mechanism to add items of information into a collection
2. Support for organization – a mechanism to arrange items within the collection.
3. Support for maintenance – for example, a mechanism to remove items from a collection
4. Support for retrieval – a mechanism to access items from the collection, via browsing, sorting or searching

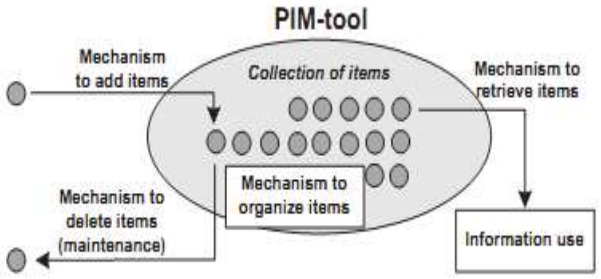

Figure 2.3: An abstract PIM-tool

PIM-tools typically support the management of personal information in a particular technological for mat. Example PIM-tools in the context of a desktop computer include the file system, email reader and web browser, which are used to manage collections of files, email and web bookmarks respectively. PIM-tools vary significantly in the extent to which they support the four sub-activities, and how they provide that support. As a minimum, a PIM-tool must provide mechanisms to both add items to a collection, and to retrieve them.

The definition of PIM used in this thesis does not include the updating of items. Therefore, functionality for editing items is not considered essential for a PIM-tool.

There is not necessarily a one-to-one mapping from PIM-tool functionality to software applications. For example, simple email applications provide both PIM-tool functionality as defined above and also editing functionality. In the extreme, some software applications may provide support for the management of multiple collections of personal information. For example MS-Outlook allows the user to manage no less than six types of information: email, tasks (to do-items), calendar entries, contacts, diary entries and notes. In this thesis the functionality dedicated to each type of personal information is considered a distinct PIM-tool. From this view applications such as MS-Outlook are best described as application suites consisting of multiple PIM-tools.

Two types of PIM-tool can be identified depending on whether PIM is a primary or secondary function:

1. Tools where PIM is their primary function – Examples of this type include the file system and contact managers. Their main function is to facilitate the management of some collection of personal information.

2. Tools where PIM is a secondary function – Examples of this type include email tools which are primarily dedicated to providing a means of asynchronous communication between people. However, they also allow the user to build a collection of electronic messages arguably, a secondary function. Many modern productivity applications sometimes have secondary functionality which may be considered as a PIM-tool. For instance, the file-history mechanism in MS-Word can be considered to be a collection of items (each a reference to an edited document), which are acquired automatically based on application history. Therefore, MS-Word as a whole is not a PIM-tool but it contains sub-functionality which may be considered as one. Note that this example also illustrates that the performance of each PIM sub-activity may be implicit (performed automatically by the tool) or explicit (performed by the user).

In this research paper, the term PIM-tool is used to refer to any software application that facilitates the management of personal information, regardless of whether that is its main function or not.

Hierarchy-based PIM-tools

The folder hierarchy is the standard mechanism for organizing collections of personal information (Dourish et al., 1999). It allows the user to create a personal classification scheme. The user may choose to create categories based on whichever organizational dimensions that they see as relevant (e.g. role, project or time).

Figure 2.4 shows a simple model of a hierarchy-based PIM tool. Hierarchy-based PIM tools support the four PIM sub-activities as follows:

Acquisition – items may be added as unfiled items in the top-level "root" folder, or placed directly into a low-level folder.

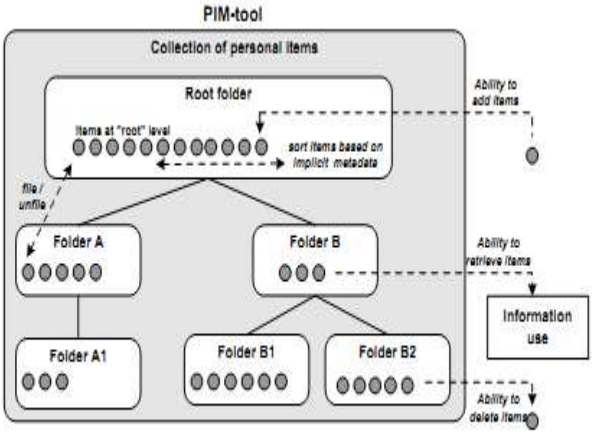

Figure 2.4: Model of a hierarchy-based PIM-tool

Organization – Explicit organization is enabled through the placement of items within folders. The user may change the folder structure by adding new folders, or renaming, deleting or moving existing folders. Typically, items are limited to placement in one folder location. However, some folder hierarchy implementations allow the user to set-up links or short-cuts which can act as references from multiple locations to a particular item.

Maintenance – Typically, PIM-tools provide a mechanism to delete items. Implicit or explicit means of archiving may also be provided.

Retrieval – PIM-tools typically provide the ability to retrieve items from the collection through a combination of mechanisms. Firstly, users may browse through the hierarchy to retrieve items. Two types of browsing can be highlighted: (1) browsing of folders, using user-defined explicit "location" metadata encoded in the folder structure; and (2) sorting/scanning of items within a folder m, ordered by user-defined metadata (e.g. "name") or implicit metadata (e.g. "date created"). The PIM-tool may also offer a search facility. Retrieved items may be re-saved within the hierarchy after editing.

Two types of inter face are commonly employed to manage hierarchies: (1) a direct-manipulation file manager (pioneered in the Xerox Alto Neptune file manager (Wadlow, 1981)), and (2) the command-line tools of UNIX or DOS.

The Personal Information Environment

The personal information environment is defined as the aggregate of all collections of personal information. Figure 2.5 offers a graphical summary of a personal

information environment encompassing both the physical and digital domains. Note that the rest of this thesis focuses on the digital personal information environment which consists of:

1. Personal information collections stored on computers that the user has physical access to Examples include desktop and laptop computers in work and home contexts.

2. Personal information collections stored on remote computers – As well as storing infor mation on their local computer, the user mat store information remotely on network drives. Furthermore, many internet websites are now providing PIM-tool technology. Examples Web based PIM-tools include email services (e.g. MS-Hotmail), on-line document management services, on-line calendars (e.g. Yahoo Calendar!), and shopping "wish-lists "stored on e-commerce sites such as amazon.com.

3. Personal information collections stored on mobile devices – Devices such as mobile phones and personal digital assistants (PDAs) are commonly used to manage contacts and notes.

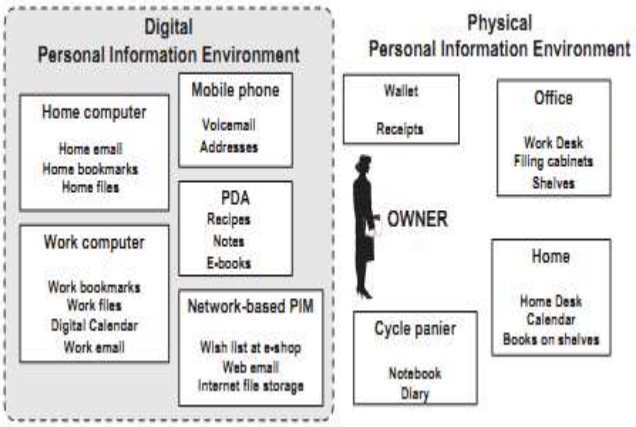

Figure 2.5: The personal information environment in both the physical and digital domains

Trends in PIM-tool Design and Usage

Several ongoing trends can be identified in the design of PIM-tool technology :

1. Increasing numbers of users – With the boom in personal computing over the past decade, millions of users now manage collections of email, files and bookmarks. Whereas in the past computer users were technically trained, today's PIM-tool users are from all walks of life and levels of technical expertise. In other words, PIM tool technology is now a mass-market.

2. More collections of personal information – As noted in the previous section, today's personal information environment has evolved in a piecemeal incremental manner as new devices, PIM-tools, and technological for mats have been invented. This growth continues as more devices and websites offer PIM-tool functionality.

3. Increasing PIM-tool complexity – This increase in tool complexity is due to the addition of extra functionality has been termed bloating (McGrenere et al., 2002). One reason for this phenomenon is that PIM-tools must cater for many possible approaches to managing personal information. PIM-tool developers must cater for all possible user groups –from corporate users who depend on email during their working day, through to novice home users who may only check their email once a week. One example of the emerging complexity is that many email tools now provide integrated to-do item support.[12]

Integration between PIM-tools

We described the historic trend towards multiple PIM-tools on multiple de-vices to for m an extended personal information environment. The provision of integration between PIM-tools is a key theme in this research paper. This research paper offers a definition of integration, and surveys common integration mechanisms.

Although the term integration appears commonly in the marketing of PIM-tool software and other inter faces, there is no agreed definition in the research community. The Oxford English Dictionary defines integration as "the act or process of making whole or entire". Here an integration mechanism is defined as a software component which provides user functionality that bridges two or more distinct PIM-tools.

Figure 2.6 summarizes the integration mechanisms on a typical desktop computer running MS-Windows. They are discussed as follows:

1. Mechanisms that allows the user to initiate an operation in another PIM-tool – For example, right-clicking on an email address in an email message in MS-Outlook, allows the user to per for m a search for that email address in the contact manager.

2. Mechanisms that allow information within one PIM-tool to be transferred to another PIM-tool – A simple example of this type is the "cut-and-paste" function provided by MS-Windows, e.g. copying some text from a file to an email. Other "higher-level" operations combine the transfer of information with the initiation of an operation in the other PIM-tool., e.g. the "Send-to" mechanism allows a file to be attached within a newly created email message.

3. Mechanisms that allow items of various technological formats to be managed in a particular collection as "primary-level items" – For example, MS-Windows allows the user to save email messages as a file within the file system.

4. Mechanisms that allow an items of various technological formats to be embedded within items of another format – Such embedded items are managed indirectly, via the item in which they are embedded. An example of this type is email attachments: the ability to attach a file or bookmark within an email message. Typically, a reverse mechanism is also provided to allow the transfer of an attached item back to its native PIM-tool.

5. Retrieval mechanisms that bridge multiple tools – One example are cross-tool search mechanisms, e.g. SixDegrees (SixDegrees), which allow the user to search multiple collections of information (e.g. files and email) in one operation. Some PIM-tools also permit cross-tool retrieval through browsing multiple collections. For instance MS-Windows Explorer allows the user to browse both the personal file system and the bookmark collection.

6. Application suites that aggregate multiple PIM-tools – An example of this type is MS-Outlook which includes the PIM-tool functionality to manage five distinct collections of information: email, to-do items, notes, calendar and diary

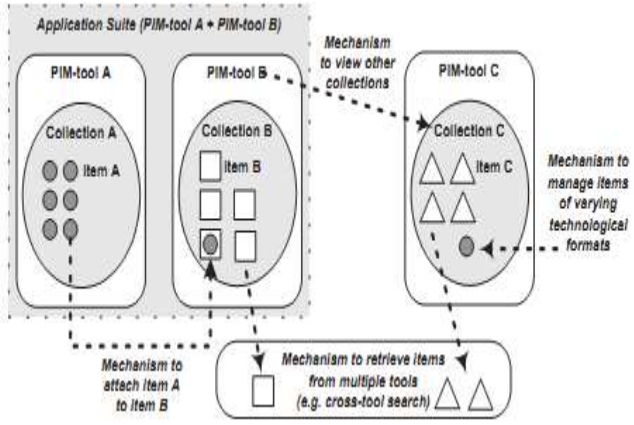

Figure 2.6: PIM-tool integration mechanisms found in modern desktop operating systems

The range of integration mechanisms listed above is typical of most commonly available operating systems at the time of writing. It should be noted that all of these common integration approaches are effectively "bolt-on" mechanisms. Despite this wide range of integration mechanisms, information in different technological for mats is managed in distinct collections within distinct PIM-tools.

Improving Integration between Distinct PIM-tools

Current PIM-tools, such as MS-Outlook, offer limited integration based on some kinds of structured information, e.g allowing the user to access the contact manager by selecting an email address in a message. Two research systems have proposed more powerful integration based on structured information. The Apple Data Detectors system (Nardi et al., 1998) parses a selected region of text for a range of structured information including dates, postal addresses, meeting information and phone numbers. For example, the recognition of a date within the selected region allows it to be placed within a calendar as a meeting, along with the surrounding text. This technology should also be highlighted for two reasons: (1) it is rooted in study data highlighting a user need for taking action on structured information(Barreau and Nardi, 1995); and (2) the system is one of the few examples of PIM-related design research that has found its way into a commercial product – Apple Mac OS. Dey et al. (1998) highlight a key limitation of standard integration based on structured information: such integration must be pre-defined by the software developer. We propose a system called Cyber desk which allows the user to define how different types of structured information should be processed.

Furthermore, our system enables the chaining of processing across multiple tools. However, Cyberdesk can be criticised for a lack of evaluation, and it is not clear if users require such advanced functionality. The Stuff-I 've-Seen (SIS) system (Dumais et al., 2003) offers search-based unification, giving users the ability to search multiple PIM-tools with one query . The system builds a unified index of all personal information. Result sets are provided in time-ordered sequence, annotated with thumbnails and item previews. Dumais et al. report a field-study based evaluation which revealed significant system up-take, and less frequent use of tool-specific search mechanism. [13]

Additionally, our feedback from users suggested that they would be less likely to feel the need to organize items in distinct folder hierarchies, if operating systems provided SIS -like functionality. So-called "identity management systems", such as Microsoft .NET Services, provide server-side integration by offering a central repository for personal information such as email, contacts and folders which can then be accessed from different PIM-tools on different devices. How-ever, such centralized systems require users to entrust personal information to a third-party, resulting in numerous privacy issues.

As well as providing integration between PIM-tools in the digital domain, our research has also focused on enabling integration between the digital and physical domains. This is based on the Protofoil system (Rao et al., 1994) which allows the management of paper documents as electronic images, including the retrieval of paper documents via keyword search.

Embedding Designs

Current PIM tools focus on the management of information in a specific technological for mat. The main exceptions are the file system in which many technological for mats can be stored, and email which allows the user to manage non-native items, e.g. files, as message attachments.

A number of research systems allow the user to manage multiple types of information with one PIM-tool, through the embedding of extra functionality. There has been a particular focus in the literature on embedding support for non-native information within email clients (Bellotti and Smith, 2000; Bellotti et al., 2003; Gwizdka, 2002). The prototypes developed by Bellotti et al. allow the management of email, documents, and to-do items as "first class citizens" which can co-exist in the tool's main "inbox". The main design rationale for the embedding approach is the observation that email acts as a "habitat" for a wide range of user activities (Bellotti and Smith, 2000; Ducheneaut and Bellotti, 2001). This causes users to develop ad-hoc means of managing information such as to-dos within email.[14]

Bellotti et al. (2003) report the field-study evaluation of their Task Master email client which as well as supporting the management of multiple types of information, also provides a mechanism for labelling any item of information with to-do metadata. Bellotti et al. note the challenges inherent in providing a sufficiently robust prototype to withstand long-term usage. De-spite these methodological issues, both sets of extra functionality were received positively by test users. However, it is noted that the test users were technically experienced. A key criticism of the embedding approach is that it increases the complexity of already complex tools, and therefore may not be suitable for less technical users. For example, the Raton-Laveur proto-type (Bellotti and Smith, 2000) includes no less than three organizing mechanisms.[15]

A number of commercial systems have also been proposed which offer equivalent functionality, e.g. SixDegrees. This is an add-on layer on top of existing applications that performs semantic clustering of related files, email and bookmarks related to a selected item. [9]

Results & Conclusion

This research has been aimed at improving the HCI knowledge base for the design of the next generation of PIM-tools. Today's computer users encounter a wide range of problems in managing information, and consequently there is a need to develop improved inter faces to better support this every day activity. The research focused on one specific area of ongoing design interest, that of improving integration between PIM-tools. Previous research relating to this area has been limited. Although many studies of PIM behaviour have been carried out, few have considered user needs beyond the boundaries of specific tools such as email. Therefore, there is a lack of empirical foundation for cross-tool design work aimed at improving PIM integration. Consequently, much of the design work in this area has been technologically motivated rather than grounded in user requirements. However, many of the innovative prototypes that offer new forms of integration have not been evaluated. Since designers' claims have not been empirically validated, they offer little research value beyond indicating possible routes for design.

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