Improving Tool Support for Personal Information Management

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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 criticised 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 overlapping folders that appeared in multiple tool contexts. This finding informs the design of WorkspaceMirror, 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 at (1) evaluating WorkspaceMirror, and (2) 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 author emphasizes the importance of assessing the strengths and weaknesses of PIM designs from both tool-specific and cross-tool perspectives.

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Chapter 1

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), performed by *"millions of users many times a day"* (Whittaker et 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 formats 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.

Improving the design of PIM tools is therefore a compelling challenge for interface 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[1]. 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, e.g. Microsoft (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 highlighted the particular problems caused by the 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). Furthermore, 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).

The rest of this chapter is structured as follows. Firstly, **Section 1.1** highlights a number of limitations of previous research on PIM, taking a particular focus on that related to improving integration between PIM-tools. Based on these limitations, **Section 1.2** states the research objec-

[1] See **Section 2.3.2** for further discussion on the roots of PIM technology.

tives of the thesis, and **Section 1.2.2** details the design-based research methodology employed. Finally, **Section 1.3**, presents an outline of subsequent chapters, and details the contributions offered in the thesis.

1.1 HCI Research on PIM

The literature review in **Chapter 3** identifies two main areas of PIM-related research: (a) empirical studies of user behaviour, and (b) explorative design and prototyping. A brief overview 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.

In this thesis, it is emphasised that particularly little research attention has been directed to the question of PIM integration. **Chapter 3** notes 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), 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. 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).

The next section reports the specific objectives of this research.

1.2 Research Agenda

Much has been written on HCI's recent "turn towards the social", e.g. *"The portrait of a solitary user finding and creating information in a computer became background to the portrait of several people working together at a variety of times and places"* (Carroll, 1997). Although the recent trend *towards the social* has opened up many interesting areas for research, it has also contributed towards many core everyday computer-based activities such as PIM being under-researched (Whittaker et al., 2000b). Turning the pages of recent HCI conferences reveals a wealth of research directed at collaborative and social interfaces, but very little on important everyday activities such as PIM. This thesis seeks to help redress this balance by taking a conscious turn back in the other direction, away from collaborative activities back towards the individual user and a focus on the most personal of activities, PIM.

1.2.1 Objectives

The thesis 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 form of PIM-integration. A key interest was to improve upon the limitations of previous prototyping in the area by emphasising 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.

The next section discusses the methodological approach employed in the thesis to achieve the above objectives.

1.2.2 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: (1) to *understand the world* in the process of gathering design requirements, and (2) 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 artefact 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 generalizable to a wider design genre. The task-artefact 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 artefact, which is then in turn evaluated in the context of the original task. Evaluation also provides an opportunity for further empirical discovery (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 centred on a 3-stage *user-centred 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.

The next section summarizes the work presented over subsequent chapters, and details the research contributions offered.

1.3 Overview of Thesis and Contributions

This section provides an overview of the research presented over the following seven chapters. Key contributions made by each chapter are italicized. **Section 8.2** provides a list of key contributions, organized in terms of those of interest to researchers and designers. **Figure 1.1** provides a diagrammatic overview of the thesis structure.

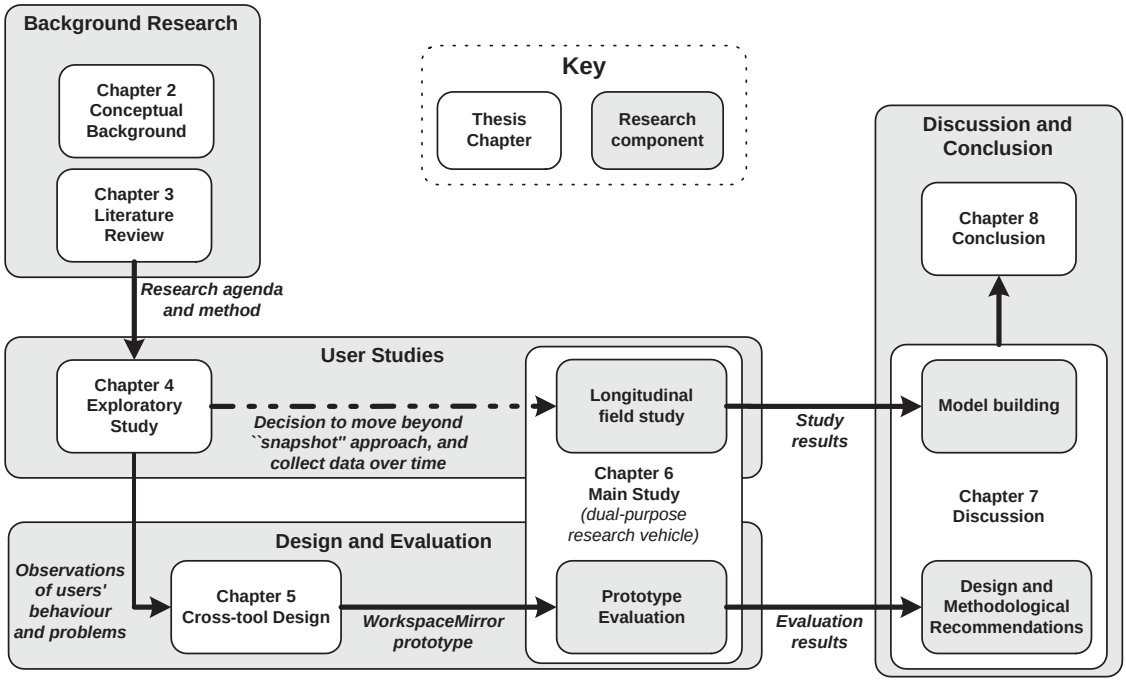

Figure 1.1: Overview of Thesis Structure

Chapter 2 provides an in-depth introduction to PIM. Previous definitions of PIM are criticised, and a new view of PIM is developed in terms of four sub-activities performed with a collection of items: acquisition, organization, maintenance and retrieval. Further conceptual background is provided relating to the current generation of commonly available PIM-tools. In particular, the concept of PIM-integration is defined and current integration mechanisms are surveyed.

Chapter 3 presents a *critical analysis of previous research relevant to this thesis.* Two main bodies of research are identified and surveyed: (1) empirical studies, and (2) prototype design. Relevant theoretical work is also discussed. Limitations in prior research in the area of PIM-integration are used to motivate the thesis research agenda and methodology. In particular, the limitations of previous technological research centred on radical invention are used to motivate the incremental design approach used in this thesis.

Chapter 4 reports an exploratory study aimed at comparing PIM behaviour across three collections of personal information – document files, email and web bookmarks. The work can be contrasted with previous PIM studies which have focused on behaviour within one tool such as email. Key contributions include:

- *A comparison of PIM behaviour between files, email and bookmarks* – This analysis is centred on the four PIM sub-activities identified in **Chapter 2**.
- *A new classification of organizing strategies in the file, email and bookmark contexts* – Observations are made of *multiple strategies* in each tool-specific context. Previous classifications of organizing strategies are criticized for not reflecting this level of detail.
- *A comparison of users' organizing strategies between files, email and bookmarks* – Evidence is provided of variation in the extent of organizing performed by many participants across files, email and bookmarks. A theoretical model is proposed to describe the multiple strategies observed both within and between collections.
- *A new technique for analysing the organizational dimensions used to name folders in each tool context* – The most common types of folder are compared between the three tools.
- *A new technique for assessing the similarity of folder structures in two PIM-tools in terms of the number of folders they have in common* – Significant folder overlap is highlighted for many participants, particularly between files and email.
- *A series of design implications for PIM-integration mechanisms* – A number of PIM-related problems are identified which bridge multiple tool contexts, confirming the promise of improved integration between PIM-tools. The above empirical findings suggest a number of potential routes for the design of such mechanisms. In particular, the *folder overlap* results provide the key empirical motivation for the design work in **Chapter 5**.

Chapter 5 reports the cross-tool design and implementation work performed by the author. In contrast to much previous design work in the area, the design approach is deliberately *incremental* to facilitate user familiarity and systematic evaluation. Contributions from the chapter are two-fold:

- *The design and implementation of WorkspaceMirror, a novel form of PIM-integration* – The design is based on the principle of folder-mirroring, which allows the user to replicate the

changes made in one folder structure to other PIM-tools. A prototype is developed on the MS-Windows platform, offering folder-mirroring between the file, email and bookmark collections. The design is motivated by the observations of *folder overlap* in **Chapter 4**.

- *Results from an initial evaluation of WorkspaceMirror* – Positive feedback received from four of the five test users confirms the feasibility of the design. The prototype is modified to accommodate participants' design suggestions.

Chapter 6 reports a longitudinal field-study which acted as a dual-purpose research vehicle to: (1) evaluate the WorkspaceMirror prototype proposed in **Chapter 5**, and (2) investigate PIM behaviour over time. The investigation is differentiated from most previous studies in the area which have consisted of short-term "snapshots" of user behaviour. A wide range of behaviour is reported through a series of case studies which highlight the idiosyncratic nature of PIM. Two major sets of substantive contributions are offered:

- *Results from the formative evaluation of WorkspaceMirror* – The evaluation confirms the potential of mirroring top-level folders between PIM-tools, based on the positive feedback from many participants. However, a trade-off is identified between the resulting consistency between folder structures, and users' needs for organizational flexibility in different tools. A large number of design improvements are also suggested including the need for improved configurability.

- *Insights into longitudinal PIM behaviour* – Most study participants did not make major changes in organizing strategy. Instead, *incremental changes* were observed for two participants. Balter's model of PIM strategies is criticised for not reflecting such subtle changes, and a new descriptive model is proposed.

  The study findings also emphasise the background, supporting nature of PIM, and suggest that the participants devote little ongoing attention to PIM compared to their work tasks. The study intervention causes increased reflection on PIM for many participants.

Chapter 7 discusses the substantive findings from the previous three chapters. The discussion offers four main contributions:

- *An extended conceptual framework of PIM* – The view of PIM outlined in **Chapter 2** is extended to reflect the *cross-tool*, *supporting*, and *ongoing* nature of PIM. Each property

is illustrated by reference to the empirical findings in earlier chapters. The author offers the framework to outline potential routes for future theory development in the area.

- *A set of design implications for PIM-integration mechanisms* – The evaluation results are discussed in the context of the extended framework. Based on the experience of designing and evaluating WorkspaceMirror, the author argues that integration designs may offer strengths and weaknesses in different tool-specific and cross-tool contexts. A number of design routes are highlighted for future integration work.

- *A set of methodological recommendations* – The theoretical framework is used to structure a series of recommendations to guide the design and evaluation of PIM-integration mechanisms, derived from the experience of pursuing this research programme. In particular, the dilemma of designing tools for supporting activities such as PIM is highlighted.

- *An exploration of potential evaluation metrics based on user experience* – A number of participants in the main study reported in **Chapter 6** were dissatisfied with their current organizing strategies and wanted to change them. Such "unsettledness" is proposed as a indication of negative user experience in PIM.

Chapter 8 concludes the thesis by summarizing the main findings and contributions from the thesis. Limitations of the research, and routes for further work are presented.

1.3.1 Publications relating to this Thesis

The author has published a number of papers relating to this thesis work. Boardman (2001a,b) reports provisional results from the exploratory cross-tool study reported in **Chapter 4**.

A subsequent series of papers report the design of WorkspaceMirror, along with the empirical results which motivated it (Boardman, 2002a,b; Boardman et al., 2002). Boardman et al. (2003) adds preliminary results from the initial evaluation of WorkspaceMirror.

Boardman and Sasse (2004) presents a cross-section through the entire thesis, reporting aspects of the exploratory study, the design of WorkspaceMirror, and the longitudinal study.

Finally, Bergman et al. (2004), outlines a Special Interest Group on PIM at the ACM CHI 2004 conference. The event has contributed to the establishment of a new PIM research community.

Chapter 2

Conceptual Background

2.1 Introduction

This chapter provides a conceptual grounding to the research in this thesis, and defines the key terminology used in subsequent chapters.

Section 2.2 provides an overview of Personal Information Management (PIM) as a fundamental aspect of computer-based activity. **Section 2.2.1** discusses the limitations of previous definitions of PIM. Then, **Section 2.2.2** outlines the view of PIM taken up in this thesis, building on the conceptual framework offered by Barreau (1995). Lastly, **Section 2.2.3** contrasts PIM with related terms such as information retrieval and information management.

The second part of the chapter, **Section 2.3**, is concerned with the software tools that support PIM, termed *PIM-tools* in this thesis. Firstly, **Section 2.3.1** defines the term PIM-tool, and describes an abstract model of a canonical PIM-tool. The next three sections consider the past, present, and future of PIM-tool technology. **Section 2.3.2** discusses the history of PIM-tools, **Section 2.3.3** surveys the current generation of PIM-tools, and **Section 2.3.4** highlights a number of ongoing trends in PIM-tool design. Finally, **Section 2.3.5** discusses the concept of *integration between PIM-tools*, a central theme to this thesis.

2.2 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 acquire, 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 artefacts 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. At the time, this device revolutionized the management of document archives. Norman discusses the *cognitive scaffolding* offered by such artefacts: they allow people to offload the overhead 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.

2.2.1 Previous Definitions

Whittaker et al. (2000b) observe the lack of systematic research within Human-Computer Interaction (HCI) on many everyday computing activities including PIM. One problem they identify is the lack of consensus regarding the definition of key terms. This means that researchers doing new work in the area add new definitions to the wide range of candidates already available. This section surveys some previous definitions of PIM and argues the need for a more systematic definition.

Many definitions of PIM draw from a traditional information management perspective – that information is stored so that it can be retrieved at a later date. For example, Bellotti et al. (2002) describe PIM as: *"the ordering of information through categorization, placement, or embellishment in a manner that makes it easier to retrieve when it is needed"*. Such definitions are founded on the assumption that information is stored to facilitate later retrieval.

Similarly, Lansdale (1988) defines PIM as *"the methods and procedures by which we handle, categorize, and retrieve information on a day-to-day basis"*. However, Lansdale notes that enabling retrieval is only one reason for managing information, referring to the work of Malone (1983) who observed the *reminding* affordance of paper documents. Malone describes how people do not only manage documents to find them again, they also do so to remind themselves of tasks to perform. Although Lansdale acknowledges the various ways in which information can be used, his definition can be criticized for not defining what is meant by "handling".

Barreau (1995) conceptualizes a PIM system as *"an information system developed by, or created for, an individual in a work environment"*. She considers how a PIM system enables the construction of a collection of items, which constitute a personal information space. Barreau describes five functions provided by a PIM system:

1. The *acquisition* of items into the PIM system, including the definition, grouping, and naming of new information (e.g. the saving of newly created or downloaded information).
2. The *organization* of items within the system (e.g. filing items into folders).
3. The *maintenance* of the system in terms of updating, archiving and deleting items[2].
4. The *retrieval* of items via search or browsing, as driven by the user's information needs.
5. The *presentation* of retrieved information in an appropriate output format.

Although Barreau's definition conveys the multi-faceted nature of "handling" items, it can be criticized on several counts. Primarily, she includes the *updating* of items in her definition of the maintenance aspect of PIM. In contrast, the author takes the view that updating items (e.g. editing a file or a diagram) is not part of PIM. Rather than proposing a brand new definition, the next section modifies Barreau's framework to deal with this and a number of other limitations. This new definition represents the view of PIM taken up in this thesis.

2.2.2 Defining Personal Information Management Step by Step

This section 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 form 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 in **Section 2.3**.

Defining "Information"

Information has been defined as *"an assembly of data in a comprehensive form capable of communication and use"* (Feather and Sturges, 2003). 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

[2]Another source of terminological confusion in the area is the lack of definition for terms such as *archiving*. Some researchers use archiving to refer to the filing of an item within a folder, e.g. (Whittaker and Sidner, 1996). In this thesis, Barreau's interpretation of archiving is employed: the removal of an item from a collection for storage elsewhere.

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 appointments, 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 application[3]. 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 undertaking, 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 performed by the owning individual.* 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 part 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 form a collection of personal information, the *organization* of items, the *maintenance* of the collection, and the subsequent *retrieval* of items. 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

[3]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.

that items may be acquired and arranged (as part of PIM) to enable reminding. **Figure 2.1** illustrates the view of PIM taken in this thesis.

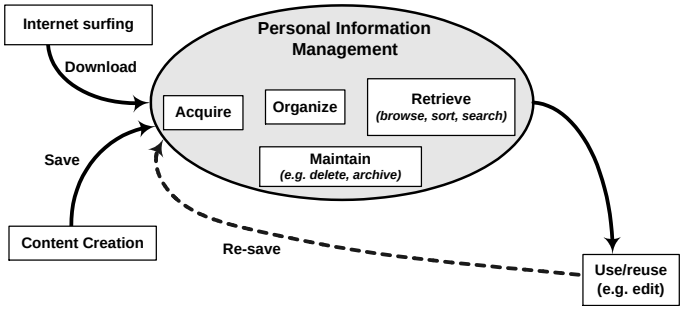

Figure 2.1: Four PIM sub-activities: acquisition, organization, maintenance and retrieval

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 that allows a user to 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.

2.2.3 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. PIM is differ-

[4]The term *knowledge management* (KM) is sometimes used in a similar sense, somewhat controversially, to refer to IM as performed by a large institution such as a company (Wilson, 2002b).

entiated 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 thesis.

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 thesis focuses on PIM performed by an individual for their own dedicated use. Issues relating to CIM are outside the scope of this research[5].

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.

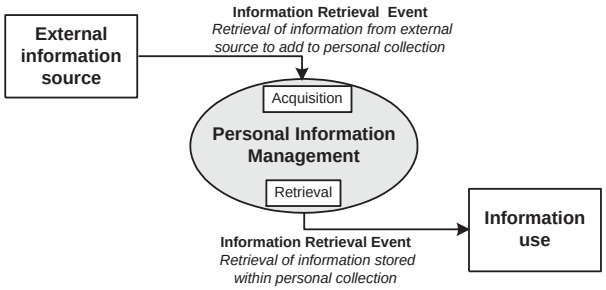

Figure 2.2: The relationship between PIM and Information Retrieval

[5]Note that a particular collection of information (e.g. a network drive) may be used for both PIM and CIM. For instance, it is possible that team members may store personal information, not intended for others, on one area of a shared network drive.

2.3 Personal Information Management Tools

This section considers the software tools that allow users to manage personal information. Firstly, **Section 2.3.1** offers the term PIM-tool to designate such software. Then, **Section 2.3.2** discusses the origins of PIM-tool software. **Section 2.3.3** surveys current PIM-tool technology, and highlights the reliance on the folder hierarchy. **Section 2.3.4** outlines ongoing trends in PIM-tool design. Finally, **Section 2.3.5** considers the provision of integration between PIM-tools.

2.3.1 Definition

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 interface defines how a user views and interacts with the collection. **Figure 2.3** illustrates the core functionality provided by a PIM-tool, consisting of support for the four PIM sub-activities outlined in **Section 2.2.2**:

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.

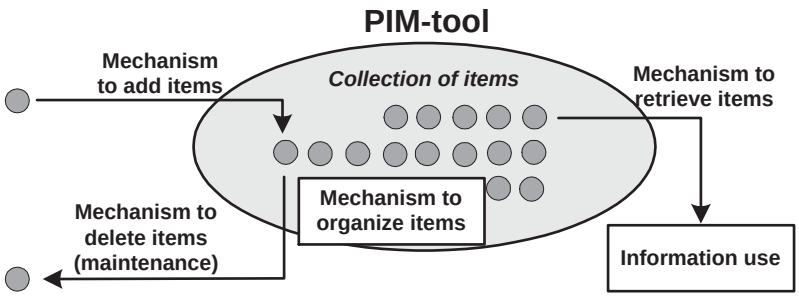

Figure 2.3: An abstract PIM-tool

PIM-tools typically support the management of personal information in a particular technological format. 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. Example PIM-tools are discussed in more detail in **Section 2.3.3**. 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 thesis 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.

2.3.2 Historical Context

The evolution of today's PIM-tool technology can be traced back far beyond the first practical personal computers. The *Memex* system (Bush, 1945) is often cited as a foresightful prediction of hypertext, envisioned using the technology of the 1940s. Bush outlined a system where a user could archive vast amounts of microfiche material, annotate items, and create links between specific items. The Memex system can thus be considered to encompass an early PIM-tool specification based on the acquisition of articles into a personal collection, demarcated by the links set up by the user.

In the 1960s and 70s two areas of work laid the groundwork for realizing today's PIM-tools: (1) mainframes that provided the first personal file storage, and (2) the first personal computers.

Personal space on multi-user systems

The first personal file storage was provided in early multi-user time-sharing computers. The *Compatible Time-sharing System (CTSS)*, developed in Project MAC at MIT, was the first mainframe to provide personal storage space to its users (Corbató et al., 1962). *CTSS* users were each allocated a private tape on which to store the programs they were developing. Previous systems only provided storage for generic programs and data.

The *CTSS* project was the direct predecessor of the *Multics* operating system, a collaboration between Bell Telephone Labs, MIT and General Electric (Daley and Neumann, 1965). *Multics* was the first system to implement a hierarchical file system for storing data. Users were each allocated a personal directory within the main file system. The command-line programs that allowed users to navigate the file hierarchy will be familiar to users of DOS and other command-line shells. They included *ls* to list the files in a directory, *pwd* to print the current working directory, and *cwd* to change the current directory. Due to development problems, Bell left the *Mul-*

tics consortium and proceeded to develop an alternative operating system called *UNIX* (Ritchie and Thompson, 1974). *UNIX* also offered its users a personal storage area called a *home directory*, and a set of command-line utilities for accessing them. Note that the early versions of UNIX were a long way in usability terms from today's systems. For example the entire system had to be rebooted every time the user wanted to create a new directory!

The directory hierarchy[6], as first implemented in these multi-user systems, remains the standard mechanism for organizing items provided by PIM-tools today.

The first personal computers

A parallel thread of research lead to the first *single-user personal computers*. Early pioneers included Douglas Engelbart, who lead the research team that developed the mouse and many aspects of the graphical user interfaces (e.g. multiple windows). Engelbart was heavily influenced by the ideas of Bush in envisioning the potential of computing technology to *augment* personal activities, rather than simply to provide raw number-crunching power (Engelbart, 1962).

Further progress in hardware and graphics technology lead in 1973 to the first desktop-sized personal computer, the *Xerox Alto* (Wadlow, 1981). The *Alto* provided the first graphical *direct manipulation* alternative to the command line interfaces that had been previously used for managing files. The Alto's *Neptune directory manager* provided a graphical representation of the file system, allowing files to be accessed, deleted and moved with the mouse.

In 1981, the *Xerox Star* was the first commercial implementation of the *Desktop Metaphor*, in which the file system was mapped onto a five-level physical metaphor consisting of cabinet, drawer, hanging, manilla envelope folders, and documents (Smith et al., 1982). Cabinets, drawers, hangings and folders provided a hierarchical storage mechanism in which documents (files), created by applications such as word processors, could be filed. Users were also able to arrange document files *spatially* as icons on the desktop. Although unsuccessful commercially, the *Star* was revolutionary in introducing the Desktop Metaphor, which was subsequently used in the more successful Apple II, and most subsequent personal operating systems.

The personal file system and desktop, as pioneered by these early personal computers, still provide the foundational PIM mechanism in today's computers. Note that the Desktop Metaphor

[6]Nowadays, the directory hierarchy is also commonly referred to as the folder hierarchy, a term that was driven by the Desktop Metaphor introduced in the *Xerox Star*.

did not replace the command line interface, but instead augmented it. The command line interface has been remarkably resilient, and still exists as an alternative to graphical interfaces in today's operating systems such as Windows, MacOS and Linux.

2.3.3 Contemporary PIM-tools

This section surveys contemporary PIM-tool technology. Note that the focus here is on tools in use by the general public. Research prototypes that have yet to enter the public domain are considered in **Chapter 3**. This thesis focuses on the PIM-tools employed to manage personal information on a personal computer, as surveyed in the next section.

Survey of desktop PIM-tools

Early personal computers were centred on managing information on the file system and on the desktop. Since then, a number of software applications have been developed that enable users to manage distinct collections of personal information based on specialized technological formats. Each new collection, although stored on the file system, was accessed via a dedicated PIM-tool interface. Examples include email, originally invented on UNIX in the 1970s, and web bookmarks, introduced with the invention of the World Wide Web in the 1990s.

Typical PIM-tools on a modern desktop computer include:

- *Personal file system* – The personal file system is defined as the portions of the file system used to store personal document files. Operating systems typically provide a default area for this purpose such as "My Documents" in Microsoft Windows, or the "home directory" in UNIX. Files can be created in a range of formats (e.g. text document, spreadsheet, presentation) depending on the application used to create and view the file. Since files of different formats are managed together in the personal file system, they are treated as members of the same collection of personal information.

  Most other PIM-tools are limited to managing a collection of information in a particular technological format. Although such collections are stored on the file system, they are accessed using a different interface.

- *The email tool used to manage electronic messages* – Note that email messages may con-

tain attached files such as text documents, or embedded web addresses. Thus the email PIM-tool, although its primary technological format is the email message, is often used to manage information of other formats.

- *The web bookmark management mechanism located within a web browser* – The key difference between the bookmark PIM-tool and other tools such as email is the nature of the items managed within. Bookmarks do not contain user-defined content, they are instead *references* to pages stored on remote websites.

  Both the web bookmark and email PIM-tools provide a hierarchical organizing mechanism dedicated to the respective technological format.

- *Calendar* – The calendar is representative of PIM-tools which are not based on a hierarchical organizing mechanism. Managed items are appointments which are ordered within the implicit chronological organizational scheme provided by the calendar software.

Other common PIM-tools include to-do lists, reference managers, image collections, music collections, and contact managers.

It can be observed that the fundamental design of PIM-tools has changed relatively little since the invention of the hierarchical file system, and the Desktop Metaphor. Although users have been offered the ability to manage many new types of personal information (e.g. email), the interfaces are still based on the same underlying mechanisms (Cooper, 2003).

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 organisational dimensions that they see as relevant (e.g. role, project or time). Studies of classificatory behaviour are reported in **Section 3.2**.

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.

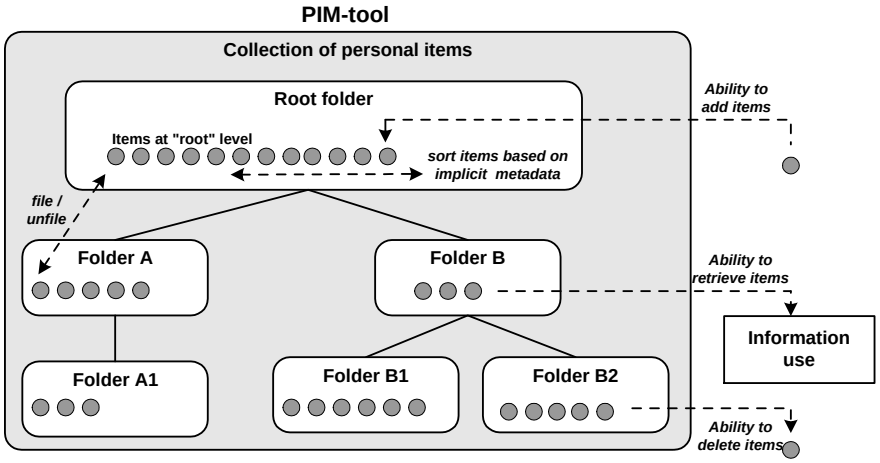

Figure 2.4: Model of a hierarchy-based PIM-tool

- *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, 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 interface 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.

Section 3.4 surveys theory relating to PIM, including arguments in favour and against the use of hierarchical organization.

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 information on their local computer, the user may store information remotely on network drives. Furthermore, many internet websites are now providing PIM-tool technology. Examples include 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.

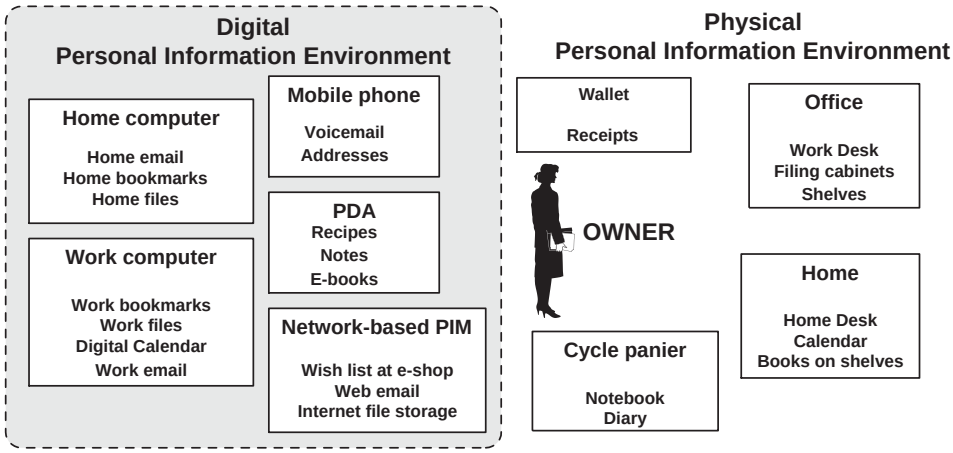

Figure 2.5: The personal information environment in both the physical and digital domains

2.3.4 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 formats 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 and 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.

2.3.5 Integration between PIM-tools

Section 2.3.3 described the historic trend towards multiple PIM-tools on multiple devices to form an extended personal information environment. The provision of integration between PIM-tools is a key theme in this thesis. This section 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 interfaces, 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 perform 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[7].

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.

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

[7]The bookmark collection is stored within a special region of the MS-Windows file system in the "Favorites" folder.

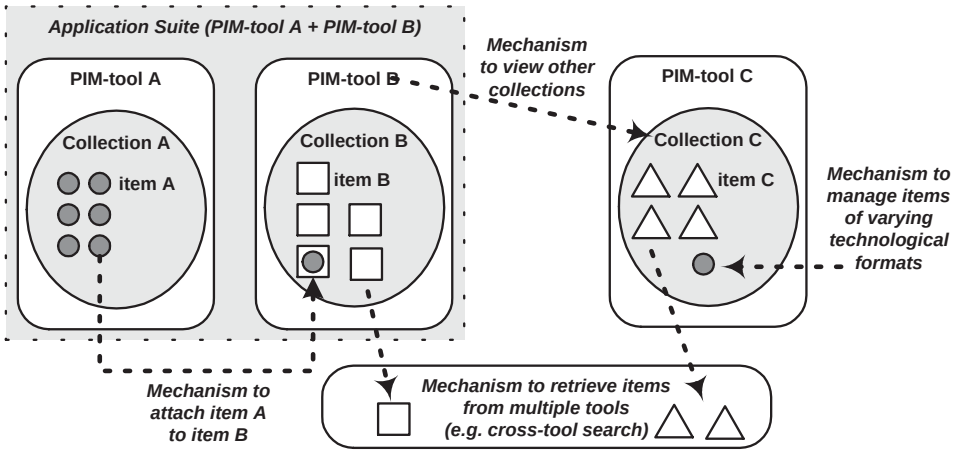

Figure 2.6: PIM-tool integration mechanisms found in modern desktop operating systems

approaches are effectively "bolt-on" mechanisms. Despite this wide range of integration mechanisms, information in different technological formats is managed in distinct collections within distinct PIM-tools.

Note that this section has focused on integration available to ordinary users. Research aimed at improving integration is discussed in **Section 3.5**, including systems that unify the management of multiple types of information within a consolidated interface.

2.4 Summary

Section 2.2 offered a conceptual framework detailing the view of PIM taken in this thesis, as an activity consisting of four sub-activities: acquisition, organization, maintenance, and retrieval. **Section 2.3** defined a PIM-tool as a software component which enables the user to manage a collection of personal information. A survey of existing PIM-tool technology was also provided, along with a discussion of their evolution from early multi-user systems.

Chapter 3 moves on to review relevant research carried out within Human-Computer Interaction and other related disciplines, aimed at investigating user needs regarding PIM, and designing improved technology to support it.

Chapter 3

Literature Review

3.1 Introduction

This chapter offers a critical review of prior research relevant to Personal Information Management (PIM). Firstly, **Section 3.1.1** provides an overview of Human-Computer Interaction (HCI), the research field to which the thesis contributes. **Section 3.1.2** identifies the three main types of HCI research related to PIM: empirical studies, technology prototypes, and theory development. The next three sections deal with each area in turn. **Section 3.2** reviews empirical work, **Section 3.3** surveys PIM technology, focusing on design efforts to improve PIM-integration, and **Section 3.4** reviews relevant theory. **Section 3.5** draws together the three areas, and identifies a key research gap, the lack of empirical support for the design of PIM-integration mechanisms. Based on this analysis, **Section 3.5.2** sets out a research agenda for the thesis, and **Section 3.5.3** justifies the selection of methodology employed in later chapters.

3.1.1 Human-Computer Interaction

Hewett et al. (1996) define Human-Computer Interaction (HCI) as the *"discipline concerned with the design, evaluation and implementation of interactive computing systems for human use and with the study of major phenomena surrounding them"*. A key aim of HCI research is to provide a knowledge base to guide the design of interactive systems. The output of HCI research includes two types of knowledge: (1) substantive, and (2) methodological. Substantive knowl-

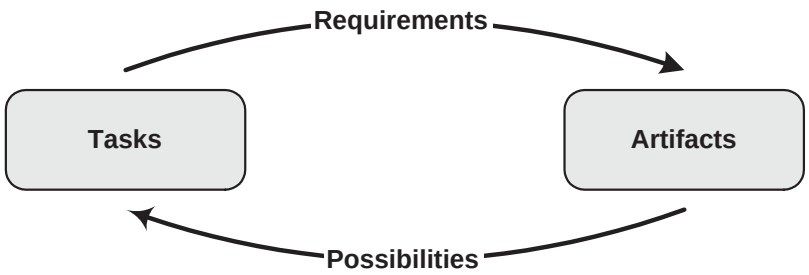

Figure 3.1: The Task-artefact Cycle (Carroll et al., 1991)

edge documents the results of research and may include experimental accounts, the designs of interactive systems and techniques, and models and theories of user behaviour. Methodological contributions offer guidance for future research and design in terms of heuristics, tools and methods.

The *task-artefact cycle* (Carroll et al., 1991) provides a conceptualization of the iterative process of technological development which HCI research seeks to influence (see **Figure 3.1**). Design requirements are derived from a situation of concern within some task context. For example, the tasks may involve the use of an interactive artefact which requires improvement in some way. Alternatively, problems in performing the task may suggest the design of a new artefact to support it. Requirements guide the process of design, the product of which is a new artefact to better support the task. However, this design intervention may change the nature of the original task. For instance, the artefact may open up new task possibilities. It is highly likely that the support offered by the artefact will be sub-optimal in some way – thus leading to the need for further design, and an iterative cycle. The cycle can be used to map out various kinds of HCI research. User studies build understanding of behaviour in a task context, and generate requirements for the design of research prototypes. Prototypes may then be evaluated in the task context to assess the value of new functionality. Both user studies and design facilitate theory-building in terms of task models, and designers' claims, which may be validated in further studies and evaluation respectively.

Sutcliffe (2000) sets out a framework which can be used to classify HCI knowledge in terms of the forms of interactive system to which that knowledge applies. Sutcliffe classifies interactive systems in terms of *architecture families* and *application/functionality families*. Architecture families represent different types of user interface components such as speech recognition and

window management. Application families represent the task domains to which interface components can be applied. Examples include finance and information retrieval.

Section 2.2 defined PIM in terms of four user activities, the *acquisition* of items to form a collection of information, the *organization* of those items, the *maintenance* of the collection, and the subsequent *retrieval* of items to satisfy the user's information needs. Therefore, within Sutcliffe's framework, PIM is an application family, to which interface technology can be applied.

3.1.2 Research on Personal Information Management

Whittaker et al. (2000b) note the importance of everyday computer-based activities such as PIM. They highlight three criteria of task importance: (1) tasks that are carried out frequently, (2) tasks that are "mission-critical", and (3) real-world tasks that are rooted in studies of actual user practice. The studies of PIM discussed in the next section show how PIM matches the first and third of these criteria, confirming the promise of research in this area. Since PIM-tools are in continual use by many millions of users, even small improvements to tool design may have profound effects in terms of productivity savings and satisfaction improvements.

In this chapter three main areas of research related to PIM are discussed.

- **Section 3.2** reviews *empirical studies of PIM behaviour*. This body of work has been concerned with understanding the usage of existing PIM artefacts, observing users' needs and problems, and making recommendations for improving design.
- **Section 3.3** reviews *technological prototyping*, the second body of research. The design of research prototypes (the design of new artefacts aimed at providing improved support for user needs). The contribution of technology design to HCI knowledge is also considered.
- **Section 3.4** then discusses *theoretical work relevant to PIM*. The overall lack of theory in this area is highlighted. Relevant theory from related fields such as information retrieval is also identified.

3.2 Review of Empirical Work

This section reviews the first body of research related to PIM, *empirical studies*. The aim of such work has been to investigate the use of current PIM-tools, and to improve understanding of user behaviour and needs. The output of such research thus provides requirements for the design of new PIM-tools. Two types of empirical work can be identified: (1) field studies, and (2) controlled studies. Field studies follow in the ethnomethodological research tradition of collecting data in real-world, naturalistic contexts. In contrast, controlled studies emphasise the collection of objective data in a lab context. They typically involve the user in carrying out a pre-specified task, thus enabling comparison across multiple participants, rather than necessarily reflecting real-world usage.

The rest of this section is structured as follows. Firstly, **Section 3.2.1** moves on to consider field studies of PIM in both the physical and digital domains. Then **Section 3.2.2** considers objective studies of low-level cognitive phenomena associated with PIM. Finally, **Section 3.2.3** discusses the overall contribution from research of this type.

3.2.1 Field Studies

Studies in the physical domain

As noted in **Chapter 2**, physical metaphors such as the Desktop Metaphor and the folder hierarchy have greatly influenced the design of PIM-tools (Smith et al., 1982). A number of researchers have studied information management practices in the physical domain with the aim of influencing the design of digital PIM-tools.

Tom Malone's work has been particularly influential in PIM research (Malone, 1983). Malone highlighted the inherent difficulties that many users encounter in classifying and retrieving documents in the physical domain, and identified a number of routes which PIM-tools could follow to avoid such problems in the digital domains. These included support for automatic classification. Malone also observed the fundamental *reminding* affordance of desks – people do not only arrange documents to find them again, they also do so to remind themselves of things to do (i.e. to contextualize their work activity). By doing so, Malone went beyond the traditional information management perspective that focuses on storing items for future retrieval.

Malone also identified two fundamental user strategies in managing paper documents: *filing* and *piling*. Kwasnik (1991) reports an investigation of classification practices in a physical office. Her study identified a number of contextual factors that influence classification decisions. She concluded that people do not make classificatory decisions based purely on document attributes, e.g. title and author. More recently, similar studies have been performed of the classification of files (Barreau, 1995) and web bookmarks (Gottlieb and Dilevko, 2001).

There have also been a number of contemporary studies in this area. Whittaker and Hirschberg (2001) took advantage of an office relocation to observe physical information management strategies. They present three main findings. Firstly, they observed that many people are irrational in terms of the information they manage, for instance they keep many items available elsewhere. Secondly, they noted that many people employ a mixture of the piling and filing strategies identified by Malone (1983), and observed that filers tended to amass more information than pilers. They also noted the importance of older archived information for many people, adding to the debate in this area (see next section). Sellen and Harper (2001) note the large amount of time wasted by office managers in managing information, leading to a distraction from their primary job roles. They suggest that there is a significant impact on manager productivity from PIM in the physical and digital domains.

Studies in the digital domain

Most studies in the digital domain have focused on user behaviour within specific PIM-tools. This section highlights a number of key findings of relevance to the work in later chapters. **Table 3.1** offers a summary of the studies that have been performed. The main focus to date has been on *email*, e.g. (Whittaker and Sidner, 1996; Ducheneaut and Bellotti, 2001), *web bookmarks*, e.g. (Abrams et al., 1998; Gottlieb and Dilevko, 2001; Jones et al., 2001) and *files*, e.g. (Barreau, 1995; Barreau and Nardi, 1995). In addition, many other types of personal information have been studied including *photos* (Rodden and Wood, 2003), *time and task management* (Payne, 1993; Blandford and Green, 2001; Palen, 1998), *contacts* (Whittaker et al., 2002), *instant messaging* (Isaacs et al., 2002), and *voicemail* (Whittaker et al., 2000a). Since the first three – files, email and bookmarks – act as the main focus of the empirical and design work in **Chapters 4** to **6** of this thesis, they are also the focus of this review.

Based on her study of file management, Barreau presents a conceptual framework that con-

Type of information	Studies
Physical documents	(Malone, 1983; Kwasnik, 1991)
Files (including the file system and desktop icons)	(Carroll, 1982; Akin et al., 1987; Barreau, 1995; Barreau and Nardi, 1995; Kaptelinin, 1996)
Email	(Mackay, 1988; Whittaker and Sidner, 1996; Balter, 1997; Ducheneaut and Bellotti, 2001)
Web bookmarks	(Abrams et al., 1998; Gottlieb and Dilevko, 2001; Jones et al., 2001; Dix and Marshall, 2003)
Images	(Rodden and Wood, 2003)
Voicemail	(Whittaker et al., 2000a)
Contacts	(Whittaker et al., 2002)
Calendar and to-do items	(Payne, 1993; Blandford and Green, 2001; Palen, 1998)
Instant messaging	(Isaacs et al., 2002)

Table 3.1: Summary of empirical studies of different PIM-tools

veys the complex, high-level nature of PIM (Barreau, 1995). In summary, she identified five aspects of the functionality provided by PIM-systems: (1) *acquisition* of items into a collection, (2) *organization* of items, (3) *maintenance* of the collection (e.g. archiving items into long-term storage), (4) *retrieval* of items for reuse, and (5) *output* of the information in an appropriate format This framework is discussed in more detail in **Section 2.2**. Barreau highlights the idiosyncratic nature of PIM leading to a wide variety of strategies between individuals, and the consequent need for tool flexibility. Barreau also notes the *satisficing* nature of PIM: the people in her study only tended to acquire information as it was required, and only maintained their information when they were forced to by circumstances such as running out of space.

Many studies have highlighted the problems users encounter in PIM sub-activities such as organization and retrieval. Lansdale highlights the core psychological difficulties inherent in the low-level processes of organization and retrieval (Lansdale, 1988). He observes that classification is a cognitively difficult task with users having to deal with problems of ambiguous and overlapping categories. Users often employ a satisficing strategy, resulting in problems such as misfiling, failed folders, and filing prematurely before the value of an item has been assessed (Whittaker and Sidner, 1996). Alternatively, users may not file, and rely on retrieving information via sorting based on implicit metadata, and search. Such loose classification facilitates additional retrieval cues such as location, time and appearance. However, such strategies are rarely scalable (ibid). Lansdale identifies two psychological processes that are used when retrieving information: (1) *recall-directed search* (to home in on a group of items), and (2) *recognition-based scanning* (selecting a particular item). He notes that retrieval systems are not tuned to the abilities of the human memory, such as the ability to remember general mean-

ings better than specific details. Users are forced to remember specific filenames and locations, whilst human memory is better at handling contextual information such as time and colour.

Several studies have surveyed the types of information that are managed by users. Barreau and Nardi (1995) identify three types of information in terms of their lifetime of use: *ephemeral*, *working*, and *archived*. Ephemeral information is valued in the short-term and includes to-do items and information for immediate use. Working information is valued over a longer period and may be kept for the period of a particular project over several months. Archived information is kept in the long-term but is not in day-to-day use. There has been some disagreement over which is the most important type of information to focus on with design work. Barreau and Nardi (1995) highlight the relative importance of ephemeral/working information (accessed via location-based finding) over archived material (and the use of search). This view is echoed by Kidd (1994) who argues that too much design is focused on supporting the management of older archived information. In contrast, other researchers have argued the importance of archived information (Fertig et al., 1996; Whittaker and Hirschberg, 2001).

Influenced by Malone's work, several studies have attempted to classify management strategies in various PIM-tools, with a particular focus on how users organize items. Whittaker and Sidner (1996) observed 3 types of strategies for managing email: *frequent filer*, *spring cleaner* and *no-filer*. Balter (1997) extends this classification by dividing the no-filer class into two further sub-classes: *folderless cleaner* and *folderless spring-cleaner* (depending on whether old items are deleted from the inbox on a daily basis). Abrams et al. (1998) proposed a similar classification of bookmark management strategies: *no-filer*, *creation-time filer*, *end-of-session filer*, and *sporadic filer*. The author is not aware of any strategy classifications in files.

In terms of retrieval, Barreau and Nardi (1995) identify a strong preference for location-based finding over the use of search. They define location-based finding as the browsing of information via the organizational structure developed by the user. Their results have been strongly criticised by Freeman and Gelernter (1996) who note that infrequent use of search can be explained by the poor design of search functionality in most operating systems. Freeman and Gelernter (1996) call for further study of the use of advanced search technology. However, it can be observed that later studies, including the one reported in **Chapter 4**, reinforce Barreau and Nardi's observation of a preference for browsing over search[8].

[8]The *Stuff I've Seen* system (Dumais et al., 2003) offers a unified search interface across a range of PIM-tools. Dumais *et al*'s evaluation results suggest that the improved search technology in their prototype lead participants to depend less on filing and browsing-based retrieval.

The prime focus of this thesis is on improving *integration* between PIM-tools. However, few studies have investigated user behaviour beyond a tool-specific context. Exceptions are discussed as follows. Kaptelinin (1996, 2003) observes that users often employ multiple PIM tools in support of their high-level activities, such as the Desktop, the file system, and email. He notes the difficulties users encounter in performing key project tasks across tool boundaries, such as archiving. He also observes the duplication of organizational schemes between digital and physical documents. Bellotti and Smith (2000) similarly note how the management of information related to a particular activity is distributed across a wide range of tools. Furthermore, they note that information of a particular technological format is often compartmentalized between different PIM-tools, e.g. files or reminders. Like Kaptelinin, Bellotti and Smith observe the duplication of filing systems between different PIM-tools. However, neither study reports a detailed investigation of the extent of such duplication. Two other studies have noted how users perform task and time management across a wide range of PIM-tools and physical artefacts (Blandford and Green, 2001; Bellotti et al., 2003). Similarly, Jones et al. (2001) note how users manage web references with a wide range of mechanisms including bookmarks, email, ad-hoc lists, and physical print-outs. All these studies make calls for improved integration between different tools.

3.2.2 Controlled Studies

As well as field studies of naturalistic PIM behaviour, a number of controlled studies have also been carried out in the area. Since the research reported in this thesis employs a field-study methodology, only a brief overview of two controlled studies is provided. A number of controlled studies have also been carried out to evaluate new PIM designs (see **Section 3.3**).

Dumais and Jones (1985) carried out a paper-based experiment designed to test the frequent assumption that spatial memory is more effective than symbolic memory. Participants were asked to organize a series of items, using a combination of location-based (spatial) and name-based (symbolic) filing systems. Over a series of retrieval tasks, spatial filing was seen to offer no benefit over symbolic filing. Furthermore, retrieval speeds for location-only deteriorated significantly as more items were added. Based on their findings, Dumais and Jones suggest that spatial management should not replace symbolic techniques, but instead act as an adjunct, much as in current desktop computers.

Dix and Marshall (2003) report an investigation of how retrieval performance depends on the time at which bookmarks are organized. Two conditions were compared: "sorting during browsing", and "sorting after browsing". Based on performance in a series of questions that involved retrieval from the set of bookmarks, the "sorting after browsing" resulted in significantly faster recall. However, the difference was not evident when users were tested a week later. Dix and Marshall suggest that the initial result may be due to the close proximity of the sorting and post-test tasks.

A key criticism that can be levelled at such controlled studies is that they lack ecological validity. Although a number of interesting results are presented, the relevance of the findings to real-world contexts can be questioned. Dix and Marshall themselves highlight two limitations of the ecological validity of their experiments: (1) the bookmarks were pre-selected, and (2) in real-life users may use a combination of during and after-browsing sorting. Whittaker et al. (2000b) call for the employment of both field and controlled studies in PIM research.

3.2.3 Discussion of Empirical Contributions

Although many interesting findings have been presented, the author echoes the view of Whittaker et al. (2000b), that there is still a lack of systematic empirical investigation in this area. They propose a simple criterion for this: *are there at least two user studies in a given area?* Although this can be considered to be a highly conservative requirement given the ubiquity and importance of PIM, they note that even this criterion is not met. They conclude that there is no accepted body of knowledge to build further research on, for example a consensus of people's tasks and problems, and appropriate metrics for evaluation. Three further limitations are identified by the author as follows.

The expressed focus of this thesis is on PIM-integration, and as the next section discusses there has been much design interest in this area. However, the majority of studies have been tool-specific and are concerned with the management of information of a particular technological format (e.g. files, email, bookmarks). In terms of the wider personal information environment this represents an inherently piecemeal approach. **Section 3.5** discusses this limitation in more detail.

Another issue that illustrates the need for more studies in this area is the lack of empirical attention paid to longitudinal aspects of PIM, e.g. how PIM strategies may change over time (Lans-

dale and Edmonds, 1992). Instead, most work to date has been based on short-term "snapshots" of user behaviour

Finally, it is observed that most studies have focused on small groups of technical users. It can be argued that such samples are unrepresentative of the wider population of users, including non-technical "home" users. Furthermore, many of the most often cited studies were carried out almost a decade ago, e.g. (Barreau and Nardi, 1995). For example, Barreau (Barreau, 1995) mentions a few users who stored information on floppies as they did not have hard drives. Although some results will be transferable to modern personal information environments, it is envisaged that user needs may have moved on from 1995.

The next section discusses the second area of research contributions: the design and prototyping of new PIM-tool software.

3.3 Review of Technological Prototypes

Section 2.3 surveyed PIM-tools in common use. This section reviews exploratory PIM prototypes that have been proposed in the research domain, as well as highly innovative commercial systems that are not in widespread use. This is an active area of design, and many systems have been proposed, particularly in the commercial sector. Therefore, this section does not aim to be an exhaustive summary, but to instead provide a representative summary.

The section is structured in terms of four design genres, defined in terms of the *level of integration* they provide:

- *Tool-specific design* – **Section 3.3.1** provides an overview of new technology aimed to improve the design of specific PIM-tools such as email. Integration is not a primary design aim of such work.
- *Systems that provide increased integration between distinct PIM-tools* – **Section 3.3.2** surveys this second genre, aimed at improving integration between distinct PIM tools.
- *Designs that embed additional support for the management of multiple types of information within one PIM-tool* – **Section 3.3.3** covers the embedding design genre.
- *Unifying designs that consolidate the management of multiple types of information within a single interface* – **Section 3.3.4** covers this final genre which represents the most ambitious design work in this area.

3.3.1 Intra-tool Designs

This section considers design work within *tool-specific* contexts. Since the focus of the thesis is on the provision of improved integration between PIM-tools, only a representative sample of tool-specific work is provided.

Many studies have observed the problems encountered by users in classifying items, e.g. (Malone, 1983; Whittaker and Sidner, 1996). Several prototypes have offered automatic filing of email messages based on user modelling techniques, e.g. the *Mailcat* system (Segal and Kephart, 1999). The system automatically processes incoming mail through an adaptive classifier, and suggests the three most likely folders for the message to be filed in. A long-term study in the

context of the authors' own email usage revealed an accuracy rate of 85%. Although later systems have improved performance, such systems require some level of user monitoring which may be problematic. Furthermore, Shneiderman and Maes (1997) observe that such intelligent interfaces may result in a loss of control on the part of the user.

Other prototypes have focused on a key limitation of the folder hierarchy, that of multiple classification not being supported, e.g. (Quan et al., 2003). Several commercial tools also provide multiple-classification support including *BookKey* and *GMail*. Such systems allow a user to assign arbitrary user-defined attributes to an item, and then to retrieve them using any combination of those attributes. Quan *et al* report an evaluation of a multiple classification interface for managing bookmarks based on a flat set of attributes. Users welcomed the multiple classification functionality, and there was some improvement in retrieval speed. However, the experiment can be criticized in terms of ecological validity, as a pre-selected data set was employed. Furthermore, several limitations were observed including: (1) duplicated attributes, and (2) poor support for data that is naturally hierarchical. The author urges further evaluation in a real-world setting.

Other tool-specific work has offered new interactive techniques for representing collections of items. The *Piles* system (Mander et al., 1992) allows the "casual organization" of items, a digital equivalent to the piling strategies observed by Malone in physical office environments (Malone, 1983). Other prototyping has offered 3D spatial environments for managing information such as bookmarks, e.g. *Data Mountain* (Robertson et al., 1998). However, the benefits of such a 3D approach have been questioned in follow-up work (Cockburn and McKenzie, 2001). Although users preferred the 3D interface, Cockburn and McKenzie observed slower retrieval times compared to a 2D system.

3.3.2 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 (see **Section 2.3.5**). 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 MacOS. 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. They propose a system called *Cyberdesk* which allows the user to define how different types of structured information should be processed. Furthermore, the 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[9]. 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 mechanisms. Additionally, feedback from users suggested that they would be less likely 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. However, 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, research has also focused on enabling integration between the digital and physical domains. The *Protofoil* system (Rao et al., 1994) allows the management of paper documents as electronic images, including the retrieval of paper documents via keyword search.

The next two sections consider systems that provide support for managing multiple types of information within a single interface. Firstly, **Section 3.3.3** considers the embedding of support

[9]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.

for managing non-native information formats within a PIM-tool.

3.3.3 Embedding Designs

Current PIM tools focus on the management of information in a specific technological format. The main exceptions are the file system in which many technological formats can be stored, and email which allows the user to manage non-native items, such as 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.

Bellotti et al. (2003) report the field-study evaluation of their *TaskMaster* 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. Despite 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* prototype (Bellotti and Smith, 2000) includes no less than three organizing mechanisms.

3.3.4 Unifying Designs

This section surveys systems that unify the management of multiple types of information within a new consolidated interface, rather than embedding it within an existing tool. Two types of unifying system can be identified:

- Systems that unify the management of multiple types of information within an interface based on a dominant *organizational dimension* such as role, project, or time.
- Systems which do not enforce a particular organizational dimension. Approaches include search-based, attribute-based and hypertext-based unification.

Firstly, systems based on a dominant organizational dimension are surveyed. **Table 3.2** provides an overview of this body of design work. The following sub-sections discuss each organizational dimension in turn.

Organizational Dimension	System	Evaluation
Time	*MEMOIRS* (Lansdale and Edmonds, 1992), *Lifestreams* (Freeman and Gelernter, 1996)	no
Role	*Role Manager* (Shneiderman and Plaisant, 1994)	no
Project	*UMEA* (Kaptelinin, 1996)	informal
Contact	ContactMap (Nardi et al., 2002)	no

Table 3.2: Unification designs based on a dominant organizational dimension

Time-based Unification

A number of PIM-unification prototypes have been based on chronological organization of personal information. Three examples are discussed here: *MEMOIRS* (Lansdale and Edmonds, 1992), *LifeStreams* (Freeman and Gelernter, 1996), and *Milestones* system (Ringel et al., 2003).

The *MEMOIRS* system (Lansdale and Edmonds, 1992) is founded on the principle of organizing all information in terms of *events*. *MEMOIRS* is based on the integration of the diary and filing system, with files managed in the same chronological mechanism as events such as meetings. Although the implemented prototype did not cater for other types of personal information such as email, this extension was envisaged. The system was proposed as a vehicle to explore the application to design of findings from cognitive psychology. The primary design aim was to enable retrieval based on temporal context, thus exploiting autobiographical memory. A second was to promote retrieval by recognition (based on visual appearance) rather than recall. This was enabled by allowing items to be colour coded. Lansdale and Edmonds stress the importance of long-term evaluation, particularly when using "fundamental research" such as cognitive psychology to direct high-level design. They note that many such findings, may not apply in a natural setting. Despite their concerns, *MEMOIRS* has not been evaluated.

Another notable time-based PIM-unification prototype is *Lifestreams* (Freeman and Gelernter, 1996; Fertig et al., 1996) which provides a time-ordered organization of all personal information. The Lifestreams system has now been realised as a commercial tool called *Scopeware*. Although the tool appears to have been received well based on press reports, the contribution in terms of HCI research is limited as no evaluation has been published. Both MEMOIRS and LifeStreams combine a primary chronological organizational mechanism with attributed-based organization of items. The attributed-based approach is detailed on page 46.

A final example is the *Milestones* system (Ringel et al., 2003) which organizes cross-tool search results in a time-line visualization annotated with "landmarks" corresponding to a user's personal information such as events and images. The reported evaluation suggests benefits from the landmarks in terms of retrieval time over a plain time-ordered result set.

Contact-based Unification

The *ContactMap* system (Nardi et al., 2002) integrates the management of multiple types of personal information based on the representation of a user's social network, derived from the user's address book. The interface offers a spatial map of the social network and enables access to files, email and bookmarks associated with contacts, as well as to communication functionality for contacting that person. Awareness information is also provided. Thus ContactMap integrates both information management and communication functionality. Although Nardi *et al.* carry out an empirical investigation into the generation of social networks from users' contact data, no evaluations of system usage have been published. However, communication with one of the authors indicates that an evaluation is soon to be published (Whittaker, 2003).

Activity-based Unification

Two PIM-unification prototypes focus on a user's *activities* as the dominant organizational dimension: *Personal Role Manager* (Shneiderman and Plaisant, 1994) and *UMEA* (Kaptelinin, 1996).

The *Personal Role Manager* (Shneiderman and Plaisant, 1994) allows the user to manage multiple technological formats under the dominant organizational dimension of *roles*, a user's high-level activities. Roles can in turn be broken down into a task hierarchy represented as windows

in which relevant files can be stored. The role and task descriptions are also made available in the user's calendar. However, like many other PIM-unification systems, no evaluation has been reported.

The *UMEA* system (Kaptelinin, 1996, 2003) allows the user to organize multiple types of information in terms of their high-level projects. The design rationale is based on the observation that a user's activities often involve multiple PIM-tools. The system allows a user to specify the current project which is being worked on. Thereafter, all information that the user interacts with, is automatically associated with that project. An informal evaluation was carried out, resulting in positive feedback from several users regarding the principle of project-centric unification. However one limitation was the need for the user to switch task manually. This is especially problematic in tool contexts where high-level activities are likely to be interleaved, e.g. email. Kaptelinin acknowledges the need for a follow-up, in-depth evaluation.

Attribute-based Unification

The rest of **Section 3.3.4** considers PIM-unification prototypes which are not based on a single organizational dimension. Here, attribute-based PIM-unification is considered. These systems combine two ambitious aims: (1) the unification of different forms of information within a common interface, and (2) the provision of an alternative non-hierarchical organizing mechanism. Attribute-based PIM-unification systems in the research domain include the *Semantic File System* (Gifford et al., 1991), *Presto* (Dourish et al., 1999), and *Haystack* (Adar et al., 1999; Quan et al., 2003)[10]. These systems also provide powerful keyword search as well as attribute-based management. Although these systems are technologically innovative, in terms of making a contribution to HCI knowledge, they can be criticised for a lack of evaluation. Although, attribute-based management has not been evaluated in a unifying context, it has been in a tool-specific context Quan et al. (2003). The issues raised in that study (see **Section 3.3.1**) suggest the need for a more extensive, long-term evaluation.

In parallel to the research work detailed above, attribute-based PIM-unification has been provided in a number of commercial systems, notably *BeOS* (Giampaolo, 1998). Also, *Lotus Agenda*, an early PIM system supported basic attribute-based organization of information such as contacts, notes and appointments (Kaplan et al., 1990). The *Chandler* system (Fitzgerald, 2003)

[10]Note that a number of the unification systems based on a single organizational dimension, combine this with attribute-based access to low-level information, e.g. (Lansdale and Edmonds, 1992; Freeman and Gelernter, 1996).

is an open-source system that provides Agenda-like functionality through current technology. Furthermore, there is currently significant interest in providing attribute-based PIM-unification in new versions of popular operating systems such as MS-Windows Longhorn (Microsoft Longhorn). However, in lieu of published evaluations, it appears the first user feedback will be available when these products appear in the marketplace.

Other Types of PIM-Unification

This final section describes other forms of PIM-unification based on search, hypertext and spatial interfaces. *The Personal Web* (Wolber et al., 2002) offers unification based on links between items in different collections. The system treats all item inter-relationships as equivalent, e.g. URL hyper-links, folder inclusion, and semantic proximity. Like most attribute-based systems, this prototype is grounded in criticism of the traditional hierarchy. Yet again the contribution of this highly interesting approach is limited by the lack of evaluation. Open design issues include whether all types of item inter-relationship should carry the same weight.

Raskin (2000) proposes two novel forms of PIM-unification. The first employs a book metaphor and emphasises incremental search of information stored in textual form. The second provides a spatial environment in which all a user's information is stored. A graphical zooming user interface (ZUI) and keyword search provide access to data. This second system is current under development as an open-source project called *The Humane Environment*.

MyLifeBits (Gemmell et al., 2002) is highly ambitious in scale. The design aim is to allow a user to collect all information they interact with during their entire life, including: TV watched, radio listened to, documents read, web pages visited and emails received. Retrieval is provided via attribute-based management, and keyword search. The system is at a technological proof-of-concept stage, although one of the researchers, Gordon Bell, is trying out the system. No evaluation has yet been published, and as yet it is not clear that such power is required by users. The potential for such a system to continuously archive personal information has also been discussed by (Dix, 2002).

3.3.5 Discussion of Technological Contributions

Section 3.3 presented research that has made technological contributions to the area. Here the overall contribution of this body of work is considered, with a focus on that aimed at improving PIM integration.

Many interesting technologies have been described. However, interesting design in itself does not necessarily correspond to a solid contribution to the knowledge base of HCI research. Standard HCI practice consists of three steps: requirements gathering, design and evaluation (Whittaker et al., 2000b). In this section, it is argued that much of the above design-based research fails to carry out the first and third of these steps, and therefore fails to make a substantial contribution to HCI knowledge.

The Need for Evaluation

The primary criticism that can be directed at much of this work concerns lack of evaluation. Evaluation of designs is crucial to validate designers' claims regarding the strengths and weaknesses of their work. Otherwise the HCI community can not be sure if a designed artefact is "better or just different" (Newman and Lamming, 1995). However, most PIM interfaces have not been evaluated (exceptions include *TaskMaster* (Bellotti et al., 2003) and *Stuff I've Seen* (Dumais et al., 2003)). Many projects have failed to carry out planned future evaluations.

Many of the PIM-unification systems discussed above are innovative and offer novel alternatives to existing tools. Such ambitious design has been termed "radical invention" (Whittaker et al., 2000b)). Many of the systems also raise numerous usability questions, e.g. those systems that offer alternatives to the traditional folder hierarchy. However evaluations are particularly rare, possibly exacerbated by the fact that such revolutionary design offers many evaluation challenges: it may be difficult to localize the effects of specific design changes in a completely new interface. An alternative design approach, is that of incremental design, or "hill-climbing" (Carroll, 2000). By making limited changes to an interface, the designer can both build on existing design expertise, and promote systematic evaluation (Newman and Lamming, 1995).

Some of the evaluations which have been carried out, were limited to short-term lab studies, e.g. (Quan et al., 2003). It has been argued that long-term, *in-situ* studies are important for eval-

uating the usability of PIM interfaces (Lansdale and Edmonds, 1992). The implications from a new design may not be fully clear until it has been used over time, meaning that evaluation is a difficult, expensive undertaking.

A key reason for the lack of evaluation may be the lack of accepted methodology (Whittaker et al., 2000b). This also means that it is difficult to compare designs that have been evaluated in different ways. Dillon (2001) notes the inappropriateness of traditional performance-based evaluation metrics for high-level, ongoing tasks such as PIM. This suggests that there may be a need to develop satisfaction-based evaluation metrics. Whittaker *et al.* argue the need for the identification of standardized *reference tasks* and the use of multiple metrics, encompassing both qualitative and quantitative techniques.

The Need for Empirical or Theoretical Grounding

Research prototypes aim to provide improved support for user needs. Thus they depend on a solid understanding of user needs to ensure that design is directed towards generating appropriate solutions to important problems. However, many of the PIM prototypes covered in this section are not grounded in a firm understanding of user problems. There are some exceptions including *ContactMap* (Nardi et al., 2002), *UMEA* (Kaptelinin, 2003), and *TaskMaster* (Bellotti et al., 2003), whose designs are grounded in observations of user behaviour and problems.

In contrast, other systems have attempted empirical grounding by referring to results from cognitive psychology. For example, several systems use the importance of autobiographical memory as rationale for systems based on chronological ordering (Lansdale and Edmonds, 1992; Fertig et al., 1996). However, Lansdale and Edmonds (1992) note that low-level results from controlled studies may not *necessarily* apply in the real-world contexts in which the tools are to be used. Other systems are rooted in theoretical critiques of the hierarchy such as its single inheritance limitation, e.g. (Dourish et al., 1999).

In general, many systems have been technologically rather than empirically motivated. It can be argued that much of the work has been based on designer intuition regarding appropriate technology to apply to the PIM application domain. However, as noted above, it is particularly important in such cases for designs to be tested through user evaluation. The fact that it has not been performed is problematic.

A final comment can be made regarding the availability of empirical support for design work offering PIM-unification. The term *cross-tool* is proposed to describe such design work that bridges more than one PIM-tool. However, **Section 3.2.3** noted that most studies of PIM behaviour, have been tool-specific. **Section 3.5** identifies a key research gap in terms of the relative lack of cross-tool empirical support for cross-tool design.

3.4 Review of Theory

This section surveys theoretical work on PIM that is relevant to this thesis. Rogers (2004) presents four aims of theory within HCI: to describe interactive phenomena, to explain interactive phenomena, to make predictions of the output of a design (e.g. in terms of user performance), and to generate new routes for design.

The section is structured as follows. Firstly, **Section 3.4.1** considers descriptive and predictive models of PIM. **Section 3.4.2** then briefly discusses two models of information retrieval. **Section 3.4.3** discusses the theory of personal classification, and critiques that have been levelled against the folder hierarchy.

3.4.1 Models of Personal Information Management

This section surveys two types of model that have been proposed: (1) descriptive models that do not attempt to make predictions of user behaviour, and (2) predictive models of user behaviour that can be used to issue prescriptive advice to direct design.

Descriptive Models

Earlier sections of this thesis have covered areas of descriptive theory. These include Barreau's conceptual framework of PIM sub-activities (Barreau, 1995), and classifications of organizing strategies in PIM-tools such as email, e.g. (Whittaker and Sidner, 1996).

As noted in **Section 3.2**, few empirical studies have captured data on PIM over time. However, based on classifications of email management strategies, Balter proposes a model representing possible strategy changes over time (Balter, 1997). The model is summarized in **Figure 3.2**, and can be can be summarized in terms of two sets of strategy transitions. These can be described as "*pro-organizing*" transitions (solid lines), and "*anti-organizing*" transitions (dashed lines). Balter suggests that under the pressure of increasing information overload, many users may follow the "anti-organizing" transitions and become less reliant on filing over time. He proposes that folderless spring-cleaner may be an optimizing "end-state" for many users who receive large numbers of email. Other users may instead choose to devote increased effort towards management and move the other way (e.g. from spring-cleaner to frequent-filer). He observes

that further longitudinal data is required to confirm his model.

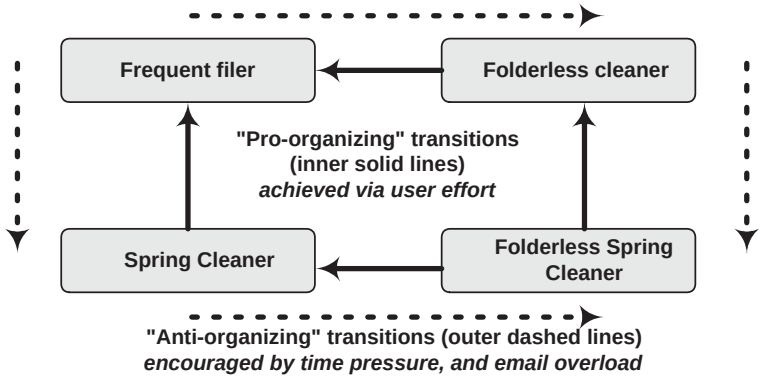

Figure 3.2: Model of changes in email management strategy over time (Balter, 1997)

Distributed Cognition (DC) is a theoretical framework which has been used to model cognitive processes distributed across time, space and multiple actors, e.g. aircraft carrier control rooms (Hollan et al., 2000). Two sets of descriptive terminology have been proposed to describe the functions provided by items and tools in the user's personal information environment. Dix et al. (1998) offers a conceptual framework describing the function of items in supporting user activities. He identifies two key concepts: (1) *triggers*, items such as reminders that can initiate action, and (2) *placeholders* which are arrangements of items which can maintain task state allowing it to be restarted at a later time. A second, more abstract set of terminology is offered by Kirsh (2001). Kirsh reports a theoretical analysis of an information environment as an activity space within which the user carries out their tasks. He proposes a number of theoretical constructs to describe the conceptual structures that users project onto the environment: (1) *entry points* (cues to start tasks), (2) action landscapes (arrangements of items that support a particular activity), and (3) coordinating mechanisms (artefacts such as calendars that allow the user to perform multiple activities). Whittaker et al. (2000b) note the need for the community to agree on standardized descriptive terminology as a stepping stone to developing predictive theories. The above frameworks represent the first steps towards establishing agreed terminology in this area.

Predictive Models

Few predictive models of PIM behaviour have been developed. One exception is that of Balter (2000) who proposes a keystroke-level model of email archiving and retrieval. Based on the model, Balter issues prescriptive advice to tool designers and to users with respect to optimizing their behaviour in terms of time efficiency. Balter's model can be criticised for its reliance on economic costs of information access and storage. For example, one of Balter's claims is that any strategy involving more than 30 folders is inefficient. Studies of email usage have observed highly experienced email users with large numbers of folders (Ducheneaut and Bellotti, 2001). Such findings suggest that either Balter's model is inaccurate, or that there is more at stake than time efficiency in dictating choice of management strategy. Factors such as the need for tidiness, or the placement of items as reminders are not captured within the model. However, Balter's work should be acknowledged as a first step in generating prescriptive advice in this complex area.

3.4.2 Models of Information Retrieval

Section 2.2.3 highlighted how information retrieval is a key aspect of PIM. Theories from information retrieval may be useful to the developers of more general PIM-related theories.

Information Foraging (IF) (Pirolli and Card, 1999) is a theory that supports the construction of computational models of information-seeking behaviour. The theory is based on evolutionary theories of survival, leading to the premise *"that information systems evolve towards a stable state of maximising the transfer of valuable information per unit cost"*. Users will seek to follow an optimal strategy so as to achieve this. Three activities are considered: (1) enrichment, (2) scent following, and (3) exploitation. The models encompasses a notion of information value in terms of information scent, and the cost of interaction (e.g. mouse clicks). IF theory has been most recently applied to website design.

Wilson (1999) observes that many models of information retrieval do not encompass how that information is used, beyond the general notion of an *information need*. He proposes a general model of information behaviour that encompasses information retrieval and other aspects of information usage. However, the model does not capture aspects of PIM such as how information may be stored and organized over time.

3.4.3 Personal Classification Schemes

Chapter 2 noted that most current PIM-tools are centred on a hierarchical classification mechanism. This section surveys some theory on classification, before describing criticisms that have been levelled at the folder hierarchy.

The folder hierarchy allows the user to specify a classification scheme within which items can be categorized. Bowker and Star (1999) define a classification scheme as *"a spatial, temporal or spatio-temporal segmentation of the world"*. They propose three theoretical properties of a classification scheme: (1) a consistent, unique classificatory principle, such as temporal or alphabetical ordering, (2) mutually exclusive categories, and (3) completeness. However, as they note, no real-world classification is this ideal – classificatory principles often contradict, categories overlap, and many items cannot be categorized (hence the use of catch-all categories such as "stuff").

Many theories of classification have been developed through the ages. The Classical Theory originated with Plato in Ancient Greece (Eysenck and Keane, 1990). The Classical Theory states that the cognitive concepts on which categories are based carry their own definitional structure. Categorizing an item is thus the process of matching its features against those of the concept. In recent years the Classical Theory has been subjected to intense criticism, and other views such as Prototype Theory (Rosch, 1978) have come to the fore. Prototype Theory states that a category is a statistical representation of the properties that its members tend to have, i.e. each category is represented by an exemplar. Under Prototype Theory, categorizing an item involves comparing it to each category's exemplar. Rosch identifies two basic principles that influence the formation of categories: (1) cognitive economy (classification is about providing maximum information about the world for the least cognitive effort), and (2) perceived world structure (categories are based on the high correlational structure possessed by the attributes of real-world objects). These two principles have implications for the level of abstraction of categories formed in a category system (inclusiveness), and the internal structure of those categories once formed (prototypes).

Classification schemes can be considered as a means of cognitive scaffolding (Jacob, 2001) – they allow people to deal with the complexity of large systems. Balter (2000) describes the retrieval-time benefits from organizing in terms of "reducing the search space". Instead of scanning a long list of unstructured items, users can home in on a particular subset directly.

Limitations of the Folder Hierarchy

Hierarchies are the standard computational mechanism used to define personal classification schemes (Dourish et al., 1999). They are both easy to program and familiar to most users. However, a number of criticisms have been levelled at the hierarchy, e.g. (Nielsen, 1996; Gemmell et al., 2002; Nelson, 1999; Freeman and Gelernter, 1996; Dourish et al., 1999; Raskin, 2000) [11]. One fundamental limitation is that of *single-inheritance* (Nielsen, 1996; Dourish et al., 1999), i.e. an item may only be filed in one place. Most operating systems provide mechanisms to override single-inheritance in the form of links (UNIX), aliases (MacOS) or short-cuts (Windows) but they often confuse users (Dourish et al., 1999). Furthermore, hierarchies have also been criticized for their static nature, and for poor scalability to large information spaces.

The question of why the traditional folder hierarchy continues to dominate PIM-systems is an interesting one. Alternatives offering more flexibility have been available for over a decade, e.g. (Gifford et al., 1991). The key technological advantage of the tree is that it is simple and easy to implement. Although the above criticisms have had a profound influence in design, questions remain over whether they are confirmed by user data. For instance, Barreau and Nardi (1995) report that the participants in their study were satisfied with their folder organizations and had little need for multiple classification. This suggests that the hierarchy, despite its limitations, has the benefits of being an organizational paradigm which users are broadly satisfied and familiar with.

3.4.4 Discussion of Theoretical Contributions

This section confirms the observation of Whittaker et al. (2000b), that there is a lack of theoretical foundation for PIM, despite its status as a fundamental computer-based activity.

Whittaker et al. (2000b) highlight the need for standardized descriptive vocabulary as a first step towards developing more powerful predictive theories that can provide principled advice to designers, and dictate design characteristics. Conceptual frameworks such as those described in **Section 3.4.1**, have made some progress in this area, but there is clearly much more to be done.

[11] Similar arguments against hierarchical schemes have also been made in other domains such as architecture. Alexander (1965) argues that a hierarchical city layout is not a good match for the dynamic and interleaved nature of human activity.

Rogers (2004) outlines a number of properties of effective HCI theories, that highlight the kind of theory needed in this area. Firstly, the theory should *scale* to an appropriate granularity of task. However, much HCI theory is focused at a low-level on the cognitive, perceptual, and motor function systems (Newman and Lamming, 1995). In the context of PIM, cognitive theories of human memory and classification may not be applicable to modelling natural real-world classification decisions in a hectic work environment (Lansdale and Edmonds, 1992). Other theory is very high-level, such as the conceptual frameworks offered by Kirsh (2001). One route may be to combine theories which focus on different levels of analysis (Barnard et al., 2000). Secondly, theory must be *applicable*. The challenge for theorists is to develop models that can be useful in a design context. It is not clear how much of the existing body of theoretical work is of practical help to designers.

3.5 Discussion

This section draws together the three areas of research – empirical studies, design and theory – discussed in **Sections 3.2**, **3.3**, and **3.4**. The overall state of HCI knowledge concerned with the PIM application domain is summarized in **Section 3.5.1**. Limitations in the area of PIM-integration are identified, and used to motivate the thesis research agenda in **Section 3.5.2**. Finally, **Section 3.5.3** details the selection of methodology for the thesis.

3.5.1 Critical Analysis of Previous Research

In this chapter, two main engines of research progress have been identified: *empirical studies* and *technology design*. However, despite the body of previous work in each area, the author echoes the affirmation by (Whittaker et al., 2000b) that PIM has not received the attention it merits as a fundamental computer-based activity. In terms of empirical studies, **Section 3.2.3** highlighted a lack of attention to longitudinal aspects of PIM, and to the needs of non-technical users. Whittaker et al. (2000b) argue that this insufficient empirical grounding has contributed to the lack of consensus on descriptive vocabulary, task decompositions, evaluation metrics, or the key problems that need to be solved.

Section 3.3.5 surveyed previous technological prototyping in the research domain, with a particular focusing on that offering increased PIM-integration. Two key problems were highlighted. Much of this body of work can be criticised in terms of making a strong contribution to the HCI knowledge base due to: (1) a lack of grounding in empirical requirements, and (2) a lack of evaluation. This situation can be portrayed as a *break in the task/artefact cycle* (Carroll et al., 1991). Studies of user practices are not providing firm grounding for design, which is in turn not being systematically evaluated.

Several reasons can be suggested for this poor epistemic state. Firstly, PIM may be seen as "an area of old technology". Carroll (1997) discusses the strong research interest on collaborative technology, and the author speculates that PIM may seem a backward, unchallenging area to some researchers. Secondly, there is a lack of theory and methodology concerning complex high-level activities such as PIM. Dillon (2001) and Whittaker et al. (2000b) note the lack of appropriate evaluation metrics for evaluating PIM designs. For instance, traditional measures of usability may be inappropriate for evaluating interfaces that support discretionary activities

such as PIM. Thirdly, PIM is a multi-faceted, ongoing, and highly idiosyncratic activity, and may be seen as too challenging an area. Perhaps this explains the much larger amount of work carried out towards the lower-level area of information retrieval. In the meantime, progress in developing PIM technology in the commercial arena, is out-stripping the level of knowledge in the research community. This phenomenon is not specific to PIM and has been termed the *research/practice gap* (Carroll, 2000; Rogers, 2004).

3.5.2 Research Agenda

Turning the pages of recent HCI conferences reveals a wealth of current research directed at collaborative and social interfaces, and other "cutting edge" areas such as virtual reality and intelligent agents, but very little on important everyday activities such as PIM. This thesis seeks to help readdress this balance by taking a conscious turn back towards fundamental, everyday user problems. After surveying the field, the author developed a particular interest in the problems caused by a user's information being fragmented across a set of distinct PIM-tools. The PIM-integration genre has attempted to provide solutions to these problems by providing functionality which bridges multiple tools. However, as noted above, much of this work can be criticised for: (1) a lack of evaluation, and (2) insufficient empirical grounding.

This high-level aim of this research programme was to provide guidance for the designers of PIM-integration mechanisms. Three key research objectives were identified:

1. *To develop increased understanding of PIM behaviour and user needs* – In order to provide a firm empirical foundation for PIM-integration design work, the author planned to investigate user behaviour and needs beyond the boundaries of specific tools. 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* – The author embarked upon the research programme with a keen interest in developing a novel PIM-integration mechanism. A key interest was to improve upon the limitations of previous design-centred research, by emphasising empirical grounding and evaluation, and thus making a more systematic contribution to HCI knowledge.

3. *To devise methodological recommendations for future research and design work* – The final objective was to provide methodological guidance for future work in the area of PIM-

integration (and PIM more generally), based on the experience gained in pursuing this course of research. Whittaker et al. (2000b) note the lack of appropriate methodology such as evaluation metrics.

3.5.3 Selection of Methodology

Methodology has been defined as *"something that avoids you having to think too hard about how to do something"* (anon.). However, the selection of appropriate research methodology is a classic HCI dilemma. As an interdisciplinary research field, HCI offers many research approaches and methodologies (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: (1) to *understand the world* through the process of gathering design requirements, and (2) to *improve the world* by creating a new artefact. 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 artefact 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 generalizable to a wider design genre. The task-artefact 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 artefact, which is then in turn evaluated in the context of the original task. Evaluation also provides an opportunity for further empirical discovery (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 supporting the exploration of user behaviour, and theoretical development. Also, it was envisaged that by experiencing design issues at first hand, the author was more likely to produce findings in a form of relevance to practitioners.

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

1. *Requirements gathering* – The research is empirically grounded in an exploratory study, reported in **Chapter 4**. The study was aimed at both developing more understanding of PIM, and establishing 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 **Chapter 5**. 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* – **Chapter 6** reports the field-study based evaluation of the prototype. 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.

Chapter 4 now moves on to report the first stage of the design-centred methodology employed in this thesis, an exploratory study that compares how people manage three types of personal information: files, email and bookmarks.

Chapter 4

Exploratory Cross-tool Study

4.1 Introduction

This chapter reports an exploratory study of everyday Personal Information Management (PIM) practices. A key objective of this study was to develop a holistic understanding of participants' PIM behaviour by collecting data across three PIM-tools: files, email and bookmarks. The study's cross-tool scope differentiates it from most previous studies in the area which have focused on specific PIM-tools (see **Section 3.2**). **Figure 4.1** compares previous *tool-specific* studies, with the the *cross-tool* approach employed here.

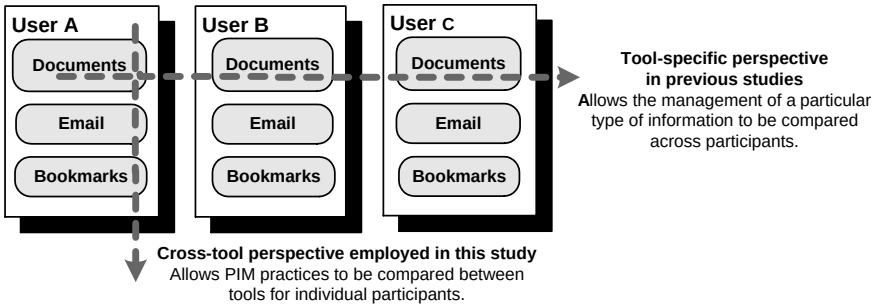

Figure 4.1: Comparing the cross-tool and tool-specific study perspectives.

The findings in this chapter, combined with the insights reported in **Chapter 3**, provide an empirical grounding for the design work in **Chapter 5**. The work presented in this chapter has been reported in a number of publications (Boardman, 2001a; Boardman et al., 2002, 2003; Boardman and Sasse, 2004).

4.1.1 Objectives

The study objectives were as follows:

1. *To compare how users manage different types of personal information* – **Section 3.3** identified a mismatch between the *tool-specific* empirical studies that have provided observations about PIM behaviour and problems, and the substantial *cross-tool* design effort directed at improving integration between PIM tools. Furthermore, it was argued that much of this design work has been based on designer intuition rather than empirical data. A case was made for more cross-tool empirical data to provide an effective empirical foundation for the design of integration mechanisms.

   The primary aim of this study was to take steps towards addressing this research gap. To achieve this, participants' PIM practices were profiled across three commonly managed collections of personal information: (1) document files, (2) email messages and (3) web bookmarks – managed within the file system, email tool and web browser respectively.

2. *To provide motivation and requirements for subsequent design* – An orienting commitment in this research was to design and evaluate a novel PIM-integration mechanism. It was hoped that the study findings would guide subsequent design work.

3. *To provide background on PIM* – **Chapter 3** highlights the lack of a systematic knowledge base of empirical data relating to PIM. In addition to building up a *cross-tool* understanding of PIM, the study was seen as an opportunity for the author to "get his hands dirty" and familiarise himself with a range of PIM-related issues, e.g. those relating to specific PIM-tools.

4. *To confirm a research focus* – Since PIM is a complex activity and offers a wide range of compelling research problems (see **Chapter 1**), the author perceived a strong need to focus his research efforts. The exploratory study was intended to help identify an interesting, worthwhile and achievable research problem.

4.1.2 Study scope

The primary aim of the study, to investigate a complex activity such as PIM from a holistic, *cross-tool* perspective, was clearly an ambitious one. In order to offset the potential analytical

complexity, the scope of the study was constrained in the following ways:

1. *Focus on PIM practice within the context of a single personal computer* – The domain of interest was limited to the computer where each participant performed the majority of their computer-based activity at their place of work. Thus the extra complexity of considering PIM on multiple computers and mobile devices was avoided.

2. *Focus on three PIM-tools* – Even within the context of one computer, users often employ a wide and varying range of PIM-tools (see **Figure 2.5**). Due to time constraints, it was decided to focus the study on three commonly-used PIM-tools: files, email and web bookmarks. A further focus was taken on the management of *personal document files* within the file system, as described in **Section 4.2.3**.

3. *Non-longitudinal study* – As noted in **Chapter 3**, PIM is an ongoing activity, and user behaviour may evolve over time (Balter, 1997). However, due to time constraints, and likemost previous studies, this investigation was based on a one-off "snapshot" of behaviour[12].

4. *Focus on personal rather than shared information* – As noted in **Chapter 2**, a user may store personal information within a group information space, such as a network drive shared with colleagues. To avoid taking into account the issues related to collaboration, this study focused on information that was not shared with other users.

4.1.3 Contributions

The following methodological and substantive contributions are offered in the chapter:

1. *A comparison of PIM behaviour between the three PIM-tools* – **Section 4.4** presents a high-level comparison between files, email and bookmarks in terms of four PIM sub-activities (acquisition, organization, maintenance and retrieval). This data emphasises how the nature of PIM varies between different PIM-tools.

2. *A comparison of organizing strategies between the three PIM tools* – A focus is taken on the organizing sub-activity in **Section 4.5**, where it is observed that many individuals employ

[12] In the exploratory study, it was still possible to collect data relating to longitudinal issues (e.g. changes in strategy) in the form of historical reports offered by participants. **Chapter 6** reports a follow-up longitudinal study carried out by the author that captured data over time.

a rich variety of organizing strategies *both within and across PIM tools*. Previous classifications of organizing behaviour are criticised for not reflecting this behaviour, and new classifications are offered for tool-specific and cross-tool contexts.

3. *The development and application of a novel technique for comparing the organizational dimensions on which folders are based in each PIM-tool* – Organizational dimensions are defined as the types of concept on which folder names are based (e.g. project or interest). The method employed is described in **Section 4.2.6**. The results in **Section 4.6** highlight the range of dimensions employed by users to name folders in the three PIM-tools. A number of previous PIM-integration systems are criticised for focusing on one type of organizational dimension.

4. *The development and application of a novel technique for assessing the similarity of a user's file, email and bookmark folder structures in terms of overlapping folders* – The method is documented in **Section 4.2.7**, and results are presented in **Section 4.7**. Significant folder overlap is observed for most study participants, particularly between their file and email collections. These results provide a key design motivation for the WorkspaceMirror tool presented in **Chapter 5**.

5. *Implications for the design of PIM-integration mechanisms* – **Section 4.9** highlights a range of cross-tool problems highlighting the potential of improving integration between PIM-tools. **Section 4.10** presents a number of design implications for improving tool integration, based on the findings in the chapter.

6. *Improved understanding of PIM behaviour in specific tools* – Although not the primary aim of the study, several incremental tool-specific contributions are provided. In particular, **Section 4.5** offers new classifications of organizing behaviour in files, email and bookmarks. **Section 4.6** characterizes the types of folders developed in each tool.

4.1.4 Structure of the Chapter

The rest of **Chapter 4** is structured as follows. **Section 4.2** reports the study method, including choice of participants, data collection, and data analysis. **Section 4.3** provides an overview of the study results which are presented over **Sections 4.4** to **4.9**. Finally, **Section 4.10** discusses the main findings from the chapter.

4.2 Method

This section describes the methodology employed in the study. **Section 4.2.1** justifies the employment of semi-structured interviews, and **Section 4.2.2** discusses the selection of participants. **Section 4.2.3** then outlines the interview structure and details the privacy-related precautions that were taken whilst working with personal data. **Section 4.2.4** details data collection and provides an overview of data analysis, including the content analysis of the interview data. This analysis focused on comparing the nature of PIM between the three tools in terms of the four sub-activities identified in **Chapter 2**.

The next three sections focus on the analysis of organizing behaviour. Firstly, **Section 4.2.5** discusses the comparison of organizing strategies between the three tools. **Section 4.2.6** describes the analysis of folder structures in terms of *organizational dimensions*, the types of concept on which folder names were based. Lastly, **Section 4.2.7** reports the investigation of folder overlap, the extent to which folders relating to the same activity appear in multiple PIM-tools.

Figure 4.2 provides a diagrammatic summary of data analysis.

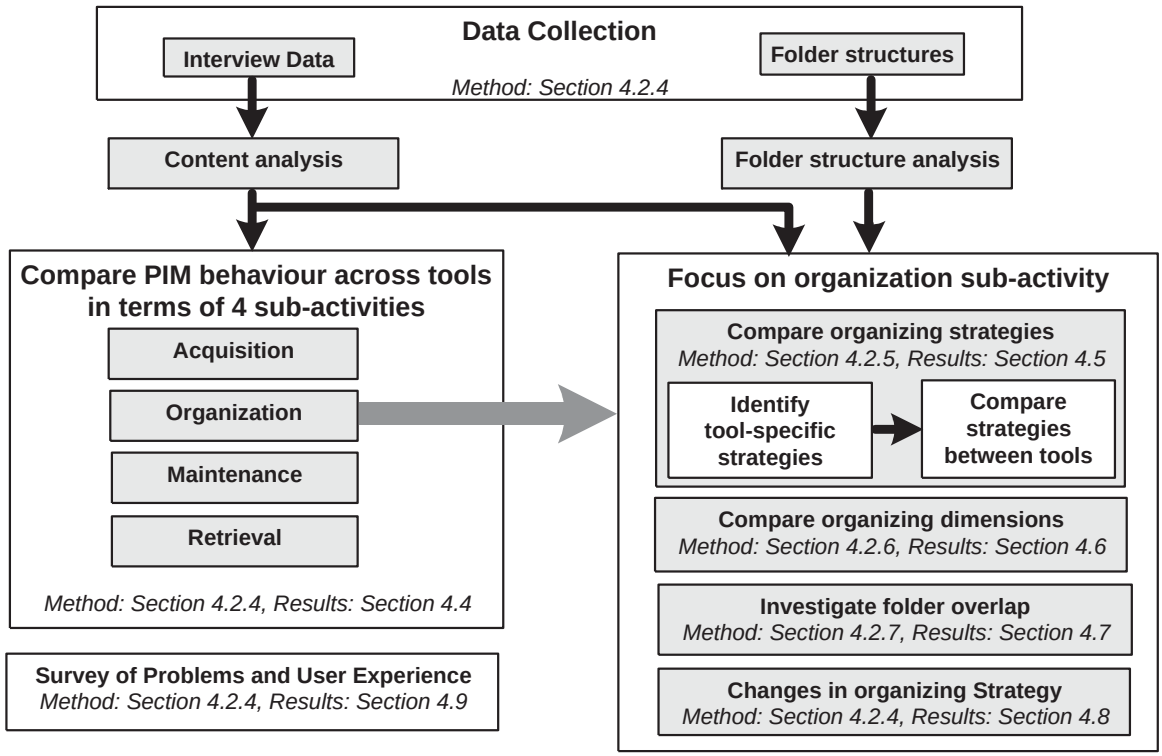

Figure 4.2: Stages of data analysis

4.2.1 Choice of Methodology

A semi-structured interview methodology was selected, in which a core framework of questions forms the basis for the interviews. In addition, when time permits, the researcher can pursue diversions to related topics as they arise, giving the flexibility to elicit feedback on unexpected, yet relevant issues. This choice is justified for the following reasons. A key aim of the study was to investigate real-world PIM behaviour in a natural setting. Semi-structured interviews are a standard HCI research methodology for investigating complex computer-based activities (Robson, 2001). Additionally, semi-structured interviews have been successfully employed in a number of previous studies of PIM, e.g. (Whittaker and Sidner, 1996).

4.2.2 Participants

Twenty-five participants took part in the study. An overview of their details is presented in **Table 4.1**. All participants had at least 5 years of general computing experience, and had used their current operating system for at least one year (19 used MS-Windows, 4 used MacOS, and 2 used Linux). Of the 25 participants, 7 were female, and 18 were male. The average age was 37 (ranging from 21 to 60). The majority (23) were recruited from the academic establishments where the author was pursuing his research programme. Roles included researchers (12), students (10), and support staff (1). The final 2 were non-academic: one was a manager for a telecommunications company, and one was unemployed. Participants did not receive any incentive to take part, financial or otherwise.

People known to the author were intentionally invited to participate due to concerns regarding the privacy issues associated with the researcher invading strangers' personal space. It was envisaged that such familiarity would establish a trust basis, leading to the ability to raise concerns that may arise at any time. Participants' comments (see **Section 4.3**) suggest this was a valid consideration.

It is acknowledged that the study participants are not a representative sample of the general population of users, and are thus not statistically significant. However, it is argued that the set of participants matches the purposes of the study well: to establish a comprehensive picture of users' PIM practices. The results should be interpreted as suggestive (i.e. directed at forming the basis for future research) rather than as providing conclusive findings.

Participant	Age	Sex	Job Role	Location	Operating System
P1	35-40	M	Academic	UK	Windows 2000
P2	20-25	M	Student	UK	Windows 2000
P3	25-30	M	Student	UK	Windows 2000
P4	20-25	F	Student	UK	Windows 2000
P5	25-30	M	Student	UK	Windows 98
P6	60+	M	Academic	UK	MacOS 8
P7	25-30	M	Student	UK	Windows NT4
P8	25-30	M	Student	UK	Windows NT4
P9	45-50	F	Academic	NZ	Macos8
P10	45-50	M	Academic	NZ	Windows NT4
P11	30-35	F	Academic	NZ	Windows NT4
P12	25-30	M	Academic	NZ	Linux
P13	50-55	M	Academic	NZ	MacOS 9
P14	35-40	M	Academic	NZ	Windows 2000
P15	35-40	M	Academic	NZ	Windows NT4
P16	40-45	M	Technical Support	NZ	MacOS X
P17	30-35	F	Student	NZ	Windows NT4
P18	25-30	M	Student	NZ	Linux
P19	35-40	M	Academic	NZ	Windows 2000
P20	30-35	M	Student	USA	Windows 2000
P21	30-35	F	Student	USA	Windows 98
P22	40-45	F	Academic	UK	Windows 98
P23	30-35	M	Academic	UK	Windows XP
P24	60+	M	Unemployed	UK	Windows 98
P25	40-45	F	Manager	UK	Windows 2000

Table 4.1: Participants in the Exploratory Study

4.2.3 Interview Process

This section provides an overview of the interview format. Complete experimental materials are included in **Appendix A**.

Each interview lasted about 90 minutes, and was carried out in the usual workplace of the interviewee where it was possible to view the participant's activity in context.

Due to the highly personal nature of PIM, a number of privacy-related precautions were employed. People frequently feel a sense of guilt towards a messy workspace, whether physical (Malone, 1983) or electronic (Bellotti and Smith, 2000). Therefore a primary concern in the study was to not cause the participants to feel uncomfortable. The participants were made aware of the nature of the study in advance so that they could take steps to hide anything that they did not want the researcher to see (e.g. confidential information, medical reports, love letters!). However, the participants were asked not to change their collections in any other way before the interview (e.g. tidying their inbox). This proved to be judicious, e.g. P25: *"So you*

know what I do now - I would have tidied it up if you'd let me".

Before each interview, the researcher stated that the user's personal approach to managing information was not being evaluated in any way, and all participants signed a release form acknowledging that the data would be anonymised before analysis and publication. Next, basic demographic information was collected (summarized in **Table 4.1**), and participants were asked about the main production activities which drove their computer usage. A screenshot of each participant's desktop was also captured.

Interviews were centred on guided tours of the files, email and bookmarks that they collected on their main work computer.

The three collections were defined as follows:

- The *document file collection* was defined as the principal area of the file system used by an individual to manage their personal document files. For the purposes of the study, document files were defined as those files containing content such as text, image and music files – as opposed to executable applications. Since files are often distributed across multiple locations in the file system, participants were asked to identify their primary collection of personal files. Operating systems typically provide a default area for this purpose, such as "My Documents" under MS-Windows, or the "home directory" under UNIX. Areas of the file collection that contained source code, simulation data, saved web pages, temporary files and internet downloads were omitted from the interview to save time. In these cases, only the root folder of each sub-structure was surveyed. So for example, if a file folder, `Downloads`, contained a set of sub-folders for downloaded programs, only the top folder was considered in the study.
- The *email collection* was defined as the collection of electronic messages stored in the participant's main email tool. If the participant employed multiple email tools (e.g. MS-Outlook on the desktop, and web-based email such as Hotmail), they were asked to nominate their primary collection.
- The *web bookmark collection* was defined as the set of "links" or "Favorites" stored by a participant in their main web browser.

The use of desktop icons to manage files, email, or bookmarks was also covered. Icons were considered to be an adjunct to the respective collection.

At the start of each guided tour, a snapshot was recorded of any folders developed by the participant. Participants were asked to go through the folders one by one, and talk about their usage. Notes were made of folders that were mentioned as being no longer in use (e.g. failed or duplicate folders). Participants were also asked about the function of any items that were not filed in folders (i.e. those items at the root-level of the collection, or those managed on the desktop).

Wherever possible during the study, additional procedural steps were taken to avoid privacy infringements. For instance the exposure of the content of specific items of information was avoided wherever possible. One simple yet effective technique was to maximize the folder-view window, thus obscuring the content of specific items.

During the guided tour participants were asked about their PIM practices within each collection. In order to cover the various aspects of PIM, the interview structure was based on the four point conceptual framework outlined in **Chapter 2**: *acquisition* of items, *organization* of those items, *maintenance* of the collection, and *retrieval* of items from the collection. Participants were also asked about any problems they encountered in each PIM-tool. Note that due to time limitations, interviews sometimes failed to cover all the above aspects.

If time allowed, other collections of personal information were surveyed including those managed in the primary digital workspace (e.g. contacts), on mobile devices (e.g. PDA devices), and in the physical workspace (e.g. piles of documents).

4.2.4 Data Collection and Analysis

In order to build up a rich picture of participants' PIM practices, both subjective and objective data were collected . User comments were captured as notes taken during the interview, and annotated with observations made by the researcher. A sample of the collected data is shown in **Appendix C** on page 280. Objective data was captured in the form of graphical snapshots of the desktop, and of any folder structures developed in each collection. The author also recorded the number of unfiled items in each collection (items located in the root folder or on the desktop).

Content Analysis of Interview Notes

Content analysis was performed on the interview data to extract key themes relating to PIM. The content analysis consisted of several passes through the interview notes. A first pass lead

to the development of a coding scheme listing key themes such as strategies, problems, design suggestions, and changes in strategy over time. Comments were also extracted relating to integration between PIM-tools. During subsequent passes, the coding scheme was used to mark up the data, and extended with any further issues that emerged. Finally, the themes were clustered using the four PIM sub-activities from **Chapter 2** (acquisition, organization, maintenance, and retrieval), and arranged in terms of frequency and importance.

The comparison of typical behaviour between the tools in terms of the four PIM sub-activities is reported in **Section 4.4**[13]. Changes in organizing strategy, and findings related to PIM problems are reported in **Sections 4.8** and **4.9** respectively.

Section 4.2.5 describes how the qualitative data also contributed towards the classification of participants' organizing strategies with respect to files, email and bookmarks.

Analysis of Folder Hierarchies

The folder hierarchies were transcribed, and marked up with participant's comments as to the function and usage of specific folders. Then, basic statistics were extracted from each hierarchy including number of folders, number of unfiled items, and hierarchy depth. These are reported under the organizing PIM sub-activity in **Section 4.4.2**. As noted above, any file folder substructures containing source code, simulation data, or downloaded programs were omitted.

The folder structures were then analysed using two novel techniques, developed by the author. **Section 4.2.6** reports the analysis of the *organizational dimensions* used to name folders (e.g. *project, contact, place*). **Section 4.2.7** reports the investigation of *folder overlap*.

[13] Note that the objective data (in the form of the folder hierarchies) was focused on one PIM sub-activity: organizing. The non-longitudinal nature of the study meant that information regarding the other PIM sub-activities (acquisition, maintenance and retrieval) was as reported by each user and subjective in nature.

4.2.5 Method: Comparing Organizing Strategies

The analysis of organizing strategies consisted of two stages:

1. Classifying each participants' strategies in each collection in turn.
2. Comparing each participants' strategies between their three collections.

Firstly, organizing strategies were characterised for each participant in the 3 PIM-tools. In each tool a classification scheme was devised by the author to categorize the participants based on their reported management strategies. Previous classifications of organizing strategies that have been proposed in email (Whittaker and Sidner, 1996) and for bookmarks (Abrams et al., 1998) were used as a starting point in those two contexts. Classifications were based on a combination of objective data (e.g. folder counts) and participants' comments. Qualitative data was employed as it was not always straightforward to distinguish current strategies based on objective data alone. For instance, a large folder count may suggest a user who files most information. However, in many cases folders were abandoned. Qualitative data was useful in indicating whther this was the case. The three tool-specific classification schemes (for files, email, and bookmarks) are reported in **Sections 4.5.1**, **4.5.2**, and **4.5.3**.

The comparison stage was carried out to investigate whether individual participants employed consistent organizing strategies across their collections. The driving interest was to investigate whether participants who were relatively organized in files were also relatively organized in the other tools, and vice versa. For each participant, a cross-tool profile was produced by collating the three tool-specific strategies from the previous stage. Since the cross-tool profiling employed the tool-specific classifications, the method is discussed in detail in **Section 4.5.4**, along with the results.

Previous empirical studies have focused on individual usage of specific tools such as email. In contrast, this analysis attempts to go beyond previous work by constructing a cross-tool profile of behaviour to investigate how organizing practices vary between the collections for individual users.

4.2.6 Method: Analysis of Organizational Dimensions

This section presents a technique developed by the author to analyse the *organizational dimensions* present in a folder structure – *the types of concept on which folder names are based (e.g. project, place, contact).*

Motivation and Aim

The development of the technique was motivated on two counts. Firstly, previous studies have noted the existence of particular types of folders. For instance, Ducheneaut and Bellotti (2001) observed that most email folders were based on *sender*, *organization*, *project*, or *interest*. They also observed that the relative proportions of folder types varied significantly between users. Similar *ad hoc* observations of common folder types have been used by designers as the design rationale for PIM-unification systems based on a dominant organizational dimension such as *role* (Shneiderman and Plaisant, 1994) or *project* (Kaptelinin, 2003). However, no systematic analysis of folder types has been performed to date.

Secondly, during the guided tours in this study, many participants referred to various organizational dimensions. For example, P22 summarized her file folders as follows: *"They are organized by projects, activities and roles such as 'PhD tutor'. Oh, and this is bad, I also have a 'Papers' folder where I keep all the papers that I've written, authored or co-authored. And they're broken down by co-author, cos I'm usually a co-writer"*. In this statement four organizational dimensions are cited: *projects*, *activities*, *roles* and *people*.

The objective of this analysis was two-fold.

1. To characterise the most common organizational dimensions within each PIM-tool.
2. To compare PIM-tools in terms of their most common organizational dimensions.

The existence of a dominant dimension across all tools for a particular user may indicate an optimum subordinate dimension for unification. In contrast, if a user employs a variety of dimensions across different collections, this would represent a possible barrier against unification, and suggest that basing organizational support on a single subordinate dimension such as *role* (Shneiderman and Plaisant, 1994) would overly constrain that user.

This approach can be contrasted with earlier investigations of classification behaviour in physical document (Kwasnik, 1991), digital file (Barreau, 1995), and web bookmark collections (Gottlieb and Dilevko, 2001). In this body of previous work, analysis was centred on participants' descriptions of their classificatory behaviour. Here, analysis focused on folder names and the descriptions of those folder names offered by participants during the guided tour. In addition, this study compares between three different PIM-tools.

Method

A coding scheme was developed representing the various organizational dimensions manifested in folder names. The scheme was initially seeded based on proposed PIM-unification technologies that have been based on a subordinate organizational dimension: *role* (defined as long-term user activity) (Shneiderman and Plaisant, 1994), *project* (defined as short-term user activity) (Kaptelinin, 2003), *time* (Freeman and Gelernter, 1996) and *contact* (Nardi et al., 2002). An iterative coding process was then applied to the folder structures. Each file, email and bookmark folder was coded with the most relevant organizational dimension. At the same time, the coding scheme was extended to include organizational dimensions that were not represented. Eventually a list of seventeen organizational dimensions was finalized that classified all the folders generated by the participants. The final coding scheme is shown in **Table 4.2**, along with some example folders of each type.

Each folder was mapped to one dimension only. Carroll (1982) observed complex conventions for naming files. Similarly complex folder-naming schemes were observed here, and in some cases folder labels were made up of several dimensions. For instance, `Personal-May` is made up of a combination of the *role* and *time* dimensions. In such cases, only the first dimension was coded against the folder.

Hierarchies often contained extensive sub-structures for source code, simulation data, backups and temporary files. Only the root folder of such sub-structures was included. So for example, consider a file folder sub-structure, `simproj/set3/monday/run2`, containing simulation data. In this case, only the top folder `simproj` was included as a *project* folder.

Folder labels that were ambiguous in some way were confirmed with the subject when possible. Where this was not possible, a subjective coding decision was made by the researcher. Assigning dimensions involved several challenges:

Organisational dimension	Code	Description	Examples
Project	P	Short-term production activity	"Experiment", "Agent code"
Role	R	Long-term production activity	"Teaching", "Personal"
Topic / Interest	I	Subject matter of item	"Banking", "Science Fiction"
Contact	C	individual or organisation	"Rick", "ACM"
Time	T		"February", "tomorrow"
General	G		"Stuff", "misc"
Format	F	Technological format of item	"Excel sheets", "Word document"
Class of document	d	Type/class of item	"Letters", "References"
Workflow	W		"Pending"
Event	E	Related to a particular occasion such as a meeting or conference	"CHI2000"
Mailing list	L		"linux-users"
Version control	V		"version1", "old"
Temporary	t		"temp", "tmp"
Application	A	Generated automatically by software	"From ICQ"
Backup	B		"backup", "archive"
Use	U		"important"
Geographic location	G		"peckham"

Table 4.2: Coding scheme of organizational dimensions

1. *Deciphering abbreviated folder names* – Some short-hand folder names were difficult to interpret, e.g. participant P24 had many minimal folder names such as `a2` and `fjk`.

2. *Non-English folder names* – Most participants used English to label folders. However, since participants were drawn from a wide range of nationalities, several other languages were occasionally used to name folders, including Swedish, German, and Portuguese. In such cases participants were asked for a translation.

3. *Ambiguous folder-to-code mapping* – In some cases, it was possible to map folder names to multiple codes. For example, the folder `jobs` may be interpreted in three ways: (1) as a *document class* (i.e. job adverts), (2) as a *topic*, or (3) as a surname (*contact*). In the absence of a description from the participant, an estimation was made by the researcher.

For each PIM-tool, the most common organizational dimensions were identified by collating the coded data across all users. The results of this analysis are reported in **Section 4.6**. This technique was also used in the subsequent investigation of folder overlap (see **Section 4.2.7**).

Several limitations to this analysis are acknowledged. Firstly, the analysis is based on explicit structural metadata only – other forms of organization was not encompassed (e.g. spatial grouping of icons on the desktop). Secondly, some areas of the folder structures were omitted (e.g. temporary data). Finally, in the cases outlined above, coding may have been non-optimal. Therefore the results should be taken as indicative only. However, it is argued that these limitations are acceptable considering the exploratory nature of the study.

4.2.7 Method: Analysis of Folder overlap

This section describes the second novel technique developed by the author to analyse personal folder structures. The technique is used for assessing the similarity of two collections of personal information in terms of *folder overlap*: the extent to which folders referring to the same activity appear in multiple collections.

Motivation and Aim

The technique was motivated as follows. Firstly, previous studies have observed overlapping folders. For example, Kaptelinin (2003) notes that a user may manage and organize multiple types of information when working on a particular project. He notes that a user working on a software project may author source code documents, receive emails and browse useful websites whilst carrying out the work – and file them within identical folders in each tool. However, no systematic investigation of folder overlap across a set of users has been carried out.

Additionally, during the guided tours in this study, several participants commented on folders that had appeared in other collections. For a few participants, some folders overlapped between all three collections. For example, P14 had `Teaching`, `Research` and `Personal` folders in his file, email *and* web bookmark hierarchies. More commonly, there was a partial overlap which varied between the different pairs of collections, e.g. P13: *"The email folders are fairly close to the file system, but with some differences. For example this folder contains correspondence-based information which does not make sense in the file system"*.

The aim here was to go beyond previous work, and investigate the extent of folder overlap for each participant. The author was interested in how folder overlap might be used as a measure of the compatibility of different personal classification schemes to be unified.

Method

For each pair of PIM-tools in which folder structures had been developed, the number of overlapping folders was calculated (see **Figure 4.3**). For a user with folders in the file, email and bookmark collections, overlaps were calculated for all three hierarchy pairs: *file/email*, *file/web* and *email/web* .

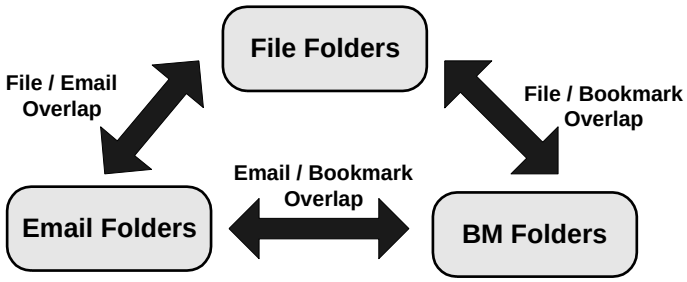

Figure 4.3: Three folder overlaps: file/email, file/bookmark, and email/bookmark

A folder was considered to overlap if one of the following three conditions held:

1. *Identically-named folders in both collections* – This was the simplest case, e.g. a folder in both the file and email collections called `Beagle`.

2. *Folder names that differed slightly* – In many cases, folder names differ slightly between collections due to spelling mistakes, or variations in *specific phraseology* (Gottlieb and Dilevko, 2001). For example, participant P24 had a `compiler-course` file folder, and a `compilers` email folder. Her comments in the guided tours confirmed that both folders related to the same course that she was teaching.

3. *The use of different folder names to refer to the same activity* – Occasionally participant's commentaries highlighted cases whereby different folder names related to the same activity. One example, which applied to three participants, again related to the teaching of a course. In one tool the respective folder was named after the *course name*, but after the *course codes* in another (e.g. `compilers` and `w345`). User descriptions were taken into account to confirm whether such folders related to the same activity.

Note that folder overlap was calculated based on a flat list of folders. Differences in terms of depth and location were not taken into account. For example, one participant had a root-level

`Student-projects` folder in email, and a `Teaching/student-projects` second-level folder in the file collection, which were classed as overlapping.

Folder overlap between a pair of collections was presented as a count of overlapping folders, along with the relative percentage of the folders in each collection. Overlapping folders were then coded in terms of *organizational dimensions* (see **Section 4.2.6**). This was carried out to investigate whether overlapping folders tended to be based on a particular organisational dimension. The results from the analysis of folder overlap are presented in **Section 4.7**.

The analysis of folder overlap was time-consuming due to the need to cater for all the above possibilities, particularly when participants had created large numbers of folders. In a number of cases, participants did not complete the guided tour of all their folders, and the author was required to make some subjective estimations of overlap. Where possible, these were confirmed with the participant. However, it is acknowledged that certain false-positives and false-negatives may have crept in. Despite this limitation, the analysis is offered as a technique to estimate the extent of folder overlap, and thus assess the extent to which user activities involve the organization of multiple types of personal information.

4.3 Initial Observations and Results Overview

All 25 participants actively collected both files and email. 24 of the 25 also collected bookmarks to some extent, but this collection was consistently considered to be much less important. The PIM-tools used varied between participants. For managing files, most participants used the graphical file manager provided by their operating system. **Table 4.1** shows the operating systems employed by participants to manage their files. Both linux users and two of the Windows 2000 users also made extensive use of command-line shells. Many participants also used the desktop to store work in progress or temporary files. **Table 4.3** summarizes the email tools and web browsers that were encountered.

Email Tool	Number of users
eudora	9
outlook	5
netscape	4
outlook express	3
xfmail	1
pine	1
mh	1
pegasus	1

Web browser	Number of users
netscape	11
internet explorer	14

Table 4.3: Email tools and web browsers used by participants

Participants were highly motivated to talk about PIM - it was an area that was important to them, and a source of problems and frustration. One participant (P24) succinctly summed up the ongoing challenge of PIM, and the need to organize: *"stuff goes into the computer and doesn't come out - it just builds up"*. Hearing about these problems at first-hand reinforced the author's belief that this was a compelling real-world problem space that merited more research.

Despite the researcher's concerns about privacy, all participants were very open, although one joked: *"this is a high-trust exercise!"*. In fact several participants seemed to enjoy "opening up", e.g. P25: *"Its like a confessional getting all my computer problems off my chest"*. Only two excluded areas of their workspace for reasons of personal and/or professional confidentiality. P8 permitted access to his work-related document files only. Access to his email and web bookmarks was unaffected. P13 restricted access to portions of his document file and email collections because they contained confidential information relating to personnel management. It is acknowledged that due to these two cases, some of the quantitative results presented in this

chapter may be slightly conservative (e.g. average numbers of folders per collection). Aside from these exceptions, the guided tours were unrestricted. It is envisioned that the high level of openness was due to participants' prior familiarity and trust in the researchers.

The study findings are presented over the next six sections, as follows:

- Firstly, **Section 4.4** presents a high-level comparison of user behaviour between the three PIM-tools in terms of four PIM sub-activities: acquisition, organization, maintenance and retrieval.

  The next four sections focus on the organizing sub-activity.

- **Section 4.5** reports the classification of organizing strategies in each tool context. It then moves on to present the findings from the cross-tool profiling, in which strategies were compared between tools for each participant.

- **Section 4.6** reports the analysis of the organizational dimension make-up of the three PIM-tools.

- **Section 4.7** reports findings from the analysis of folder overlap for those participants who organized multiple types of information.

- **Section 4.8** surveys participants' reports of historical and planned changes in their organizing strategy.

- **Section 4.9** surveys reported problems relating to PIM. Both tool-specific and cross-tool problems are discussed.

Figure 4.2 on page 65 provides an overview of the different sets of findings and the respective methodology. A sample of the qualitative data collected for each participant is shown in **Appendix C** on page 280.

4.4 Results: Comparing PIM Behaviour

The next four sections compare typical PIM behaviour between files, email and bookmarks in terms of the 4 PIM sub-activities outlined in **Chapter 2**: acquisition, organization, maintenance, and retrieval. Finally, **Section 4.4.5** summarises the key observations.

4.4.1 Acquisition and Collection Characteristics

Barreau defined acquisition as *"the methods and rules by which information becomes part of the PIM system"* (Barreau, 1995). **Table 4.4** compares the main characteristics of acquisition behaviour between the PIM tools.

	Document File	**Email**	**Web Bookmark**
Item acquisition	Manual creation. User decides what to add.	Automatic creation on download. User decides what to keep.	Manual creation. User decides what to add.
Creation rate of items	Low. Most common participant estimate: 1-5 per day.	High (up to many 100s per day)	Low. Most common participant estimate: 1-5 per week.
Naming of items	Each file must have a unique name.	Default "name" is defined by subject as specified by sender. Hard to change.	Default name is title of the page to which bookmark refers.
Standard implicit metadata	Date created, date modified, size, author.	Date received, from, to, message thread, size.	Date created, date modified, size, author.
Problems reported	Naming of files.	Ascertaining value of new email. Changing message subject.	Default name often unsatisfactory and hard to change.

Table 4.4: Comparison of acquisition behaviour between files, email and bookmarks

Two very different modes of acquisition were observed. In the document file and web bookmark collections, acquisition is *explicit*: the user decides what items to add. In email, acquisition is *implicit*. The onus is on the user to assess the value of items and decide what to delete, P11: *"everything just gets stuffed into the inbox – basically the whole world has write access"*. Several participants had developed elaborate schemes for managing newly arrived messages, e.g. P21: *"I try to keep it [the inbox] as small as possible, so it acts as a to-do list. I have another folder called 'Diverse' which is stuff to deal with that's been tidied from inbox"*. A number of participants also used filters to organize mailing list messages and delete spam.

Table 4.5 compares the underlying characteristics of the items stored in each collection, and the nature of each collection as a whole. Emails are clearly differentiated in terms of *authorship* – the majority of email messages are authored by users other than the owner of the email col-

lection. For this reason there is a need for users to ascertain the value of email messages after they have been acquired. In contrast, files and web bookmarks are created by the owner of the collection. A second key difference is in terms of item *form*. Email messages and most files contain some form of information, much of which has been authored or edited by the managing user. In contrast, web bookmarks are *references* to content stored remotely on websites [14].

The three collections also differed in terms of their *value* to their owner. File collections were highly prized, and many participants expressed the pride they felt towards the contents, much of which they had kept over a number of years, P9: *"Some of them I'll need again, some of the things I'm quite proud of ... why should I throw it away? It doesn't cost me anything"*. Email collections were valued less than files, but most participants noted the sentimental or professional value of a subset of their messages, *P24: "I keep them to make sure I've got one thing from them to reply to. Also it's nice that the person has written"*. Bookmarks were of low importance for most participants, supporting findings in (Jones et al., 2001). However, all but one collected them to some extent. Bookmarks were valued less due to: (1) the existence of other ways of re-accessing websites, e.g. search engines, and (2) websites' ephemeral nature, P1: *"It's often not worth the overhead of adding links, I only use the pages once or twice. And then there's the overhead of managing the organization"*. Bookmark collections were very small (tens of items), compared to file and email (thousands of items).

4.4.2 Organization

Table 4.6 shows an overview comparison of organizing behaviour across the 3 PIM-tools. This analysis is based on the qualitative data and initial analysis of the folder structures.

By far the dominant organizational mechanism employed was the folder hierarchy which acts as the focus of this section. However, desktop icons were also used by many users to manage document files or web bookmarks on a temporary "work in progress" basis. Although organizing behaviour varied between participants, common approaches stood out for each type of information.

As shown in **Table 4.6**, most participants organized files most extensively, with deeper folder

[14] Document file collections also facilitate the creation of references that point to other files. These are known as *short-cuts* under MS Windows or *links* under UNIX. However in this study only one participant mentioned the regular use of links within their file collection (in their case a link to a network drive from their UNIX home directory). File links were observed more frequently for managing applications on the desktop.

Characteristics	Document File	Email	Web Bookmark
Management interface	Graphical file manager, icons on desktop, command-line.	Email application.	Web browser application.
Size of collection	Large (many hundreds).	Very large (thousands).	Small (tens).
Authorship of item content	Many files authored by owner. Some authored by other users (e.g. downloads).	Majority of emails authored by other users. Some may be self-addressed or copies of sent messages.	Bookmarks do not contain content.
Form of items	Most contain content (e.g. text). May contain embedded bookmarks or files. Also, possible to create links (short-cuts).	Contain content. May contain "attached" files or bookmarks.	References to remote web pages on the internet.
Homogeneity of items	Many different technological formats for files (e.g. text, image).	Common technological format	Common technological format
Age of collection	Many years. Many files are kept over the long-term (e.g. over job changes)	A few years. Relatively more ephemeral then files (e.g. collection restarted after job-change).	Most bookmarks tend to be ephemeral. Collection often abandoned and restarted.
Importance/value of collection	Very important. Many files are highly valued.	Subset of messages highly-valued (typically recent messages in inbox).	Only small subset valued.
Context of collection	Personal document file collection co-exists with system files in file system.	Stand-alone collection, although stored on file system.	Stand-alone collection, although stored on file system.

Table 4.5: Comparing the characteristics of files, email and web bookmarks

	Document File	Email	Web Bookmark
Participants with active folders	*25*	*23*	*16*
Average number of folders	*49 (SD: 30, min: 5, max: 122)*	*37 (SD: 41, min: 0, max: 181)*	*12 (SD: 15, min: 0, max: 55)*
Average maximum depth of folders	*3.0 (SD: 1.6, min: 1, max: 7)*	*1.7 (SD: 1.2, min: 0, max: 4)*	*1.1 (SD: 0.9, min: 0, max: 3)*
Average number of unfiled items	*65 (SD: 104, min: 0, max: 340)*	*777 (SD: 1235, min: 7, max: 5577)*	*43 (SD: 47, min: 0, max: 200)*
Most common organizing behaviour	"One touch" file-on-creation. Occasional spring-cleaning..	Some incremental filing but many left in inbox. Use of filters to file mailing lists. Occasional spring-cleaning..	Mostly left in default chronological order. Occasional spring-cleaning. Folder structures often abandoned.
Extent of filing	High: most files organized in folders.	Variable. Large number of unfiled items in "inbox".	Majority in chronologically ordered list.
Location of "active" items	Most active files located in folders. Some participants had unfiled "work-in-progress" area.	Inbox. Occasional project folders.	Most likely to be recently added unfiled items.
Other organizing mechanisms (non-folder based)	Spatial placement on desktop. Use of different drives and partitions.	Occasional separation of roles between different email accounts.	Occasional spatial placement on desktop. Use of “links bar”.
Key problems	Anxiety of order. Keeping collection tidy (unfiled items, pruning folders).	Anxiety of order (focused on size of inbox).	Anxiety of order. Time to organize outweighs value of doing so (items rarely used again). Poor interface.

Table 4.6: Comparing organizing behaviour between files, email and bookmarks

hierarchies, and fewer unfiled items compared to the other collections[15]. On average, participants had 49 file folders, as opposed to 37 in email, and 12 in bookmarks.

Furthermore, a greater proportion of file folders were estimated to be in active use. Although no detailed measures were taken, this appeared true for most participants, based on their comments. An active folder was defined as one in which an item had been filed into, or retrieved from over the past week. In particular, many participants mentioned that their web bookmark folders were old and/or redundant. An interesting further experiment would be to harvest detailed folder currency information.

During the guided tours of email, participants talked about organization in terms of keeping their inbox tidy. This *inbox-focused* organizing tended to be as much about deleting items as filing them away. The participants indicated that their inboxes often got "out of control" so incremental organizing was backed-up with occasional spring-cleans, e.g. P13: *"I try and file systematically but right now my inbox is pretty big because I had no time over Christmas"*.

Spring-cleaning was most commonly referred to in the context of email and was typically focused at filing and/or deleting items in the inbox once it had reached a certain size. Spring-cleaning appeared to be less common in the document file context where items were typically organized incrementally. For those participants for whom tidiness was important, spring-cleaning was typically initiated when a collection reached a certain level of messiness. Others were more pragmatic and spring-cleaned when they failed to find an item, e.g. P18: *"If I lose something, then I make the hierarchy richer"*.

Bookmark collections were of little value to many participants, P2: *"I have lots of unfiled bookmarks as they're hard to file. I could go through and delete them but not high-priority."*. Four participants reported completely restarting bookmark collections rather than devote time to organizing them. However, interestingly, they would then proceed to start the collection again using similar folders as before.

Organizing strategies influenced how active items were distributed in each collection. Active document files tended to be scattered around a set of active folders. Some participants also stored active document files on the desktop on a temporary basis however in many cases these were never cleared away. Active email messages tended to be heavily concentrated in the inbox. Thus messages related to different roles and projects were interleaved in the same list, along

[15] An item was considered to be *unfiled* if it was located on the desktop or in the root folder.

with newly arrived messages yet to be processed. Active bookmarks tended to be those added to the root level most recently.

Two high-level attitudes could be identified towards organizing:

- *Pro-organizing attitude* – Several participants perceived distinct benefits in being tidy, P11: *"These are ongoing projects which I like to keep tidy as they could be of future importance. Having an organized computer has clear benefits for future research by making it easy to find and read stuff when you need it again"*.
- *Organizing-neutral attitude* – Other participants were less driven to organize, e.g. P6: *"I'd characterise myself as being (1) busy and (2) lazy. I need to carefully prioritize my time with a bias towards (1) fun, and (2) must-do/sense of duty. Since PIM isn't either of these I don't do it"*. Several participants indicated that organizing was a complete waste of time, P19: *"I've just happened to start filing as an experiment. But I worry that its just like filing trash – like having a tidy waste paper basket"*.

Participants tended to be more pro-organizing in files, and more organizing-neutral in email and bookmarks.

Several other sets of findings later in this chapter focus on organizing behaviour. **Section 4.5** presents a systematic investigation of the consistency of participants's organizing behaviour across the three PIM-tools. New tool-specific and cross-tool classifications of participants' organizing strategies are offered. Then, **Section 4.6** compares the folder structures in terms of their *organizational dimensions*, and **Section 4.7** reports the amount of folder overlap between different tools.

4.4.3 Maintenance

Although most participants acknowledged the worth of maintenance, they did not devote much time towards it in any of the three three collections. **Table 4.7** compares observed maintenance practices between the collections.

Old items were rarely archived out of the collections. It was more common for archiving to be *in situ*. For example several participants occasionally purged old emails from the inbox to a local "old-inbox" folder. Thus collections tended to include a mix of ephemeral, work-

	Document File	Email	Web Bookmark
Deletion	Occasional.	Incremental deletion of messages from inbox. Also occasional spring-cleaning.	Rare. More likely to abandon entire collection
Archiving	Much of collection is effectively archived in situ. Users archive additional files into collection.	For some participants: occasional in-situ archiving of inbox or sent messages.	Not encountered.
Backing-up	Manual backing-up for important files. Use of automatic mechanisms rare.	Rare. Some participants left a copy of all messages on server.	Not encountered.
Synchronization	Occasionally performed manually between computers.	Some participants downloaded in parallel on multiple machines.	Not encountered.

Table 4.7: Comparing maintenance behaviour between files, email and bookmarks

ing and archived information. One reason for this was the perceived difficulty in retrieving archived items. Most participants reported that extensive archiving only occurred during major life change stages such as starting a new job, or changing computer. Due to the availability of cheap storage, space appeared to be less of an issue than in previous studies (Barreau, 1995). Only 4 participants reported archiving portions of the file or email collections when they ran out of space, e.g. P21: *"There's a lot of stuff that shouldn't have been there ... I need to tidy up, I'm always out of memory"*.

Backing-up and synchronization were rarely observed. Occasionally, highly important work was backed up manually. In several cases this was in response to a previous loss of data. Many participants expressed a desire for automatic mechanisms.

In general, these findings confirmed previous observations that maintenance is performed regularly but is instead carried out in reaction to events such as data loss, lack of space, and life changes (Barreau, 1995).

4.4.4 Retrieval

Table 4.8 summarizes the observations regarding retrieval behaviour. Unlike acquisition and organization where greatly differing behaviour was observed across PIM-tools, some consistency was seen in retrieval practices. Participants reported a strong preference for *browsing* over *search* in all three tools. This cross-tool consistency supports and extends tool-specific findings in files (Barreau and Nardi, 1995)[16]. However, there was variation between the col-

[16] Fertig et al. (1996) suggested that a factor contributing to the rare usage of search may be poor implementation. Participants' comments confirm this, suggesting that there has been little improvement in search implementation.

lections in terms of the type of browsing employed. Two types of browsing were encountered: (1) *location-based browsing* of folders/desktop icons (Barreau and Nardi, 1995), and (2) the *sorting/scanning* of items, ordered by user-defined metadata (e.g. `name`) or system-defined metadata (e.g. `size`). When retrieving files, participants employed a combination of both – browsing to a folder, and then sorting items within it, e.g. P2: *" If I'm looking for something, I'll firstly browse about. I only search as a last resort"*. Additionally, many participants employed application-history when working in tools such as MS-Word – thus avoiding the need to browse or search.

	Document File	**Email**	**Web Bookmark**
Most common behaviour	Browse (supported by sort). Search as last resort.	Sorting of items in inbox. Search as last resort.	Browse or frequent use of an alternate mechanism (e.g. search engine).
Likelihood of retrieval	High. Biased towards "work in progress". Occasional for older items.	High for recently added items in inbox. Low for older items.	Low. Bias towards recently added items.
Use of sorting	Sorting: alphabetical, creation-date, format.	Sorting: date received, author.	No sorting mechanisms provided. Left in default chronological ordering.
Alternate retrieval mechanism	Use of application history (e.g. MS-Office).	Use of on-line mailing list archives. Asking sender to resend as last resort.	Frequently use of: web search engine, browser history, URL 'auto-completion.
Key retrieval problems	Failure to find highly frustrating but rare. Slow integrated search	Failure to find an item highly frustrating but rare. Slow integrated search	Poor browsing interface. Lack of search.

Table 4.8: Comparing retrieval behaviour between files, email and bookmarks

For email, retrieval was focused on sorting/scanning the inbox - location-based browsing of folders was less common. Search was used more in email than in files, but was still seen as a last resort by most participants in both collections: P25: *"I usually know exactly where I'm going and what I'm looking for. If I search I wouldn't necessarily know the exact keyword. If you know where you're going, browsing is a lot quicker"*.

Bookmark retrieval was focused on scanning recently added, or frequently accessed items. However, several participants stated that they preferred to search the web again rather than find a bookmark: P18: *"If something is really exciting then I bookmark it ... when I come back to it, I just use Google"*. Nevertheless, participants continued to save bookmarks, even though many were never used. Similar behaviour was observed in email, in particular collecting/filing messages from mailing lists, which were never read: P16: *"Of the emails you do save, 90% you never read again"*. Similar "irrational" behaviour, pointing to an innate need to acquire, has been observed in paper archives, e.g. keeping personal copies of items that are publicly avail-

able (Whittaker and Hirschberg, 2001).

In all three collections, retrieval was biased towards active and/or recently added items. However, many participants mentioned tasks that required access to older information, archived in situ, e.g. P22: *"You look at what exam questions you had for the previous years and you decide to recycle a question or two"*. This finding is not consistent with previous claims that archived information is not useful to people(Barreau and Nardi, 1995). This suggests that although older items were only accessed erratically, they can be highly valued by people, supporting findings in (Whittaker and Hirschberg, 2001).

Interestingly, in all three collections failure to find items appeared to happen only occasionally: P18: *"If it exists then I'll find it. The only cases I don't is when I deleted it because I thought I didn't need it again"*. Participants expressed confidence that in general they "just knew" where to find items. However, those rare occasions when they could not find items were highly frustrating. Three main reasons were cited for failure: (1) deleting/archiving items, (2) clutter, and (3) misfiling. Several participants reported looking for items for up to ten minutes before resorting to an alternative method (e.g. asking a correspondent to resend an email).

4.4.5 Discussion

The previous four sections have contrasted acquisition, organizing, maintenance and retrieval behaviour across files, email and bookmarks. **Table 4.9** provides a summary of the most commonly observed strategies.

	Document File	**Email**	**Web Bookmark**
Acquisition	Manual. User decides what to add.	Automatic. User must decide what to keep.	Manual. User decides what to add.
Organization	File-on-creation. Some working or temporary files managed on the desktop. Occasional spring-cleaning.	Focused on inbox. Incremental filing and spring-cleaning.	Occasional filing. Many items left in default chronological list.
Maintenance	Occasional.	Incremental deleting of old items in inbox.	Rare. Many users abandon collection and start over.
Retrieval	Preference for browse/sort over search.	Inbox-focused. Preference for sorting over search.	Focused on recently added items. Use of alternate mechanisms.

Table 4.9: Summary Comparison of PIM Strategies in the three collections

Although in many ways, the interface functionality provided in each PIM-tool is similar, the results point to many differences between typical user behaviour across the three PIM-tools. A

number of similarities were also highlighted, such as the preference for browsing over search in multiple tool contexts, and the satisficing nature of maintenance.

The findings reported in this section provided the author with an empirical foundation for the rest of the thesis work. **Chapter 7** argues that Barreau's conceptualization of the computer as a "monolithic" PIM system (Barreau, 1995) should be extended to reflect the similarities and differences between behaviour in the different PIM-tools. Subsequently, a new perspective is proposed which conceptualizes the computer as a set of distinct PIM sub-systems.

4.5 Results: Comparing Organizing Strategies

The previous section provided a high-level comparison of PIM behaviour between files, email and bookmarks. This section presents a more detailed comparison of organizing strategies. **Section 4.2.5** describes the approach that was employed. **Sections 4.5.1**, **4.5.2** and **4.5.3** classify participants' behaviour in each PIM-tool in turn. Then **Section 4.5.4** reports the cross-tool profiling in which strategies were compared across tools.

4.5.1 File Organizing Strategies

Since no classifications of file management strategies had been proposed in previous work, the author developed one from scratch based on participants' strategy descriptions. Three strategies were identified and are reported in **Table 4.10**.

Strategy	# Users	Average # Folders	Average # unfiled items
F1 total filers: file majority of items on creation.	16	50 (SD: 29, min: 12, max: 122)	14 (SD: 9, min: 0, max: 30)
F2 extensive filers: file extensively, but leave many items unfiled.	7	58 (SD:29, min: 5, max: 108)	132 (SD: 137, min: 31, max: 340)
F3 occasional filers: file occasionally, leave most items unfiled, have few folders.	2	5 (SD: 0, min: 5, max: 5)	240 (SD: 127, min: 150, max: 330)

Table 4.10: Classification of observed file management strategies [n=25]

23 of the 25 participants were *pro-organizing*, and had extensive folder structures. They could be divided into two groups (F1 and F2) based on the extent to which they employed a *file-on-creation* strategy (filing new items immediately). F1 participants employed a predominantly file-on-creation strategy, and tended only to leave items unfiled by accident, except for a few temporarily placed work-in-progress files. F2 participants filed the majority of items on creation, but also managed a large unfiled subset of working/ephemeral items. F2 participants filed these items on completion of the relevant task, or during a spring-clean. Thus the location of ephemeral/working files varied between the two groups. F1 participants distributed them around active folders, whilst F2 participants left many unfiled. However, even for the F2 participants, unfiled items were a small proportion of their total collection.

The remaining two participants (group F3) were *organizing-neutral*. They filed less extensively, and stated that filing was not a priority. In contrast most F1/F2 participants said that being

organized was an important (though not always achievable) goal.

In addition. most participants occasionally performed spring-cleaning of their file collections. Note that most of the participants could not be described as filers or non-filers. Instead, they employed *multiple-strategies* – filing some items on creation, leaving some unfiled, and carrying out occasional spring-cleaned. Multiple strategies were similarly observed in the other collections.

4.5.2 Email Organizing Strategies

The author attempted to categorize participants' behaviour using previous classifications of email organizing behaviour (Whittaker and Sidner, 1996; Balter, 1997). However, this was only a partial success. The sample included 2 *no-filers* (folderless spring-cleaners), and 7 *frequent filers* - but no *spring-cleaners* (participants who only clean their inbox periodically). The remaining 16 participants had large inboxes (>75 items, average 1137), like the no-filers and spring-cleaners in (Whittaker and Sidner, 1996), however their reported strategies did not match these classifications. They filed some new emails immediately (typically those of perceived long-term value such as e-commerce receipts), and deleted low-value spam. Other messages were left in the inbox, which was occasionally spring-cleaned. In other words, as in files, they employed *multiple strategies* - a combination of frequent filer, spring cleaner, and no-filer, e.g. P25: *"I'd like to manage as and when I receive them but I don't. I do it periodically - 10 minutes a day just to categorize the things that are important. 10 or 15 I'll categorize ... the rest of them I think oh I'll get round to doing that at some stage - but I don't normally. However I did spend an hour on a train last week tidying my emails because I was bored. I reduced my inbox by about 1500"*.

A new classification was developed based on participants' strategy descriptions (see **Table 4.11**). The 16 *multiple-strategy* participants could be divided into two sub-groups, E2 and E3, based on the extent to which they reported manually filing new messages on a daily basis. E2 participants filed many emails everyday, whilst E3 participants only filed a few (<5) messages of particular long-term value, P31: *"I have a folder for registrations. I've got other [unused] folders - I don't even know what they are. The vast majority [of email] is a big long list"*. E1/E2 participants were pro-organizing, whilst E3/E4 participants considered it to be less important.

Strategy	# Users	Average # Folders	Average # unfiled items
E1 frequent filers: file or delete most incoming messages everyday.	7	56 (SD: 62, min: 3, max: 181)	26 (SD: 15, min: 7, max: 50)
E2 extensive filers: try to file many messages everyday.	12	42 (SD: 24, min: 8, max: 91)	1002 (SD: 1497, min: 87, max: 5577)
E3 partial filers: file only a few (<5) messages everyday.	4	4 (SD: 3, min: 0, max: 6)	1251 (SD: 1254, min: 205, max: 3000)
E4 no-filers: do not file any messages.	2	0 (SD: 0, min: 0, max: 0)	1106 (SD: 1265, min: 211, max: 2000)

Table 4.11: Classification of observed email management strategies [n=25]

4.5.3 Bookmark Organizing Strategies

The author attempted to map participants' behaviour onto an existing classification (Abrams et al., 1998). However, as with email, the previous classification did not reflect the observed behaviour, and another new classification was developed (see **Table 4.12**). Only 8 participants matched a previous classification, that of "no filer".

Strategy	# Users	Average # Folders	Average # unfiled items
B1 extensive filing: file many bookmarks as they are created or at the end of browsing session	6	31 (SD: 16, min: 13, max: 55)	24 (SD: 19, min: 10, max: 40)
B2 partial filing: file bookmarks sporadically	10	10 (SD: 7, min: 3, max: 24)	35 (SD: 32, min: 7, max: 120)
B3 no-filers: never file, all folders abandoned.	8	1 (SD: 2, min: 0, max: 5)	71 (SD: 67, min: 4, max: 200)
B4: non-collector	1	-	-

Table 4.12: Classification of observed bookmark management strategies [n=25]

The remaining 16 active collectors of bookmarks instead employed *multiple strategies*. They filed a subset of bookmarks on creation, leaving others unfiled, often as reminders, until they were spring-cleaned or simply abandoned, *P12: "The main thing is a mess and completely littered with things. The only exception is when I mirrored web pages for experiments. Also I keep a folder with homepages"*. The multiple-strategy participants were divided into two groups, B1 and B2, based on the extent to which they reported filing new bookmarks on creation. Organization was of lower priority for the B2 participants who had fewer folders and more unfiled bookmarks.

Participant	File strategy	Email strategy	Bookmark strategy	Cross-tool profile
P1	F1	E2	B2	CT2
P2	F1	E2	B1	CT1
P3	F2	E2	B3	CT2
P4	F1	E3	B3	CT3
P5	F2	E2	B2	CT2
P6	F3	E3	B3	CT4
P7	F3	E4	B3	CT4
P8	F1	E3	B2	CT3
P9	F2	E2	B3	CT2
P10	F1	E4	B3	CT3
P11	F1	E1	B1	CT1
P12	F1	E1	B3	CT2
P13	F1	E2	B2	CT2
P14	F1	E1	B1	CT1
P15	F2	E2	B1	CT1
P16	F1	E2	B2	CT2
P17	F1	E1	B1	CT1
P18	F1	E2	B1	CT1
P19	F1	E2	B2	CT2
P20	F1	E2	B2	CT2
P21	F1	E1	B2	CT2
P22	F1	E1	B3	CT2
P23	F2	E1	B2	CT2
P24	F2	E3	B2	CT3
P25	F2	E2	B3	CT2

Table 4.13: Table of participants' tool-specific strategies, and cross-tool profile

4.5.4 Cross-tool Profiling

This section presents the results from the cross-tool profiling analysis. The aim of this analysis was to investigate the consistency of each participant's approach to organizing files, email and bookmarks.

The middle three columns of **Table 4.13** list the three *tool-specific* strategies for each participant. A cross-tool profile was then identified for each participant by collating the three strategies as a *3-tuple*, e.g. `F1/E2/B2` for Participant P1. Across the twenty-five participants, fourteen unique tuples were identified. The *cross-tool profiles* were then clustered based on the following criterion:

> *In which of the three collections were the participants pro-organizing? (i.e. in which collections did they report making significant organizing effort?)*

The first step of clustering the cross-tool profiles was to classify each set of tool-specific strate-

Level of organizing effort	Files	Email	Bookmarks
"Pro-organizing", strategies that involve high organizing effort	F1	E1	
"	F2	E2	B1
"Organizing-neutral", strategies that involve low organizing effort	F3	E3	B2
"		E4	B3

Table 4.14: Cross-tool profiling schema

Cross-tool profile	# Users	% Users
CT1: pro-organizing in all 3 tools (e.g. F1/E1/B1)	6	24%
CT2: pro-organizing in files & email only	13	52%
CT3: pro-organizing in files only (e.g. F2/E3/B3)	4	16%
CT4: organizing-neutral in all tools	2	8%

Table 4.15: Four user groups identified from the clustering of the cross-tool profiles [n=25]

gies as either *pro-organizing* (involving high organizing effort) or *organizing-neutral* (involving low organizing effort). This process was necessarily subjective since the nature of PIM in each tool varies, along with the objective criteria used to define the tool-specific strategy classifications. Several classifications were attempted, from which the one shown in **Table 4.14** emerged as the best match for the data.

Based on this classification of the tool-specific strategies, four clusters of cross-tool profiles were identified, CT1-CT4 (see **Table 4.15**).

Six participants were *pro-organizing* in all three tools (profile CT1), meaning that they reported making significant organizing effort consistently across all three collections. The most common CT1 profile was F1/E1/B1 (three participants). Thirteen participants were *pro-organizing* in files and email only (profile CT2), with F1/E2/B2 being the most common CT2 profile (five participants). Many of the CT1 and CT2 users had a significant level of folder overlap where similar folder labels were used in different collections (see **Section 4.7**).

Four were *pro-organizing* in files only (profile CT3). Two described the file system as being the most important part of their workspace, compared to email and web bookmarks which were not seen as worth organizing. Several cited lack of time, and the perceived effort involved in developing folder structures, as the reason for not structuring the other collections. Some went to elaborate lengths to avoid having to organize multiple types of information. For instance, P4

organized email messages in her file collection as Word documents, and organized them within file folders rather than developing another set of email folders.

Two participants were *organizing-neutral* in all tools (profile CT4). They made use of no folders beyond those provided by default in the email tool (e.g. `Inbox`). Both had created folders in the past (P6: 4 file folders, 4 email folders; and P7: 4 file folders) but these were no longer in use. Their files, emails and web bookmarks were all managed as unstructured lists. Both users relied on sorting mechanisms based on implicit metadata and the occasional use of search. In addition one of the users made extensive use of spatial arrangements of icons on the desktop to manage documents, which had become very cluttered. Both users mentioned that they occasionally misplaced items but this inconvenience outweighed the perceived overhead of organizing items into folders, e.g. P6: *"I've got better things to do than organise my stuff."*

It is acknowledged that this comparison of organizing strategies is at a high-level, based on overall organizing tendency. However it makes an important point: that most participants (17 participants, cross-tool profiles CT2 and CT3) reported employing different levels of organizing in different tools. Note that there was a strong tendency for participants to organize files more extensively than emails or bookmarks.

4.5.5 Discussion

The results presented over the previous four sections illustrate the multiple strategies employed by users when they organize information. **Sections 4.5.1**, **4.5.2** and **4.5.3** highlighted that many users employ multiple strategies in different *tool-specific* contexts. Furthermore, the cross-tool analysis in **Section 4.5.4** indicates that PIM strategies also vary significantly *between* tools for many individuals. In other words, multiple strategies can be identified at both tool-specific and cross-tool levels of analysis for many participants. **Section 4.10.2** develops a model of organizing strategies to describe these observations.

4.6 Results: Analysis of Organizational Dimensions

This section reports findings from the analysis of the file, email and bookmark folder structures in terms of organizational dimensions. **Section 4.5** presented classifications of organizing strategies for files, email and bookmarks in terms of extent/style of filing. However, lower-level variation was also observed between tools in terms of the *types of folders created*, and *how folders were arranged*. For example, P17 organized *both* the email and files related to one of her main projects extensively. However, although she organized both types of information extensively, she organized them in different ways. Whilst she kept all the email in one top-level folder, she had a hierarchy of project folders for different types of files (e.g. those relating to different versions of a report). As a first step towards exploring low-level variation in filing behaviour between the tools, participants' folder structures were analysed to investigate the *organizational dimensions* used to manage information (the concepts employed to name folders). The method used is detailed in **Section 4.2.6**, and the coding scheme that was used to label folders is shown in **Figure 4.2**.

Most participants employed a wide range of organizational dimensions in each collection. Therefore, due to space limitations, results are presented in aggregate form as follows.

4.6.1 Files

The identified organizational dimensions for *file* folders are listed in **Table 4.16**. The three most common dimensions for document file folders were *Project* (e.g. `Term-paper`), *Role* (e.g. `Teaching`) and *Document Class* (e.g. `reports`), representing folder percentages of 29%, 17% and 14% respectively. The wide range of organizational dimensions indicate that participants employed many types of folders when managing information.

4.6.2 Email

The most common organizational dimensions for *email* folders are listed in **Table 4.17**. The most commonly observed dimensions were *Role* (e.g. `Personal`), *Contact* (e.g. `Alexis`), *Project* (e.g. `term-paper`), *Topic/Interest* (e.g. `Java`), and *Mailing List* (e.g. `linux-users`), representing percentages of 25, 19, 17, 12 and 11% respectively. This indicates that the participants rely on

Rank	Dimension	Count (aggregated across all participants)	%
1	Project	317	29%
2	Class of document	185	17%
3	Role	148	14%
4	Contact	84	8%
5	Topic / Interest	72	7%
6	Format	58	5%
7	Event	47	4%
8	Temporary	45	4%
9	Version control	38	4%
10	Geographic location	26	2%
11	General	22	2%
12	Time	18	2%
13	Backup	17	2%
14	Others (<1%)	8	1%
	Total	1085	100%

Table 4.16: Organizational dimensions in files (aggregated across participants [n=25])

Rank	Dimension	Count (aggregated across all participants)	%
1	Role	192	25%
2	Contact	150	19%
3	Project	133	17%
4	Topic / Interest	90	12%
5	Mailing list	89	11%
6	Class of document	51	7%
7	General	27	4%
8	Event	22	3%
9	Temporary	13	2%
10	Others (<1%)	16	2%
	Total	783	100%

Table 4.17: Organizational dimensions in email (aggregated across participants, [n=25])

a wide range of organizational dimensions when naming email folders. This in turn suggests that users would be constrained by an organizational mechanism that constrained them to organizing email along one dominant dimension such as role.

Interestingly, the *contact* dimension appears relatively low in the list. This may be explained by the fact that users could rely on implicit `Sender` metadata, rather than having to organize messages explicitly based on contact.

4.6.3 Bookmarks

The most common organizational dimensions for *bookmark* folders are listed in **Table 4.18**. In contrast to the document file and email collections, web bookmark collections were dominated

Rank	Dimension	Count (aggregated [n=25])	%
1	Topic / Interest	135	55%
2	Class of document	32	13%
3	Project	18	7%
4	Role	17	7%
5	Contact	15	6%
6	General	14	6%
7	Event	5	2%
8	Others (<1%)	6	2%
9	Format	3	1%
	Total	245	100%

Table 4.18: Organizational dimensions in bookmarks (aggregated across participants, [n=25])

by one dimension, that of *Topic*. Example topic-based folders that were encountered included `Star Trek`, `Cooking` and `Java`. The *Topic* dimension accounted for 55% of folders. This ties in with the findings of Gottlieb and Dilevko (2001) who noted that a majority of classificatory decisions in bookmarks were dependant on topic-related factors.

Note the special meaning of *Document class* in the web bookmark context. The document in question related to that of the referenced website, rather than the bookmark itself. In other words, *document class* was equivalent to that of website function, e.g. "search engines".

4.6.4 Discussion

The data indicates that participants employed a wide variety of organizational dimensions both within a particular collection, and across different collections. Note that being aggregated results, the results tend to reflect the organizational dimensions manifested by those participants who tended to create more folders in a particular tool. However, it is argued that they are adequate to illustrate broad trends across the tools.

The most common types of file folder were *project* (short-term activities, e.g. `ucl presentation`) 34%, *document class* (e.g. `letters`) 17%, and *role* (long-term activities, e.g. `teaching`) 9%. The most common types for email folders were *role* 22%, project 20%, *contact* (e.g. `bill`) 18%, *topic/interest* (e.g. `linux`) 11%, and *mailing list* 11%. For bookmarks, the most common types were *topic/interest* 61%, *document class* 10%, *project* 6%, and *contact* 6%.

The file and email folder structures had broadly similar dimensional make-ups. Both are dominated by *project* and *role*, which account for 49% of file folders, and 42% of email folders re-

Rank	Dimension	Count (aggregated [n=25])	%
1	**Project**	468	22%
2	Role	357	17%
3	Topic / interest	297	14%
4	Document class	268	13%
5	Contact	249	12%
6	Mailing list	90	4%
7	Event	74	4%
8	Format	64	3%
8	General	63	3%
9	Temporary	58	3%
10	Version	43	2%
11	Other (<1%)	32	2%
12	Geographic location	29	1%
13	Backup	21	1%
	Total	**2113**	**100.0%**

Table 4.19: Total dimensions (aggregated across all three tools, and all participants, [n=25])

spectively. This similarity in terms of organisational dimensions suggests that the file and email classification schemes are potentially more suited to unification. In contrast only 15% of web bookmarks are made up of *role* and *project*. The similar nature of files and emails, relative to web bookmarks may be a contributory factor here - they both represent actual documents, in contrast to web bookmarks that are references or pointers. In addition files and emails are both owned by the individual concerned, whilst bookmarks refer to remotely managed websites outside their control. Certain dimensions only appeared in certain tool contexts: for instance *Mailing List* was email-specific.

Table 4.19 show the organisational dimensions aggregated across all three collections, and across all participants. Three dimensions dominate: *project*, *role* and *topic* at 22, 17 and 14% respectively. The roughly even split between these three types suggests that users may be constrained by unification based on a particular organizational dimension, such as *roles* (Shneiderman and Plaisant, 1994), *activities* (Kaptelinin, 2003) and *contacts* (Nardi et al., 2002). These approaches can be criticised for focusing on one organisational dimension, whilst the results in this section suggest that users employ a range of dimensions.

4.7 Results: Analysis of Folder Overlap

This section describes the investigation of the extent of *folder overlap* between collections to explore whether participants tended to create similar folders in different tool contexts. The motivation and method used in this analysis is discussed in **Section 4.2.7**.

The amount of overlap varied significantly between participants, and between collection pairs:

- Of all the participants, the highest overlap was observed for P13 who had 21 overlapping folders between his file and email collections, which had 60 and 85 folders respectively. This was equivalent to 35% of his file folders and 25% of his email folders (he was one of the few participants with more file folders than email folders). His file/email overlap mainly related to *roles* (e.g. `General dept`, `Admin`, `Admin resp`, `Grading working-group`, `Course-planning`), and *projects* (e.g. `Digital-library`, `LIDS`, and `Niupapa`). However, since he had only 6 bookmark folders, the other overlaps were relatively smaller. The *file/bookmark* overlap was 1 folder (`Digital-library`), and the *email/bookmark* overlap was 2 folders (`Digital-library` and `Conferences`).
- In contrast, Participant P19 had much smaller overlaps between each pair of collections. Three folders overlapped between files and email (`Personal`, `Research`, `VB`), 2 between files and bookmarks (`Personal`, `414`), and 1 between email and bookmarks (`Personal`).

Rather than go through participants individually, aggregate results are presented as follows to provide an overview of the data (see **Table 4.20**)[17]. Significant overlap was observed for many participants, particularly between files and email. For the twenty-two participants who had both file and email folders, the average *file/email* overlap was 7.4 folders (SD: 4.6, min: 0, max: 21). The other overlaps were consistently smaller. For the eighteen participants with file and bookmark folders, the average *file/bookmark* overlap was 2.6 folders (SD: 1.94, min: 0, max: 8). Eighteen participants had created email and bookmark folders. The average *email/bookmark* overlap was 2.0 folders (SD: 1.5, min: 0, max: 5). In other words, folder overlap was not distributed evenly between the hierarchy pairs[18].

Interestingly, as in the case of P19 above, the *file/bookmark* and *email/bookmark* overlaps tended to be a subset of the larger *file/email* overlap. For the majority of subjects, the two smaller over-

[17] Note that Participant P5 who saved email messages as Word documents within the file structure was not included.
[18] Overlaps were lower than previously estimated in (Boardman, 2001b). This is due to the earlier results being skewed upwards by the smaller number of subjects at that stage in the study.

laps were almost identical. In other words, the subset they represented was common to all three tools.

Tables 4.21, **4.22**, and **4.23** show the organisational dimensions for the overlapping folders in each collection pair. Interestingly, all three overlaps were predominantly based on the users' *roles* and *projects* (file/email: 75%, file/bookmark: 79%, email/bookmark: 79%). This suggests that the dimensions of *role* and *project* are more likely to carry meaningful context across an entire workspace than other types of label.

4.7.1 Discussion

The observation of a significant partial folder overlap for most participants points to a subset of user activities that involve the management of multiple types of information. Folder overlap indicates that the study participants were devoting effort towards organizing resources relating to the same production activity in multiple tools. In other words, there are *redundant* aspects to user's information management activity when viewed from a cross-tool perspective. Most overlapping folders corresponded to *roles* and *projects*, suggesting that these concepts may be usefully shared between collections, as in (Kaptelinin, 2003).

However, it should be emphasized that folder overlap was only partial: all collections contained many unique folders. This suggests that: (1) some production tasks are supported by single PIM tools and may not necessarily benefit from increased integration; and (2) users may have different organizational needs in different tools. Several factors may contribute towards the disparity in overlap between different pairs of tools.

- Firstly, the number of folders differed greatly between the tools. Typically bookmark col-

	File/email	**File/web**	**Email/web**
# participants with folders in corresponding tools	22	18	18
Average overlap (# of folders)	7.4 (SD: 4.6, min: 0, max: 21)	2.6 (SD: 1.94, min: 0, max: 8)	2.0 (SD: 1.5, min: 0, max: 5)
Average overlap as % of file folders	16.3% (SD:12.2%, min: 0%, max: 46.4%)	6.6% (SD:5.4%, min:0%, max: 22.2%)	n/a
Average overlap as % of email folders	21.6% (SD:11.8%, min:0%, max: 40%)	n/a	9.6% (SD:10%, min:0%, max: 33%)
Average overlap as % of bookmark folders	n/a	24.7% (SD:17.2%, min:0%, max: 66.7%)	17.3% (SD:12.4%, min:0%, max: 40%)

Table 4.20: Folder overlaps between the three pairs of PIM-tools

Rank	Dimension in file/email folder overlap	Count	%
1	Project	60	36%
2	Role	59	36%
3	Contact	14	8%
4	Topic / interest	13	8%
5	Document class	5	3%
6	Format	5	3%
7	Event	4	2%
8	General	3	2%
9	Other (<3 folders)	3	2%
	Total	**166**	**100%**

Table 4.21: Organisational dimensions in file/email folder overlap [n=22]

Rank	Dimension in file/bookmark folder overlap	Count	%
1	Project	17	41%
2	Role	11	27%
3	Topic / interest	9	22%
4	Contact	2	5%
5	Other (<2 folders)	2	5%
	Total	**41**	**100%**

Table 4.22: Organisational dimensions in file/bookmark folder overlap [n=18]

lections contained fewer folders, resulting in smaller overlaps. In general bookmark organisation was not seen as being of as high a priority as file and email organisation, with subjects often preferring to use search engines in preference to recording bookmarks.

- The previous section outlined the organisational make-up of each hierarchy and it was noted that the file and email hierarchies were relatively similar, both being dominated by *projects* and *roles*. This may account for their higher overlap. In contrast, the majority of bookmark labels were based on *interests* that had little relevance outside the information-seeking context of the web.

- Document and email folders also tended to be managed more consistently in an ongoing manner – thus the folders might be expected to match to a greater extent.

Rank	Dimension in email/bookmark folder overlap	Count	%
1=	Project	11	35%
1=	Role	11	35%
2	Topic/interest	5	16%
3	Document class	2	6%
4	Other (<2 folders)	2	6%
	Total	**31**	**100%**

Table 4.23: Organisational dimensions in email/bookmark folder overlap [n=18]

- The information stored in each hierarchy may also be a factor. The file system was used to manage the user's own documents, or those authored by colleagues or friends. Likewise the email folders were often used to store threads of communication in which the user had actively participated (the storing of mailing lists is an exception). Both the document and email folders convey ownership over the static resources archived within. On the other hand, bookmark folders are used to store references to remotely authored websites.

Most participants were not aware of the often significantly high level of overlap between their hierarchies. Some participants seemed surprised when their high level of folder overlap was pointed out, suggesting that they had not reflected on how they organized different types of information. A few were more aware and actually performed ad-hoc synchronisation of organisational structure. One participant (P11) had spent a large amount of time synchronising her email and web hierarchies. However the amount of effort involved meant the structures had not been kept in full synchronization.

Folder overlap was greatest between the file and email collections. This highlights the potential compatibility for integration of files and *filed* email. Also both types of information are either self-created or assessed as having long-term value. However complete unification between files and *all* email (as pointed to by designs such as (Bellotti et al., 2003)) may lead to the disruption of more controlled items (e.g. files, tasks) by unprocessed email. In some cases it may be appropriate not to integrate, but to instead retain tool separation. Further design implications are presented in **Section 4.10.3**.

The observation of folder overlap contributes to the design rationale for the development of the WorkspaceMirror prototype in **Chapter 5**.

4.8 Results: Changes in Organizing Strategy

The study had an immediate "self-auditing" influence on the behaviour of most participants. Many participants rediscovered items they had lost, and twelve performed ad-hoc tidying during the interviews, e.g. filing or deleting files they had forgotten about.

Fourteen participants reported historical strategy changes from before the study. Five reported historical changes in file strategy, all of which involved increases in organization, e.g. P5: *"Now I've got a set of folders and create a new one if I've got too many unfiled. Historically I use to be less organized and everything was unfiled. I still have to search for this using type or date metadata"*.

In email, seven participants reported historical changes in organizing strategy – three increases and four decreases in filing tendency. Several participants also reported major incidents, such as a hard disk failure which lead to the loss of an email collection. One example decrease in organizing tendency was as follows, e.g. P12: *"I used to have lots of folders for each sub-project [of a main research area] but there just wasn't enough time to manage them. In an ideal world there'd be a rich structure ... and the hierarchy is now flattened and simplified"*.

In the case of bookmarks, six historical changes were reported: one increase, and five decreases in organization (e.g. abandoning all folders).

4.8.1 Discussion

Note that both increases and decreases in organizing tendency were observed. This stands in contrast to previous work which has emphasized decreases in organizing tendency, e.g. the abandoning of folder structures (Balter, 1997).

Additionally, many indicated that taking part in the study had caused them to think about PIM more than normal, causing them to plan future changes. However, the snapshot nature of the nature meant that it was not possible to track these changes over time. **Chapter 6** presents a longitudinal study of PIM behaviour, a key objective of which was to track strategy changes.

4.9 Results: Problems and User Experience

The study provided much evidence of dissatisfaction regarding current PIM interfaces. The author was often surprised at the vehemence expressed regarding PIM-related problems, and applied the term "bugbear" for recurring problems that frequently affected users. Since PIM is an ongoing and often repetitive everyday activity, it appeared that even relatively minor short-term grumbles (e.g. inconvenient interface support for naming files) can build up and have a negative impact on ongoing user experience (e.g. perceived level of control).

A wide range of problems and concerns were raised by participants relating to all PIM sub-activities in all three PIM-tools. Furthermore, issues varied significantly between participants. This section highlights some of the issues that are relevant to subsequent work in this thesis. Three types of problem were identified:

1. Tool-specific issues that were limited to single tool contexts.
2. Tool-specific issues that occurred repeatedly in multiple distinct tool contexts.
3. Cross-tool issues that bridged multiple tool contexts.

4.9.1 Tool-specific Issues

Numerous PIM-problems were reported within each tool collection. File-related problems included difficulties managing multiple versions of files, and slow search mechanisms. A key email-related problem was that of ascertaining the value of large numbers of newly-arrived messages. Common issues in the bookmark context included lack of sorting and search functionality, and the ephemeral nature of websites.

Since the thesis takes a focus on problems that bridge multiple tools, tool-specific problems are not discussed in more detail.

4.9.2 Tool-specific Issues that Occurred in Multiple Tools

Other problems were of a tool-specific nature, and were manifested in multiple contexts for many participants. Examples included difficulties in naming items, and "anxiety of order".

One common problem that appeared in multiple tool contexts related to the naming of items. Participants complained of the difficulty of selecting appropriate, meaningful names in their file collections. One particular bugbear resulted from the attempts of software to offer default names based on a file's initial content (e.g. a report title). In email, many participants complained of the difficulty in changing message subjects. Those created by other users were often considered inadequate. Likewise, in bookmarks participants complained of the poor interface provision for changing the names of newly-created bookmarks. This was often necessary as by default bookmark names are set to the title of a web page to which they refer. Several participants observed that web page names were often general to entire web-sites.

Another problem that appeared in multiple tool contexts was that of "anxiety of order" (Levy, 2001). This describes the tendency for many users to "feel bad" for "being untidy". In other words, a perceived failure to manage personal information may seriously dent user's self-image.

Anxiety of order was widespread in the study reported in this chapter. Many participants felt it necessary to excuse themselves for perceived mess, e.g. Participant P21: *"I'm sorry, those files must have gone there accidently"*. Anxiety was most extreme in the context of email, where participants emphasized the overheads of managing email, due to the higher (and uncontrolled) creation rate of messages compared to manually created files and bookmarks. However, participants also tended to be dissatisfied with the organizational state of document files and bookmarks, especially in terms of old or unfiled items, and failed folders. Dissatisfaction was expressed in terms of guilt, shame, stress, and lack of control, P11: *"I'm really ashamed ... Its such a mess! I have stuff in there that needed organizing ages ago"*.

A particular source of exasperation was the existence of old unfiled items, such as emails in the inbox, and icons on the desktop. Most participants wanted to devote more time to managing their personal information but could not do so due to lack of time or were unwilling to do so because of perceived overheads.

The level of anxiety was influenced by user disposition towards tidiness, with organizing-neutral participants being less affected. Interestingly, some of the most pro-organizing participants, those who invested a lot of time in filing, remained dissatisfied with the tidiness of their collections.

Anxiety of order was possibly exacerbated by other "classic" classification problems which were reported in all tool contexts by many participants. These included difficulties classifying items,

lack of multiple classification support, failed folders, duplicate folders, and the static nature of the folder hierarchy. The increasing amount of storage in modern computing devices may be a contributory factor in user dissatisfaction: since (1) they are able to collect more stuff, and (2) there is less pressure to delete information in an ongoing manner.

Only a few participants complained of the impact on their productivity due to time spent organizing, and time spent retrieving items. However this is subjective and hard to confirm objectively. Impact of messiness is not clear on retrieval since participants indicated that they could generally find required items.

4.9.3 Issues that Bridged Multiple Tools

A number of problems were observed that bridged multiple tool contexts:

1. Design inconsistencies between different PIM-tools.
2. The inability to share folder structures between PIM-tools.
3. The fragmentation across PIM-tools of information in a particular technological format.
4. The fragmentation of information related to a particular activity across PIM-tools.

Annoyance was caused by inconsistencies between different PIM-tools in terms of how they provided equivalent functionality. One example was the interface used to manipulate the folder structure by changing folder names, or reorganizing the folder structure. Participants found this particularly irritating between tools from the same vendor. In other cases, a function was available in one tool, but not in others. One example was the ability to highlight an item as "important". Email clients such as MS-Outlook provide the ability to "flag" an item, whereas file and web bookmark management software typically does not.

Several participants complained of the need to manage different collections of information separately, noting that it was not possible to share organizational structure between tools. One went to the lengths of saving email messages as files to avoid having to manage two distinct collections. When viewed from a cross-tool perspective it is clear that the management overheads that have been reported in specific tools are compounded when multiple PIM tools are considered.

Participants also complained that information in some technological formats was fragmented across multiple distinct collections. For instance, many participants managed files using several parallel mechanisms: (1) within the file system, (2) spatially as desktop icons, and (3) as email attachments. Each mechanism requires separate organization. This distribution of the management of a particular type of information between distinct PIM-tools has been referred to as *compartmentalization* (Bellotti and Smith, 2000). **Table 4.24** summarizes the observations of the compartmentalization of document files, email, and web bookmarks – both within a single computer, and across the extended personal information environment[19]. Several participants reported that the compartmentalization of files lead to problems of retrieval, especially in the case that they were looking for a particular file and had to search both the file and email collections.

	Document File	**Email**	**Web Bookmark**
On primary computer	Document files can also be managed as desktop icons or as email attachments.	Email typically managed only within email tool.	Web bookmarks often managed as desktop icons or as embedded links within emails.
Outside primary desktop computer	Network drives. Personal document files stored on other computers or devices.	Email stored on other computers or devices. Web-email collections (such as Yahoo! or Hotmail)	Web bookmarks stored on other computers or devices.

Table 4.24: Compartmentalization of different types of information

Another aspect of fragmentation concerned information relating to a particular user activity such as a project. A number of participants highlighted difficulties in coordinating multiple PIM-tools in carrying out a particular project. One difficulty was encountered in *project management*-related tasks such as starting a new production activity (setting up folders in distinct tools), and finishing a production activity (archiving items in distinct tools). One participant talked of the difficulties involved in archiving two types of information, P1: *"After the project finished it was all 99% useless stuff [files and email]. I just wanted to get it out of the way"*. In such cases, it was necessary to perform these actions repeatedly in multiple tools. This type of fragmentation also impacted retrieval, when a user is not sure if the information related to an activity is stored in an email or a file.

Some participants wanted a facility to gather different types of information within a single interface. One example was *brainstorming* which involved collating information from multiple

[19]Compartmentalization was also observed for other types of personal information such as contacts and to-do items. For example, contacts were frequently scattered between email, personal diaries, notebooks, and mobile phones.

PIM-tools into her email, P9: *"I like to pull things together here, URLs, notes ... and jumble them up in broad categories. My categories tend to be fairly wide and get quite big. It's great for brainstorming and ideas. However the cost is that sometimes you can't find things"*.

Most participants employed a range of PIM-tools in performing task and time management, e.g. setting reminders in multiple tool contexts such as icons on the desktop, emails in the inbox, and links to websites to visit. Most also made extensive use of physical artefacts such as diaries. Two participants complained that there was no easy way to collate such reminders together.

Participants varied in the extent to which they reported using existing integration mechanisms. The most commonly mentioned was attaching files to an message from within an email tool. Several also mentioned using the "Send-to" mechanism in MS-Windows for attaching files to an email message.

4.9.4 Discussion

The previous two sections illustrate a number of user problems that involve multiple PIM-tools. Firstly, **Section 4.9.2** highlights *tool-specific* problems which appeared in multiple tools. Secondly, **4.9.3** highlights a number of *cross-tool* issues. Such problems suggest that there is a need for improved integration between PIM-tools. **Chapter 5** discusses prospective cross-tool design solutions to some of the problems discussed in this section.

4.10 Discussion and Conclusion

This section discusses the chapter's main findings, and relates them to the work presented in subsequent chapters. Firstly, **Section 4.10.1** highlights methodological issues which should be taken into consideration when interpreting the study results. **Section 4.10.2** moves on to discuss the observation of multiple organizing strategies, within and across PIM-tools for many participants. A model is presented to illustrate this new conceptualization of organizing strategies. **Section 4.10.3** considers implications for the design of PIM-integration technology based on the study findings. Finally, **Section 4.10.4** considers whether the study achieved the objectives in **Section 4.1**.

4.10.1 Methodological Limitations

The wide range of PIM-related behaviour observed emphasizes the highly individual nature of PIM. Note that this was the case despite the relatively narrow subject group of technically-experienced, mostly academic participants. It is envisaged that an even wider variety of strategies would be expected in the wider population of computer users. Due to the limited sample size it should be emphasised that the results presented here are intended to be indicative rather than statistically significant across the general user population.

It is acknowledged that the study did not control for a number of factors which may influence PIM. Subjects differed both in terms of the operating system used, as well as the specific applications used to manage document files, email and web bookmarks. Previous studies have noted the variety of tools encountered in studies of email and task management (Bellotti and Smith, 2000), and similarly a wide range of PIM tools was observed here. However, it is argued that most tools were equivalent in terms of functionality offered (hierarchical folder structure, search mechanism etc.). Furthermore, choice of PIM tool did not appear to be a major determinant of PIM strategy, as behaviour varied greatly between participants using the same tool.

Participants also varied in terms of the features used in each tool, and how they used those features. This should not be surprising: PIM tools are complex tools, suffering from "software bloat" (McGrenere et al., 2002). There is clearly scope for more systematic studies focusing on different aspects of PIM interfaces in specific implementations.

4.10.2 Multiple Organizing Strategies

Section 4.5 highlighted that not only are organizing strategies highly idiosyncratic (varying between users), but they also vary *within and between tools for specific user*. As far as the author is aware, this is the first study to systematically investigate the variety of PIM strategies employed by an individual across a range of tools.

Previous studies have noted variation in organizing strategies between users for a specific tool. However, the findings presented in **Section 4.5** suggest that much user behaviour does not map onto strategy classifications that have been offered in email and bookmarks (Abrams et al., 1998; Balter, 1997; Whittaker and Sidner, 1996). Although such classifications offer useful abstractions of PIM practice, the author contends that they exaggerate the extremes – portraying users as either *messy* or *tidy*, *filers* or *no-filers*. **Section 4.5** attempts to classify behaviour in more detail to take account of multiple strategies. Previous work has also noted multiple strategies in the context of paper archives, where people tend to combine filing and piling strategies (Whittaker and Hirschberg, 2001).

The cross-tool data indicates that PIM strategies also vary significantly *between* tools for many individuals. Previous work has not taken such cross-tool variation into account. The results presented in **Section 4.5** focus on variations in organizing strategy, e.g. participants tended to organize files more extensively than emails or bookmarks. In other words, one can not assume that a frequent filer in email is necessarily tidy everywhere. The following factors may contribute towards variation in organizing strategy:

- *The perceived value of information* – Users feel a strong sense of ownership over files, which they have often invested significant time in authoring, and are therefore willing to take the time to organize. In contrast they feel less ownership over email and the websites referred to by bookmarks, which are typically authored by other users.

- *Likelihood and style of retrieval* – The study data suggests that users are more likely to reuse files than emails or bookmarks, particularly over the long-term. Users perceive that file organization is more worthwhile since the cost of filing is offset by predicted benefits at retrieval time. Also, users tend to retrieve email by sorting on metadata, such as "sender" and "date received". Therefore there is less need to organize to facilitate folder-based browsing.

- *Acquisition-related factors* – Files and bookmarks are created incrementally, making them easier to organize than email, which is acquired in an uncontrolled way. Many users who would like to organize their email do not have time to do so due to the high number of messages (Whittaker and Sidner, 1996).

- *Attitude towards organizing* – As well as the nature of information managed in each tool, the data suggests that a user's tendency to organize may be influenced by personality factors. Participants who stated that being tidy was important tended to be consistently pro-organizing in multiple tools.

Model of Multiple Organizing Strategies

A new conceptualization of organizing strategies is suggested by the findings in **Section 4.5**. **Figure 4.4** illustrates three levels at which strategies can be described:

1. *Item-level* – Within the boundaries of a particular PIM-tool, a user may employ various organizing strategies for different items. For example, within an email collection, those messages relating to a particular project may be carefully filed in a dedicated folder, whilst other messages may be left in the inbox.

2. *Tool-level* – Within a single tool context containing many types of items, a user may employ *multiple organizing strategies*, e.g. 20% frequent filer, and 80% spring-cleaner. **Chapter 6** builds on this conceptualization of multiple strategies to model the incremental nature of changes in organizing strategy.

   These multiple strategies may be combined as a reflection of the user's overall "trait", such as the proposed *pro-organizing* and *organizing-neutral*. An outside observer glancing at a user's PIM-tool would build up an impression of their PIM strategies at this level, for example as "messy" (organizing-neutral), or "tidy" (pro-organizing). However, such traits abstract much low-level detail. For example an apparently "messy" email user may be highly organized with respect to certain types of email. Previous classifications of organizing behaviour have been shown to be limited in this way.

3. *Cross-tool level* – At the level of the entire computer, tool-specific strategies can be aggregated to form a "cross-tool trait", as with the cross-tool profile in **Section 4.5.4**. Again, it is noted that a focus at this high a level again abstracts much lower-level behaviour.

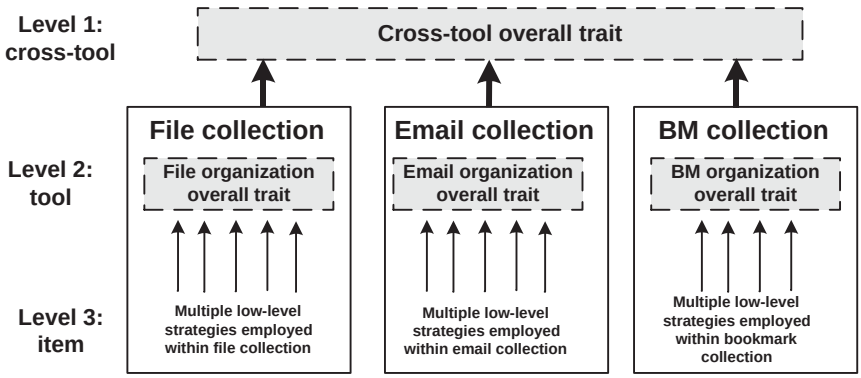

Figure 4.4: Three-level model of an individual's organizing strategies

This conceptualization emphasises the importance of specifying the level of analysis when talking about phenomena such as organizing strategies.

4.10.3 Implications for Design

Integration between PIM-tools has been repeatedly put forward as a worthy design aim (Bellotti et al., 2003; Bergman et al., 2003; Boardman, 2001b; Dumais et al., 2003; Kaptelinin, 2003), but with little empirical support. It is argued that cross-tool studies such as this one can provide an empirical foundation for such design by highlighting: (1) synergies between tools that can be exploited to improve integration, and (2) differences between tool usage that may indicate barriers to integration. **Section 4.9** highlighted a number of problems that either, (a) occur in multiple tool contexts, or (b) bridge multiple tools. The first type of problem can potentially be solved by a cross-tool design strategy, where the same improvement is made to multiple tools. The second type of problem confirms the potential of improving integration between PIM-tools. Other findings from the study indicate possible routes for integration.

The observation of *folder overlap* in **Section 4.7** points to a subset of user activities that involve the management of multiple types of information. Most overlapping folders corresponded to *roles* and *projects*, suggesting that these concepts may be usefully shared between collections, as in UMEA (Kaptelinin, 2003). However, it should be emphasized that most folders did not overlap. This suggests that: (1) some production tasks are supported by single PIM tools and may not necessarily benefit from increased integration; and (2) users may have different organizational needs in different tools. Folder overlap forms the empirical basis for the integration

technology developed in **Chapter 5**.

The author notes the potential compatibility for integration of files and *filed* email. Both types of information are either self-created or assessed as having long-term value. Also, folder overlap was greatest between these collections. However, complete unification between files and all email (as pointed to by designs such as TaskMaster (Bellotti et al., 2003)) may lead to the disruption of more controlled items (e.g. files, tasks) by unprocessed email. In some cases it may be appropriate not to integrate - but to instead retain separation between tools. This measured view of the pros and cons of integration is developed further in **Chapter 7**.

The investigation of *organizational dimensions* in **Section 4.6** points to users having different organizational needs in different tool contexts. It indicates that email contains more *contact*-based folders, whilst bookmark folders are mainly *interest*-based. This variety suggests users may be constrained by any PIM-tools that are based on specific types of concept. An example in the PIM-integration genre is UMEA (Kaptelinin, 2003), which focuses on *projects*.

Finally, the discussion in **Section 4.10.2** underlines the challenge of PIM design. Designers must not only cater for individual differences between users, but also for an individual user's *multiple strategies*. Future design must take account of strategy variation by providing the flexibility to manage different types of information in distinct ways – both within a single collection, and across collections. For instance, tools should allow users to different items as required, whilst not penalizing those users who do not want to organize.

4.10.4 Conclusion

It is argued that the study reported in this chapter was successful in meeting its objectives. A wide range of findings have been presented. In addition to helping the author gain a foundational understanding of the research domain, a number of novel contributions were also made. Key contributions include improved understanding of the nature of organizing strategies within and across PIM-tools, and the design implications presented above.

This study provides an empirical foundation for later chapters. Firstly, it provides empirical motivation for the design work in **Chapter 5**. In particular, the observation of folder overlap lead to the invention of the folder-mirroring principle. The observation of changes in organizing strategy, motivated the need for the longitudinal study reported in **Chapter 6**.

Chapter 5

Cross-tool Design

5.1 Introduction

This chapter reports the design, implementation, and initial evaluation of the *WorkspaceMirror* prototype, abbreviated to WM henceforth. WM provides a novel integration mechanism between three collections of personal information (files, email and bookmarks) based on the principle of *folder mirroring* – the sharing of organizational structure across PIM-tools.

5.1.1 Aims

The design component of this thesis had three high-level objectives, each relating to a limitation of previous design work in this area:

1. *To propose a design that offers a new form PIM integration to better meet user needs* – **Chapter 3** criticises a number of previous research prototypes in this area for a lack of empirical grounding. Instead, many have been founded on designer intuition. To avoid similar criticism, the author set out to ground his design efforts in findings from **Chapter 4**.

2. *To implement the design with an aim of performing a long-term evaluation* – This was to counter a second limitation of previous prototypes: that in most cases they have not been evaluated to test designers' claims. Therefore, any implementation had to be sufficiently robust to sustain long-term usage in real-world conditions.

5.1.2 Design Approach

In contrast to most previous work in this area, the design reported here was deliberately *incremental* – aimed at extending, rather than replacing existing technology. This relates to a third criticism of previous work made in **Chapter 3**: that there has been an over-focus on *revolutionary design*, the innovation of radical alternatives to current tools. Although many interesting designs have been proposed, such *radical invention* does not necessarily entail a strong contribution in terms of HCI knowledge, especially if no evaluation has been performed. In response, a number of researchers have emphasized the need for an iterative, incremental process of design (Lansdale, 1988; Newman and Lamming, 1995; Whittaker et al., 2000b; Carroll, 2000). This approach has been termed cumulative design, or "hill climbing" (Carroll, 2000). In the context of this thesis, an incremental approach was chosen for the following reasons:

1. *To enable effective evaluation* – As noted above, a key aim of the work reported in this chapter was to enable effective evaluation. One downside of radical invention is that it is difficult to measure specific improvements as so many interface aspects may change (Carroll, 2000). Newman and Lamming (1995) argue that incremental, localized changes that are well-understood and result in subtle improvements, are to be preferred over more ambitious changes which may result in complex side effects.

2. *To promote user familiarity* – By basing design on existing technology, it was envisaged that the likelihood of system uptake would be increased. Employing familiar concepts and tools will mean that users have less to learn (Carroll, 2000).

3. *To promote system up-take* – Building on current tools implicitly encourages compatibility with previous data formats. It was envisaged that this would make long-term evaluation more straightforward, since a tool that can be easily integrated into a user's existing toolset is more likely to be used. A major concern was to avoid prospective users having to go through complex data-import processes, or abandon carefully nurtured collections of personal information in favour of an unproven technology.

4. *To encourage an achievable design goal* – Another key concern was that the design and implementation needed to be achievable in the context of the limited time and man-power resources available. An incremental approach allowed the author to build on previous design expertise manifested in already available tools.

Carroll (2000) observes a fundamental limitation of incremental design. Along with the benefits of building on previous design expertise comes the risk of inheriting previous design limitations. Therefore, the designer may be constrained to making little more than local optimizations. However, it is observed that an incremental design approach facilitates subsequent iterative refinement once initial changes have been evaluated. In other words, following an incremental strategy does not mean that further more ambitious changes cannot be made.

5.1.3 Structure of the Chapter

This chapter reports how an incremental perspective was employed within a user-centred design process. The first step of the design work was to brainstorm improvements to address user problems identified in the exploratory study reported in **Chapter 4**. Since a key aim was to investigate routes for improving integration between PIM-tools, a focus was taken on the problems in **Section 4.9** that bridged multiple PIM-tool contexts. **Section 5.2** presents two design avenues which emerged from the exploratory study findings. Due to time constraints, the thesis focused on one of the candidate design routes, that of *folder-mirroring*. The rationale behind this design focus is presented in **Section 5.3**, along with a description of the design. **Section 5.4** reports the development of a folder-mirroring prototype, called *WorkspaceMirror* (WM). **Section 5.5** then presents an initial evaluation that was carried out to assess the viability of the folder-mirroring principle. Finally, **Section 5.6** contrasts WM with other research prototypes.

5.1.4 Contributions

This chapter makes two main contributions to the thesis:

1. *The design and implementation of the WM prototype* – As well as being a novel PIM-integration mechanism, WM acted as a research vehicle to enable the investigation of general issues relating to PIM-integration.

2. *The results from the initial formative evaluation of WM* – These results confirmed the worth of pursuing a more in-depth evaluation. **Chapter 6** reports a follow-up longitudinal evaluation of a modified version of WM which incorporated suggestions from the initial evaluation.

5.2 Initial Forays in a Cross-tool Design Space

This section reports initial incremental design and prototyping directed at solving two of the *cross-tool* problems identified in **Section 4.9**. Note that both are incremental adjustments to commonly available PIM-tools.

5.2.1 Highlighting and Gathering To-do Items

Several participants in the exploratory study mentioned problems relating to the use of information as reminders. These included a lack of consistency between different tools regarding support offered for highlighting an item as a *to-do item*. A second problem was that it was hard to gather together to-do items from different tools.

The author's proposed solution allowed any item of information to be highlighted and marked as a to-do. To-do items are highlighted in a consistent manner across all tools via a standardized context-menu mechanism. At the same time, a reference to each new to-do item is added to a unified list. An initial proof-of-concept was developed on MS-Windows using MS-Visual Basic 6.0, allowing any desktop icon, file, or bookmark, to be selected and highlighted as a to-do. This resulted in the icon background changing to red. A short-cut to the item was also added to the MS-Outlook "tasks view". However, it was not possible to provide the same mechanism for highlighting emails due to imitations on the MS-Outlook object model. This design can be related to the functionality present in attribute-based systems that allow users to label arbitrary pieces of personal information with an attribute such as "to-do" or "important", e.g.(Dourish et al., 1999). The author's work can be differentiated due to the incremental design stance of providing functionality on top of standard PIM-tools.

5.2.2 Managing Multiple Types of Information in Parallel

A second area of difficulty reported by users related to the need to manage distinct collections of personal information across a range of PIM-tools, each with a distinct organizational structure. After initial brainstorming, two possible approaches were identified to make it easier for users organize information in multiple PIM-tools:

1. *Folder sharing* – This would allow the storage of multiple types of information (e.g. files

and email) within a consolidated folder structure. Two key problems were identified with this route. First, it was not clear how such a scheme would co-exist with current tools, and whether users would employ it in preference to those tools. Secondly, an initial investigation of the technical feasibility of folder-sharing on MS-Windows, concluded that it was beyond the time and manpower resources of a single PhD researcher.

2. *Folder-mirroring* – Rather than storing multiple types of information within the same unified storage, this alternative design allows folder names and their structure to be shared between PIM tools. However, distinct folder structures are retained in different PIM-tools such as files and email.

Figure 5.1 compares these two approaches. The second approach, *folder-mirroring*, was selected as the focus for the thesis, for two reasons: (1) stronger empirical grounding, and (2) more straightforward implementation. The rest of **Chapter 5** details the empirical and technological design rationale, implementation, and initial evaluation of a folder-mirroring prototype.

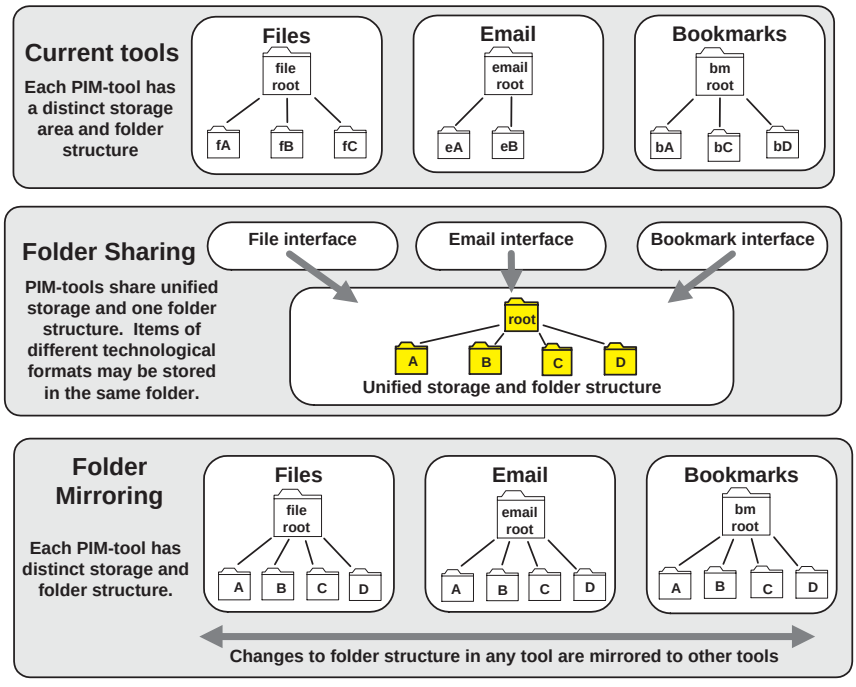

Figure 5.1: Comparison of folder-sharing and folder-mirroring

5.3 Design Focus: Folder mirroring

This section describes the design focus in the thesis, the principle of *folder-mirroring* – allowing the user to replicate changes made to the folder structure in one tool to the folder structures in other tools. **Section 5.3.1** presents the empirical and methodological design rationale behind this focus. **Section 5.3.2** describes the core functionality of folder-mirroring in terms of changes to the interaction model of the standard folder hierarchy.

5.3.1 Design Rationale

The next two sections present the empirical and methodological rationale behind the design focus.

Empirical Design Rationale

A number of findings from the exploratory study in **Chapter 4** lead the author to consider the potential benefits for users if they were able to share organizational structure between PIM tools. Key findings offering evidence in favour of this design route are listed as follows:

1. *Observations of existing folder overlap between different PIM-tools* – Firstly, the observation of substantial *folder overlap* for many participants, indicated that many users who perform filing in multiple PIM-tools, create similar folders in different tool contexts (see **Section 4.7**). Furthermore, during the guided tours, eleven participants highlighted similarities between their folder structures in different tools. Folder overlap suggests that certain user activities are cross-tool and involve the organization of multiple types of information. However, with current tools, each type of information must be organized separately. Such cross-tool activities therefore involve organizing effort that is distributed: (1) across tools, and (2) over time.

2. *Users expressing the wish to share folder structures between tools* – Several participants complained about the effort of managing multiple collections of personal information separately, and expressed annoyance that it was not possible to manage their files and email together in the same set of folders, e.g. *P25: "I suppose not as they've got very distinct*

usages and purposes but to me it would be easy if I could have everything in one location. But at the moment I have the sense that things are managed in two quite separate ways".

3. *Manual mirroring behaviour* – Some participants had attempted to manually mirror folders between tools. These participants reported that it was hard to keep folder structures synchronized, and they tended to diverge over time, *P13: "All of them [my folder structures] started off with an identical folder structure, but over time they've diverged somewhat"*. Therefore most had abandoned manual folder-mirroring because of the amount of effort involved, e.g. *P11: "I maintained my usability knowledge base for 6 months but it was too much hassle and I got out of practice. I want to get restarted in email, file system and web"*. These observations suggested that some users may welcome folder-mirroring.

4. *Difficulties in retrieving information* – Some participants mentioned problems when retrieving information caused by them not being sure if it was stored in the file collection or the email collection. In particular, retrieval problems were caused by the ability to manage files as attachments within the email collection, e.g. *P22: "If it wasn't there [in the file folder] I would think damn I forgot to file it in the folder where it belongs and go straight to email"*. Retrieval problems may be exacerbated by the existence of different organizational structures in each tool. This means that as well as looking in two tools, users may have to look in different locations in each tool.

The exploratory study also provided evidence that folder-mirroring may *not* be useful. Folder overlap was in many cases partial, and often limited to certain types of folders such as roles and projects. In other words, there was some variation in organizational behaviour across the three tools for many participants. Furthermore, some users did not rely on folders and instead relied on sort and search mechanisms. Therefore would stand to gain little benefit from folder-mirroring.

The two sides of this argument indicated that this was be an interesting area to investigate further. An implementation of folder-mirroring was envisaged as a research vehicle to investigate the potential of increased integration. The following issues were identified for exploration: how would users respond to the ability to share folders between tools? Do folder labels carry meaning beyond the boundaries of particular tools? Do users really need the flexibility to develop distinct classification schemes for different types of personal information?

The subsequent implementation and evaluation of a folder-mirroring prototype was directed at investigating whether the folder-mirroring mechanism would help users manage the multiple types of information relating to certain activities more effectively.

In the personal information environment offered by current desktop computers, users must make adjustments separately to the folder structures in different PIM-tools. Since the folder structures are managed separately, even if users try to keep them synchronized, they tend to diverge over time. With folder-mirroring, it was envisaged that the folder-structures in different collections of personal information may converge.

Methodological Design Rationale

Folder-mirroring was also seen to be highly compatible with an evolutionary, incremental design route:

1. It was envisaged that folder-mirroring functionality could be applied to existing folder structures, which would be extended incrementally with mirrored folders. Therefore there are few barriers to initial usage since the user does not have to adjust existing collections in any way. Furthermore, folder-mirroring could be made optional, allowing users to retain the flexibility to organize different types of information in different ways.

2. Folder-mirroring can be considered a step towards the PIM-integration offered in systems such as MS-WinFS (Microsoft Longhorn). It was envisaged that this design route represented a practical/pragmatic choice, achievable within the limited time and manpower constraints available, that would provide insight for the developers of more advanced PIM-integration technology. Based on the author's previous technical experience, it was estimated that the folder-mirroring principle would be possible to implement in a robust way with the limited available time and manpower resources.

3. Sharing one set of folders across PIM-tools would act as a foundation for more powerful PIM functionality. For example, organizational consistency in this way facilitates the straightforward grouping of related information in different technological formats. Envisaged uses for such cross-tool grouping include collating information for knowledge transfer, starting a new project, or project archiving.

5.3.2 Core Functionality

In this section, the folder-mirroring design is outlined in detail. Firstly,the interactions afforded by the traditional folder hierarchy are described in terms of three fundamental operations:

1. *Creating a new folder* – The folder's location within the folder structure, is defined by the folder's path relative to the root folder.
2. *Deleting a folder* – Items and sub-folders contained within the folder are also deleted.
3. *Renaming a folder* – In the simplest case, a folder's name is changed, but the folder remains at the same location. *Moving* a folder can be considered a special case of renaming where the folder's path is changed but the name remains the same.

The folder-mirroring principle allows the user to replicate the three above operations across multiple folder structures as shown in **Figure 5.2**. In other words, if a change is made made to the folder structure in one collection, it is replicated to the folder structures in the other collections.

The core functionality of folder-mirroring, can be defined as follows, in terms of the three above operations:

1. *Mirroring the creation of a folder* – If the user adds a new folder "C" in one collection, an equivalent folder "C" should be created in the same location in the other collections. If a folder with that name already exists in that location in one of the other collections, no action should be taken there.

   It may be necessary to mirror an entire set of parent folders as follows. Consider the scenario of a folder being mirrored from the file system to email. The file folder in question is `File-root/A/B`. In email, the intermediate folder, `Email-root/A` does not exist. Therefore, the parent folder, `Email-root/A` must be created before `B` is created.

2. *Mirroring the deletion of a folder* – When the user deletes a folder "C" in one collection, the equivalent folder (if one exists) should be deleted in the other collections. If that folder does not exist in one of the other collections, no action should be taken there.

3. *Mirroring the renaming of a folder* – A scenario is considered when the user renames a folder "B" (termed the *source folder*) as folder "C" (termed the *destination folder*). If the

source folder exists in one of the other collections at that same location, *and* if the destination folder does not exist, then renaming should be mirrored. If the source folder does not exist, or the destination already exists in a particular collection, then no action should be taken there[20].

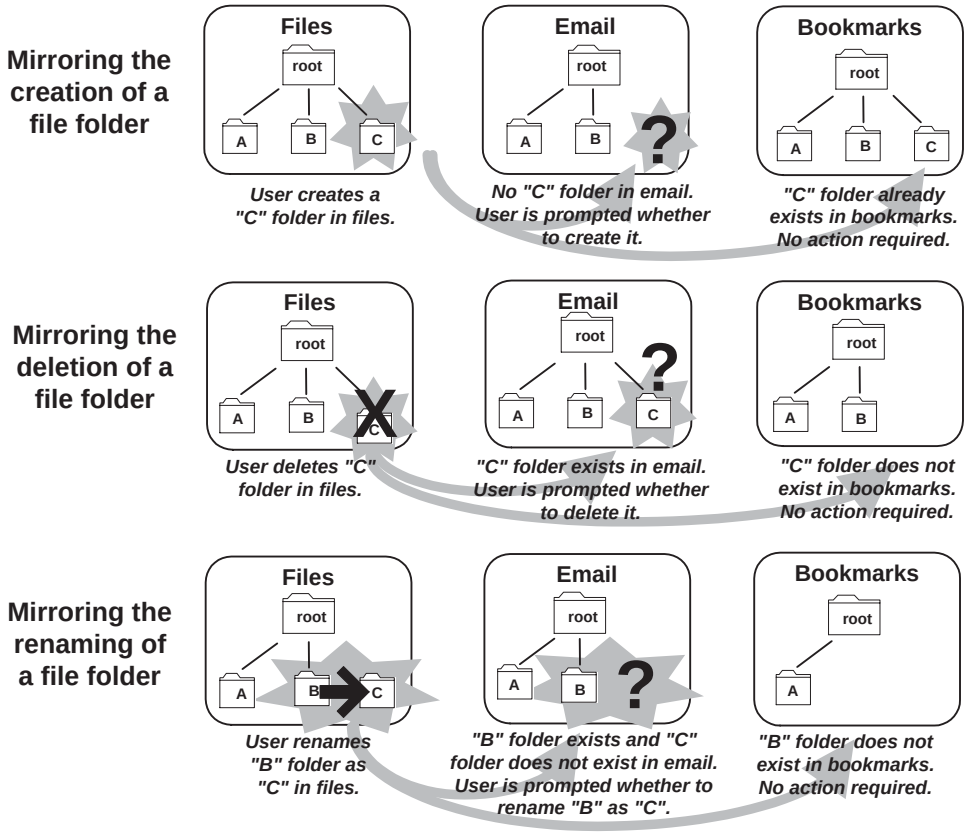

Figure 5.2: Principles of mirroring

The file, email and bookmark collections were deemed suitable for folder-mirroring since they all employ hierarchy-based organizations to arrange items. Other PIM-tools such as the calendar and contact manager are not suitable because in most cases they do not rely on hierarchical organization[21]. Two modes of operation were envisaged: *automatic* and *manual*. In the automatic mode, folder actions are mirrored automatically. In the manual mode, the user is

[20] An alternate design was also considered for renaming, in the case when the source *and* destination folders do not exist in another PIM-tool. Instead of the action detailed above, the destination folder could be created in the other PIM-tool, and so make the folder structures more consistent. This alternate design was not implemented in the course of the thesis but remains a possibility for future work.

[21] One can envisage the sharing of folder labels between hierarchy-based tools such as email, and non-hierarchy-based tools such as calendars. However, this functionality was beyond the scope of the work in this thesis.

prompted with a dialogue box as to whether mirroring should be performed.

Note that folder-mirroring should not be considered as an attempt to develop an alternative to hierarchical organization. Limitations of the hierarchy such as single-inheritance (Dourish et al., 1999) are beyond the scope of the thesis. Also, it should also be noted that folder-mirroring does not provide an alternative means for interacting with folder structures. The user interacts with the three PIM-tools as before (e.g. via direct manipulation, or the command-line).

Usage Scenarios

Two scenarios were developed, based on comments from the exploratory study, to illustrate how folder-mirroring could be used:

- *Starting a project* – Bill is about to embark on a new coding project. The project involves creating source code and documentation, coordinating with colleagues, and researching information on the internet. Therefore he predicts that the project will involve the management of associated files, email and bookmarks.

  Using current tools, Bill must create folders separately in each tool in turn. However, with folder-mirroring, Bill can create a project folder in one location and is then immediately prompted as to whether he wants the folder also created in the other locations. He decides to mirror and the folder is created in the three tool contexts.

- *Finishing a project* – Gemma has just completed a term report on the mating habits of hamsters. Whilst carrying out this activity, she has managed a large amount of associated files, email and bookmarks within a `hamster` folder in the respective PIM-tools. Having backed up the term report itself, Gemma wants to delete all the information relating to the report which are cluttering up her workspace.

  Using current tools, she must go to each tool in turn and delete the respective folders and the items they contain. With folder-mirroring, she is prompted to delete the folder in all three tools, thus saving mouse-clicks and time. The scenarios assumes that she had previously created the folder in each tool[22].

[22] Note that an equivalent cross-tool archiving function can also be imagined as an alternative to the cross-tool deletion portrayed in this scenario.

5.4 Prototype Implementation

This section describes the implementation of a folder-mirroring prototype, *WorkspaceMirror* (abbreviated in this thesis as WM). Development was carried out on the MS-Windows desktop operating system, using the languages MS-Visual Basic 6.0 and MS-Visual Basic.NET. The popular MS-Windows operating system was selected so as to provide access to the largest possible number of potential users. Rather than recounting the rounds of iterative development and testing performed by the author, a focus is taken on the final architecture of WM.

WM runs as a background application, monitoring for the creation, deletion, or renaming of folders in three PIM-tools:

1. *One user-selected area of the file collection* – The exploratory study highlighted that users often store personal files in multiple locations such as the desktop, the local hard disk, and drives on remote servers. It was decided to focus on one area of the file system (e.g. "My Documents") for two reasons: (1) to enable straightforward mirroring with the email and bookmark collections which are each centred on one primary folder structure, and (2) to enable fast implementation.

2. *MS-Outlook (email collection)* – A wide range of email clients are in common usage including MS-Outlook, Eudora, Netscape and MS-Outlook Express. Initial investigation revealed that each client employs incompatible storage formats meaning that it was not possible to support all the clients within the limited time available. MS-Outlook was chosen as the supported client because: (1) it possessed a well-defined API accessible from Visual Basic, and (2) it was the most common client encountered in the exploratory study.

3. *MS-Internet Explorer (bookmark collection, also known as "Favorites")* – MS-Internet Explorer was selected as the most common web browser on the MS-Windows platform.

WM operates in one of two modes: *automatic* or *prompted*. A configuration setting allows switching between the two modes. In automatic mode, events are mirrored without user intervention. In prompted mode, WM runs in the background except for prompting the user when the user performs a folder-related operation. The creation, deletion or renaming of any folder causes a dialogue box to be displayed asking the user if they want to replicate the operation in the other two tools. An example dialogue box is shown in **Figure 5.3**. Each of the

three PIM-tools are represented by a check box, which can be selected to request mirroring to be performed in that tool. The check box corresponding to the PIM-tool which has sourced the event is hashed out. A configuration setting allows the user to specify whether the check boxes are enabled or disabled by default. If the check boxes are enabled by default, simply pressing the 'OK' button on the dialogue box causes mirroring to proceed.

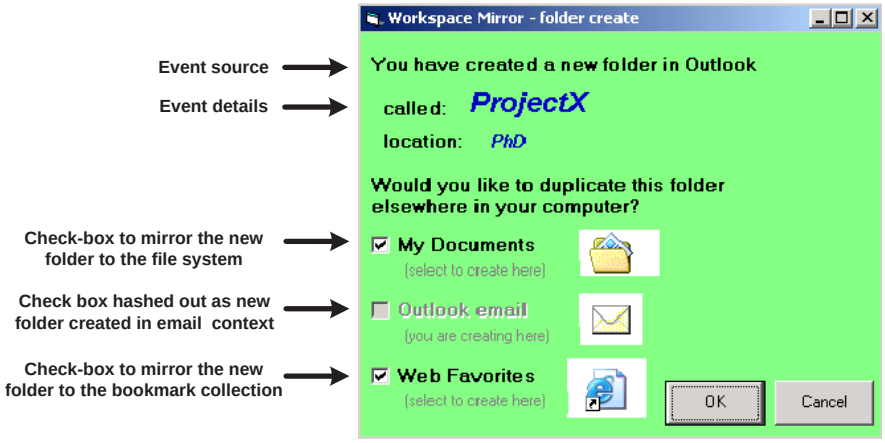

Figure 5.3: Example WM dialogue: the folder `PhD/ProjectX` has been created in email.

Figure 5.4 describes the architecture of the WM prototype, which consists of four main components: (1) `dotNetWatcher`, (2), `OutlookWatcher`, (3) `EventProcessor`, and (4) `Mirrorer`[23].

The first two components, `dotNetWatcher` and `OutlookWatcher` monitor the three PIM-tools for folder-related events. `dotNetWatcher` monitors the portions of the file system corresponding to the user's personal files (e.g. "My Documents"), and bookmarks (termed "Favorites" in MS-Windows). `OutlookWatcher` monitored the folder structure in MS-Outlook. These two components instantiate a `FolderCreate`, `FolderDelete` or `FolderRename` object containing the details of any detected creation, deletion or renaming event. For example the `FolderCreate` object contains details on the folder name, folder path, and the PIM-tool which generated the event. All events are then relayed to the `EventProcessor` component.

The `EventProcessor` component contains the main application logic for WM. Firstly, `EventProcessor` filters two types of spurious events which are not appropriate for mirroring. The

[23]Most of the application coding was performed in MS-Visual Basic 6.0. The only exception was the `dotNetWatcher` component which was coded in MS-Visual Basic.NET. This version was selected since it offered significantly enhanced support for file system monitoring through the `FileSystemWatcherClass` class. The `dotNetWatcher` component communicates with the other components via the "COM/.Net interop" mechanism. Since MS-Visual Basic.NET was a beta product at the time of development (Summer/Autumn 2002), integration between the COM and .NET components was coded manually and was non-trivial.

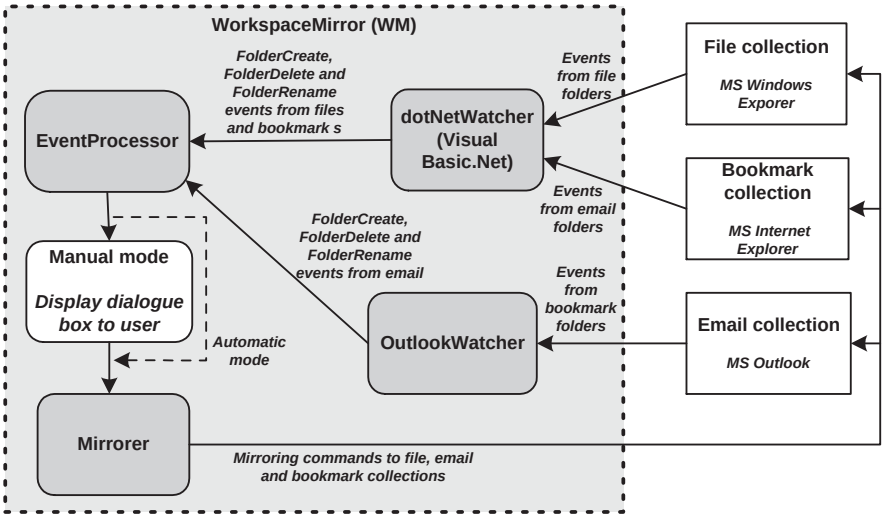

Figure 5.4: WorkspaceMirror: overview of technical architecture

first type of event are those that relate to default folders (e.g. the creation of a new folder under "Deleted items" in email). `EventProcessor` maintains a cache of default folders from commonly encountered applications for this purpose. The `EventProcessor` component also handles the possibility of event recursion due to folder mirroring. For example, consider the mirroring of a newly created folder from the file system to email. The newly mirrored email folder causes a second `FolderCreate` event to be created, this time by the `OutlookWatcher` component. `EventProcessor` avoids event recursion by filtering new events based on a cache of previously mirrored events. Non-filtered events are processed as follows:

- *FolderCreate event* – The existence of the folder is checked in the same location in the other PIM-tools. If there is at least one PIM-tool where there is no corresponding folder, `EventProcessor` proceeds to mirror the event. In manual mode, a dialogue box is displayed asking the user if they want to create the folder in those PIM-tools where that folder does not already exist (see **Figure 5.3**). A configuration setting specifies whether the check boxes are selected by default. Those check-boxes corresponding to the source PIM-tool, and any PIM-tools where the new folder already exists are disabled. In automatic mode, folders are mirrored automatically as appropriate.

- *FolderDelete event* – The existence of the folder is verified in the other PIM-tools. If there is at least one other PIM-tool where the folder exists, `EventProcessor` proceeds to mirror

the event. In automatic mode, any equivalent folders are deleted automatically[24]. In manual mode, a dialogue box is displayed asking the user if they want to mirror the deletion. As with creation, a configuration setting specifies whether the check boxes are checked by default. If so, simply clicking OK causes the folder to be deleted in all PIM-tools as appropriate. The check-boxes corresponding to the source PIM-tool, and any PIM-tools where the folder *does not* exist are disabled.

- *FolderRename event* – Handling the `FolderRename` event (from a *source* folder to a *destination* folder) was more complicated. Mirroring proceeded if in at least one other PIM-tool, the source folder existed and the destination folder did not. In automatic mode, mirroring proceeds automatically. In manual mode, a dialogue box is displayed asking the user whether the event should be mirrored to appropriate PIM-tools (i.e. those where the source folder to be renamed exists, and the destination folder does not). There were implementation difficulties with the handling of `FolderRename` events. These are discussed in **Section 5.4.1** below.

The `Mirrorer` component provided the low-level mirroring functionality. Firstly, it repeated the safety checks made by the `EventProcessor` (e.g. that a folder to be created does not already exist). `Mirrorer` also handled various exceptional cases. For example, consider the mirroring of a newly-created `Email-root/Projects/MondayDemo` folder from email to the file system. If the parent folder `File-root/Projects` does not exist in the file system, it must be created before the `MondayDemo` folder is created.

5.4.1 Implementation Challenges

The development process posed a number of significant technical challenges. These are briefly surveyed, along with consequent design decisions, as follows:

- MS-Windows creates temporary "`New folder`" and "`Copy of X`" folders when the user creates or copies a file folder. They must then be renamed by the user as required. Application logic was added to the `EventProcessor` module to filter these events to prevent mirroring before they were renamed. Events corresponding to the renaming of "`New Folder`"

[24] It may be argued that such "automatic deletion" functionality is dangerous as it makes it too easy for the user to remove information without thinking. Consequently, WM took full advantage of any "Recycle Bin" functionality so as to allow the user to restore deleted folders later.

or "`Copy of X`" folders are mapped to a `FolderCreate` event.

- Differences between the PIM-tools in terms of their folder hierarchy implementation raised a number of challenges. First, within MS-Outlook, a user may create folders beneath the default `Inbox` folder, or at the root "`Personal folders`" level. This is problematic when mirroring to the file and bookmark collections where it does not make sense to have an `Inbox` folder. In the WM prototype described here, it was decided to ignore folders beneath the `Inbox`. Second, MS-Outlook allows "shell" characters such as '&' and '/' to appear legally in folder names. This is not the case in the MS-Windows file system where such characters are not permitted in folder names. For this reason, events relating to folders containing shell characters in their names were removed by the `EventProcessor` component, and the user notified that mirroring would not be performed.

- MS-Outlook provides a COM interface that generates events when folders are created, deleted and changed. However, some major limitations were encountered. In particular, the `delete` and `rename` events do not convey information about which folder has been deleted or changed. Therefore, `dotNetWatcher` stores a cache of the email folder hierarchy that can be interrogated to provide this information.

  However, significant difficulties in handling the mirroring of rename events in MS-Outlook which involved the movement of a folder between different parent folders (e.g. moving folder `B` from `Email-root/A/B` to `Email-root/C/B`). The limitations in the MS-Outlook object model, combined with the limited development time available, meant that it was not possible to implement this email event in the evaluated version of the WM prototype.

- One acknowledged limitation of WM is that it only monitors the folder structure beneath one root folder in each PIM-tool. However, in the file system, users may distribute their personal files in multiple locations (e.g. "My Documents" and the "Desktop"). It was envisaged that a facility for multiple roots within one PIM-tool context could be added in later versions.

5.5 Initial Evaluation

The aim of this initial evaluation was to assess the workability of the design, and identify bugs before deploying the tool to users over the long-term. In particular, feedback was sought regarding several unresolved design questions:

- What feedback should be provided to indicate that WM is running and folder-mirroring is operational?
- Do users prefer WM to operate in automatic or manual modes?
- Should mirroring be enabled or disabled by default in the dialogue box?

5.5.1 Method

Five colleagues of the author took part in the initial evaluation (see **Table 5.1**.) Three (F1, F2 and F4) had previously taken part in the exploratory study described in **Chapter 4**. Four (F1, F2, F3, F5) also agreed to subsequently take part in the long-term study described in **Chapter 6**. Previous to the evaluation described here, all five participants relied on folders for organizing their file, email and bookmark collections.

Participants were interviewed as follows. Firstly, WM was installed on the participant's main work computer. The author then introduced WM, and provided a walk-through of folder mirroring. WM was deployed in prompted mode, so as to give more control over the mirroring process. Participant were then asked to try out the tool and provide feedback on any aspect of the design. Data was collected in the form of notes taken by the author.

ID	ID in Exploratory Study (Chapter 4)	ID in Main Study (Chapter 6)	Age	Sex	Job role	OS	Cross-tool profile
F1	P1	M1	35-40	M	Academic	Win2000	CT2 (F1, E2, B2)
F2	P2	M2	20-25	M	Student	Win2000	CT1 (F1, E2, B1)
F3	-	M3	20-25	M	Student	Win2000	CT3 (F1, E3, B2)
F4	P23	-	30-35	M	Student	WinXP	CT2 (F2, E1, B2)
F5	-	M4	30-35	F	Student	WinXP	CT1 (F2, E2, B1)

Table 5.1: Participants in initial evaluation of WM

5.5.2 Results

Four of the participants provided positive feedback. They found the idea of mirroring folders between tools both intuitive and compelling, and welcomed the increased consistency between the three folder structures that they predicted would result from extended use of WM. For instance, participant F1 stated, *"You only have to create a folder once ... you create a [file] folder, you create a word document in that folder – and the next thing you think oh I have to do a web search on the topic. So you do a web search and you find some interesting websites, but you don't really have to think about where you're going to store those websites"*. Participant F2 foresaw one situation where he would find folder-mirroring particularly useful: *"One scenario where I would currently use it would be when I'm browsing the web for software ... I always create a new web bookmark and document folder manually with the same names"*.

However, the feedback from these four users was not entirely positive. Two of the four also observed that there was not always a one-to-one mapping between the folder structures in different PIM-tools. They stated that not all folder operations should be mirrored between tools due to differing organizational requirements, e.g. F1: *"In the web bookmarks, you might have sub-folders which are slightly different than the ones you want in the file system. So in my web bookmarks I might want to say I've got projects called 'semantic web' and 'XML' ... But you don't really want to do that in the file system because whatever report you're going to write one report about the semantic web and one about XML"*. Two participants also expressed concern regarding the bootstrapping of the system, i.e. its incorporation within an existing working habits, e.g. F5: *"It's all a matter of getting into the habit. It's difficult when you start but you get used to it"*. Longer-term evaluation was deemed necessary to explore issues relating to the adoption of the mechanism within a well-developed personal information environment.

The final participant (F3) was much less positive and provided a useful counter-example. He did not see any point in mirroring folders between the three tools. He was the most *organizing-neutral* of the five participants. Although he performed some organizing in files, he filed very few emails or bookmarks. He also found the idea of prompting intrusive. Despite his reservations he agreed to leave the software running to test its robustness.

A number of design recommendations were made by the participants and incorporated in WM before the main evaluation reported in **Chapter 6**:

- All participants wanted to be made aware that WM was running in the background. Resulting from this feedback, an animated icon was added to the task bar.
- Participants wanted to have close control over mirroring and so preferred the prompted mode of operation. Most participants were not concerned about the intrusion of the dialogue, e.g. F1: *"its not that often that you create new folders anyway"*. However, one suggested the dialogue box should carry a "do not ask me about mirroring again" check-box. Three participants wanted the mirroring check-boxes selected by default.

Feedback also included a number of suggestions for extensions to the core functionality. The main evaluation was based on the core functionality as described in this chapter. Longer-term design suggestions are discussed along with those from the main evaluation in **Section 6.5.3**.

During the interviews, several implementation-related issues were also uncovered:

- The `FileSystemWatcher` .NET class was found to be incompatible with UNIX-based network drives (e.g. those mounted via `Samba`). In addition, due to a bug in the "COM/.NET interop" mechanism, casing information was lost from all folder and path information. Fixes for these issues were not implemented before evaluation.
- Installation was found to be a time-consuming and intricate process as a .NET library developed by the author had to be installed. This learning experience proved invaluable for rolling out WM to more users in the main study. Also, MS-Visual Basic.NET was incompatible with older versions of MS-Windows, meaning that several prospective trial users were ruled out.

Summary

In summary, the initial evaluation indicated the potential benefits of folder-mirroring, but also highlighted the need for investigation of the trade-off between the potential benefits of WM such as improved consistency, and downsides such as interruptions caused by the dialogue boxes. Overall it was decided that a longitudinal study would be worthwhile.

5.6 Discussion

This section compares the WM prototype with other related PIM technology.

Firstly, WM can be compared with standard PIM-integration mechanisms. These are typically aimed at the transfer of information between different tools, e.g. the "send-to" facility in MS-Windows. The author is not aware of any commonly available integration mechanisms that provide the ability to share organizational structure across different PIM-tools.

One similar commercial prototype was *"My Categories"*, part of Microsoft's now defunct .NET Services architecture (Microsoft .NET My Services). This allowed an individual to store a set of organizational categories on a central server, which could then be imported into different applications. The system was abandoned by Microsoft over concerns regarding entrusting all personal information to one entity. Furthermore, no evaluations were reported.

Within the research domain, several proposals have been made for the sharing hierarchical folder structure across multiple PIM-tools – the *subjective classification principle* (Bergman et al., 2003), and the *Personal Unifying Taxonomy* (Jones, 2004). Note that both these proposals were published subsequently to the work reported in the thesis. In addition, unlike WM, neither approach has been prototyped or evaluated.

WM can be considered to be an evolutionary step towards more ambitious research systems that have proposed to unify PIM within a consolidated interface, e.g. *LifeStreams* (Freeman and Gelernter, 1996), *Haystack* (Adar et al., 1999), and *Presto* (Dourish et al., 1999). Such revolutionary systems, although exciting in technological terms, were criticised in **Chapter 3** for a lack of evaluation. In contrast, a prime aim in this work was to facilitate evaluation by pursuing an incremental design based on relatively modest changes to standard software. This has the added advantage of enabling in situ evaluation with minimal disruption to the users concerned. These systems also combine multiple design aims, such as developing an alternative to traditional hierarchical organizing mechanisms, as well as unifying the storage of items based in different technological formats. Instead, WM is not concerned with providing an alternative to the folder hierarchy, and it is acknowledged that the limitations of this organizational mechanism are inherited in this incremental design. WM instead has one design aim – to allow users to mirror one hierarchical folder structures between different PIM-tools.

Other PIM-integration prototypes have offered users a unified organizational hierarchy based

on a particular organizational dimension, e.g. *RoleManager* (Shneiderman and Plaisant, 1994) and *UMEA* (Kaptelinin, 2003). In contrast, WM allows the user to develop folders based on arbitrary organizational dimensions. The results in **Section 4.6** illustrated that this was important for many of the study participants.

It is the view of the author that many previous PIM-integration mechanisms have been highly complex, and thus add to the complexity of already complex tools. Indeed most of the design work has implicitly acknowledged this point by aiming prototypes at technically experienced users. A key concern in this work was to avoid increasing the existing complexity of current interfaces (McGrenere et al., 2002), and if possible, to reduce complexity. The need to simplify PIM-tools has been previously called for by Hurst (2000). The design of WM is based on the sharing of PIM functionality *between* PIM-tools, namely the folder structure in which items are organized. Rather than having to manage different organizational schemes for different types of personal information (e.g. files, email and bookmarks), folder-mirroring makes it possible to share one organizational structure across all. In this way, folder-mirroring can be considered to be a "simplifying" PIM design that provides benefits to the user through improved consistency. This stands in contrast with the recent design trend for *embedding* support for managing non-native types of information such as to-dos within email (Bellotti et al., 2003; Gwizdka, 2002). Such embedding approaches run the risk of adding to the complexity of already complex tools.

Finally, folder-mirroring can be considered to be a type of synchronization system, e.g. (Swierk et al., 2000). However, most synchronization systems mirror entire collections based on specific technological formats between devices (e.g. the file collection from a laptop to a desktop computer). WM instead synchronizes changes to the organizational structure between collections containing *different* types of information (e.g. file to email collection). Note that although the WM implementation described in this chapter is limited in scope to one computer, the folder-mirroring principle can be extended to multiple devices.

Chapter 6 moves on to present the main longitudinal evaluation of WM.

Chapter 6

Main Study

6.1 Introduction

This chapter reports a field-study in which eight participants' management of files, email and bookmarks was tracked for an average of 286 days. The field-study acted as a dual-purpose research vehicle to satisfy two high-level objectives:

1. To evaluate the WorkspaceMirror prototype presented in **Chapter 5**.
2. To build on the "snapshot" findings reported in **Chapter 4**, by investigating PIM behaviour over a period of time.

In terms of both objectives, the study makes important progress over previous work. Firstly, few PIM designs have been effectively evaluated. In particular, this work represents the first *in situ* evaluation of a PIM-integration mechanism. Secondly, as well as being one of the few longitudinal studies of PIM practice, this work is the first *cross-tool*, longitudinal study. The next two sections discuss each objective in turn, and detail the progress made over previous work.

6.1.1 Objective 1: Evaluation of WorkspaceMirror

Robson (2001) defines evaluation as an attempt to assess the worth of some innovation or intervention. The evaluation of interactive designs is an essential component of HCI research, since an interactive artefact, however innovative, does not on its own constitute a substantial

contribution to HCI knowledge without some assessment of its worth (Dix et al., 1997; Carroll, 2000). However, much of the body of PIM-related design-based research is limited in this regard. **Chapter 3** highlights the lack of evaluation of proposed PIM designs.

A starting aim of this thesis was to avoid such a limitation by evaluating any design resulting from the research. Therefore the evaluation of the WorkspaceMirror (WM) design proposed in **Chapter 5** was considered essential. WM is a PIM-integration mechanism, which allows a user to mirror adjustments to the folder structures in three collections of personal information: files, email, and bookmarks. An incremental design approach was taken to enable the straightforward incorporation of WM within a user's existing set of PIM-tools.

Chapter 5 concluded with an initial assessment of the workability of WM based on the subjective first impressions of five users[25]. Based on the positive feedback of four of the five users, it was decided that the design was feasible, and that a more in-depth evaluation should be pursued. The longer-term evaluation had three sub-objectives:

1. To facilitate the formative redesign of WM, as a specific instance of PIM-integration.
2. To derive general recommendations for design aimed at PIM-integration.
3. To explore appropriate methods and metrics for evaluating PIM-tools.

The first sub-objective was to assess the value of WM as a specific instance of PIM-integration, and identify routes for its improvement. The specific areas to be investigated included the following:

- *Usefulness* – Do users value the ability to mirror folders between PIM-tools? How do users mirror folders across files, email and bookmarks?
- *Usability* – How can the usability of the design be improved? Do users prefer the prompted or automatic modes of operation? Does extended use of WM improve users' satisfaction regarding their level of organization?
- *Learnability and bootstrapping issues* – How easy is it for users to understand folder-mirroring? Is it easy for users to accommodate WM within an existing workspace?

[25] Note that the tool had also been tested in extensive ongoing usage by the author/developer.

- *How do different types of user respond to WM?* – The exploratory study in **Chapter 4** identified a wide range of user profiles. A key interest was to investigate how different types of user respond to WM (e.g. *pro-organizing* versus *organizing-neutral* individuals).

Secondly, as well as assessing the WM design specifically, it was also hoped that the evaluation would allow the derivation of general design recommendations for systems aimed at improving integration between PIM tools.

Finally, it was envisaged that lessons learned during the study would provide insights regarding appropriate metrics and methods for the evaluation of PIM-integration mechanisms. **Chapter 3** highlights the lack of such methodological guidance.

6.1.2 Objective 2: Longitudinal Study

As well as evaluating WM, the study also offered the opportunity for further empirical investigation of PIM. Other researchers have successfully combined design interventions with studies of work practice, e.g. (Blomberg et al., 1996).

A long-term study offered a chance to improve on the shortcomings of previous PIM-related empirical work. **Chapter 3** reviewed previous empirical studies of PIM, and observed how most have been based on short-term "snapshots" of behaviour. One exception was Balter (1997) who proposed a model of strategy changes in email, but noted a need for further longitudinal data to confirm his model. In the context of the thesis, a field study also provided an opportunity to build on the "snapshot" exploratory study reported in **Chapter 4**. It was envisaged that collecting longitudinal data would provide insight into the following issues:

- *How do PIM practices change over time?* – Historical strategy changes were reported by many participants in **Chapter 4**. It was envisioned that longitudinal data relating to strategy changes may provide evidence for or against the model presented in Balter (1997). The cross-tool nature of the study also enabled the comparison of long-term findings between the file, email and bookmark contexts.
- *How are ongoing activities such as archiving, deletion and retrieval performed?* – During "snapshot" studies, participants provide subjective reports of how they perform such sporadic tasks. It was hoped that the field trial would enable the collection of more objective data on these aspects of PIM.

6.1.3 Contributions

The contribution of this chapter towards the thesis is two-fold, based on the dual-purpose nature of the study:

- Firstly, the chapter offers the results from the formative evaluation of WM, and suggestions for its redesign. As well as evaluating the specific WM design, the chapter provides empirical groundwork for deriving general guidelines for the design of PIM-integration. These are discussed in **Chapter 7**, along with methodological recommendations for evaluating PIM tools based on the experience gained in evaluating WM.
- Secondly, the chapter offers insights into the nature of PIM from a longitudinal perspective. These include the analysis of observed changes in PIM strategy. Based on these results, **Section 6.7** criticises the model of changes in email management strategies from Balter (1997), and offers a new model.

6.1.4 Structure of the Chapter

Firstly, **Section 6.2** describes the study methodology. Then, **Section 6.3** provides a high-level overview of the results which are presented in detail over the subsequent three sections. **Section 6.4** presents a case study of each participant, summarizing their PIM practices and usage of WM. Then, **Section 6.5** focuses in detail on the evaluation results, and **Section 6.6** reports findings relating to longitudinal issues. Finally, **Section 6.7** offers a discussion of the results.

6.2 Method

Section 6.2.1 justifies the use of a field study approach. Then **Section 6.2.2** describes the decisions made to limit the study scope. **Section 6.2.3** details the study participants, and **Section 6.2.4** describes the 6 stages of the study. Finally, **Section 6.2.5** covers data analysis.

6.2.1 Choice of Methodology

This section describes the rationale behind the selection of a field study approach. Such an approach was clearly in line with the second objective outlined above, that of investigating user behaviour over time. In terms of the evaluation objective, two fundamental methods were considered: (1) controlled study, or (2) field study. The author ruled in favour of a field study for the following reasons:

- Primarily, a need was ascertained to investigate the usage of WM *over the long-term*. Lansdale and Edmonds (1992) argue the need for a long-term perspective in the evaluation of PIM software. They stress that the experimenter must give the participant time to get to know the features of the tool, and observe that important behaviour may take time to emerge. They also note that a long-term study may facilitate the observation of both routine and exceptional behaviour.
- A second concern was to carry out the investigation *under realistic conditions* to maximise ecological validity. Controlled studies have significant benefits in terms of controlling unforeseen variables, and ensuring that all participants carry out the same task, thus enabling effective comparison between them. However in this case, the author decided that the benefits of evaluating WM *in-situ*, in the context of realistic day-to-day behaviour, would be more valuable.

The author was aware of a number of challenges from the field study approach, and its application to PIM. Firstly, there are *logistical challenges* in installing and supporting software on peoples' desktops, and collecting feedback. Secondly, participants may be put off by *privacy concerns*. Appropriate precautions must therefore be taken by the researcher to alleviate such concerns, e.g. anonymizing all data collected. Furthermore, there may be *reticence to switch*

from a familiar tool to evaluate a new, un-trusted design, which may interfere with mission-critical work (Bellotti et al., 2003). PIM plays an important part in supporting user's day-to-day roles, so any prototype being evaluated must be fully tested and robust. Another challenge results from the *highly idiosyncratic* nature of PIM. Participants may select their own tasks, or use different tool features, and it may therefore be difficult to compare between them. The author therefore envisaged observing a wide range of behaviour.

Further challenges resulted from the lack of accepted methodology or set of metrics for evaluating PIM tools (Whittaker et al., 2000b). This is a general problem relating to the evaluation of tools that support complex, high-level, discretionary, interleaved, activities such as PIM, where many traditional measures of usability, especially those based on efficiency and effectiveness may be inappropriate (Dillon, 2001). For example, in **Chapter 4**, several examples of "irrational" collecting behaviour were observed, when users collected items that they knew would never be needed again. It is not clear how efficiency based measures can ever fully reflect the sheer range of needs that people encounter in PIM. The difficulty in defining evaluation metrics may be a reason why few evaluations have been carried out in this area. Consequently, this work had a strong exploratory nature. **Section 6.2.4** reports the wide range of data collection techniques employed in this work, a key aim of which was to make recommendations regarding appropriate methodology and metrics for the evaluation of PIM software.

Additional challenges resulted from evaluating a *cross-tool* design such as WM. Typically evaluations assess the impact of a new tool design in the context of user tasks centred on that specific tool. However, as a PIM-integration mechanism, WM affects the operation of three distinct PIM-tools: files, email, and bookmarks. Therefore, the installation of WM, although one piece of software, causes a design intervention in three different tool contexts. All three interventions must therefore be taken into consideration during evaluation.

6.2.2 Study Scope

Several constraints were applied to the study to compensate for its ambitious scope (both cross-tool and longitudinal), and the limited manpower resources available:

- *One computer per participant* – As in the exploratory study, a focus was taken on PIM performed in each participant's self-nominated primary work computer.

- *Three collections of personal information: files, email and bookmarks* – The study focused on the three PIM-tools influenced by WM.

- *One area of the personal file system* – WM was limited on monitoring one area of the file system, nominated by the participant as their primary location for storing personal documents, e.g. "My Documents". Likewise, a decision was taken to focus the study on the same area of the file system. However, two participants (F3 and M7) actively managed files in two locations. In their cases, both areas were covered by the study.

  Furthermore, as in the exploratory study, areas of the monitored portion of the file system which contained source code, temporary files, and program executables were omitted from the data analysis.

6.2.3 Participants

Eight colleagues of the author were selected to take part in the study. **Table 6.1** summarizes their details. The use of colleagues as participants is justified as follows. Firstly, it was hoped that the study could leverage the existing trust basis between the researcher and his colleagues – avoiding possible privacy problems of working with strangers' personal data. Secondly, they were all technologically aware and ready to work with beta software. A third reason was pragmatic: it was easy to meet with them to carry out interviews, and install software.

Two methodological problems result from this set of participants. Firstly, since they already knew the researcher, there is the possibility of potential bias in favour of WM. To try and counter this, participants were asked to be unbiased and honest in their feedback. The wide range of feedback received on WM – both positive and negative – suggests that this was achieved. Additionally, the small number of participants meant that the results are unlikely to be applicable to the wider population of computer users. However, the intention was to produce interesting, indicative results, and to highlight routes for follow-up research. Overall, it is argued that the above benefits outweigh these downsides.

The eight participants were grouped into two groups as follows:

- *Track 1* – The first four participants (identified as F1–F4) had previously taken part in the initial evaluation reported in **Chapter 5**. In addition, participants F1 and F2 had also taken part in the exploratory study in **Chapter 4** as participants P1 and P2 respectively.

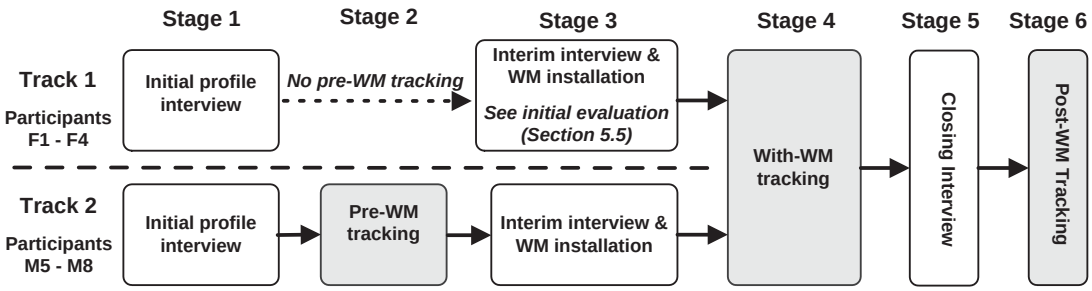

Figure 6.1: Main Study: overview of method

- *Track 2*: the second four participants (identified as M5–M8) had not participated in any earlier investigations by the author.

6.2.4 Study Process

The study process consisted of six stages, as illustrated in **Figure 6.1**:

1. Initial profile interview *(all participants)*.
2. *Pre-WM* tracking *(track 2 participants only)*.
3. Interim interview and installation of WM *(all participants)*
4. *With-WM* tracking, with WM installed *(all participants)*.
5. Closing interview and uninstall of WM *(all participants)*.
6. *Post-WM* tracking *(all participants)*.

Figure 6.1 shows how the two tracks differed in terms of their participation in the various stages of the study. In summary, the track 1 participants did not take part in stage 2 (pre-WM tracking), as stages 1 and 3 (the initial and interim interviews) were combined in the initial evaluation reported in **Chapter 5**. Therefore they proceeded straight on to stage 4. **Table 6.3** provides a detailed breakdown of participation on an individual basis.

Throughout the study, data was collected through a range of methods including interviews, diary and logging. A range of methods were employed for two reasons. Firstly, it was envisaged that their triangulation would help build a rich picture of participants' behaviour. Secondly, the author also had an interest in exploring the worth of each method.

Main Study ID	ID in Exp. Study (see Ch. 4)	ID in Initial eval. (see Ch. 5)	Age	Sex	Job Role	Operating System	# file folders	# email folders	# BM folders	Cross-tool profile
F1	P1	F1	35-40	M	Researcher	Win2000	33	50	3	CT2 (F1, E2, B2)
F2	P2	F2	20-25	M	Student	Win2000	128	41	55	CT1 (F1, E2, B1)
F3	-	F3	30-35	F	Student	WinXP	139	10	7	CT3 (F1, E3, B2)
F4	-	F4	20-25	M	Student	WinXP	31	33	196	CT1 (F2, E2, B1)
M5	-	-	25-30	M	Student	Win2000	59	20	11	CT2 (F2, E2, B2)
M6	-	-	20-25	M	Student	Win2000	235	10	6	CT1 (F1, E1, B1)
M7	-	-	25-30	M	Student	Win2000	28	6	0	CT3 (F2, E3, B3)
M8	-	-	30-35	M	Researcher	Win2000	69	10	26	CT3 (F2, E3, B3)
Average							90.3	22.5	38.0	

Table 6.1: Participants in the main study

The following sections discuss each stage of the study in more detail. Copies of the experimental materials are included in **Appendix B**.

Stage 1: Initial Interview (all participants)

The initial interview followed a similar format to that employed in the exploratory study in **Chapter 4**[26]. Participants were asked about their PIM practices regarding files, email and bookmarks in turn. An additional question was added regarding views on existing levels of integration between the three PIM-tools. Note that the privacy precautions outlined in **Chapter 4** were also followed here. Studies were carried out in the work environment of the participant and took about one hour. All interviews were recorded on mini-disc and fully transcribed.

In the exploratory study, folder structures had been recorded via a screenshot and transcribed by hand. To automate this process in the main study, a tool called *WorkspaceSnapper* (WS) was developed by the author. WS recorded the file, email and bookmark folder structures as a text file, along with counts of items within folders. To limit intrusion, details of specific items – such as filenames – were not recorded. During the interview, WS was installed and used to obtain snapshots of the initial folder structures. Participants were shown the resulting text file to alleviate any privacy concerns. After the profiling interview, WS was left installed.

Stage 2: Pre-WM Tracking (track 2 participants only)

The PIM practices of the four *track 2* participants (M5–M8) were observed over several weeks *before* WM was installed[27]. This was done to characterise their "normal" PIM behaviour, and so better ascertain the effect of the design intervention. Average participation in stage 2 was 57 days (min: 32, max: 75, SD: 21.6). Multiple methods of data collection were employed to help build up a rich picture of participants' behaviour:

- *Snapshots of the three folder structures* – Participants were asked to manually initiate snapshots using WorkspaceSnapper to lessen the infringement of their privacy. Snapshots were requested via email at two-week intervals.

[26] Profiling interviews were not carried out for participants F1 and F2 since they had already taken part in the exploratory study.

[27] The track 1 participants were directly exposed to WM during the initial evaluation reported in **Chapter 5**, and therefore did not take part in stage 2.

- *Diary* – Participants were also asked to keep a diary of significant incidents relating to the management of the three collections. Two incidents were provided as examples: (1) creating a new folder, and (2) failing to locate an item.

Stage 3: Interim Interview (all participants)

The *track 2* participants then took part in a 30 minute interim interview[28]. Firstly, they were questioned regarding major events in the three collections of personal information over stage 2. A transcript of folder changes and diary events was used as a shared resource in the interview (see **Section 6.2.5**). Then, WM was installed on their machines, folder-mirroring was demonstrated by the author, and the participants were asked for their first impressions.

It was difficult to find users with a set of PIM-tools that were fully compatible with WM, and many potential participants had to be ruled out. **Table 6.2** summarizes the incompatibilities encountered for the final participants which limited the extent of mirroring. In each case, they were asked to consider whether they would have mirrored events, and if so, to perform mirroring manually. Participant M5 stored his personal files on a UNIX-based network drive which was incompatible with the file-monitoring capabilities of WM. Participants M3 and M7 managed files in two areas of the file system, whilst WM was limited to monitoring one area. M4 and M5 used MS Outlook Express to manage email, rather than MS Outlook as required by WM. M5 switched to MS-Outlook before installing WM, as he reported planning to do for some time.

Participant	File-related problems	Email-related problems	Bookmark-related problems
F1	-	-	-
F2	-	-	-
F3	Personal files split over two areas of the file system (Desktop and My Documents)	-	-
F4	-	Use of MS-Outlook Express (incompatible with WM)	-
M5	Use of network drive (incompatible with WM)	Use of MS-Outlook Express (incompatible with WM). User agreed to switch to MS-Outlook.	-
M6	-	-	-
M7	Personal files split over two areas of the file system (My Documents and 'D' drive)	-	-
M8	-	-	-

Table 6.2: WM installation problems: incompatibilities with PIM-tools

[28] For the *track 1 participants*, this stage was reported in the initial evaluation in **Chapter 5**.

Stage 4: With-WM Tracking (all participants)

The next stage involved the tracking of participants' PIM practices with WM installed. Average usage of WM was 44 days (min: 16, max: 93, SD: 50.4, see **Table 6.3** for more detail).

Both methods of data collection from stage 2 were employed: (1) bi-weekly snapshots of the three folder structures captured with WS, and (2) a diary of significant events. Additionally, two other forms of data collection were used. Firstly, occasional interviews were carried out to check WM was working satisfactorily, and to get feedback. Secondly, WM maintained a log of mirroring events. Apart from the early version used in the feasibility study, WM was robust and did not crash. By default, WM was started automatically at start-up, and most participants left it running continuously whilst their computer was switched on.

Stage 5: Closing Interview (all participants)

In the closing interview, participants were asked for feedback on the WM prototype via a series of questions addressing impact on file, email and bookmark management in turn. Secondly, participants were asked about changes to their PIM strategies over the course of the study to date, and what factors had influenced those changes. Finally, WM was uninstalled from their computer[29].

Stage 6: Post-WM Tracking (all participants)

Approximately six months after the closing interview, participants were requested for a final snapshot using WS, after which it was uninstalled.

Average total participation was 286 days (min 218, max 309, SD: 32.2). Participation in the different stages of the study varied between participants and is summarized in **Table 6.3**.

6.2.5 Data Analysis

All interview and diary data was transcribed into one text file for each participant. An initial coding scheme was developed relating to areas of key interest: (1) feedback on WM, and (2) comments relating to changes in strategy. The coding scheme was iteratively applied to the

[29] Participant F2 requested to keep WM, and continued to use it for 80 days after the study had finished

Participant	Stage 1: Initial interview	Stage 2: Pre-WM tracking (# days)	Stage 3: Interim interview and WM installation	Stage 4: With-WM tracking (# days)	Stage 5: Closing interview	Stage 6: Post-WM tracking	Total participation (# days)
F1 (track 1)	✓(see exploratory study, **Chapter 4**)	-	✓(see initial evaluation in **Chapter 5**)	57	✓	✓	260
F2 (track 1)	✓(see exploratory study, **Chapter 4**)	-	✓(see initial evaluation in **Chapter 5**)	120	✓	✓	309
F3 (track 1)	✓	-	✓(see initial evaluation in **Chapter 5**)	143	✓	✓	309
F4 (track 1)	✓	-	✓(see initial evaluation in **Chapter 5**)	111	✓	✓	305
M5 (track 2)	✓	32	✓	65	✓	✓	219
M6 (track 2)	✓	75	✓	18	✓	✓	302
M7 (track 2)	✓	75	✓	16	✓	✓	306
M8 (track 2)	✓	46	✓	20	✓	✓	281
Average (#days)	-	57	-	68.75	-	-	286

Table 6.3: Summary of participation in each stage of the main study

data, and extended with additional interesting themes that came to light. A sample of the qualitative data collected is shown in **Appendix C** on page 282.

The folder snapshots recorded in stage 1 were analysed in terms of *organizational dimensions*, and *folder overlap*. Participants' organizing strategies were also characterized, and a cross-tool profile produced. Please see **Chapter 4** for detail on these three techniques.

All longitudinal data was collated into a *workspace evolution transcript* (WET) for each participant. The WET included the following pieces of information:

- *Incremental changes to the folder structures* – These were identified manually for each of the three PIM-tools. Changes in the overall number of folders and unfiled items were also calculated to ascertain the growth of the collections.
- *Folder-related events* – Events such as folder creation were identified and annotated with any relevant diary or interview comments.
- *Other events* – Events that may have had an impact on PIM behaviour were also included, e.g. holidays, starting or finishing a project, or technical problems.

Folder-related events in stage 4 were coded as follows:

- *Type of folder event* – Did the event relate to a creation, deletion, or renaming?
- *Source and trajectory of event* – What was the source PIM-tool for the event: files, email or bookmarks? What destination PIM-tools was the event mirrored to? (see **Figure 6.2**).
- *Folder details* – including name, organizational dimension, and depth
- *Was the event mirrored?* – Was WM used to mirror the folder event? If so, which PIM-tools was it mirrored to?
- *Were the mirrored folders subsequently used?* – This was based on a simple criterion: did the folder contain any items at the end of stage 4?

Events were also annotated with relevant comments from the diaries and interviews. This highlighted examples of *mistaken mirrorings* (when the participant did not intend to mirror an event, but did so accidently), *missed mirrorings* (when a participant did not mirror, but subsequently indicated that it would have been useful to do so), and *manual mirrorings* (when

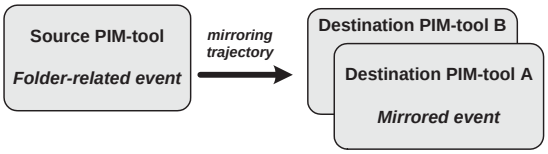

Figure 6.2: The trajectory of a mirroring event

mirroring was performed by the participant, e.g. due to an incompatibility between WM and a PIM-tool).

Table 6.4 shows a portion of the WET for participant F2 from during stage 4. Each line in the table corresponds to one folder creation event. The table shows seven mirrorings of creation events, six of which relate to a particular project, "BOD" (project name changed). Each event is emboldened and underlined in the column corresponding to the source PIM-tool. Mirrored folders are underlined and italicised. For example, the first event shows a `Meetings` sub-folder being created under the `BOD` folder in the file collection, and mirrored to email only. The final column indicates whether newly created folders were put to use by the end of stage 4.

Date	Folder event description (all are creation events)	File system	Email	Bookmark	Was folder used to store items by the end of stage 4?
12-Nov-02	Mirror: from files to email	**BOD/Meetings**	*BOD/Meetings*	-	Used in files (many subfolders), email (many subfolders)
12-Nov-02	Mirror: from files to email	**BOD/Meetings/ TMT**	*BOD/Meetings/ TMT*	-	Used in files (2 subfolders), email (2 subfolders)
12-Nov-02	Mirror: from files to email	**BOD/Meetings/ TMT/2002_1113**	*BOD/Meetings/ TMT/2002_1113*	-	Used in files (1 item), email (4 items)
12-Nov-02	Mirror: from files to email	**BOD/Meetings/ PMC**	*BOD/Meetings/ PMC*	-	Used in email (1 subfolder)
12-Nov-02	Mirror: from files to email	**BOD/papers**	*BOD/papers*	-	Used in files (6 items), email (1 item)
21-Nov-02	Not mirrored from files	**BOD/WP4/ htmldocs**	-	-	Used in files (>10 items)
28-Nov-02	Mirror: from email to files and BM	*Context-Aware*	**Context-Aware**	*Context-Aware*	Used in files (12 items)
02-Dec-02	Mirror: from files to email	**BOD/audit**	*BOD/audit*	-	Used in files (9 items), email (12 items)
02-Dec-02	Not mirrored from files	**BOD/WP4/ Mpeg7Schema**	-	-	Used in files (>10 items)
03-Dec-02	Not mirrored from files	**BOD/audit/ graf**	-	-	Used in files (3 items)
03-Dec-02	Not mirrored from files	**BOD/audit/ hutter**	-	-	Used in files (3 items)
04-Dec-02	Mirror: from files to email and BM	**BOD/WP4/ MPEGDocs**	*BOD/WP4/ MPEGDocs*	*BOD/WP4/ MPEGDocs*	Used in files (2 items), email (1 item)
06-Dec-02	Mirror: from email to files and BM	*BOD/FP6*	**BOD/FP6**	*BOD/FP6*	Used in files (3 items), email (13 items)

Table 6.4: Extract of the workspace evolution transcript from stage 4 for participant F2.

6.3 Overview of Results

A sample of the qualitative data collected for each participant is shown in **Appendix C** on page 282. The results from the main study are divided into four sections as follows:

1. **Section 6.3.1** provides a brief overview of participants' profiles.
2. Usage of WM varied dramatically between participants, along with their level of PIM activity. Therefore, **Section 6.4**, presents a case study summary of each participant.
3. **Section 6.5** focuses on the evaluation component of the study. Usage of WM is reported, along with participants' positive and negative feedback on the design.
4. Finally, **Section 6.6** reports other findings, not directly related to the WM evaluation, such as changes in organizing strategy.

6.3.1 Participant Profiles

All eight participants actively collected files, email and bookmarks. As in the exploratory study, behaviour varied between participants, and between tools for individual participants. A brief summary is presented as follows. All were active collectors and organizers of document files (average: 94 folders). In email, seven participants had large inboxes. Three of these combined a large inbox with extensive filing (F1, F2 and F4). Participant M6 pursued a frequent-filer strategy. The remaining four participants, F3, M5, M7, M8, had large inboxes and filed only a few messages everyday. On average, participants had 22 email folders. Bookmarks were indicated to be of low importance by seven of the eight participants who collected them at a very low rate (average 15 folders). There was one exception, participant F4, who collected bookmarks extensively, distorting the overall average total of bookmark folders up to 38. Cross-tool profiles were calculated using the method outlined in **Section 4.5.4**: CT1 (3 participants), CT2 (2 participants), and CT3 (3 participants). They are reported along with profile details in **Table 6.1**.

Seven of the eight participants were involved in long-term research, teaching, and administrative activities, reflecting their academic careers. The one exception was participant M6. He was as an undergraduate with a highly structured set of short-term activities corresponding to his degree courses . As in the exploratory study, all participants proved to be very open. None of them restricted access to their personal collections.

6.4 Participant Case Studies

As behaviour varied enormously between the eight participants, case study summaries of each are presented as follows. Each case study summarizes usage of WM, major events (e.g. OS reinstalls), and changes in PIM strategy.

Participant F1

Participant F1, cross-tool profile CT2 (F1, E2, B2), was a male lecturer at Imperial College London (ICL). Initially he was highly positive towards WM: *"You only have to create a folder once ... you create a [file] folder, you create a word document in that folder – and the next thing you think oh I have to do a web search on the topic. So you do a web search and you find some interesting websites, but you don't really have to think about where you're going to store those websites because you can put them in the folder that's already there"*. However, although he ran WM for 57 days, he made relatively little use of it, only mirroring 4 folder creation events. F1 explained that the low usage was due to the fact that he was changing university and had been away from his computer for long periods of time. After moving to his new job, he proceeded straight onto stage 6. However, in his closing interview he expressed a desire to continue using WM: *"I would like to create equivalent folders in the file manager [to the 'Eyegaze' email folder] but I haven't got time. I haven't got your program here"*. In the process of moving, he transferred his files and email, but abandoned his bookmarks. This illustrates the relatively higher long-term value of those two collections.

Participant F2

Participant F2, cross-tool profile CT1 (F1, E2, B1), was a male PhD student at ICL. Out of all the participants, he made the most extensive use of WM – mirroring 26 creation events over the 120 days he had WM installed. Of these, 21 were related to a major group project called 'BOD' (name changed). His most common mirroring trajectory was files to email (18 events). Of the 26 events, he identified 2 mistaken mirrorings, and 5 manual mirrorings (made when WM was not operating). He chose to carry on using WM after the closing interview for an additional 80 days. His primary reason for using WM was to increase the consistency between different folder structures in support of his projects: *"[WM] helps with project management. For example, I*

started the 'BOD' project by creating a folder in email. Straight away, I was prompted whether I wanted it under documents as well. Therefore it was synchronized from the beginning rather than working in a hotchpotch". He also stated that through the prompting, WM increased his reflection on PIM, resulting in an improved state of organization: *"I think it's forced me to think about my workspace more, and in particular to synchronize between outlook and my files. Before I was not being methodical and I would lose track of things. Now things are more consolidated and structured"*. Despite his take-up in mirroring, F2 did not make any significant changes in organizing strategy. An extract from his WET is provided in **Table 6.4**.

Participant F3

Participant F3, cross-tool profile CT3 (F1, E3, B2), was a male PhD student at ICL. He was highly organizing-neutral at the start of the study, *"I'm lazy quite frankly. I don't naturally organize. I'd have a pile as opposed to something filed. And it's also partially due to the fact I have amazing spatial awareness really - I don't have to file things, I can remember [where they are]"*. Initially, he provided negative feedback with respect to WM, *"Its just not my scene, you need someone else"*.

However, 120 days into the study, he made a significant change in his file organizing strategy as part of a New Year resolution *"to be more organized"*. In summary, he reorganized his files by moving his active documents to the desktop and creating a number of new folders there. His change in strategy is discussed in detail in **Section 6.6.3**. At that point he also started *manually mirroring* new folders, between the Desktop and email (4 events). He also used WM to mirror 5 folder creation events between "My Documents" and bookmarks. Participant F3 thus provide a key example of emergent PIM behaviour which would not be clear from a one-off lab study.

In the closing interview, he suggested that WM may be appropriate for someone setting up folder structures for the first time: *"I'd say you get you'd get some seriously different results if you installed WM for someone with a brand new computer ... I think you'd get a very different dynamic, and you my might even get a completely different usage out of the same person. You installed it after 'Downloaded Papers' was made in 'My Documents'. If the mirror had opened up when I'd done that I would have said 'yes stick it in the Favorites as well' ... but most of my pre-organization had already occurred by then, reasonably quickly after purchasing the computer"*.

Participant F4

Participant F4 was a female PhD student at ICL, with cross-tool profile CT1 (F2, E2, B1). In stage 1, she complained in depth about not having enough time for PIM, and as a result feeling disorganized. Despite this lack of time, she was the only participant to collect and structure bookmarks extensively. However, 70% of her 250 bookmark folders had "failed" in terms of containing 2 items or fewer). She had also restarted her bookmark collection three times, on each occasion storing the old collection in a "`old Favourites 200x`" sub-folder.

She provided positive initial feedback on WM, and made significant usage over the study – mirroring 13 newly created folders, 8 of which were from bookmarks to files and email. In particular, she welcomed the increase in consistency between folder structures: *"Now its more consistent - and easier to remember. Good for tracking, makes it easier to remember where things are. It forces/reminds you to organize. When I've got a deadline, I save things anywhere. I plan to organize at a later date but never get round to it"*. Due to the incompatibility of WM with her email client, MS-Outlook Express, she did not mirror to email, but reported that she would have found it useful to do so for many of the folders which related to conference submissions. In the closing interview, she also reported missing 2 potentially useful mirroring opportunities due to lack of time and dismissing the WM dialog box.

One limitation of WM that she identified was its focus on one area of the file system, and she requested WM support for mirroring between multiple file areas. However, she also observed that the focus on one area had a key benefit: *"It's good to have everything centralized into one directory. Before I had a problem remembering where to find things. Now it's more consistent - and easier to remember. Previously I'd create a separate folder for each project or conference - but I'd put it anywhere. Mainly on my D-drive but it could be anywhere"*.

Participant M5

Participant M5, cross-tool profile CT2 (F2, E2, B2), was a male PhD student at University College London (UCL). He was one of two participants to make a change in organizing strategy, and cited the study participation as a key factor in reorganizing his files and email. This change in strategy is discussed in detail in **Section 6.6.3**.

He encountered two installation issues with WM. Firstly, his email tool was Outlook Express

which was incompatible with WM. However, as he had planned before the study, he switched to Outlook before installing WM. Secondly, he stored his personal files on a network drive which was incompatible with WM. This had an impact on his usage of WM: "*The tool could not prompt me to mirror anything in Outlook because the only thing it could have prompted me for was the creation of bookmarks, which I don't use! The ones that could have been useful it couldn't prompt me for because they were in the 'H:' drive*". Also, he was initially negative towards WM, arguing that he made relatively little use of folders in email and bookmarks. However, over the course of the study he *manually* mirrored 4 folders between files and email, and was more positive by the closing interview: "*Quite impressively, the idea of mirroring structures in emails and in the folders didn't really cross my mind. I think before I had similarly named folders in both systems but they were never agreed in any way. And now I think the structures are a bit more coherent*". This represents a second example of emergent behaviour over time.

He also acknowledged the increase in reflection offered by WM: *"the act of being prompted ... is useful because it reminds you that you should think about how you should organize your stuff. But its also someone saying "clean up your room"*. However, he interpreted this as a hint to do less PIM: *"When I get the WM message up it reminds me that I'm wasting time with information management, creating folders and putting things in folders!"*.

Participant M6

Participant M6, cross-tool profile CT1 (F1, E1, B1), was a male MSc. student at ICL. He was initially negative towards WM. Although he was highly organized in all three tools, he considered his organizational needs to differ between them. His files were extensively structured, but although he organized his email extensively, he only did so in a few top-level folders. However, he observed a partial overlap between files and bookmarks: *"Bookmarks and 'My Documents' are very much more related to each other. If you say in Bookmarks, `'my phd work'` and then underneath you have `'centra-fusion'` and `'cog-robotics'` and `research-labs` ... the first two you would have in files as well, but the third thing you probably wouldn't as you wouldn't put files in there"*. During the study, he only mirrored one folder creation, `Loreal`, from email to files, despite having no installation problems.

At the end of the study, he suggested that mirroring should be one-way from email to files, for top-level folders only: *"In my opinion it is 'one to many', or like 'one to a folder structure' really.*

You know ... its always email (one thing) links to one thing in my documents which does not necessarily have to be top-level, it could be above or could be in my documents directly but it's just more likely to have other branches underneath". Again, this change in opinion regarding WM highlights the benefits of evaluating over the long-term. M6 made no change in strategy over the course of the study.

Participant M7

Participant M7, cross-tool profile CT3 (F2, E3, B3), was a male PhD student at UCL. He was *organizing-neutral* in all three PIM-tools, and considered filing to be low priority.

He responded unfavourably to WM from the start, expressing a requirement for a stronger form of integration between the tools: *"My guess is I won't like it. I want something I can use in every tool. I want a tool with everything in it, so this isn't enough to warrant my adoption. I don't need it, as I don't organize with folders particularly. I mean I like the concept, the idea of unifying these working differences. I do think that's necessary and useful but I would want that next step - Version 2 or Version 10 - the complete new file-web and email manager - that would be interesting*". He also foresaw that empty folders resulting from mirroring would cause a problem for him: *"I'd like to create a folder that would be accessible from all three, rather than just an extra empty folder in the other two so I wouldn't get this massive bloat ... the problem with the mirroring is the empty folders ... and that to me would be annoying and would impact how I work*".

Despite not having any installation problems, he made no use of WM during the trial: *"There's been no chance - mainly because it hasn't actually done anything as I haven't actually created any folders. Also, even if I did, I haven't felt the need to mirror them*". This illustrates the logistical challenge of evaluating PIM-tools via a field trial, the experimenter can not force the participant to use the designed functionality.

In the closing interview, although he had not used WM, he indicated that certain users may find it useful: *"if they used the same kind of folder structures in the different applications ... I might recommend it because I'd see it as being useful for them conceptually to mirror the folder structures in the other environments*".

Participant M8

Participant M8, cross-tool profile CT3 (F2, E3, B3), was a male research assistant at UCL. He used the metaphor of a house to describe the different levels of organizing he employed in the three tools: "*my living room [file space] is really tidy because I've been making the effort to tidy it up. The rest of the house [emails and bookmarks] is a tip because everything I need is in the living room now ... Only certain elements are tidy. Other elements are rotting!*"

Although he encountered no installation problems with WM, and was initially positive, he made no use of it over stage 4. However, he remained positive about the tool: *"Partially [I haven't used it] because I've been working on another machine. And partially because I tend to have a structure which I put things in, keep that for a period of time, then have a spring-clean and change the structure. And I haven't been through the process of changing the structure with WorkspaceMirror running. Its something that I'll do eventually, but I just haven't done my reorganization recently"*.

Participant M8 made a number of design recommendations including the need to limit mirroring to top-level project folders: *"once you've mirrored there [at the top-level] - you might not want to mirror it further down. I think it would work at that level. Here are the projects I'm working on. Here are the emails about that project. And here are web links related to the project. That makes sense to me"*.

6.5 WM Evaluation

The above case studies surveyed each participant's usage of WM in turn. This section focuses in depth on the results from the WM evaluation. Firstly, **Section 6.5.1** summarizes the usage of WM based on the objective data collected in stage 4. Then, **Section 6.5.2** presents qualitative feedback regarding WM, both positive and negative. Finally, **Section 6.5.3** reports the design recommendations suggested by participants.

6.5.1 Use of WM

This section provides an overview of the objective data recorded during stage 4. In total, 57 *folder creation events* were mirrored (not including test mirrorings performed during the interim interview). However, the usage of WM varied widely between participants as indicated in the case studies above. **Table 6.5** provides an overview on an individual basis.

Six of the 8 participants mirrored folder creation events during stage 4:

- Two participants, F2 and F4 made extensive use of WM, mirroring 26 and 13 newly created folders respectively, over an average of 116 days. For F2, 21 folders related to his 'BOD' project, and the most common source tool was files (20 folder creation events). The most common organizational dimensions were *project* (12) and *event* (5).

  For participant F4, the most common organizational dimensions for mirrored folders were *project* (4), and *event* (6). The event-based folders related to conferences she was considering submitting papers to. In contrast with F2, her most common source tool was bookmarks (10 folder creation events).

- Participant F1, despite being very positive towards WM, only mirrored 4 folder creation events (all *role* or *project*). He mirrored at least one event from each PIM-tool. He highlighted his job change as a primary cause of his low PIM activity and WM usage.

- Participant M5 *manually* mirrored 4 folders from files to email, with organizational dimensions *project* (3), and *document type* (1). He did not use WM to mirror due to its incompatibility with his Samba-based network drive.

- After his New Year reorganization, Participant F3 *manually* mirrored 4 folder creation events (3 from the 'Desktop' to email, and 1 from 'Desktop' to bookmarks). He employed

manual mirroring as WM was not compatible with the 'Desktop' area of the file system. He also used WM to mirror 5 events from files to bookmarks. His events were based on a wide range of organizational dimensions including *format* (2) and *role* (2).

- Participant M6 mirrored 1 *project* folder from email to files.

One immediate observation is that all mirrored events related to *folder creations*. No participants used WM to mirror a folder delete or folder rename event, except to test the WM functionality during stage 3. As reported in **Chapter 5**, WM was limited to mirroring renaming events within a particular folder. Renames corresponding to moving a folder between parent folders were not supported by WM, and resulted in a warning message being displayed. However, no users reported encountering this over the study. Possible reasons for the bias in favour of creations over deletes and renames are discussed in **Section 6.7.1**. The rest of this section focuses on the mirroring of folder creation events.

Mirrored folders were high up in most participants' folder structures. The average depth across all participants was 1.83 (SD: 0.89)[30]. A wide range of organizational dimensions were encountered. Across all participants, the most common dimensions for mirrored folders were *project* (40%) and *event* (22%). These aggregate figures are biased towards those participants who mirrored more folders (F2 and F4).

As noted above, participants employed WM with a range of mirroring trajectories. **Table 6.6** summarizes the mirroring trajectories that were observed. Across all participants, the most common source was files (64% of all events), followed by bookmarks (21%), and email (14%). The most common trajectories were *"files to email"* (45% of all events), *"bookmarks to files and email"* (16% of all events), and *"files to bookmarks"* (13% of all events).

For the six participants who used WM, the percentage of total folder creation events that were mirrored varied substantially. For example, participant F2 mirrored the most folder creation events, 26. Twenty were in files (equivalent to 48% of all file-based creation events), 5 were in email (71% of email creation events), and 1 was in bookmarks (25% of BM creation events). **Table 6.5** provides a detailed summary for each participant.

The remaining two participants, M7 and M8, made no use of WM. However, they both ran WM on their computers to test its robustness, and provided qualitative feedback. Overall, there was

[30]This was biased in favour of participant F2 who mirrored a number of deeper folders related to his 'BOD' project. Without participant F2, the average depth was 1.43 (SD: 0.57).

ID	Cross-tool profile	Initial attitude to WM	Final attitude to WM	Installation problems, see also Table 6.2	Level of WM usage	Source folder events in stage 4 (creates, deletes, renames)	Folder creation events mirrored in stage 4	Source tools and trajectories of mirrored events	% of folder creation events mirrored	WM usage (# days)	Mirrors per day
F1	CT2 (F1, E2, B2)	Positive	Positive		Some use before change of job	Files (3, 0, 0), Email (2, 0, 0), BM (0, 0, 0)	4	Source: files 2, email 2	Files 66%, EM 100%	57	0.07
F2	CT1 (F1, E2, B1)	Positive	Positive		Extensive use, ongoing after study	Files (42, 3, 1), Email (7, 2, 0), BM (4, 0, 1)	26 (5 manual, 2 mistaken)	Source: files 20, email 5, BM 1. Most common traj: “files to email” (18)	Files 48%, EM 71%, BM 25%	120	0.22
F3	CT3 (F1, E3, B2)	Negative	Neutral	files	Some use of WM. Started manual mirroring towards end of stage 4	Files (71, 0, 20), Email (1, 0, 0), BM (1, 0, 2)	9 (4 manual, 1 mistaken)	Source: files. “Files to BM” (5). “Desktop to BM” (4)	Files 13%, EM 0%, BM 0%	143	0.06
F4	CT1 (F2, E2, B1)	Positive	Positive	email	Extensive use	Files (23, 0, 0), Email (0, 0, 0), BM (14, 0, 0)	13	Source: files 2, BM 11. Most common traj: “BM to files and email” (8)	Files 9%, BM 79%	111	0.12
M5	CT2 (F2, E2, B2)	Neutral	Positive	files, email	Some mirroring towards end of stage 4	Files (14, 1, 7), Email (5, 3, 12), BM (0, 0, 0)	4 (all manual)	Source: from files, to email only	Files 29%, EM 0%	65	0.06
M6	CT1 (F1, E1, B1)	Negative	Neutral		Low	Files (12, 0, 0), Email (1, 0, 0), BM (0, 0, 0)	1	Source: from email, to files only.	Files 0%, EM 100%	18	0.06
M7	CT3 (F2, E3, B3)	Negative	Negative	files	None	Files (0, 0, 0), Email (0, 0, 0), BM (0, 0, 0)	0	-	-	16	0.00
M8	CT3 (F2, E3, B3)	Positive	Positive		None	Files (4, 0, 0), Email (0, 0, 0), BM (0, 0, 0)	0	-	Files 0%	20	0.00
Total							57			550	
Average	-	-	-	-	-		7	-		68.75	0.07

Table 6.5: Summary of WM usage

Source PIM-tool	# mirrored creation events	Destination: files	Destination: email	Destination: BM	Destination: files and email	Destination: files and BM	Destination: email and BM
Files	36	-	25	7	-	-	4
Email	8	3	-	0	-	5	-
BM	12	2	1	-	9	-	-

Table 6.6: Trajectories of mirrored folder creation events (all participants)

a marked difference between the track 1 and track 2 participants, who mirrored an average of 14 folders, and 1.5 folders respectively. Possible reasons for this variation are discussed in **Section 6.7.1**.

6.5.2 Feedback from WM Users

Pros and Cons of Mirroring

The core aim of the WM evaluation was to investigate whether the participants would use it to share folder structures between the PIM-tools. A range of positive and negative feedback was received regarding the current design of WM.

The two heaviest users, F2 and F4, both observed and welcomed the increase in consistency, and described how it helped them manage information for a variety of projects (see case studies above). Both also suggested that mirroring lead to easier navigation, e.g. F2: *"Its easier to navigate with a mirrored structure, compared to three different ones"*. Three participants (F1, F3, and M5) who performed more limited mirroring also acknowledged the benefits of an increase in consistency. In addition, participant M8 who did not use WM, imagined that its use would offer benefits: "*It will homogenize that across my PDFs from the web, emails about a particular project, and files about a particular project. I could do that anyway without WorkspaceMirror but I don't ... Why not? Never really thought about it. The use case here would be that there would be a document for a particular project or experiment or study in that case and I could just look at all my emails that relate just specifically to this project. I mean, it's a different way of doing it to at the moment. At the moment I've got a 'ProjectX' group that does not contain anything about that project. So it would be a finer grain of categorization to organize my emails at that level which might be quite useful in terms of finding things again*".

In the closing study, 4 participants (F1, F2, F3, F4) indicated that mirroring was useful between all three tools, whilst 4 (F5, F6, F7, F8) indicated that it was most worthwhile between files and emails. Note that all members of this second group placed little importance on mirroring to their bookmark collections.

However, a general theme mentioned by all eight participants was that mirroring should not follow a one-to-one mapping between PIM-tools due to differing organizational requirements. In many cases, participants had more complex organizing requirements in their file collections compared to email and bookmarks, e.g. F5: "*It doesn't make sense to create an email folder for every single publication so I just have a single submissions folder that goes across the publications and has, let's say, at the moment maybe 30 entries or so. In my H-drive on the other hand, every single publication is a project - and deserves its own folder because it consists of much more files than just the five emails. So that's an example where it makes sense that H-drive and email correspond but are not exactly mirrored*".

M7 felt that mirroring would result in clutter due to unused empty folders. However, comments from several other participants suggested that they felt the benefits of increased consistency between folder structures outweighed the risk of clutter. For example, F3 welcomed having folders mirrored and ready for use in the future, even if they were not used immediately, *"I haven't written any latex so I haven't used it, but I'm keeping it. I think it may be useful"*.

Seven participants suggested that mirroring was particularly appropriate for *top-level folders*, e.g. M8: *"Images related to my project and all the substructure of that project ... it's very difficult to see why you'd want to mirror all that. Once you've mirrored there [at the top-level] - you might not want to mirror it further down. I think it would work at that level. Here are the projects I'm working on. Here are the emails about that project. And here are web links related to the project. That makes sense to me"*.

Section 6.5.3 reports design suggestions relating to making mirroring more selective.

Prompting

Participants had a range of views on the prompts generated by WM. Three (M5, M6, M7) found it annoying, and suggested possible alternatives. For example, M5 suggested WM should prompt more selectively: *"It is not necessary to always replicate - it should prompt me in sensible cases.*

Maybe in higher-level folders, and not in lower level folders". However, M6 noted that it was only a minor problem, *"It kept on popping up and asking me the same silly question ... Well it's not really a problem since its just one cancel. Compared to what Word normally does to you, or Office or Windows - all kinds of harassing boxes - its negligible"*.

Three participants (F2, F3, F4) highlighted the extra decision-making introduced by WM – i.e. deciding whether to mirror a folder event between tools. This contributed to a number of missed and mistaken mirrorings:

- Both F3 and F4 reported missing 2 useful mirroring opportunities since they did not always have time for making such a decision and just pressed the 'cancel' button on the WM dialog, W4: *"It would have been useful to mirror to email but I didn't as there was no time, it [the associated work] was a deliverable"*.
- There were also a number of *mistaken mirrorings* reported by participants F2 and F3 (2 and 1 respectively). Again, participant F3 highlighted rushed mirroring decisions to be the key cause, in which he just clicked the 'OK' button on the WM dialog box.

Three participants (F2, F3, and M5) reported carrying out *manual mirroring*. F2 did so when WM was not running. The other two performed manual mirroring due to WM incompatibilities (see **Table 6.2**). F3 manually mirrored 4 folders from the 'Desktop' to his bookmarks, and M5 manually mirrored 2 folders from his network drive to email.

Getting Started with WM

Participants F3 and M8 noted difficulties in accommodating WM within an existing personal information environment where differing file, email and bookmark folder structures have already been developed. Participant M8 noted that he would need to perform a significant re-organization of his workspace to make WM worthwhile. Although he reported planning to do so, he had not got round to it over the course of the study. Participant F3 suggested that WM would be most appropriate to people setting up a new computer, *"I'd say you get you'd get some seriously different results if you installed WM on someone with a brand new computer about to start to using it ... I think you'd get a very different dynamic, and you might even get a completely different usage out of the same person ... Most of my pre-organization had already occurred by then, reasonably quickly after purchasing the computer"*.

Reasons for not using WM

Three participants, M6, M7 and M8 made very little use of WM, each for a different set of reasons. Their cases are summarized as follows.

Although participant M6 was profiled as *pro-organizing* in all three collections, he had very different organizing behaviour in each. In files he had a deep hierarchy containing 235 folders, whilst his email only contained a 10 top-level folders. He argued for the unidirectional mirroring of top-level folders from email to files only.

Participant M7 was initially unfavourable towards WM, and demanded more powerful integration based on folder-sharing, *"I'd create a folder but it would be accessible from all three - rather than just an extra empty folder in the other two. So I wouldn't get this massive bloat ... the problem with the mirroring and the way I work is the lots of empty folders ... and that to me would be annoying and would impact how I work"*. In any case, during stage 4, he carried out little foldering, stating that he had instead been working on paper.

The primary reason offered by participant M8 for not using WM, was that he had performed very little PIM on his main work computer, as he had instead been using another computer for experimental work. Although he stated that he could foresee benefits to using WM in the future, he also suggested that he would have to perform significant reorganizing of his files beforehand. In other words, he foresaw significant overheads in accommodating WM within his existing personal information environment.

Unanticipated Feedback

Several participants reported benefits and problems due to WM that had not been anticipated by the author.

Firstly, three participants (F2, F4 and M5) reported that prompting from WM lead to them thinking more about PIM than they would normally. F4 saw this as a benefit that encouraged her to be more organized. M5 reported benefits of a very different kind, suggesting that WM encouraged him to spend less time filing, *"When I get the WM message up it reminds me that I'm wasting time with information management, creating folders and putting things in folders"*. Participant F2 argued that the increase in reflection had both positive and negative consequences, F2: *"WM has made me more aware of the directories in Outlook and on the Hard Drive. I'm cer-*

tainly thinking more now about how I organize. This is both good and bad. Good because I'm producing a better organization. But bad, because I'm spending more time doing it [organizing]".

The second unanticipated benefit was reported by participants F2 and F4. They noted that since WM was limited to monitoring one area of the file system they were implicitly encouraged to store more files there to take advantage of the mirroring facility. F4 described this as follows: *"Its good to have everything centralized into one directory. Before I had a problem remembering where to find things. Now it's more consistent, and easier to remember"*.

The final theme concerned *problems due to too much integration between PIM-tools*. Firstly, participant M8 observed that integrated "application suites" such as Netscape Communicator were overly complex, *"I did use Netscape for a while and I found it kind of annoying ... it just seemed like too many functions in one application"*. In terms of WM, participant F3 predicted that the increased integration offered by WM may cause problems for novice users, F3: *"One more thing - talking about novice users ... say my mum. If you gave her your tool I'd worry that she'd have a massive retrieval problem. She saves things and then lose them and then calls me up and asks me where they are. And I need to direct her to them. She'll say 'I saved it in X' but if it all looks the same ... Maybe it's an extreme example but maybe integration can go too far for novice users as well, that's all I'm saying. It could be a problem if all the folders look the same - cos they actually may give hopeless users like her a clue as to where she is"*.

Participant M6 also made a similar comment: *"I would never give it to anyone who wasn't experienced at all ... because again it does a lot for you ... and most people, if they don't know what to do they just say 'yes'! So if my mum was using it I would come home in the holidays and there would be 5000 folders, all empty, all her email lying in her inbox - you know what I mean ... You need someone who's at the stage of using a folder structure and understands folders"*.

6.5.3 Design Recommendations

This section presents the design suggestions made by the participants over the course of the evaluation. All participants, whether they responded positively or negatively to WM, were helpful in making suggestions.

Customizing mirroring functionality

A number of suggestions were made for making the mirroring process more selective, or making it customizable:

- As noted above, seven participants suggested that mirroring should focus on top-level folders only, e.g. M5: *"It should not always prompt me ... it should prompt me in sensible cases. Maybe in higher-level folders, and not in lower level folders"*.
- Three participants expressed the need to mirror a new folder between different locations in distinct folder structures, e.g. M6: *"It would nice if you could browse and say 'I want to create the folder at that level'. You know a button 'browse' where you can select where you want to create a new one."*.
- Two suggested the option to give a mirrored folder a different name in each PIM-tool.
- Two wanted to be able to associate a newly-created folder with another already existing folder in another tool, M6: *"You might have to say 'I don't want to create a folder, because that one already exists' ... You might start a project and not have an email folder, but you receive so many emails on it that you create a folder for it later"*.
- Participant M6 saw the need for a *one-way mirror* from email to files, limited to top-level folders only, *"if you create a folder in email you will nearly always have, or will create, a folder in my documents"*.

Extending mirroring functionality

WM was limited to monitoring one user-nominated area of the file system. Three participants (F2, F3 and F4) expressed the need to monitor more of the file system (e.g. files on different drives or disk partitions). Furthermore, two of these (F2 and F4) raised the potential of mirroring between different parts of the file system, e,g, F4: *"It would be good for you to have separate top-level folders within documents. I could do with one for 'projects', one for 'papers' with categories mirrored between them"*.

Two participants talked about how the mirroring scheme could be made "more intelligent" by automatically mapping a new folder in one PIM-tool to one with a similar name elsewhere,

e.g. F3: *"If I was duplicating a folder that I didn't need to duplicate, like I did there - it could have reminded me. And then I would have gone 'ah', instead of creating a new folder and arsing around like that, what I should have been doing was using that one"*. One participant suggested that folder-mirroring could be combined with a *history-based mechanism*. This would lessen the potential clutter due to unused folders, by hiding unused folders by default.

Participant F1 argued that mirroring could be extended to other PIM-tools local to the desktop, such as photo managers. He also raised the possibility of applying folder-mirroring to the organizational schemes used to manage software applications in MS-Windows, such as the "Start Menu", the "Program Files" folder, and clusters of program icons on the desktop [31].

Finally, participant F4 was interested in "collaborative mirroring" – sharing folder structures between users, *"How about institutional templates? The department could define starting points for PhD students. A PhD student might want their supervisor's folders. My Mum might for instance like Elton John's folder structure or Schumacher's!"*.

Additional integration

Several suggestions were made regarding using WM as a platform on which to add extra integration mechanisms. Two participants (F1 and M6) explained how mirroring could enable improved support for attachments, e,g, F1: *"If I got an email with an attachment and I dragged that email into the MERL [email] folder. Then the attachment should be filed in the file system in the MERL folder"*. Since mirrored folders relating to a particular activity are implicitly linked in terms of their location, two participants suggested that it would be straightforward to provide a facility to directly navigate between equivalent folders in different tool contexts.

Three participants (F1, F2, and F4) wanted increased support for cross-tool project management. Two participants wanted a "cross-tool start-project" facility, e.g. 6.1: *"Sometimes a project is started after an exchange of emails and so usually you keep the emails in your inbox ... after a while it becomes clear that the project is going to emerge and then what I'll do is create a new folder in my email, copy all those emails in there and that gets mirrored to the other things ...*

[31] Interestingly, no participants suggested applying folder mirroring around the wider personal information environment beyond the local computer, such as: (1) to a user's other computers, (2) to other devices involved in PIM such as PDA devices, and (3) to on-line PIM-tools such as web-mail. Within the web domain, one can also imagine the application of mirroring to "web portals" that offer a suite of PIM-tools. For instance, providers such as Yahoo!, Google and MSN offer a range of PIM tools (e.g. email, task list, contacts, document storage, notes). Currently, each PIM-tool enables the management of a distinct collection of personal information which must be separately structured. The application of folder mirroring to other domains is discussed in **Chapter 8**.

that would be good. But sometimes I say we've got this new project which I want to start and I'm going to start it now. This is more or less the same as you get in Visual Studio where you say 'new project' and it creates all the necessary folders for you. Maybe you ought to have that on the desktop". Two (F1 and F4) were also interested in cross-tool archiving, e.g. F1: *"If the project has finished it would be archived or something like that. It would go somewhere - like a central folder like 'Completed Projects' where you get all your emails, all your files and all your bookmarks together"*. Furthermore, two participants suggested using templates for setting up multiple folders and files for new projects, e.g. *F4: "You could have a project template to set up a sub-tree structure in one action. Example standard files would include project plan, document templates"*.

Participant M7 was adamant that the current level of integration offered by WM was not enough and he wanted a more advanced mechanism based on folder-sharing: *"This isn't enough to warrant my adoption. Well sharing means that the different objects (well files and email and bookmarks) actually share the same structure. Whereas mirroring means that the actual folder structure is copied but the actual contents of the folders in the bookmarks isn't visible from the email. For me mirroring is not really useful. Sharing I'd be a lot happier with, because it wouldn't impact at all the way I work currently ... so I'd create a folder but it would be accessible from all three - rather than just an extra empty folder in the other two"*.

Such requests for additional integration stand in contrast to the dangers of over-integration reported in the earlier section, "Unanticipated feedback".

The evaluation results presented in this section are discussed in **Section 6.7.1**.

6.6 Other Study Findings

This section presents results from the field trial that were driven by the second objective of the study – to investigate longitudinal aspects of PIM. **Section 6.6.1** reports the *external factors* that affected PIM behaviour during the study. Then, **Section 6.6.2** analyses the *growth rates* of the file, email, and bookmark collections. Next, **Section 6.6.3** reports participants' *changes in organizing strategy*. Finally, **Section 6.6.4** presents findings highlighting the *background nature of PIM*.

6.6.1 External Factors

A key consideration in any field trial is the *typicality* of the study period. The following external factors were noted as having an influence over participants' PIM activities:

- *Christmas holidays* – The study ran from Summer 2002 to Spring 2003, and therefore included the Christmas holidays, as well as other ad-hoc holidays for various participants.
- *Natural lulls in computer usage* – Both M7 and M8 noted that the study coincided with a period of time in which they made relatively little use of their primary work computer.
- *Major life events* – Two months into the study, participant F1 changed job. However, after a short interruption, he continued to take part. During the move he transferred his file and email collections, and restarted his bookmark collection.
- *Other computer problems* – Participants F2 and M6 had to perform complete reinstalls of their operating systems for reasons unrelated to the study or the WM design intervention. Fortunately neither lost any data, but in each case their file system was recreated, and consequently some date-related metadata was lost.

The range of unforeseen events that occurred highlight the challenges of performing long-term field studies. Many of these were beyond the control of the researcher, and were the consequence of working in an uncontrolled real-world context. Additionally, the effect caused by the WM design intervention is acknowledged, and is taken into consideration as a factor that contributed towards changes in organizing strategy.

6.6.2 Growth in Collections

The capture of folder snapshots during the study enabled the calculation of the growth in the three collections. Changes were calculated as follows:

- *Item growth rate* – The net change in the total number of items in a collection, per day of participation.
- *Folder growth rate* – The net change in the total number of folders in a collection, per day of participation.

The growth rates relate to the period of time in which the WorkspaceSnapper tool was installed on the participant's computer. For the *track 2* participants (M5–M8), this equated to the entire study period (stages 1–6). Tracking varied for the *track 1* participants. Participants F2, F3 and F4 were monitored from partway through stage 4 until the end of the study. Participant F1 changed job before monitoring commenced, and so his figures relate to stage 6 after his job change.

The following procedures were employed when measuring the growth rates in each collection:

- *Files* – Two participants, F3 and M7, split their file management between two areas of the file system. For these two, the two areas were treated as a single combined collection. For all participants, areas of the personal file collection used solely for code development, simulations, temporary storage, and downloaded software were not included. In these cases, only the root folder and the items stored there were counted.
- *Email* – Except for the 'Inbox', default folders and items contained therein were excluded. For MS-Outlook, these included 'Sent Items', 'Drafts', 'Outbox' and 'Trash'.
- *Bookmarks* – Again, default folders and items contained therein were excluded. In MS-Internet Explorer, these included 'Media', and 'Channels'.

The intention was to compare the growth rates for the primary collections of files, email and bookmarks. It is acknowledged that the figures do not take into account other collections: all participants stated that they had personal files, email and bookmarks on other computers (e.g. web-based email collections). However, the aim in this study was to obtain an indicative comparison based on the primary collections only. **Table 6.7** summarizes average changes in collection size. Each collection is discussed in turn below.

Participant	**# file folders added per day (average)**	**# file items added per day (average)**	**# email folders added per day (average)**	**# email items added per day (average)**	**# BM folders added per day (average)**	**# BM items added per day (average)**
F1	0.17	2.05	0.07	6.08	0.01	0.06
F2	0.22	7.43	0.12	6.14	0.06	0.08
F3 (archived files)	*0.06 (archiver)*	*-0.19 (archiver)*	0.03	3.05	0.04	0.17
F4	0.06	1.79	0	*not recorded*	0.13	1
M5 (archived files)	*0.01 (archiver)*	*5.97 (archiver)*	0.08	9.5	0.01	0.11
M6 (archived email)	0.4	9.58	*0.01 (archiver)*	*-4.26 (archiver)*	0	0.03
M7	0.13	4.14	0.01	5.83	0	0.08
M8 (archived email)	0.12	1.67	*0.04 (archiver)*	*-21.02 (archiver)*	0	0.09
Average	**0.15**	**4.06**	**0.05**	**0.76**	**0.03**	**0.20**
SD	0.12	3.35	0.04	10.52	0.05	0.32
Minimum	0.01	-0.19	0.00	-21.02	0.00	0.03
Maximum	0.40	9.58	0.12	9.50	0.13	1.00
Notes	*Average without archivers [n=6]: 0.18 (SD 0.13)*	*Average without archivers [n=6]: 4.44 (SD 3.11)*	*Average without archivers [n=6]: 0.05, (SD 0.05)*	*Average without archivers [n=5]: 6.12(SD 2.29)*		

Table 6.7: Growth rates of file, email and bookmark collections

Growth of File Collections

The average growth rate for files was 0.15 folders, and 4.06 items, per day of participation. File collections increased in size (in terms of folders and items) for all but one of the participants (F3). For F3, the number of files decreased due to the archiving he performed, transferring a number of items to his home computer and network drives. M5 also archived to save on space on his network drive. Despite his archiving, M5's collection increased in terms of both files and folders over the course of the study.

Other participants reported that they performed archiving very rarely, e.g. M7: *"I've done one spring-clean in the past year ... my past experience with computers is that I tend not to"*. In contrast to F3 and M5, many archived material (such as websites) *into* their file collections, which contributed towards the high growth rate. One mentioned reason for not archiving material out of collections was that it made items harder to find at a later date. Average growth rates without the two archivers were 0.18 for folders, and 4.44 for items.

Growth of Email Collections

Due to technical difficulties it was not possible to collect message counts for participant F4. This was due to the incompatibility of WS with the storage format in her MS-Outlook Express email tool[32]. Across the remaining seven participants, average email growth was 0.76 for items. The low item growth rate was due to two participants (M6 and M8) who archived an average of 3600 messages out of their collections in one-off tidying sessions. Without the non-archivers, item growth rate increased to 6.12 per day.

Compared to files, a smaller average *folder* growth rate was observed (0.05 compared to 0.15 folders per day for files). All participants except one (M5) had greater folder creation rates in files compared to email, reflecting a greater emphasis on filing in the file context. M5's file folder growth rate was impacted by his file archiving activity.

Growth of Bookmark Collections

For most participants, bookmark collections grew very slowly. Participant F4 was the one exception. She collected bookmarks extensively, having a daily growth rate of 0.13 folders, and 1 item per day.

The remaining seven participants had a much lower growth rate in bookmarks compared to the other collections. The average rates for these seven were 0.02 per day for folders, and 0.09 for items.

Later in this chapter, **Section 6.7.2** discusses these findings in depth.

6.6.3 Changes in Organizing Strategy

During the exploratory study reported in **Chapter 4**, fourteen participants mentioned historical changes in how they managed information. A key aim of the study reported in this chapter was to track and investigate changes in management strategies as they happened. Firstly, reports made in stage 1 regarding historical changes are described. Then, changes in strategy that happened during the main study (i.e. during stages 2–6) are reported.

[32] M5 also started the study using the same email tool, but switched to MS-Outlook two weeks into stage 2.

Reports of Historical Changes

Five participants mentioned historical changes from before the study. In the file collection, two participants (F2 and M8), reported significant increases in organizing tendency, e.g. M8: *"I went through a phase of completely working on my desktop but it gets very cluttered"*. In contrast, F4 reported filing more in the past when she *"had more time"*.

In email, participant M6 reported an increase in organizing tendency, *"I used to have them all in my inbox - and I didn't know who I'd answered - well I do know who I've answered but its like emails would disappear off the end of the list and you never see them again. I got sick of worrying about that. Now I get an email, I put it in the right folder when I've answered it - and when I get too many in the inbox I know that I need to answer some"*.

Three participants (F1, F4, M8) reported changes in the bookmark context, which involved the abandonment of substantial numbers of folders. Whilst F1 and F4 continued to file within new folder structures, M8 abandoned filing altogether, *"I started off with a pre-set idea of where things should go, but when the information came along it didn't go anywhere, so I ended up just creating lots of folders and then realised there was no point doing that and stopped"*.

Identifying Strategy Changes during the Study

Section 6.2.5 described how a workspace evolution transcript was constructed for each participant. This transcript, combined with analysis of the interview data, allowed the monitoring of organizing strategies over time. Based on this analysis by the author, no major shifts in organizing tendency were observed, along the lines of those discussed in Balter (1997). However, in stage 6, when the participants were asked whether they had changed their organizing strategies, two said yes (F3 and M5). In other words, it was primarily left to participants to self-identify changes.

The eight participants could be split into two groups depending on whether they reported changing strategy or not: (1) *non-changers*, and (2) *changers*.

Non-changers

In the closing interview, six participants said that their strategies had not changed over the course of the study: F1, F2, F4, M6, M7 and M8. This group of *non-changers* included participants with a range of organizing tendencies. Whether pro-organizing or not, existing strategies were seen to be satisfactory or not worth changing:

- Four of the non-changers (F1, F2, F4 and M6) remained broadly pro-organizing in all 3 tools. Note that this group included participant F1 who changed job during the study. In the move, he transferred his file and email collection, organizing them within the same folder structure as before. With bookmarks, he abandoned his existing collection, and started again from scratch. However, since his strategy was pro-organizing as before, it was not classed as a change in strategy.
- Participant M8 expressed the desire to reorganize his files and start using WM. However, he observed that the effort in reorganizing his files was too high to be worth performing, *"Although the system I use at the moment is broken, I know how it works. To take on board a new system, I'd basically have to deal with 2 systems for a while"*.
- Participant M7 remained broadly organizing-neutral in all three tools. In fact, he only organized items within the file collection over the course of the study. Unlike M8, he was highly satisfied with his strategies and felt no need to be more organized.

Changers

Two participants reported changing strategy over the course of the study: F3 and M5.

Participant F3 (CT3: F1/E3/B2) reorganized his files during stage 4, two months into the study. He moved many of his working files onto his desktop: *"I'd feel more comfortable using My Documents as an archive position and the Desktop as my working area"*. Until then, he had pursued a predominantly *file-on-creation* strategy under 'My Documents'. He also stated that the change involved an increase in his level of organizing. During the reorganization, he created 7 folders on the 'Desktop', and moved 6 across from 'My Documents'. When asked about the reorganization, he highlighted two factors that contributed to the change: (1) the need to separate active files for synchronization with his laptop, and (2) the greater influence of the interviews over our

design intervention: "*Overall the tool hasn't done that much, its more the conversations between me and you. It's weird because I've become much more aware of all my directory structures*". Later, he mentioned a third additional factor, *"I think society puts certain pressures upon people to think that being organized, being slim, being certain things are good"*. This perceived social pressure might explain why most of the reorganizing happened in the context of a New Year resolution: *"I feel the need to reinvent myself, to get some good working practices together, to stop drinking, stop smoking, fix bike, and organize my computer"*.

Participant M5 (CT2: F2/E2/B2) was the second participant to report a change. He reorganized both his files and email two weeks into stage 2. He identified the reorganizations as a significant change in strategy, towards being more organized. In each collection he moved completed project folders under an 'old' folder: *"in the top level I have all the projects I have done in my PhD and they have become too many"*. He also created a number of new top-level folders in each tool. He stated that participation in the study was a major factor in the reorganization – although he had been planning the changes for some time, previously he had been put off by the effort involved: *"I went through the mental workload of categorizing things as important or not important [in the study], so whilst this information is fresh in my memory I might as well just use it"*. He also reported an increased reliance on filing for a task which had previously been paper-based: *"the 'submit here' [folder] is the most significant change because that is the first time that I archived stuff to remind me ... it was paper-based before"*.

It should be noted that for both F3 and M5 the changes did not amount to global changes in overall organizing tendency. Instead they were incremental changes, representing subtle shifts in how certain types of information were organized. However, for both participants, the changes, though subtle, were worthwhile, M5: *"the [email] folders that I've created, they only take up 2% or 4% [of the inbox]. [Does that make a difference?] Yes, because most of the stuff that comes in is day-to-day stuff I deal with today, the things I extract now are things with a longer due time"*). **Section 6.7.2** discusses these findings in more depth.

6.6.4 Background Nature of PIM

This final set of results presented here relate to the background, supporting nature of PIM. This theme emerged during the content analysis of the qualitative interview data.

Whilst talking about their PIM practices, many of the study participants portrayed PIM as a

necessary activity, yet one that was not considered to be "real work". In fact, it was often considered to be a distraction, e.g. M6: *"There is never enough time to manage stuff, and whatever time you do spend on it is often wasted ... its so easy to get distracted, I need to do some email, I need to organize this"*.

When asked how their time could be better spent, participants typically responded that they should be doing *"real work"* rather than managing their information. For example, participant F2 identified *"writing papers"* as what he should be doing rather than managing files.

Several participants highlighted the short-term, satisficing nature of PIM, e.g. F3: *"I put things wherever is easiest, wherever is quickest"*. Similarly, M5 observed, *"It [my file organization] could definitely be improved further but it's a trade-off between time I'm willing to spend, and having something that works"*. Participant F4 referred to how she typically had little time for PIM, meaning that it was often carried out in a rush, *"When I've got a deadline, I save things anywhere. I plan to organize at a later date but never get round to it"*. Later in the interview she mentioned that the resulting mess made her feel untidy and embarrassed. Participant F2 also commented on problems resulting from his short-term approach to file management, *"You start working with something, create a new dedicated area, and then forget about it. Really I might be more wary ... Generally things start as a small project, when I'm not expecting very much, not expecting the project to last very long. But then I have to live with the consequences of my poor short-term organization"*.

As in the exploratory study, the field trial clearly had an "auditing effect" on the participants. Most indicated that taking part in the study had caused them to think more about PIM than they normally would, and to plan future strategy changes. Both the study and the design intervention were mentioned as factors.

Influence of the Study

Most performed some ad-hoc tidying during the interviews such as rediscovering files they had forgotten about, and filing or deleting them. For example, participant F1 commented: *"I also keep one file here, I don't know why, hmm ... Ah, I know why, that's the AVI2000 paper which was originally archived on my new hard disk but when I was writing another paper. I needed that one so I copied it back and put it there temporarily. But I'd forgotten about it, so now its still there. Everything's got a reason - eventually"*. Many participants deleted or organized a number

of folders and items in the interviews, or made notes to do it later.

One interview highlighted the potential benefits from the additional time spent reflecting on his collections, F1: *"Now this 'ITN' folder, what's that? I don't know ... oh that gives me an idea, maybe we can approach ITN with this [funding application] although they are content-providers"*.

The two participants who made strategy changes (see **Section 6.6.3**), highlighted the increased reflection on PIM due to the study as a main factor in making those changes. For example, participant F3 commented: *"Overall the tool hasn't done that much, its more the conversations between me and you. It's weird because I've become much more aware of all of my directory structures – there's a bit more thought trying to go into it and how it's organized and stuff – but I think that's probably because of the conversations we have, i.e. being part of the user study than because of the tool ... I've been definitely trying harder to be neat. But that's not because I'm trying to look nicer and smarter or something for the study, that's not what I'm saying ... it's that I've become more aware of its effect on productivity"*.

Influence of the Design Intervention

Several participants also reported that the prompting mechanism in WM made them think more about PIM, e.g. F2: *"I think it's useful. It helped me put some order in my directory structure and it helped me to think about management a bit more. [Researcher: what do you mean by order?] In an indirect way, it forced me to think about why I was organizing my things the way I was doing. Here, I am trying to just manage project documents in the 'Project Documents' area [of files]. I've moved the code elsewhere"*. However he then observed the possible distraction from his work in spending more time thinking about PIM.

Participant M5 also acknowledged the increase in reflection offered by WM: *"The act of being prompted ... is useful because it reminds you that you should think about how you should organize your stuff. But it's also someone saying "clean up your room"*. However, instead of obeying the order, he interpreted it as a hint that he was doing less PIM, *"When I get the WM message up it reminds me that I'm wasting time with information management, creating folders and putting things in folders"*.

Section 6.7.2 discusses the results presented in this section in more depth.

6.7 Discussion

Firstly, **Section 6.7.1** discusses the results from the evaluation of WM. Then, **Section 6.7.2** discusses the longitudinal results presented in **Section 6.6**.

6.7.1 Discussion of Evaluation Findings

This section discusses the evaluation results which were reported in **Sections 5.5**, **6.4**, and **6.5**. Although the responses to the tool were mixed, it is argued that the evaluation of WM was a success on several counts. Firstly, the author succeeded in rolling out a prototype PIM tool to eight participants, integrating it into their existing desktop environments, and obtaining feedback over an average of 69 days. Furthermore, this is one of the few examples of PIM-tool evaluations performed to date. A key design aim of WM was to explore the potential to share folder structures between PIM-tools. Based on the range of feedback received – some positive, some negative, and some unanticipated – it is argued that the study achieved this aim.

However, it is acknowledged that like most previous PIM studies, the selection of participants was not ideal. Only a small number of participants took part, all of whom were technically experienced. Ideally, similar studies should be carried out with a wider range of users, including some without strong technical experience. Such follow-up studies are outside the scope of the work reported here in this thesis. In addition, the participants were all known to the author. This was a deliberate precaution, taken to alleviate privacy concerns. However, the author acknowledges the potential experimental bias from using colleagues to evaluate software. To counter this, participants were encouraged to be open and honest with their feedback. The range of positive and negative feedback suggests that this was accomplished.

Variation in WM Usage

As described in the case studies in **Section 6.4**, the eight participants varied in how they responded to WM. Overall, the usage of WM, as indicated by the objective data reported in **Section 6.5.1**, was lower than the author had envisaged before the study. Only two participants (F2 and F4) mirrored more than 10 folder creation events each. Three other participants, F1, F3 and M5, mirrored 4 or 5 folders (F3 also performed some mirroring manually). The remaining three (M6, M7 and M8) did little or no mirroring.

It is argued that the variation in usage was a natural consequence of a design intervention in such a complex and idiosyncratic activity as PIM. The range of uptake emphasises the fact that the evaluation took place in "natural conditions" – participants were not forced into using WM, but were asked to use it as seemed appropriate within the context of their normal everyday PIM. Indeed, it can argued that the wide range of responses is useful as an illustration of the idiosyncratic nature of PIM.

The following factors may have contributed to the low usage of WM by some participants:

- *Length of time which participants were exposed to WM* – As noted in **Section 6.6.3**, users can be slow to change management strategies and when they do so, changes may be of an incremental nature. Adopting a new tool, such as WM, may involve adaptation of strategies by the user. It is acknowledged that the length of the study may not have been long enough for some participants to adjust to WM. In particular, participant M8, stressed the need to reorganize his files and email to make full use of WM. This emphasises the importance of evaluating PIM-tools over the long-term. Despite this, all participants indicated that they had been exposed to WM for enough time to evaluate it.

- *Frequency of folder events* – As indicated by the data in **Section 6.6.2**, organizing (the creation of new folders) is a sporadic activity. This meant that participants only had limited opportunities to try mirroring out. Furthermore, two of the participants who did not use WM (M7 and M8), carried out little PIM on the installation platform during stage 4. M8 suggested that if he had not been working on another machine, he would have made more use of WM. This indicates the challenge of carrying out evaluations that involve discretionary activities in a natural environment. It also indicates one of the strengths of the objective study approach, where it can be ensured that users try out desired functionality. However, despite organizing activity being relatively infrequent, all participants indicated that they had had enough exposure to WM to give feedback.

- *Unforeseen events* – Another consequence of a field-study based evaluation was that a number of external factors influenced usage of WM. For example, participant F1 changed job, and consequently performed less PIM than normal.

- *Installation issues* – A range of incompatibilities were encountered between WM and participants' PIM-tools (see **Table 6.2** on page 145). In particular, M5 suggested that he may

have made more use of WM if it had been compatible with his network drive. This lead both him and F3 to successfully take up *manual mirroring*. It is envisaged that both participants would have made more use of WM without these technical problems.

- *Differences in organizational requirements between PIM-tools* – Participants organized different types of information in different ways, which resulted in a major impact on the utility of folder mirroring. In particular, M6 used WM very little since he had very different organizational requirements in each tool. This issue is discussed in more depth below.

Section 6.5.1 highlighted that the *track 2* participants made significantly less use of WM compared to the *track 1* participants (an average of 1.25 versus 12.75 folder creation events mirrored). The following factors contributed to this anomaly: (1) differing organizational requirements between tools for participant M6, and (2) a lack of PIM activity for participants M7 and M8. Furthermore, M5, M6 and M7 had negative attitudes towards WM initially, although M5 and M6 performed some mirroring towards the end of the study. Finally, the *track 2* users were exposed to WM for less time (an average of 30 days, compared to 108 days for *track 1*), meaning they had less time to mirror folder events. It is envisaged that both participants M5 and M8 may have made more use of WM if the study had been longer.

All mirrored events corresponded to *folder creation events*. A key reason for this was that the participants performed few *folder deletion* or *folder renaming events* during stage 4 as indicated in **Table 6.5** on page 160. Participants F3 and M5 performed most of these types of events during the reorganizations they performed. However, most of the events did not result in prompts by WM because they occurred in areas not monitored by WM, e.g. M5's network drive. Secondly, as reported in **Chapter 5**, the WM functionality for mirroring folder renaming events was incomplete. This meant that events which involved moves between parent folders were not mirrored. Thirdly, participants may have been wary of this functionality. In the initial interview, one commented that mirroring deletes was "dangerous technology".

Benefits of Long-term Evaluation

The field study highlighted the benefits of evaluating over the long-term. Primarily, emergent behaviour was observed for three participants who changed their attitude towards WM over the course of the study. **Table 6.8** shows a break-down of the participants based on their initial

Initial Attitude to WM	Used WM extensively	Made limited use of WM	Did not use WM
Positive	F1, F2, F4		*M8 (little PIM, used other computer)*
Negative		*F3 (manual mirroring, some use of WM), M5 (manual mirroring)*	M6, M7

Table 6.8: Initial attitude to WM, and usage over stage 4 of main study

attitude to WM, and and their subsequent usage of WM. Participants F3 and M5 were initially negative but ended up making some use of WM, M5: "*Quite impressively, the idea of mirroring structures in emails and in the folders didn't really cross my mind. I think before I had similarly named folders in both systems but they were never agreed in any way. And now I think the structures are a bit more coherent*". In addition, M8 although positive towards the tool at the start of the study, performed no mirroring. In other words, initial attitude did not define whether WM was used over the long-term.

Additionally, the field trial unearthed some unforeseen effects of the design intervention for some participants: (1) increased reflection, and (2) the positive side-effect of a user being constrained to one portion of the file system. It is argued that such results may be less likely to be uncovered in a short-term controlled study.

Differences in Organizational Requirements between PIM-tools

A wide range of design suggestions were reported in **Section 6.5.3**. This section focuses on the most common area of feedback – the need to make mirroring more selective.

Several participants welcomed the promise of increased consistency between the folder structures across PIM-tools. However, in the closing interview, seven of the participants suggested that mirroring was most appropriate for top-level folders. Furthermore, participants disagreed with respect to whether *all* top-level folders should be mirrored. Some argued that if a folder is tool-specific, then it is unnecessary to see that folder in other tool contexts. Others favoured the increase in consistency, even if some mirrored folders remained unused in some tools.

This points to a trade-off between *organizational consistency* (having the same folder structure in different tools) and *cross-tool organizational flexibility* (being able to organize different types of information in different ways). Several participants welcomed the increase in consistency,

indicating that it made navigation easier. However increasing consistency in this way, carries the cost of constraining the user to organize different types of information in the same way. Overall, most participants favoured flexibility over consistency. However, seven participants said that mirroring folders made sense in some cases – typically for top-level folders.

A key reason for the bias in favour of flexibility was that there were differences in organizational requirements between tools. For many participants, email and bookmarks tended to be based on shallow, one layer folder structures, whilst files were organized within deep, many-branching structures. Therefore they saw little need to mirror all low-level file folders to email and bookmarks. In those other tool contexts, unless the user changes organizing strategy, the low-level folders will not be used[33].

The study indicates that folder-mirroring has potential, especially for top-level mirroring. The formative redesign of WM is outside the scope of this thesis. However, based on the response from the participants, the next step would certainly be to limit mirroring to top-level folders by default. Participants varied in terms of the trajectories of mirroring events. Although overall files-to-email was the most common trajectory, several participants (e.g. F3 and F4) mirrored mainly between files and bookmarks. Therefore, a customization facility to select the PIM-tools between which mirroring occurs would also be worth investigating.

Exploring the Limits of Integration

The study participants conveyed a number of views regarding the pros and cons of PIM-tool integration. Participant M7 advocated more powerful integration based on folder sharing, and a number of other participants requested "add-on" functionality on top of WM. However, a number of participants noted that integration of folder structures may cause problems for less technical users – making the structures consistent removes one contextual cue of the user's current location. In the next chapter, **Section 7.3** weighs up the possible pros and cons of design work aimed at increasing PIM-integration more generally.

[33]The author would like to reinforce the difference between two similar terms used in the thesis: *organizing tendencies* listed in the cross-tool profiles in **Chapter 4**, and *organizational requirements*. For example, M6 was *highly pro-organizing* in both files and email (i.e. he had similar organizing tendencies in each tool). However, he made little use of WM due to having different organizational requirements in each tool. In his file collection, he arranged files in a richly-developed folder structure. However, in email, where he was also pro-organizing, he employed a frequent filer strategy but only required a flat set of folders.

Prompting Overheads

Another design issue raised in the evaluation was the intrusive nature of the WM prompts. Several participants reported not always having time to decide whether to mirror or not. Consequently they sometimes mirrored mistakenly, or missed occasions when it would have been useful to mirror. Participant M4 encountered particular problems, explaining how she did not always have time to make a mirroring decision.

It is noted that running WM in prompted mode adds to the cognitive overhead during organization. The user has to make two additional decisions when creating a folder. In standard tools, users must decide whether to organize, and if so where a folder should be placed, and what it should be named. With WM, they must also decide: (1) whether to mirror the new folder, and (2) which tools to mirror it to. Of course, if the mirrored folders are put to use in the other tool contexts at a later time, then the extra up-front overhead may be worthwhile, as the user avoids subsequent organizing overheads in those other contexts. However, it is noted that to take advantage of this, the user must remember that the mirrored folder is available for use. Another concern is that users may place more weight on short-term, immediate costs over long-term, potential benefits. Despite the extra organizing decisions due to the WM mirroring prompts, participants, including M4, wanted to retain control over mirroring.

Designing for Non-technical Users

The author believes that the selection of participants (all were technically experienced) had a strong influence on two areas of feedback: (1) the need for high organizational flexibility, and (2) the need for control over mirroring.

It is hypothesised that WM in its current form may be most suitable for novice, less technical users who may have less demand for specialized organizational requirements in different tools. Furthermore, it is hypothesised that novice users may welcome the simplicity of mirroring all folder events without prompting. The author still holds this view, despite the comments by participants F3 and M6 regarding possible downsides for novice users from increased consistency. Ideally, a repeat evaluation should be carried out with less technical users. However this is outside the scope of this thesis, and is discussed in **Chapter 8** as possible future work.

Success of the Incremental Design Approach

The incremental design approach was successful in allowing the prototype to be added to an existing set of PIM-tools, with a minimum of disruption to the users. However, the limitation of *local optimization* (Carroll, 2000) is acknowledged. WM was only aimed at dealing with one limited PIM-related problem, that of keeping multiple collections of personal information organized. In several cases, it was difficult to manage the expectations of some participants who tended to focus on the functionality which WM did not have (e.g. more advanced PIM-integration mechanisms), than on what the presented design offered. Participant M7 wanted more advanced WM-like functionality based on folder-sharing. Several other participants expressed a desire for a secretary agent, F3: *"that can look through things and work out what they are and where they should go"*.

This highlights a key challenge for designers pursuing an incremental approach: users may not be satisfied with incremental improvements.

Summary

This section considered the results from the evaluation of the WM prototype. Although responses to WM were mixed, a range of design recommendations were provided by all participants. In particular, the majority of participants expressed their support for the mirroring of top-level folders. These results raised the researcher's awareness of the pros and cons of integration. In the next chapter, **Section 7.3** moves on to present general implications for the design of PIM systems, particularly those aimed at increasing integration. Routes for formative redesign, driven by the evaluation feedback, are outlined as potential future work in **Chapter 8**.

6.7.2 Discussion of Study Findings

During the study, a broad range of data relating to PIM behaviour was collected over several months. Whilst the exploratory study reported in **Chapter 4** was novel in terms of being a *cross-tool* study, the study presented in this chapter is one of the few *longitudinal* PIM studies carried out to date. It is the only *cross-tool, longitudinal* study that the author is aware of. However, a number of methodological limitations are acknowledged. These limit the generality of the results, and indicate possible directions for more follow-up work. Firstly, like most other PIM studies, only a small number of participants took part. In addition, the participants were all known to the author, and were technically experienced. Ideally, similar studies should be carried out with more users from other backgrounds. However, such follow-up studies are outside the scope of this thesis.

Longitudinal Insights into PIM behaviour

The study provided further insight into the four PIM sub-activities identified in the conceptual framework in **Chapter 2**.

Primarily, the growth of collections provided insight into the acquisition sub-activity. All participants actively collected files and email over the study. In contrast, bookmarks were less actively collected, and increased in number at a much smaller rate (an average of 0.2 per day, compared to 4 per day for files). This ties in with the lack of importance of the bookmark collection reported by participants in the exploratory study. However the idiosyncratic nature of PIM means that it is hard to generalize, since one participant, M4, collected them extensively.

The average figures suggest that items were added to the collections at a slow steady pace (in the two fastest-growing collections, files and email, approximately 5 items a day). However, it is argued here that acquisition was sporadic, and varied significantly over the course of the study. Acquisition was marked by bursts corresponding to new pieces of work, and troughs corresponding to times away from the computer, e.g. holiday or using another computer. An interesting direction for future work would be to track the increase in items per day, and correlate with the user's production activities.

Note that the figures presented reflect the net increase in items over the study (i.e. acquisitions minus deletions). In particular, the email growth rate does not reflect the turnover in messages,

including thousands of messages that were deleted and not kept. It is argued that such a net figure is a better reflection of email growth, compared to the number that are downloaded. In email, acquisition over the long-term, is best conceptualized as acquisition minus deletion.

Growth rates were much lower for folders compared to items. As organizing activity was relatively sparse, folder structures evolved slowly over the course of the study. Even the participant who created the most folders, F2, only created 51 folders over the course of the study across all three tools. Very few folder deletion and renaming events were observed over the study. The two exceptions were F3 and M5 who deleted and moved a number of folders during one-off reorganizing episodes. This sparseness indicates the need to evaluate prototypes such as WM, which provide new organizing functionality, over the long-term.

As can be seen from **Table 6.7**, folder growth rates were higher in files relative to email and bookmarks for all but one participant. The exception was F4 who carried out significant bookmark organization. For the other participants, the higher folder growth in files reflects greater reliance on organizing in that collection.

In all three tools, maintenance, e.g. archiving or deleting information, was performed rarely, if at all. In email, two participants archived large numbers of items (but no folders). In bookmarks, no archiving was performed. In files, two participants archived items and folders out of their collections: F3 to transfer information for working at home, and M5 due to a lack of space on his network drive. In contrast, most participants, archived files (such as websites) *into* their file collections. This in-situ archiving runs counter to the traditional definition of archiving as the removal of items from a collection, e.g. (Barreau, 1995). One interesting reason for not archiving material out of collections was that it made items harder to find at a later date.

No objective data was collected on the retrieval sub-activity. Like the exploratory study, participants' qualitative feedback indicated that they relied on browsing and sorting, in preference to keyword search. To collect objective data on retrieval practices, future research could potentially collect more detailed logs on one-off retrieval events. However, such logging may be considered too invasive by participants.

The data provides insight into the relative frequency of PIM sub-activities. Acquisition, retrieval are ongoing but "bursty", as driven by the user's information needs. Organization is more sporadic, and maintenance is very rare. PIM can therefore be conceptualized as the process of incrementally adding items to a mass of older items, partially organized within a slowly evolv-

ing folder structure. Many of the older items are archived in situ and rarely retrieved. However, as reported in **Chapter 4**, users still consider some of their older information to be highly important.

The relative frequency of PIM sub-activities contributes to the improved model of PIM developed in **Section 7.2**.

The Supporting Nature of PIM

Section 6.6.4 presented a range of qualitative comments from participants which highlighted the background nature of PIM. PIM was seen as an activity they performed every day to support their research, administrative, and educational roles. However, it was also seen to be of low priority, and in some cases as a distraction, or as a "break from real work". This indicates a paradoxical situation, whereby participants were driven to manage their information, yet ran the risk of wasting time in doing so. Indeed the *discretionary* nature of PIM means that users can choose whether to perform it or not, and if they do, to what extent they perform it.

The study also highlighted the *lack of attention* many users devote to PIM. Although they carried out PIM everyday, PIM was not an activity that many participants reported spending time focused on. Most participants in the main study indicated that their participation, combined with the design intervention, lead them to devote more attention to PIM.

These results support the conceptualization of PIM as a *supporting* activity. This theme is developed further in **Section 7.2**, where it is suggested that it is user's high-level production activities and goals, their "real work", that provide direction to their otherwise discretionary PIM activities.

Changes in Organizing Strategy

Two of the eight participants made significant changes to their PIM strategies over the course of the field study:

- Participant F3 changed the way that he managed his active files, moving many from "My Documents" to the "Desktop" and creating a number of new folders to organize them.
- Participant M5 made two changes. Firstly, he changed how he managed old information

in both files and email – moving all old project data under an "Old" folder in each collection. Secondly, he reported filing more email by the end of the study. In particular, he described how he was filing more messages relating to conference paper submissions.

The study provided examples of the changes which may occur in user's management strategies over time. However, the changes observed were *incremental* rather than the *global*, wholesale shifts discussed in Balter (1997), e.g. *no-filer* to *spring-cleaner*. In other words, the changes amounted to subtle changes in the participant's overall PIM practices, equivalent to adaptations in low-level organizing strategy for certain types of information. The next section, extends the model of strategy changes from Balter (1997) to reflect these observations.

For both participants, the changes, though subtle, were worthwhile: M5: *"the [email] folders that I've created, they only take up 2% or 4% [of the inbox]. [Does that make a difference?] Yes, because most of the stuff that comes in is day-to-day stuff I deal with today, the things I extract now are things with a longer due time"*.

The changes observed over the field study were all *pro-organizing* (involving increases in organizing effort). No study participants were observed changing in favour of being less organized, although some had reported such changes from before the study. Note that although participant F1 abandoned his existing bookmark folders on starting a new job, he started building up a new collection using similar filing strategies as before.

As discussed in **Section 6.6.4**, many users devote little time to planning and executing changes in strategy. Thus it makes sense that only subtle shifts in strategy were observed. As participant M8 commented, there is a huge amount of effort involved in a major reorganization or change in strategy. His feedback emphasised that such "grand shifts" are time-consuming and non-trivial. Instead, it is much easier to make small adjustments. Of course, substantial changes in overall trait may occur, but these would happen at major life points and it is not surprising that none were encountered during the study.

The observed changes emphasise the need to evaluate PIM designs over the long-term, since designs which depend upon a change in strategy may take time to be adopted. In terms of WM, the incremental nature of the observed changes may be a partial explanation for the slow uptake of WM. As indicated by participant M8, the change in strategy to make use of mirrored folders may be substantial.

Factors influencing the Changes

A number of factors were noted that influenced the changes in strategy. Firstly, participation in the study clearly had an effect on the study changes. Both *changers* stated that increased reflection on PIM due to the study was the main factor causing the changes. It should be considered whether the changes would have happened anyway without the study intervention. Participant M5 stated that he had been planning the changes for some time but had not implemented them due to the perceived effort involved. He stated that the guided tour during phase 1 involved carrying out much of the effort (assessing folders on a case by case basis). Thus, the amount of effort left to reorganize his folder structures was much lower. Such influence is an unavoidable effect of a field trial – the experimenter will always have some influence on what users are doing. Not carrying out face-to-face interviews may be one route to lessening such effects.

Secondly, the author's design intervention also impacted PIM behaviour. However, against the author's expectations, neither changer considered WM to be a major contributory factor, even though both performed some mirroring over the course of the study. M5 stated that the prompting increased his reflection on PIM but to a lesser degree than the interviews. The author had anticipated that WM would stimulate pro-organizing strategy changes by allowing users to leverage filing investment in one collection across to other collections. However, this was not the case – the participants who used it extensively, employed WM in support of their existing filing strategies, and did not report filing more than they had done previously.

Finally, Participant F3 also noted a social pressure to be more organized, *"I mean I really am envious of people like X who has all his folders worked out. He is really organized"*.

Towards a Model of Changes in Organizing Strategy

A model of changes in email organizing strategy was proposed in Balter (1997). Firstly, this can be criticised for focusing on unrealistic user traits such as *frequent filer* and *spring cleaner*. **Section 4.10.2** argued that such classifications are inaccurate as they portray abstract, extreme user traits. Secondly, the model can be criticised for portraying strategy changes as major shifts. In this section, Bälter's model is extended to account for the observations of *incremental* changes made in this chapter. As in Bälter's work, a focus is taken on *email*, but the model can be also

applied to other tool contexts[34].

The model draws on the multiple strategies model from **Section 4.10.2** in which a user's tool-specific organizing strategy can be represented as the relative percentages of low-level strategies employed. If one assumes two low-level strategies (*frequent filing* and *spring cleaning*), the multiple strategy can be plotted on a graph, where each axis indicates the relative proportions of new messages that are organized with each strategy. An incremental change can therefore be represented as a *shift in the relative proportions of information managed with a particular strategy*. **Figure 6.3** provides two example changes based on the life of an example fictional user, Joe. Joe starts with an overall multiple strategy of 10% frequent filing and 90% spring cleaning, indicated on the graph with a star. The two changes are as follows:

- *Scenario 1: Joe starts e-dating with Mary* – In the early stages of this intense relationship, Joe receives a large number of messages from her. He files all of Mary's messages immediately within a "Mary" folder as they mean so much to him. Thus the overall percentage of email that is frequently filed increases to 12%, resulting in a *pro-organizing* shift. This reflects the larger percentage of emails which are being organized immediately.
- *Scenario 2: Joe starts going out with Mary in the real world* – The second change happens when Joe starts spending all his time with Mary. Due to the demands on his time, he has less time to read email, let alone to file messages. The relative proportion of email being immediately filed goes down. Joe still files, but starts to rely on spring-cleaning messages. This is an example of a *organizing-neutral* shift.

A number of simplifying assumptions are acknowledged. A first assumption is that all messages are filed at some point, via frequent filing or spring-cleaning. A more realistic model would be multi-dimensional to account for other strategies, e.g. the non-filing of some messages. Secondly, the model does not capture changes in how items are organized with a particular strategy. For example, participant M5 moved many older project folders into a top-level 'old' folder. This does not represent a shift between strategies, but an adjustment to information that has already been filed. Despite these simplifications, it is argued that the model provides a more realistic portrayal of changes in organizing strategy, and emphasises their incremental nature.

[34] Note that different changes may happen simultaneously in different tools, as each represents an independent PIM sub-system. For example, a user may abandon her bookmarks, but start filing her email more carefully. However this is beyond the scope of the model proposed here.

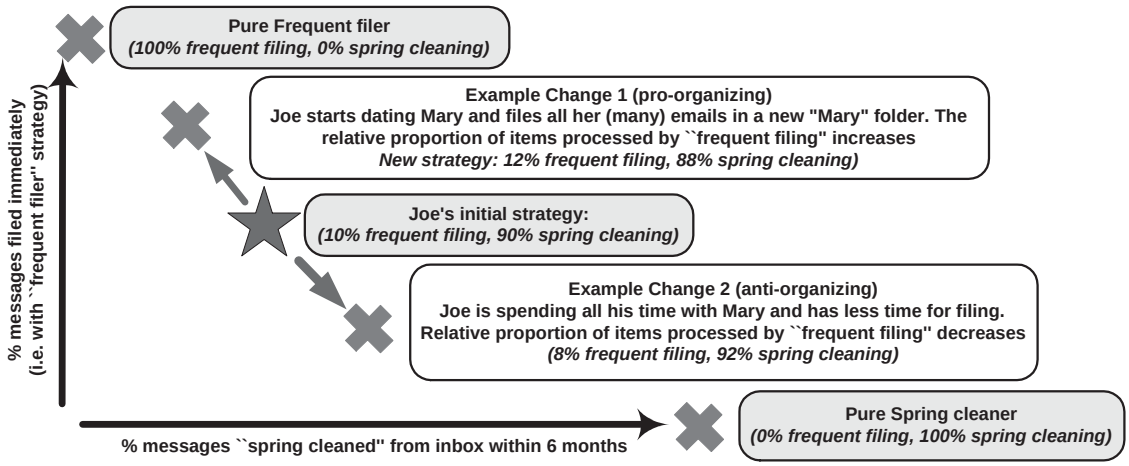

Figure 6.3: A model of incremental changes in email organizing strategy

Furthermore, the model indicates the potential for developing improved conceptualizations of PIM strategies, and how they change over time.

Summary

This section has discussed a number of the findings from the study component of the field trial. Firstly, growth rates were compared between the three collections, along with the relative frequencies of the different PIM sub-activities. The study highlighted the supporting property of PIM, and the lack of reflection on the part of users. The study also provided data on a number of real-life adaptations of PIM strategy. A simple model of incremental strategy changes was proposed.

Next, **Chapter 7** moves on to combine the findings from this chapter with those from the wider thesis.

Chapter 7

Discussion

7.1 Introduction

This chapter discusses the substantive findings from **Chapters** 4 to 6. The discussion is made up of the following four sections:

- **Section** 7.2 develops a theoretical framework which reflects three perspectives of PIM that have been highlighted over the course of this research: 1) PIM as a *cross-tool* activity, (2) PIM as a *supporting* activity, and (3) PIM as an *ongoing* activity. Each perspective illustrates a future direction for theory development in this area.
- **Section** 7.3 revisits the evaluation of WorkspaceMirror (WM), and uses the perspective of PIM as a supporting activity to interpret the results. Based on this analysis, and empirical findings in the thesis, implications for the wider design genre of PIM-integration are considered.
- **Section** 7.4 presents a series of methodological recommendations for carrying out work in this area. The framework from **Section** 7.2 is used to structure the recommendations.
- **Section** 7.5 explores possible qualitative measures of *PIM user experience* that could be used as evaluation metrics. **Section** 7.5.1 considers one aspect of negative user experience in depth, dissatisfaction with management strategies. The results from the main study in **Chapter** 6 are used to provide examples of such dissatisfaction.

7.2 Three Perspectives on PIM

This section discusses three properties of PIM which emerged over the course of this research:

1. **Section 7.2.1** considers PIM as a *cross-tool* activity, one which is distributed across multiple tools such as files, email and bookmarks.
2. **Section 7.2.2** discusses PIM as a *supporting* activity, and considers the relationship between it and a user's production activities.
3. **Section 7.2.3** considers the *ongoing* nature of PIM, viewing it from two longitudinal perspectives: (1) as a series of discrete events, (2) as a thread of continuous activity.

Each perspective is motivated using findings from earlier chapters, and is then used to incrementally extend the conceptual framework of PIM from **Section 2.2.2**. **Section 7.2.4** discusses how the three perspectives indicate routes for future theory development in the area. Within this chapter, the three perspectives are used to structure the discussion in subsequent sections.

7.2.1 PIM as a Cross-tool Activity

Today's computing environments allow users to manage information in a variety of PIM-tools. However, as noted in **Chapter 3**, most previous PIM studies have focused on specific tools such as files or email. In contrast, this research employed a deliberately cross-tool approach to investigate ways of improving integration between PIM-tools. A focus was taken on three PIM-tools: files, email and bookmarks. Almost all of the study participants from **Chapters 4** and **6** actively managed all three PIM-tools. The observations of *folder overlap* indicate the information relating to a particular activity was fragmented across PIM-tools. In other words. multiple PIM-tools were involved in certain user activities. Also, the management of information in a particular technological format (e.g. files), was *compartmentalized* across different PIM-tools.

These observations lead the author to conceptualize PIM as a *cross-tool* activity, one that is distributed across multiple tools. Previous tool-specific research in the context of email, has considered how the collection of messages acts as a *"habitat"* for user activities (Ducheneaut and Bellotti, 2001). In contrast, this section considers PIM from a cross-tool perspective, whereby email is one component of the wider habitat of the user's personal information environment.

Various strands of related research come together in supporting this perspective. In terms of theory, the view draws on the conceptualization of a computer as an *activity space*, populated by the tools and resources that facilitate action, and the constraints that limit it (Kirsh, 2001). From this theoretical perspective, activities such as PIM, are not confined to specific tools, but are distributed across a range of tools throughout digital activity space. Recent empirical work has also highlighted how the management of certain types of information is fragmented across multiple PIM-tools, e.g. to-dos and appointments (Blandford and Green, 2001; Bellotti and Smith, 2000), bookmarks (Jones et al., 2001), and contacts (Whittaker et al., 2002).

Extending the Conceptual Framework from Chapter 2

Chapter 2 presented a conceptual framework of four PIM sub-activities: acquisition, organization, maintenance and retrieval. This was based on Barreau (1995) who models the computer as a *single PIM system*. Here it is argued that another more accurate conceptualization of a personal computer is as a *set of distinct PIM-systems*[35]. **Figure 7.1** illustrates the extension of Barreau's framework to reflect this view. PIM can therefore be viewed from two perspectives as follows:

1. Firstly, from a *tool-specific* perspective, each PIM-tool can be considered as a distinct PIM system which provides the functionality to acquire, organize, maintain and retrieve information based on a specific technological format. Although different PIM-tools share commonalities, they also have many unique aspects. **Chapter 4** surveyed how the nature of the PIM sub-activities varied across files, email and bookmarks.

   Linking the independent "PIM-subsystems" are *integration mechanisms*, such as email attachment functionality, and the WM prototype proposed in **Chapter 5**.

2. Secondly, from a *cross-tool* perspective, the entire desktop computer can be considered as one federated PIM system composed of the set of tool-specific PIM sub-systems. From a cross-tool perspective, the acquisition sub-activity is the sum of all the tool-specific acquisition processes, including email messages received from other people, and files and bookmarks created by the user.

[35] Barreau's abstraction of the computer as a single PIM system may be due to the fact that her work was focused on the file system, and furthermore was carried out in 1995. Other PIM-tools, such as email and web browsers were not as common then as now. Indeed, Barreau notes that only two of her eight participants managed email.

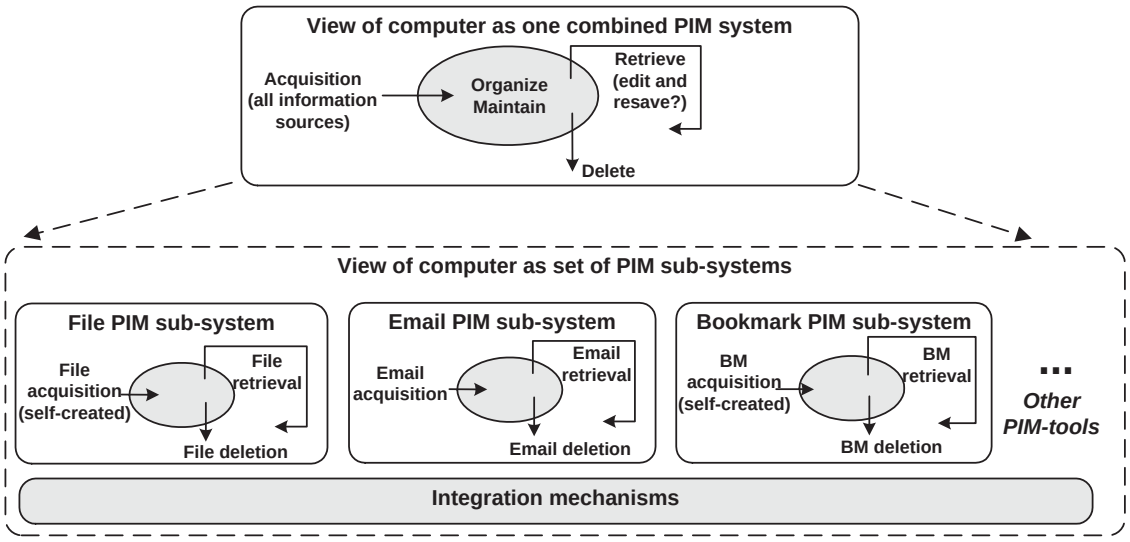

Figure 7.1: An extension of Barreau's PIM framework to reflect the cross-tool perspective

Figure 7.1 is limited to a focus on three PIM-tools: files, email and bookmarks. However, these three are intended as indicative examples only. Other PIM-tools could be included such as calendars and to-do lists. Future extensions could also consider the extended personal information environment beyond the desktop – shared drives, web-based information, as well as information stored on other devices and in the physical environment. For now, the point to be taken by the reader is that PIM can be considered as a cross-tool activity.

The key benefit of the extended framework is that it allows the accommodation of cross-tool integration mechanisms. **Section 7.2.2** moves on to further develop the framework in **Figure 7.1** to encompass the relationship between PIM and the production tasks that it supports.

7.2.2 PIM as a Supporting Activity

In both studies participants reported that the interviews caused them to spend a lot more time thinking about PIM than normal. Although they carried out PIM everyday, PIM was not an activity that most reported spending time focused on. In the main study, when asked about their PIM practices regarding files, email and bookmarks, PIM was portrayed as a necessary activity, yet one that was not considered to be "real work" (see **Section 6.6.4**). In fact, a number of participants saw PIM as a chance for a welcome break, or as a waste of time!

These results support the conceptualization of PIM as a *supporting* activity. This section sug-

gests that it is a user's high-level production activities and goals, their "real work", that provide direction to their otherwise discretionary PIM activity. The next section extends the theoretical framework from **Section 7.2.1** to encompass this view.

Production and Supporting Activities

Based on the above discussion, two types of activity are introduced:

1. *Production activities* are defined as the "high-level" work and leisure activities which drive a user's computer usage. In a work context, these are the activities on which the user's performance is appraised. For example, a lawyer's production activities may include presenting court cases and writing wills for clients. For a student, production activities may include completing coursework and revising for exams.

2. *Supporting activities* are performed to promote the completion of production activities. In other words, they are not carried out for their own sake, instead they are "the things one does to get something else done". PIM, the focus of this thesis, is a key supporting activity. It is argued that PIM is not the primary reason people use computers. Instead, it is performed to support their production activities.

Production activities may involve multiple supporting activities. **Figure 7.2** illustrates the supporting activities driven by an example production activity, that of writing a confidential report. These include the management of files, email, and bookmarks, communication with colleagues, updating software applications, and effective IT security practice (e.g. choosing a good password, and locking the screen). There may also be a nested arrangement of production/supporting relationships. For example, email-based PIM can be seen as an activity that supports collaboration with co-authors, which in turn supports the overall production goal of writing the report.

In a work context, some supporting activities, such as security awareness may be enforced through guidelines. The others shown in **Figure 7.2**, including PIM, are important, but *discretionary*. Typically, the employee is not directly appraised regarding their execution. In fact, PIM is often the personal responsibility of the employee who can choose whether and to what extent they perform it. This *discretionary* nature of PIM has both positive and negative consequences. Users are given the freedom to manage information as they choose, and may well have strong

views about how to do so. However, users typically receive little help from employers regarding the problems they encounter.

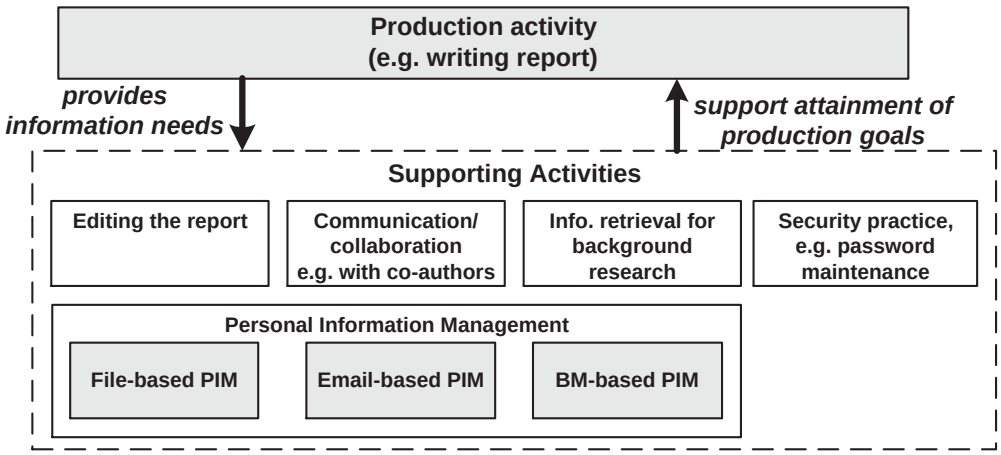

Figure 7.2: Supporting activities involved in the production activity of writing a report

The production/supporting relationship can be contrasted with a previous conceptualization of *work* and *enabling* tasks (Whitefield et al., 1993). Enabling tasks are tasks that are *required to achieve a work goal.* For example, the enabling task of "pressing a key" helps achieve the work goal of "typing a sentence in a report". In contrast, the supporting activities outlined above are secondary, but *discretionary.* Furthermore, Whitefield et al. (1993) focus on lower-level tasks than those discussed here. In contrast, all the example supporting activities in **Figure 7.2** are ongoing high-level activities.

Extending the Theoretical Framework

Figure 7.3 extends the framework from the previous section to accommodate the relationship between PIM as a *cross-tool, supporting activity* and a user's production activities. Production activities provide the information needs which drive PIM[36]. PIM offers support for the production activity by supplying information resources and reminders.

Two types of production activity can be identified in terms of the number of PIM-tools which support them:

1. Some production activities are *tool-specific* – they only involve PIM activity within the

[36]A similar idea is common in the information retrieval literature whereby an external need drives a user's information seeking (Wilson, 2000).

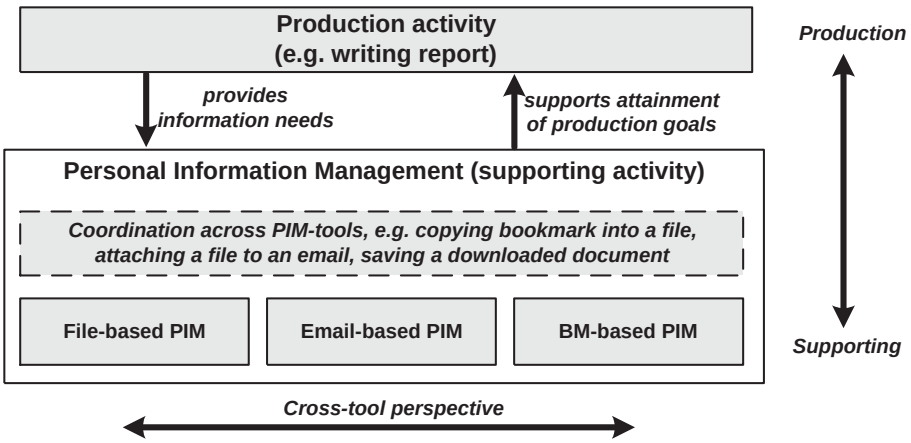

Figure 7.3: Theoretical framework extended to reflect the cross-tool, supporting nature of PIM

bounds of one PIM-tool. A simple example of a tool-specific production activity is offered: arranging a picnic with friends. This involves the exchange of emails with friends, and their storage. At a later time, the received messages are consulted to edit a reminder to coordinate who is bringing what food and drink. The PIM needs for this task are email-specific. Tool-specific production activities do not require integration support.

2. Other production activities are *cross-tool* – they involve the management of information in multiple PIM-tools. For example, planning a holiday may involve collating websites, sending and storing emails, and creating files with possible itineraries. When production activities involve multiple PIM tools, there is the need for *coordination* between those PIM-tools. This may be as simple as transferring a bookmark from a web browser to include in an email message. Alternatively, coordination may be more extensive, e.g. the ongoing management of emails and bookmarks relating to a long-term project. *Integration mechanisms* can be viewed as interface functionality which support cross-tool coordinating activities, thus avoiding the need for manual coordination. By making it easier to coordinate information requirements across multiple PIM-tools, the overheads of manual coordination are lessened.

This section has discussed how PIM is not a self-contained, stand-alone activity, but one that is driven by a user's production activities. However, note that information management can itself be a production activity. For example, consider how librarians manage information for others as one of their key job responsibilities.

The relationship between PIM as a supporting activity, and a user's production activities also illustrates the distraction that PIM can cause. At times, PIM may interfere with a user's production activities by consuming all of a user's attention. For example, consider the situation when a user is unable to find a very important document and devotes an entire morning to finding it. In this case, PIM may displace the goals corresponding to the "real" production activity. **Section 7.5** discusses the methodological implications caused by the potential of PIM to cause such distraction: do PIM designers run the risk of encouraging users to spend less time on their production activities?

7.2.3 PIM as an Ongoing Activity

This section views PIM from a third theoretical perspective, as an *ongoing* activity. The main study reported in **Chapter 6** tracked PIM behaviour over time in terms of four PIM sub-activities: acquisition, organization, maintenance and retrieval. **Figure 7.4** illustrates how each of these sub-activities can be viewed on a both a short-term and long-term time-scale:

1. From a *short-term* perspective, each sub-activity consists of a sequence of discrete events. For example, the acquisition sub-activity within a file context consists of a series of file-saving events. **Section 6.7.2** noted the relative frequency of a user performing the four sub-activities. This is reflected in **Figure 7.4**: whilst acquisition and retrieval occur frequently, organization and maintenance are more sporadic.

2. Alternatively, from a long-term perspective, PIM can be viewed as four continuous threads of behaviour, each corresponding to the four PIM sub-activities and consisting of a sequence of discrete events. PIM behaviour over time is therefore the combination of the four interleaved sub-activities, amounting to a continuous, background thread of activity. In the extreme, PIM behaviour is now *lifelong* since users can collect and store information over their entire lifetime (Gemmell et al., 2002; Dix, 2002).

Following from the long-term view of PIM, a number of discussion points can be raised.

- Just as production activities may evolve over time (consider the stages of writing a report), so may the activities supporting them. For example, **Section 6.6.3** described how PIM strategies may change over time. The very notion of a PIM strategy suggests that

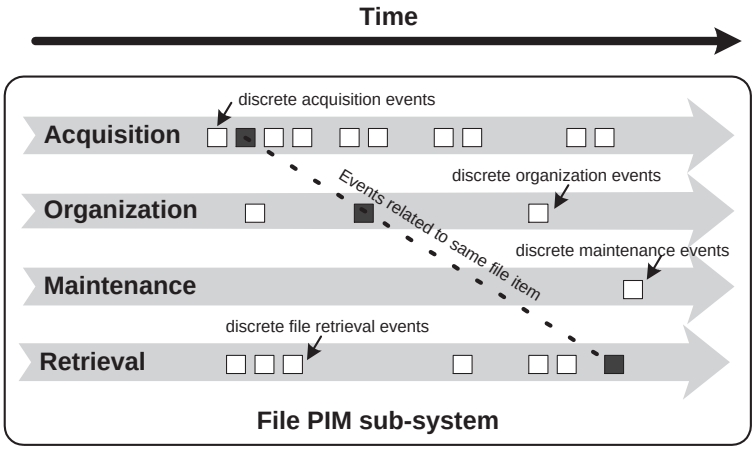

Figure 7.4: PIM as an ongoing activity, consisting of four parallel threads corresponding to the four PIM sub-activities

behaviour is pre-planned and consistent. However, the supporting nature of PIM means that users rarely devote time to planning and executing changes in strategy. Instead, PIM strategies are not pre-determined, but the amalgam of many spur-of-the-moment discrete events. For example, Participant 2 in the exploratory study reported: *"I start working with something, create a new dedicated area, and then forget about it"*. In the past, when researchers have talked about "organizing strategies", they are typically describing *average behaviour over the long-term* [37].

- The long-term perspective allows PIM to be contrasted with information retrieval, which is typically considered to be a one-off discrete event. In contrast, Wilson's "human information behaviour" (Wilson, 2000) is equivalent to the ongoing retrieval sub-activity thread, portrayed here as one aspect of PIM.

- The four threads in **Figure 7.4** are not independent – they each represent a series of actions performed within a single collection of information. Indeed, discrete events in two different threads may be associated by involving the same item of information. To illustrate this point, the black squares in **Figure 7.4** indicate the association between the acquisition, storage and later retrieval of a particular item.

  The nature of one sub-activity can influence how users perform other sub-activities. For example, the rate at which users acquire items, influences their choice of organization,

[37] The term *average* acknowledges the multiple strategies employed by many users to manage different types of information, e.g. filing information related to some production activities but not others (see **Section 4.10.2**).

maintenance and retrieval strategies. Also, organization and maintenance have a strong influence on retrieval. Several participants commented that maintaining their collections (e.g. tidying, deleting items) could make it harder to find items.

Extending the Theoretical Framework

Figure 7.5 shows the theoretical framework extended to accommodate all three perspectives discussed in this section: (1) *cross-tool*, (2) *supporting*, and (3) *ongoing*.

The figure shows two example production activities (A and B) and the associated PIM activity. The squares and triangles refer to PIM events relating to production activity A and B, respectively. PIM is also shown to be distributed *across tools*, and *over time* (horizontal axis). The figure reflects variations in the frequency of PIM events between tools. Due to the discretionary nature of PIM, events in the parallel threads, relating to various production activities, may be interleaved arbitrarily.

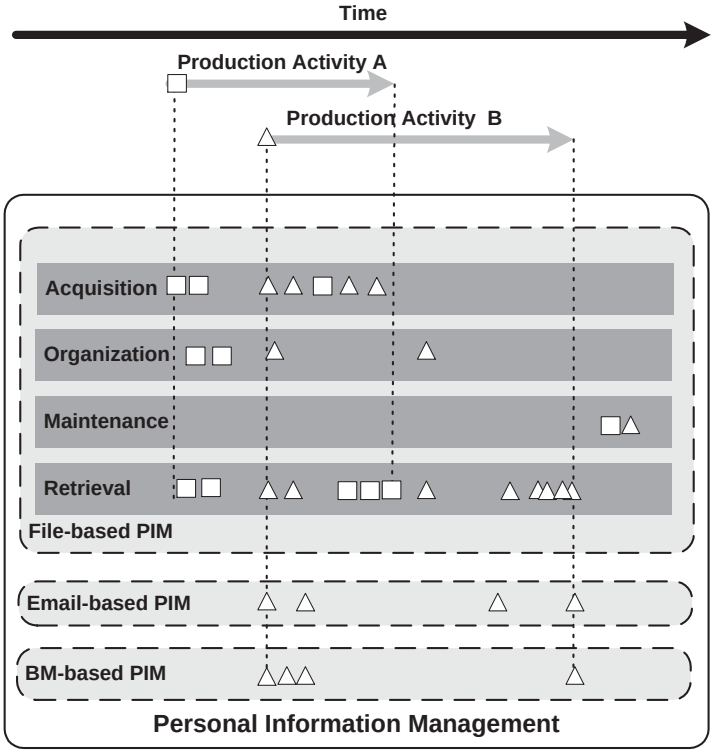

Figure 7.5: Theoretical framework extended to reflect the cross-tool, supporting, and ongoing nature of PIM

7.2.4 Towards a Theory of PIM

The framework in **Figure 7.5** illustrates three important aspects of PIM that have emerged over the course of this research programme. Note that the framework is not intended to represent a complete model of PIM. Instead, it is presented to illustrate three areas that must be accommodated in future theoretical work in this area. The framework also highlights the analytical complexity of PIM as a HCI phenomenon. One way to deal with such complexity, may be to develop an inter-linked set of theories, rather than a monolithic one (Barnard et al., 2000).

There are also many other areas in which the theoretical basis of PIM could be improved. One other area suggested by Whittaker et al. (2000b) is to improve the *descriptive vocabulary* for talking about personal information. The author echoes this call. This research points at one fundamental area in need of attention – that is the need for a richer vocabulary to describe items of personal information beyond *technological format*, and *lifetime of use* (Barreau and Nardi, 1995). For example, **Chapter 4** advocated that the term "archived" is misleading, since most users do not archive explicitly. Two alternative sets of terms are suggested:

1. *Information usefulness – active* (relating to current production activities, including ephemeral and working items), *dormant* (inactive, potentially useful), *not useful* (should be deleted), and *un-assessed* (e.g. new emails).

2. *Information ownership – mine* (including self-created files, and items that have been assessed as having value, e.g. filed email), and *"not-mine"* (e.g. much of the email inbox, and information on the internet).

The subsequent sections of this discussion chapter draw on the theoretical framework developed over **Sections 7.2.1** to **7.2.3**. Firstly, **Section 7.3** revisits the WM evaluation in lieu of the discussion of PIM as a supporting activity. A number of design implications are discussed, focusing on improving integration between PIM-tools.

7.3 The Design of PIM-Integration Mechanisms

Integration between PIM-tools has been repeatedly put forward as a worthy design aim, e.g. (Bellotti et al., 2003; Bergman et al., 2003; Kaptelinin, 2003). However, **Chapter 3** noted that most of the research prototypes that have been developed have been founded on designer intuition rather than on a systematic *cross-tool* investigation of user needs. Furthermore, few evaluations of PIM-integration mechanisms have been published. A key aim of this research was to systematically investigate the potential to integrate PIM-tools. This section discusses implications for the design of more coherent, integrated PIM technologies based on the experience gained in this research.

7.3.1 Revisiting the WM Evaluation

Chapter 5 described the design and implementation of a novel PIM-integration mechanism, WorkspaceMirror (WM), which allows the user to share folder structures between the file, email and bookmark collections via *folder-mirroring*. WM was evaluated to explore the potential to share folder structures across PIM-tools.

Section 6.7.1 identified a trade-off between *organizational consistency* and *organizational flexibility*, resulting from usage of WM:

- On one hand, folder-mirroring allows the user to improve the consistency of organizational structures in different collections of information. Several participants welcomed this consistency and indicated that it made retrieval more straightforward.
- On the other hand, an increase in consistency reduces the user's flexibility to organize different types of information in different ways. Participants stated that they required some flexibility so they could have different folder structures in different tools, as organizational requirements varied across them. However, feedback indicated that top-level folders (typically based on their roles and projects) were often suitable for mirroring.

The next section offers a theoretical explanation to explain the need for organizational flexibility: *why are some folders useful in multiple tool contexts, but others are not?* The discussion employs the concepts of production and supporting activities from **Section 7.2.2**.

7.3.2 When is Folder-mirroring Appropriate?

Production activities are a user's high-level activities, those which provide the information needs that drive their PIM activity. Here, it is proposed that a user's production activities are a key influencing factor in the creation of new folders[38]. For instance, when a user starts a new production activity that he or she predicts will involve the management of associated information, he or she may create a new folder. Alternatively, the user may create the folder some time after starting the production activity. **Section 7.2.2** also introduced the notion of *tool-specific* and *cross-tool* production activities. Tool-specific production activities only involve one PIM-tool, whilst cross-tool production activities are supported by multiple PIM-tools. The appropriateness of folder-mirroring for each type of production activities is discussed as follows:

- *Tool-specific production activities* – Folder-mirroring is likely to be inappropriate in cases whereby an information need is tool-specific, i.e. when it corresponds to a tool-specific production activity. Only users who place a high value on organizational consistency are likely to find folder mirroring useful in this context. For most users, mirroring may be seen to result in the creation of "spurious folders" in tool contexts where they are not relevant. This may in turn lead to clutter and a sense of untidiness, causing negative user experience and retrieval difficulties. Such side-effects may be distributed in time relative to the folder creation event, e.g. the interference caused by spurious folders may not be clear until retrieval time.

- *Cross-tool production activities* – Folder-mirroring is most appropriate in those cases where a new folder is driven by a cross-tool information need. The observation of folder overlap in **Chapter 4** provided evidence of cross-tool information needs. In these cases, folder-mirroring avoids the user having to create a folder separately in three different tool contexts. In this way, folder-mirroring may help the user in coordinating their PIM requirements across all three tools.

  However, folder-mirroring may not be appropriate for all cross-tool production activities. Firstly, the user may wish to store information related to a particular cross-tool production activity in folders with different names in different tool contexts. For example, folders corresponding to a software project may be named after the project code in email, but

[38] The author notes that there may be other factors influencing the creation of folders, e.g. whether the user believes organization to be important.

after the project manager in the file system. Secondly, users may have varying organizational requirements across different tool contexts. Files are generally much more richly and deeply structured than emails or bookmarks. This explains the bias towards mirroring top-level folders: lower-level folders as developed most often in the file system are not useful in the other contexts.

These examples illustrate that it should not be assumed that a cross-tool production activity will always require mirroring. However, the author argues that the conceptualization of cross-tool production activities is useful as an indication of where folder-mirroring is likely to be appropriate.

The above discussion highlights some of the strengths and weaknesses of the folder mirroring technique, in terms of the benefits offered for different kinds of production activity. The question to be investigated in evaluation is: does the *consistency* introduced by folder-mirroring outweigh the impact on the *flexibility* to have different folder structures in different tools? The evaluation results suggest that response to this question is idiosyncratic: some users value consistency more, whilst others value flexibility higher. Since users vary in their need for such a mechanism, the author concludes that such functionality should be optional and configurable[39].

WM represents a modest step towards the more advanced integration promised by new operating system designs such as *MS-Longhorn* (Microsoft Longhorn), and research prototypes such as *Haystack* (Adar et al., 1999). Whilst WM offers integration in terms of mirroring folder structures between PIM-tools, these more ambitious systems facilitate the management of different types of information within a common organizational mechanism. With WM, users still have to manage distinct collections of information separately.

Feedback from the evaluation of WM included several recommendations for improving its design as a specific PIM-integration mechanism (see **Section 6.5.3**). However, the evaluation also offers two lessons for the wider design genre of PIM-integration:

1. *The consistency/flexibility trade-off* – The WM evaluation illustrates that an increase in organizational consistency across different types of information may impact organizational

[39]The author observes that the WM design has other strengths and weaknesses which must be taken into account during evaluation beyond the trade-off between flexibility and consistency. For instance, two other weaknesses include: (1) the additional cognitive load of making the decision on whether to mirror, and (2) the effect of the prompting interruption. In evaluation, the net strengths of the design must be weighed against the net weaknesses.

flexibility. The author believes that an awareness of this trade-off will be useful for the designers of integration mechanisms that incorporate organizing functionality.

2. *The pros and cons of integration* – Some cross-tool designs will not provide integration in terms of organizing functionality as WM does. However, the WM case-study illustrates another more general implication for the wider design genre: that for any integration design, there will be a cost-benefit trade-off which must be carefully considered when evaluating the design.

7.3.3 The Pros and Cons of Integration

The second implication listed above, that an integration design may have pros and cons, may appear obvious to the reader. However, the author observes that in many cases, only the positive aspects of integration are considered, e.g. in marketing literature. The author is not aware of any in-depth investigations of the possible downsides of integration.

The implications of any design may be difficult for designers to predict before it is evaluated. This is particularly the case for integration mechanisms, where costs and benefits may be distributed both across tools and over time. In other words, benefits in tool A at time X, may be offset by costs in tool B at time Y. The attachment mechanism is employed to illustrate this point. This functionality allow non-native information to be communicated via email without the need for re-formatting, and was the most-common form of integration mentioned by participants in the main study. However, the attachment mechanism has a side-effect when viewed from a cross-tool perspective: it enables the storage of files in multiple locations. This distribution of files across multiple tools, so-called *compartmentalization* (Bellotti and Smith, 2000), may cause retrieval difficulties if a user is not sure of the location of a required file. This negative issue is a side-effect of designer's well-intentioned aims to improve integration between email and other tools. The benefits of allowing the attachment of files to emails results in the negative consequence of the file collection being compartmentalized.

Another negative consequence of some integration designs may be increased complexity. **Section 3.3.3** observed the increase in complexity caused by *embedding* support for managing non-native technological formats within a PIM-tool. In addition, one participant in the main study commented that application suites which contain multiple PIM-tools, such as Netscape Communicator or Outlook, were "too integrated".

The examples described in this section illustrate that integration may offer benefits whilst at the same time causing problems for users. At this closing stage of the research, the author therefore takes a measured view on the pros and cons of PIM-integration. This message represents a shift away from the author's original view that integration is a wholly desirable design aim. Although integration has the potential to be a useful design aim, this is not automatically the case. The author therefore raises a note of caution to people working in the field: be aware that integration may have associated downsides. The need for careful analysis of user requirements, and post-design evaluation is emphasised. In some cases it may not be appropriate to integrate – but instead to retain separation between tools. **Section 7.4** presents a series of methodological recommendations for the design and evaluation of cross-tool integration mechanisms.

Two extremes can be envisaged for how PIM-technology may evolve in terms of integration:

- *Multiple, distinct, simple PIM-tools which are optimized for the management of one type of information* – This design route may be likened to Norman's argument in favour of *information appliances*, simple focused tools, focused on performing one thing very well (Norman, 1998). He argues that tools that try to do everything often lead to complexity. However, the downside of such tool specialization is that the user will have to coordinate multiple tools when they are involved in a common production activity. Integration in this case consists of "bolt-on" mechanisms, along the lines of the MS-Windows "Send-to" mechanism, which allow tools to be used together.
- *One single consolidated PIM-tool* – The other extreme is a unified design that offers support for all types of information within a common interface, along the lines of *Haystack* (Adar et al., 1999). Although the resulting design will be complex, there will be no need for the user to coordinate across distinct software applications.

Johnson (2002) suggests that Apple are taking up the first philosophy with a move towards a suite of "iApps" – each dedicated to a particular type of information, e.g. photos or music. In contrast, he argues that Microsoft is moving towards a unified, integrated approach with their plans for MS-Longhorn. More recently, Apple are planning to offer unified search support in the next generation of their MacOS Tiger operating system. It will be very interesting to see how PIM-tool design evolves over the next few years. Furthermore, the author hopes that systematic, cross-tool research, such as that reported in this thesis, will provide helpful guidance to designers.

7.3.4 Suggested Routes for Integration Design

This section highlights a number of potential routes for the design of integration mechanisms based on findings from the two studies reported earlier in the thesis. In lieu of the above discussion regarding the potential pros and cons of integration, the envisaged limitations of each route are also considered:

- *Integration across distinct technological formats* – Currently personal information is clustered within distinct PIM-tools, each focused on one technological format. The cross-tool studies reported in **Chapters 4** and **6** compared how different types of information were managed. Situations where two different types were managed in a similar way may suggest an appropriate route for unification of the corresponding PIM-tools. In particular, the studies highlighted the potential compatibility of personal files and *email that has been filed in folders*. A number of similarities were observed between these information types. Firstly, for many users, they are both either self-created, or assessed as having long-term value. Also, folder overlap was greatest between these collections. Finally, WM usage was strongest between these tools. However complete unification between files and all email (as pointed to by designs such as *TaskMaster* (Bellotti et al., 2003)) may lead to the disruption of the relatively static file collection by unprocessed email. Do users really want to manage spam in the same space that they are dealing with important documents?

- *Integration based on other properties of information except technological format* – Alternatively, designers could attempt to move away from the current fragmentation of personal information based on technological format. Instead, information could be clustered based on other properties – for example *active* versus *inactive*, or *ephemeral* versus *long-term* information. Another alternative route may be "*information created by the user (mine)*" versus "*information downloaded or sent by other people (theirs')*".

In conclusion, there are many PIM-integration routes that are yet to be explored, and evaluated to assess their potential. The next section presents a series of methodological recommendations for designing and evaluating PIM-integration mechanisms.

7.4 Methodological Recommendations

This section presents a series of methodological recommendations for future design in this area, derived from the experience gained in performing this research. The recommendations are organized in terms of the theoretical framework outlined in **Section 7.2**: (1) PIM as a *cross-tool* activity, (2) PIM as a *supporting* activity, and (3) PIM as an *ongoing* activity.

7.4.1 Designing for a Cross-tool Activity

Section 7.2.1 considered PIM from a cross-tool perspective, and portrayed the computer as a set of PIM sub-systems (see **Figure 7.1**). From this federated cross-tool conceptualization, two design perspectives can be developed:

- From a *tool-specific* perspective, each PIM-tool is a distinct sub-system to be optimized independently. **Chapter 4** surveyed problems encountered by users in managing their collections of files, email and bookmarks. Many of these problems were tool-specific, suggesting that tools can be greatly improved through local design improvements.
- On the other hand, a *cross-tool* perspective emphasises the need to optimize the combined sub-systems. In other words, the designer is more concerned about how well the PIM sub-systems *work together*. **Section 4.9** highlighted a number of issues which were not due to the design of particular tools, but instead were attributed to the fragmentation of PIM across a range of poorly integrated and inconsistently-designed tools.

The author advocates that designers and researchers should employ both perspectives when working in this area. In general, PIM design should pay attention to accommodating user needs at the sub-system level, whilst also ensuring effective integration with other PIM-tools.

An over-focus on either perspective can be problematic. Whilst the author acknowledges the need to improve user interfaces to specific tools, a tool-specific focus can ignore user needs in the wider context. Historically, both research and design, have tended to focus on the tool-specific perspective. In terms of design, PIM-tools are complex pieces of software, and accommodating multiple tools during the design process is a formidable challenge. Development teams are typically focused on specific tools, e.g. developing an email tool, and integration may be considered the concern of operating system developers. Indeed, the state of today's

fragmented PIM support can be attributed to a historic tool-specific focus by designers. Within research, HCI methodology tends to focus on individual tools. There are good reasons for this: investigating user behaviour across multiple tools will increase analytic complexity. However, here it is argued that research carried out in any tool-specific context, such as email, cannot fully satisfy the cross-tool needs that many users have in PIM. Indeed, HCI research that only focuses on improvements within specific tools runs a danger of producing results that are as compartmentalized as current personal information environments.

The aim of this research is to influence design practice, and in particular to guide the design of effective PIM-integration mechanisms. The rest of this section offers a series of concrete recommendations to help designers accommodate cross-tool issues in their work. The recommendations correspond to three stages of the user-centred design process: (1) requirements gathering, (2) design/implementation, and (3) evaluation.

Cross-tool Requirements Gathering

Recommendations are presented in two contexts: (1) the design of integration mechanisms, and (2) tool-specific design:

- *The design of integration mechanisms* – When investigating user needs, designers should pay attention to current user behaviour across all the tools that will be affected. The compatibility of user needs in different tools should be carefully assessed. Firstly, cross-tool benefits should be balanced with possible downsides that may only be manifested in a tool-specific context. Furthermore, a requirement in one tool context may directly conflict with one in another. One useful approach may be to develop a series of *cross-tool scenarios* which involve a range of tools, e.g. starting a major project, or planning a holiday. The scenario may be useful in allowing the user to express their needs in the context of a concrete situation.

- *Tool-specific design* – If the focus is tool-specific (e.g. email), the designer should consider how that tool is employed along with other tools in supporting cross-tool production activities. The author acknowledges that investigating requirements from a cross-tool perspective increases analytical complexity. However, it may be useful in identifying user needs which would otherwise be overlooked. Again, cross-tool scenarios may be useful

here, to contextualize questions for prospective users regarding the ways in which the tool of focus must inter-operate with other tools.

Cross-tool Design and Implementation

Recommendations are made in terms of three design situations:

1. *Tool-specific design (modifications to an existing tool)* – Careful attention should be paid to potential side-effects in other tool contexts. For instance, the designer should avoid replicating functionality that is available in other tool contexts. If the functionality does exist elsewhere, it should be designed in a consistent manner.

2. *Tool-specific design (introducing a new tool)* – Designers of new PIM-tools need to be aware that they are adding to a set of existing PIM sub-systems. The downsides of adding a new PIM-tool may outweigh the functionality offered by that tool. For instance, does the envisaged functionality already exist in another tool context? Can the functionality instead be offered within another existing tool? Furthermore, designers should pay attention to what existing integration mechanisms are offered within the operating system.

3. *The design of integration mechanisms* – A key implementation challenge is dealing with the sheer range of PIM-tools in use (Bellotti and Smith, 2000). Integrating one email tool and a web browser is a challenge, but integrating between a wide variety of email tools and web browsers may be too much work. The complexity of designing and implementing cross-tool integration mechanisms can be compensated for by taking up an *incremental design approach*, as employed in this thesis. **Section 5.1** considers the benefits of such an approach.

Cross-tool Evaluation

Whether evaluating a tool-specific or cross-tool design, the impact of any design should be investigated across all PIM-tools:

- *Evaluating tool-specific designs* – The impact of a design intervention in one tool-context may not be limited to that tool-context. For example, users may respond negatively if a

new search mechanism within one tool has an inconsistent appearance to those in other tools.

- *Evaluating integration mechanisms* – Integration mechanisms are in effect *cross-tool design interventions* – they impact upon users' behaviour in multiple tool contexts. For example, WM impacts the usage of three PIM-tools: the file system, the email tool, and the web browser (see **Figure 7.6**). During evaluation, the positive and negative implications of the design must be assessed in all contexts, allowing the overall net impact of the design to be established.

  As "cross-tool artefacts", integration mechanisms break the familiar notion of evaluation focused on users performing tasks within a stand-alone software tool. Much evaluation methodology assumes such a focus. The *Reference Task Agenda (RTA)* (Whittaker et al., 2000b) is used to illustrate this point. Whittaker et al. advocate the identification of standardized "reference tasks" to act as an evaluation focus, and therefore allow the comparison of different designs. However, their consideration of reference tasks is centred on specific tool contexts (e.g. retrieving an item of information from voice-mail). Whittaker et al. do raise the notion of a general task, one that is independent of data type. They observe that research on a general task in the context of one tool may be transferred to another tool where that same task is also relevant. However, they do not consider cross-tool issues beyond this. The author suggests that attention must also be paid to choosing reference tasks that represent relevant cross-tool behaviour, e.g. transferring an item from tool A to tool B.

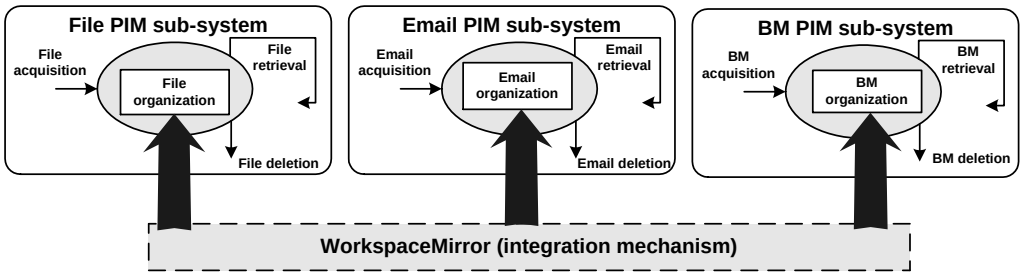

Figure 7.6: WorkspaceMirror conceptualized as a cross-tool artefact which acts as a design intervention in multiple PIM-tools

This thesis acts as a case-study to illustrate how many of these recommendations can be put into practice. **Chapter 4** reported a cross-tool study which surveyed user behaviour across files,

email and bookmarks. **Chapter 5** reported a cross-tool design and implementation based on those requirements. **Chapter 6** reported the cross-tool evaluation of the design.

7.4.2 Designing for an Ongoing Activity

Section 7.2.3 detailed two longitudinal perspectives from which PIM can be analysed: (1) as a sequence of discrete events, and (2) as a ongoing activity. Here it is argued that both perspectives can be useful during requirements gathering and evaluation:

- *Requirements gathering* – Attention should be paid to both time-scales when assessing user needs. For example, user needs in the short-term may conflict with those in the long-term. As well as analysing interactions as one-off events, the impact of a design intervention on associated events, such as storage and retrieval, should be considered. For example, consider the design of a new search mechanism. In the short-term, the optimization of the efficiency of a discrete individual retrieval event may be paramount. However, over the long-term, users may want to reuse search requests. This would suggest the need to save and possibly organize those requests. This in turn may increase the time and complexity in making the initial request.

  One useful approach may be to employ a scenario centred on the *life-cycle of a piece of information*. Tracking interactions with a particular piece of information over time may highlight user issues in terms of a sequence of PIM actions involving all the PIM sub-activities.

  Some user needs may only be apparent over the long-term. For instance, the folder hierarchy is often criticized for not being easily adaptable to fast-changing user needs. Consequently, requirements for dynamic views of personal information are often emphasized in PIM design, e.g. (Dourish et al., 1999; Dumais et al., 2003). A long-term perspective may suggest a contrasting view: that the slow-changing nature of the folder hierarchy may benefit users by promoting familiarity with the personal information environment. Such familiarity in turn supports location-based finding for which users expressed a clear preference. Thus, *persistence* is highlighted as an often overlooked, yet desirable design goal.

- *Evaluation* – Evaluation should be performed over the long-term. The fact that several

participants changed their opinion regarding the WM prototype in **Chapter 6** emphasises this point. Such key observations would not have been revealed in a "snapshot" study. Furthermore, the incremental nature of strategy changes, as reported in **Chapter 6**, means that it may take time for users to adapt to new tools and for stable behaviour to emerge.

7.4.3 Designing for a Supporting Activity

Section 7.2.2 discussed how PIM is not a self-contained activity. Instead, it is driven by the production activities which provide the user's information needs. Such a view suggests that the evaluation of PIM technology should not be limited to measuring improvements in the context of PIM alone. The effectiveness of how well that PIM-tool supports production activities, may be a useful measure of tool effectiveness. However, the author notes that such indirect measures of design success may be hard to capture in practice.

The author also observes that the very notion of PIM as a supporting activity leads to a dilemma for the designers of PIM-tools. As a supporting activity, PIM can both help and hinder production activities. More time spent on PIM may result in better strategies and higher productivity. However, there may be a very different consequence of spending more time managing information: distraction from the very production activities that PIM supports.

- *Encouraging users to spend more time on PIM* – During the main study, participants reported that they were more focused on PIM due to the author's study and design interventions. Those participants who changed strategies noted that this increased focus was a key factor in helping them optimize their management style. Although the changes observed in the main study were subtle, participants found them beneficial.

  This suggests a potential design route: encourage users to devote more attention to PIM, so they can improve their strategies, and receive the same benefits that resulted from the "self-auditing" effect of the study. As an alternative to redesigning tools to promote reflection (e.g. providing statistics on time spent filing and searching), organizations could also play a part here. Typically, organizations are more concerned with knowledge management and other strategic IT – whilst PIM is left to the individual. Nevertheless, PIM is a key aspect of employees' activities and has the potential to cause frustration and waste time. Organizations could publicize PIM-related issues, and encourage employ-

ees to self-diagnose problems to improve their PIM effectiveness. There may even be a case for PIM training days to recommend guidelines for effective PIM, e.g. (Allen, 2003). However, managers should take care not to be overly prescriptive, or they may be seen to be interfering with individuals' preferred style.

- *The downsides of spending too much time on PIM* – Some main study participants also noted the downsides of paying increased attention to PIM: that less attention is available for other activities. This raises a challenge for users, managers and designers alike – they must help the user to *balance* PIM and the production activities that it supports.

  The dilemma for PIM-tool designers is discussed further as follows. Several of the main study participants gave examples of how ticking off to-do items or filing email messages could be highly satisfying, and even act as a therapeutic break from "real work". One can envisage a PIM-tool that is so effectively designed and so satisfying to use, that its users spend all their time managing the information it contains. Should designers be encouraging users to spend more time on PIM? Although this may have the benefit of helping the user improve their strategies, there may also be associated costs. Every extra minute spent on PIM, is a minute taken away from production activities. A key challenge for designers is to help users find their "balance point". Designers should encourage users to do enough PIM to support their production activities, but not so much to cause distraction from them.

7.5 PIM User Experience

Traditional measures of usability focus on performance-related metrics of efficiency, accuracy and productivity (Dillon, 2001; Preece et al., 2002). Preece et al. describe a recent shift towards a wider set of design goals related to the concept of *user experience* – "what the use of a system feels like to the user". They discuss a series of experience-related design goals such as enjoyability and motivation which are hard to assess with traditional measures. Similarly, Dillon (2001) argues the importance of user-experience in evaluating designs. In particular, he highlights the inadequacy of traditional usability measures for many high-level, ongoing tasks such as information retrieval and data analysis. Dillon notes that in such tasks, efficiency may not be the user's priority. Furthermore, such tasks do not always have a definite goal, meaning that effectiveness may be hard to define. The author observes that Dillon's arguments also apply to PIM. **Section 4.4** reported observations of "irrational user behaviour", such as storing items that are never used. In such cases, participants were using interfaces in a clearly inefficient manner. **Section 7.2.3** discussed the ongoing nature of PIM. Although, effectiveness may be meaningful for discrete one-off PIM events (e.g. moving a folder), it is not clear how the effectiveness of PIM-tool usage can be measured in the long-term. This section considers what measures of user experience could be applied in the context of PIM.

Much of the feedback received from the study participants in **Chapters 4** and **6** emphasised *negative user experience* in terms of PIM – participants liked to moan. Many complained of the short-term problems they encountered in retrieving, naming, and classifying items. The effect of such one-off problems may be minor and limited to short-term frustration. However, if they reoccur, the effects may build up over time leading to negative user experience over the long-term. The studies provided some evidence of this. A number of participants reported feeling ashamed or guilty over the state of one or more of their collections[40]. In the extreme, such feelings may even impact a user's sense of self-worth.

The improvement of PIM user experience should be a key concern for the designers of PIM-tools as PIM is a frequent, everyday activity. Therefore, measures of PIM user experience may be a useful qualitative evaluation metric. A number of aspects of negative PIM user experience which could be observed in interview data are highlighted as follows:

[40]The reports of shame and guilt may have been exaggerated since the participants were being asked for a guided tour by the author. However, other studies have also reported this phenomenon, e.g. (Bellotti and Smith, 2000).

- *Sense of untidiness* – Constrained by a finite amount of time and attention resources, the user is faced with a dilemma of how much time to spend managing information. If the user devotes relatively little attention towards PIM, the possible consequences are that they will feel messy or worry that others will see them that way. The user may also be concerned that their productivity may be impacted if they are unable to find items. However, the reasons for feeling untidy may be irrational from an efficiency perspective. For example, having a "messy" inbox may not impact user productivity if search is used effectively. Whether grounded in productivity concerns or not, guilt over messiness still has the potential to cause poor user-experience. Levy (2001) describes such symptoms as "anxiety of order". This may be expressed in terms of the user "feeling untidy" or "out of control". Such feelings may be exacerbated by the pressure from society to see tidiness as a positive trait (Economist, 2002).

- *Sense of wasting time* – In contrast, guilt may also be generated if the user devotes relatively large amounts of time to PIM. In this case, the user may feel guilty for ignoring his or her production activities.

Each of these aspects of negative user experience, may cause the user to feel dissatisfied with their current strategies, and want to adjust them. Several examples of "dissatisfaction with current PIM strategies" are provided in the next section, grounded in observations from the main study.

7.5.1 Satisfaction with Current PIM Strategies

During the main study reported in **Chapter 6**, two types of user were identified, *changers* and *non-changers*, based on whether they changed strategy over the course of the study. Two participants (F3 and M5) made minor changes to how certain types of information were organized. The remaining six participants did not make significant changes to their PIM strategies. However, several of these *non-changers* were dissatisfied with their strategies, and expressed the desire to change them in some way. However, the changes they desired were often seen to be too expensive in terms of time and effort.

Based on this analysis, two more user types are identified, based on whether users were satisfied with their current strategies.

1. *Satisfied with current strategies* – These users are content with their current management strategies, and do not want to change them.

2. *Dissatisfied with current strategies* – These users are not content with their management strategies, and want to change them in some way.

Figure 7.7 presents a series of user profiles which illustrate some examples of "strategy dissatisfaction". These are also used to describe observations from the main study in **Chapter 6**. The horizontal axis indicates whether the user's current organizing behaviour is pro-organizing or organizing-neutral. The vertical axis indicates how satisfied the user feels towards their current strategies. Note that the figure does not specify a particular tool context. Five user profiles are identified as follows:

1. *Profile A: Satisfied and organizing-neutral* – Profile A has a pragmatic attitude towards PIM. She considers organization to be low priority, and feels confident that she can find information when she needs it. Participant M7 in the main study was an example of this profile in all tool contexts – he was satisfied with his organizing-neutral strategies and enjoyed positive user experience.

2. *Profile B: Satisfied and pro-organizing* – Profile B is also satisfied, but is highly organized. She spends a lot of time filing information and believes the time and effort is worth it. Participants M1, M2, and M6 in the main study were examples of this profile in terms of their file and email practices. M5 is also considered an example of this profile in files and email. Although he made pro-organizing changes to his strategies, these were relatively minor.

   The remaining three profiles are examples of users who are dissatisfied with their current strategies and consequently suffering poor user experience.

3. *Profile C: Dissatisfied and organizing-neutral* – Profile C is "image-concious". He considers himself untidy, and feels guilty for not being more organized. Participant M3 was an example of this profile in his file collection: he devoted relatively little effort to organizing, but talked of the social pressure he faced to be more organized. He made some pro-organizing changes towards the end of the study.

4. *Profile D: Dissatisfied and pro-organizing*: Like profile C, profile D is also "image-concious". Although relatively organized, she is still not satisfied with the state of her workspace. Par-

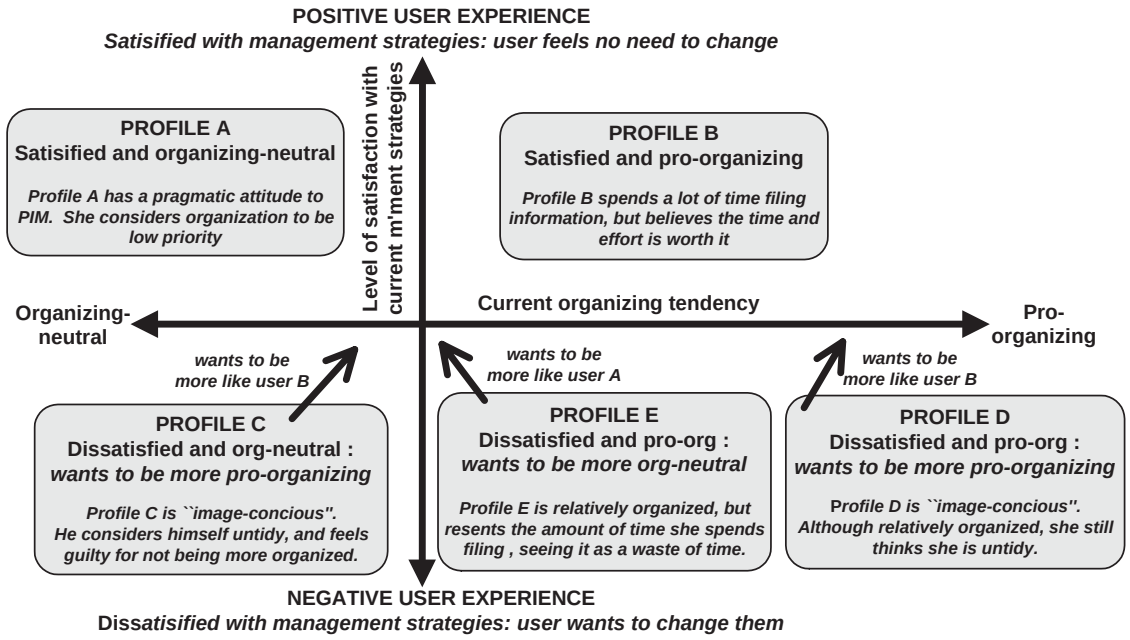

Figure 7.7: Examples of poor PIM user experience caused by "dissatisfaction with PIM strategies"

ticipants M4 and M8 fit this profile in terms of their file management: they both devoted a significant amount of effort to PIM, but wanted to be more organized. However, both stated that they did not have enough time to perform the significant reorganizing they felt was necessary.

5. *Profile E: Dissatisfied and pro-organizing* – This last profile is a hypothetical example. None of the study participants matched the profile, however it is included as an interesting example of behaviour. Profile E devotes significant effort to PIM, but resents the amount of time she spends filing information, seeing it as a waste of time. She believes that she could benefit by not filing, and instead rely on search like one of her colleagues. However, she is not willing to take the plunge and stop relying on folders.

These examples illustrate that users with either pro-organizing or organizing-neutral behaviour may feel dissatisfied with their strategies, and want to change them in some way. It is hypothesized that an ongoing need to change one's behaviour, combined with an inability to achieve the change, may contribute to poor PIM user experience. This may be exacerbated if the symptoms which make the user want to perform the change get worse in the meantime.

Chapter 8

Conclusion

Section 8.1 reviews the aims and methodology of the research, **Section 8.2** discusses the contributions offered over the previous seven chapters, and **Section 8.3** offers a critical reflection of the thesis. Finally, **Section 8.4** considers future work possibilities.

8.1 Revisiting the Research Problem and Approach

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 interfaces to better support this everyday activity. The research focused on one specific area of ongoing design interest, that of improving integration between PIM-tools. As discussed in **Chapter 3**, 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.

After assessing the state of prior research in the area, the objectives of this research programme were defined as follows:

1. *To develop increased understanding of PIM behaviour and needs* – In particular, the researcher set out to investigate behaviour across multiple PIM-tools, to improve the empirical foundation for the design of PIM-integration mechanisms. A secondary aim was to develop theoretical models to describe and explain empirical observations.

2. *To design, implement and evaluate a novel PIM-integration mechanism* – One of the author's key motivations was to develop software to alleviate user problems. A further intention was to avoid the methodological limitations of previous work by emphasising empirical grounding and evaluation.

3. *To develop methodological recommendations for future design work* – The final objective was to provide guidance for future design and evaluation in this area. It was envisaged that the experience of designing and evaluating the PIM-integration prototype would allow the development of such guidelines.

To achieve these aims a the research methodology was structured on a three-stage process of user-centred design: (1) requirements gathering, (2) design, and (3) evaluation:

1. *Requirements gathering* – The exploratory study, reported in **Chapter 4**, investigated user behaviour across three PIM-tools – files, email and bookmarks. This enabled the comparison of behaviour between the tools, and the exploration of potential routes for integration.

2. *Design and prototyping* – **Chapter 5** described the design of a PIM-integration mechanism which allows the user to share folder structures between different collections. The design was motivated by the observation of significant folder overlap for many participants in the exploratory study. Also, the design approach was deliberately *incremental* to facilitate systematic evaluation, and cause minimum disruption to users.

3. *Evaluation* – **Chapter 6** reported the third stage of the research, the field-study based evaluation of the designed prototype. The evaluation facilitated the assessment of the specific design, as well as the development of guidelines for the wider PIM design genre. The field study also enabled the investigation of long-term user behaviour such as changes in organizing strategies over time.

8.2 Contributions

Firstly, key contributions are highlighted in **Section 8.2.1**. The next two sections detail all the contributions made in this thesis. **Section 8.2.2** presents contributions resulting from the study components of the thesis. Then, **Section 8.2.3** discusses contributions resulting from the design, implementation and evaluation of the WorkspaceMirror prototype.

8.2.1 Summary of Key Contributions

This thesis offers a variety of contributions. Here the most significant contributions are highlighted.

The study components of the thesis offer a significant advance over previous work through the investigation of PIM (1) across multiple tools, and (2) over time, thus enabling the development of richer understanding. **Chapter 4** compared PIM behaviour across file, email and bookmark collections, and developed *improved classifications of management strategies*. In particular, it was shown how many users employ multiple organizing strategies, both within and between distinct PIM-tools. In turn, **Chapter 6** collected data over time, leading to the *development of an improved model of changes in organizing strategies*. The knowledge cultivated in the two studies lead in **Chapter 7** to *the enhancement of Barreau's PIM model to accommodate the cross-tool, supporting and ongoing nature of PIM*.

Other contributions result from the design component of the thesis. The key contributions in this area include the *design of the WorkspaceMirror prototype*, in **Chapter 5**, driven by observations of folder overlap in **Chapter 4**. The *evaluation of the design* in **Chapter 6** confirmed the promise of mirroring top-level folders. This represents one of the few systematic, longitudinal evaluations of a PIM-tool performed to date. The evaluation resulted in the *development of a series of design recommendations*, primarily the importance of recognizing that a PIM-integration mechanism may have strengths and weaknesses in different tool contexts. In addition, a number of *methodological recommendations* were developed including the need to evaluate all PIM designs in both tool-specific and cross-tool perspectives.

The next two sections provide more detail on the contributions from the study and design/evaluation components of the thesis.

8.2.2 Improved Knowledge of PIM

This section details contributions that relate to the first aim of the thesis: to develop increased understanding of PIM behaviour. **Table 8.1** provides a summary of the empirical, methodological and theoretical contributions in this area.

Chapter	Contribution	Type of contribution
2	Definitions and PIM conceptual framework	theoretical
3	Critical review of previous work	theoretical
4	Comparison of PIM behaviour between file, email and bookmark collections	empirical findings
4	New classifications of organizing strategies in file, email and bookmark collections	empirical findings
4	Comparison of organizing strategies between files, email and bookmarks	empirical findings
4	Development and application of method to analyse folder structures in terms of *organizational dimensions*	methodological, empirical findings
4	Development and application of method to compare folder structures in terms of *folder overlap*	methodological, empirical findings
4	Model of multiple PIM strategies within tool-specific and cross-tool contexts	theoretical model
6	Insights into longitudinal PIM behaviour: (1) PIM strategy changes, and (2) supporting nature of PIM	empirical findings
6	Model of incremental changes in organizing strategy	theoretical
7	Extended conceptual framework of PIM illustrating its cross-tool, supporting, ongoing nature	theoretical
7	Discussion of qualitative measures of PIM user experience, including "satisfaction with current strategies"	theoretical

Table 8.1: Contributions providing increased understanding of PIM

Two studies of PIM behaviour were reported. Firstly, **Chapter 4** reported an exploratory study in which a semi-structured interview methodology was employed to investigate PIM behaviour across three tools: files, email and bookmarks. Secondly, **Chapter 6** reported a follow-up longitudinal field study, again across the three tools. As well as investigating PIM behaviour over time, the field study also acted as a research vehicle to evaluate the WorkspaceMirror prototype. Both studies are distinguished from previous work by their cross-tool nature.

The primary contribution from **Chapter 4** was *a comparison of PIM-behaviour between files, email and bookmarks* in the terms of four PIM sub-activities: acquisition, organization, maintenance, and retrieval. A number of similarities were noted between the tools including: (1) a preference for browsing-based retrieval over search in all three tool contexts, and (2) the importance of older items for many participants[41]. However, some major differences in behaviour

[41] These contributions, although minor, add to existing HCI knowledge in each tool-specific context, as well as contributing new cross-tool knowledge.

were also noted. These included: (1) the relative unimportance of the bookmark collection, and (2) the uncontrolled nature of acquisition in email.

The rest of **Chapter 4** focused on the organizing sub-activity. The next contribution was *a comparison of each individuals' organizing strategies across the three tools*. Previous strategy analysis has been limited to specific tools such as email and this is the first attempt to analyse strategies from a cross-tool perspective. The comparison of organizing strategies between files, email and bookmarks firstly necessitated the characterization of strategies in individual tools. Multiple low-level organizing strategies were observed for many participants in all three tool contexts. Three *new tool-specific strategy classifications* were offered to reflect this behaviour. Previous classifications were criticised for not capturing this level of detail. Then, at the cross-tool level, *multiple organizing strategies* were observed for many individuals, as in specific tools. This confirmed that users do not employ consistent strategies across different collections of personal information. A number of causal factors were identified including the relative value of the information in each collection – since files are valued most highly, and are most likely to be retrieved, they are seen to be most worth organizing. *A theoretical model of multiple strategies* was developed to describe the tool-specific and cross-tool observations of multiple strategies.

Chapter 4 also reported the development and application of two new techniques for comparing organizing behaviour between collections:

- *A technique for analysing folder structures in terms of the organizational dimensions* – An analysis of the aggregated data characterized the most common dimensions in each tool context. Although projects and roles were the most common dimensions observed, a wide range of organizational dimensions were employed. This lead to the criticism of prototypes such as the *Personal Role Manager* (Shneiderman and Plaisant, 1994), which enforce a dominant organizational dimension. This data suggests that such designs would require users to significantly change their current behaviour.

- *A technique for assessing the level of folder overlap between a participant's file, email and bookmark structures* – Significant overlap was observed for many participants, particularly between the file and email folder structures. This observation provided the key empirical motivation for the development of the WM prototype in **Chapter 5**.

The field study in **Chapter 6** offered two further empirical contributions:

- *The observation of the incremental nature of changes in organizing strategy* – Tracking PIM behaviour over time revealed that few study participants made significant changes in how they organized information in any of the collections. Only two participants were observed making strategy changes, which were of a subtle, incremental nature. Previous theory in the area was criticised for portraying strategy changes in terms of global swings in overall organizing behaviour (Balter, 1997). This data was combined with the model of multiple strategies to develop *a model of changes in organizing strategy* which reflected their incremental nature.

- *The identification of the supporting, background nature of PIM* – This was based on participants' comments that they devoted relatively little attention to PIM compared to their work tasks. Both the study and design interventions caused many participants to report increased reflection on their PIM strategies.

The discussion presented in **Chapter 7** lead to two final contributions in this area:

- *An extended theoretical framework describing the cross-tool, supporting, and ongoing nature of PIM* – This framework offers several advances over previous theory in the area, including: (1) a conceptualization of PIM-integration mechanisms which bridge between distinct PIM-tools, and (2) the representation of the relationship between PIM and the production activities it supports. The framework was used to identify routes for theoretical development in the area.

- *Discussion of PIM user experience* – A number of qualitative measures of PIM user experience were offered as alternatives to traditional performance-focused evaluation metrics, which it was argued are inappropriate for activities such as PIM. A focus was taken on "dissatisfaction in strategies" as a key source of poor user experience. Several participants expressed dissatisfaction with their current strategies, but did not change them because of the perceived costs involved. This data was used to illustrate the forms that such dissatisfaction could take.

8.2.3 Design, Implementation and Evaluation

The second main area of contribution resulted from the design, implementation, and evaluation of the WorkspaceMirror prototype (abbreviated to WM). **Table 8.2** provides an overview.

Chapter	Contribution	Type of contribution
5	Design and implementation of WorkspaceMirror (WM)	design and implementation
5	Results from the initial evaluation of WM	empirical findings
6	Results from the field-study longitudinal evaluation of WM	empirical findings
7	Design implications from the WM evaluation: (1) the trade-off between organizational consistency and organizational flexibility, and (2) the pros and cons of integration mechanisms	design guidelines
7	A series of methodological recommendations to guide the design and evaluation of PIM-tools based on the cross-tool, ongoing, and supporting aspects of PIM	methodological recommendations

Table 8.2: Contributions relating to the design of WorkspaceMirror

The first contribution is the WM prototype itself, as described in **Chapter 5**. WM is offered as *a novel, empirically-grounded form of PIM-integration.* It enables the user to mirror changes made to folder structures between three tools: files, email and bookmarks. In contrast to much of the technological prototyping carried out in the area, WM is an example of *incremental* design, and offered as a case-study of the benefits of this approach. As well as suiting the limited development resources available, this approach enabled straight-forward incorporation of the prototype onto user's computers with minimum disruption. The initial evaluation of WM, reported in **Section 5.5**, resulted in a number of design improvements before more extensive evaluation was performed. These included setting WM to operate in prompted mode by default so that users can retain control over mirroring.

The follow-up field study, reported in **Chapter 6**, resulted in two further contributions: (1) an assessment of WM as a specific form of PIM-integration, and (2) a number of design implications for designers working in this area:

- *Results from the evaluation of WM* – The evaluation of WM represents one of the few that have been carried out of a PIM-integration mechanism. A wide range of behaviour was observed, illustrating the idiosyncratic nature of PIM. Although participants welcomed the ability to mirror entire folder structures, most participants indicated that folder mirroring was appropriate for top-level folders only. For the majority of participants, their requirements for organizational flexibility between tools, outweighed the benefits of organizational consistency offered by WM. Therefore, the study suggests that the potential to share folder structures between PIM-tools is only partial. The study was highly successful in obtaining a wide range of suggestions for improving the design. The most common request was to make mirroring more selective, e.g. limiting it to top-level folders only.

Section 7.3 offered a theoretical explanation of why only certain folders were worth mirroring based on the concept of tool-specific and cross-tool production activities.

- *A series of design guidelines based on the WM evaluation* – Firstly, the designers of mechanisms which offer integration of organizing functionality were urged to pay attention to the trade-off between organizational consistency and organizational flexibility. This was generalized to an implication for the wider PIM-integration design genre: that any PIM-integration design will have both pros and cons. Two examples were provided: WM and email attachments. Furthermore, the positive and negative effects of integration may be distributed across tools, and over time, emphasising the need for careful evaluation.

The final contribution was presented in **Section 7.4**: *a set of methodological recommendations for the design and evaluation of PIM-tools*. These were structured in terms of the extended theoretical framework developed in **Section 7.2**. Firstly, it was argued that PIM-tool designers should consider cross-tool issues during requirements gathering, design, and evaluation. Cross-tool scenarios were recommended as a potential technique to achieve this. Examples were provided to illustrate the importance of such a cross-tool perspective in both tool-specific and cross-tool design contexts. The importance of evaluating PIM designs over the long-term was also highlighted, as illustrated by the main study participants who changed their opinion towards WM over time. Finally, **Section 7.4** highlighted the dilemma of designing for supporting activities such as PIM: encouraging users to spend more time on PIM, may result in them spending less time on their production activities. A long-term PIM-design goal was suggested: that tools should help users achieve a balance between PIM and their production activities.

8.3 Critical Review of the Thesis

Section 8.3.1 considers the overall success of the design-based research methodology in achieving the research aims. Then, **Sections 8.3.2** and **8.3.3** consider the strengths and weaknesses of the study, and design/evaluation components on the research.

8.3.1 Design-based Research Approach

The use of design as a research vehicle was influenced by Carroll's discussion of the applied research paradigm (Carroll, 2000). The design-centred methodology was also motivated by the philosophy that if you want to provide guidance to designers, you need get in there and get your hands dirty doing some design work yourself. In summary, it is argued that this research approach was successful in generating a number of contributions. As well as producing design requirements, the study component of the research offered significant advances on previous knowledge, by investigating behaviour across multiple PIM-tools. Furthermore, a novel form of PIM-integration was invented by the author, and although its evaluation resulted in both positive and negative feedback, the potential to share high-level folders between PIM-tools was confirmed. Although the prototype is not as technologically innovative as previous designs, the author argues that it represents a more complete contribution to HCI knowledge, due to its systematic evaluation.

The extended conceptual framework in **Section 7.2** illustrates the complexity of PIM as a research domain. Since the author acted as the sole researcher, performing all studies, design and evaluation work, a number of pragmatic constraints were applied to the research scope. Firstly, the scope of concern was limited to three PIM-tools – files, email and bookmarks – on one personal computer in a work context. Ideally, other related tools such as calendars and to-do lists would have been studied in-depth, as well as PIM activity on other devices. Furthermore, there is potential for follow-up work outside the work context.

8.3.2 Study Component

The studies reported in **Chapters 4** and **6** yielded a rich data set. A key achievement was the cross-tool nature of the empirical work which sets the research apart from previous work in

this area. Furthermore, few longitudinal studies have been carried out, and the main study was successful in revealing insights that would not be possible in a shorter-term study (e.g. changes in PIM strategy). Although the work set out with a focus on PIM-integration, it is noted that many of the contributions relate to PIM in general. This was a natural consequence of performing a cross-tool investigation, which facilitated both tool-specific and cross-tool insights. It is hoped that the work reported here, as well as building on previous results, has opened up new directions for future work.

However, a number of limitations are acknowledged regarding the empirical work. The first study was exploratory, and it is acknowledged that the results are preliminary. Areas that could be revisited, assuming sufficient resources, are the folder-overlap and organizational dimensions analyses. Routes for improvement include the use of inter-rater reliability in the coding of organizational dimensions, and identification of folder overlap. Further validation of results would also be desirable through reflective interviews with participants.

Other limitations are noted in the main study methodology. The author acknowledges that his design intervention had a significant influence on participants' behaviour, e.g. changes in strategy. This was acknowledged in the results section, and was an unavoidable consequence of the dual-purpose nature of the study. It can also be argued that the main study could be extended longitudinally. Several aspects of PIM were relatively sporadic (e.g. folder-based organization), so more data would be useful. This is difficult however, as the study already involved significant commitment on the part of the participants.

A final limitation of both studies was the number and selection of participants. The studies focused on a small technically experienced group of users. However, it must be stated that this criticism can be applied to the vast majority of work in this area. Different behaviour and problems may well be expected for other types of user, leading to different user needs. **Section 8.4.1** describes follow-up studies which could be performed to deal with these limitations.

8.3.3 Design and Evaluation Component

It is argued that the design component of the study served the purposes of the researcher well. Firstly, it resulted in a novel PIM-integration mechanism, which was subsequently evaluated. The evaluation identified strengths and weaknesses of folder-mirroring, expressed in terms of the trade-off between organizational consistency and organizational flexibility. This lead to

a moderation of the author's initial view of integration being a purely desirable design route, to one with both pros and cons. Based on the evaluation findings, a number of design and methodological guidelines were developed for the wider field. In particular, the author argued the need for designers to carefully assess the pros and cons of integration, both from a cross-tool and tool-specific perspective.

The incremental design approach lead to a number of benefits. Firstly, it meant that a robust prototype could be developed within the resource constraints available. Secondly, systematic evaluation was also promoted by making a limited set of changes (Newman and Lamming, 1995). A final logistical benefit was that test users were able to install the tool within their existing PIM-tool environment with minimum disruption. Since WM was installed on top of existing folder structures, the testers could try out folder-mirroring without any need to reorganize their data. Although incremental design is often recommended in HCI, e.g. (Carroll, 2000), it has rarely been used in the field of PIM. One reason may be that the limitation of *local optimization* puts off designers with ambitious aims. However, it is argued that the overall benefits of incremental design as described above, outweigh this limitation. Based on these experiences, a move away from revolutionary design towards an incremental approach is recommended in future research. In this thesis, it has been shown how this approach is particularly appropriate when resources are limited.

One acknowledged limitation of the design work in this thesis is that it was not possible to re-design the tool based on the feedback reported in **Section 6.5.3**. The most promising extensions are discussed as possible future work in **Section 8.4**.

During evaluation, the author chose to promote the ecological validity of results by employing a field-study method. This choice lead to several logistical challenges, including the need to install and support the prototype on a number of computers across London. Furthermore, significant commitment (and some bravery!) was required from the participants. However, the field study approach also had a number of advantages. Firstly, it gave participants time to try the tool in an unpressured context. Furthermore, it also provided opportunity for behaviour to emerge as the tool was used, and to assess whether use was long-term. Also, the fact that participants F3 and M5 both changed their mind regarding the usefulness of WM, illustrates that first impressions as revealed in shorter-term studies may not be correct. Another retrospective benefit from evaluating over the long-term was that organizing was performed infre-

quently. However, it can be argued that the study was not long enough, as several participants performed scant organization, or mostly performed PIM on different computers. These were all inherent challenges of performing research in the real world.

Eight participants took part in the longitudinal studies and responded to the tool in eight different ways, highlighting the idiosyncratic nature of PIM. Despite the small set of participants, the investigation was successful in obtaining a wide range of feedback, some of which was unanticipated (e.g. the promotion of reflection on PIM, as a result of the prompting from WM).

As in the studies, participant selection was somewhat unusual due to the reliance on friends and colleagues. Ideally participants should be randomly selected and not known by the researcher to avoid bias. In this case, participant selection is defended due to the privacy problems that arise when inspecting users' personal file, email and bookmark collections. The existing familiarity between participant and researcher lead to an established trust basis, making access to personal data less problematic.

Section 8.4 now moves on to consider possible directions for future work, many of which are driven by the limitations identified in this section.

8.4 Future Work

This section identifies avenues for future research. **Section 8.4.1** outlines promising directions for empirical work, **Section 8.4.2** discusses prospects for design and evaluation, and **Section 8.4.3** highlights the need to develop the theoretical foundation on PIM.

8.4.1 Further Studies to Improve Understanding of PIM

This study has opened up two new avenues for empirical investigation of PIM: (1) across multiple tools, and (2) over time. Since PIM is a complex, and highly idiosyncratic phenomenon, there is a clear need for follow-up studies along both routes. Assuming no resource constraints, a "wish list" for a follow-up study is laid out as follows. The study would be carried out over a full year, using a combination of data collection methods as in **Chapter 6**. The number of monitored PIM-tools would be extended to encompass multiple areas of the file system, calendars and to-do lists as appropriate. Improved instrumentation would be developed to make it possible to track specific acquisition, organization, and retrieval events in each PIM-tool. Beyond the desktop, there is a need to investigate PIM behaviour across multiple devices, and into the physical domain (for instance, are users who are highly-organized in the digital domain, also highly organized in the physical domain?). Attention would also be paid to a user's high-level production tasks – the work and personal activities which provide the information needs to drive PIM. One interesting angle would be to track a large project from start to finish and relate that to PIM activity, and needs for integration. Since this rich data set would allow the researcher to build up a detailed picture of participants' lives, privacy issues would need to be carefully handled.

One general criticism that can be levelled at most PIM-related research to date, including this thesis, is that it has focused on professional users, people who manage information in a work context. The author calls for the field to devote increased attention to the needs of "social" users – people who use their computers for personal rather than work activities. It is envisaged that many of these users, especially those with less technical know-how, will have different needs and problems to those encountered in previous studies.

8.4.2 Designing More Effective PIM tools

The author reiterates the importance of evaluation within the design process. Without evaluation it is not clear whether a new design is "better or just different" (Newman and Lamming, 1995) In particular, the author would encourage published evaluations of innovative PIM approaches such as *attribute-centred organization* as proposed in systems such as *Presto* (Dourish et al., 1999). Such insights would prevent the designers of similar systems, e.g. *MS-Longhorn*, from repeating earlier mistakes which may have been made.

Design is never-ending (Carroll, 2000). A number of design improvements for WM were suggested by the evaluation participants. The most common request for follow-up design would be to make folder-mirroring more selective, e.g. "mirror top-level folders from email to files only". Two further design routes are raised by the author. Firstly, the scope of folder-mirroring could be widened beyond the desktop to include other devices, and web-based PIM services. Another potential of folder-mirroring is within the PIM-tool suites offered by websites such as "Yahoo!". A second intriguing, design direction is inspired by the work of Chaffee and Gauch (2000). They investigated how user-defined categories could be used to structure sets of search results. It may be revealing to investigate whether a user's mirrored folder structure could be used in this way, thus taking a step towards the unification of information management and information retrieval.

As in the area of empirical studies, the author encourages more design attention to be paid to "non-technical" users. There is a need for the design of specialized interfaces for specific user groups, e.g. home users, older people. Currently such users have to use the same PIM-tools as technically-experienced users. In terms of WM, the author hypothesises that such "non-technical" users may find the cross-tool consistency introduced by folder-mirroring helpful. However, two study participants argued a contrasting point of view – that novice users (both participants used "My Mum" as an example) would find it confusing. An evaluation of WM with such users is called for to assess the utility of folder-mirroring.

8.4.3 Developing a Theoretical Foundation for PIM Research

A final route for future work is to develop the theoretical foundation on PIM. **Section 7.2** has outlined the groundwork for this, extending previous theory to encompass the supporting, ongoing, cross-tool nature of PIM. However, the author acknowledges that this work is preliminary, and only represents the first steps towards a more complete descriptive theory. Theoretical frameworks such as Activity Theory (Nardi, 1995) and Distributed Cognition (Kirsh, 2001) may be appropriate foundations on which to develop more extensive models of PIM. One key area to accommodate in such a model is the relationship between *production* and *supporting* activities. This break-down might also be usefully applied in theoretical descriptions of other supporting activities such as security practice.

An alternative route to developing a "monolithic" theory may be to combine theories which operate at distinct analytical levels (Barnard et al., 2000), e.g. theories of short-term versus long-term behaviour. Also, a theory of information retrieval could be accommodated within a more general PIM theoretical framework.

Another possibility would be to extend Information Foraging Theory (Pirolli and Card, 1999) to encompass PIM behaviour. This is explained as follows using an evolutionary metaphor similar to that employed by Pirolli and Card. Information Foraging Theory allows the modelling of information seeking, which in evolutionary terms equates to "deciding what food [information] to take back to the cave" (where the cave is one's personal information environment). A model of PIM must be more encompassing, and should reflect what happens to the information after it has been foraged. Is it stored in the cave or quickly discarded? Is it looked at again? Is it used to decorate the walls of the cave? Is it arranged in neat piles or hurled into a heap? Furthermore, Information Foraging Theory assumes that the user has no prior knowledge of the environment from which information is retrieved. Therefore, in order to model the retrieval PIM sub-activity ("the foraging of information that has already been foraged"), some measure of prior familiarity with the information environment must be included.

The author emphasises that whatever form a theory of PIM takes, it must be accessible to designers, or it will be ignored outside of the research domain.

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Appendix A

Materials from Exploratory Study

The following documents are included in this appendix:

A.1 Exploratory Study: Informed consent form

Place-holder for consent form

A.2 Exploratory Study: Interview structure

Place-holder for interview template

Place-holder for interview template

Place-holder for interview template

Place-holder for interview template

Place-holder for interview template

Place-holder for interview template

Place-holder for interview template

Place-holder for interview template

Place-holder for interview template

Place-holder for interview template

Place-holder for interview template

Appendix B

Materials from Initial WM Evaluation and Main Study

The following documents are included in this appendix:

B.1 Main study: Informed consent form

Place-holder for B.1 consent form

B.2 Main study: Profiling interview

Place-holder for B.2 profiling interview

B.3 Main study: Diary template

Place-holder for B.3 diary template

B.4 Cross-tool design: Initial evaluation

Place-holder for B.4 initial eval

Place-holder for B.4 initial eval

Place-holder for B.4 initial eval

B.5 Main study: Interim interview

Place-holder for B.5 interim interview

Place-holder for B.5 interim interview

Place-holder for B.5 interim interview

B.6 Main study: Closing interview

Place-holder for B.6 closing interview

Place-holder for B.6 closing interview

Place-holder for B.6 closing interview

Place-holder for B.6 closing interview

Place-holder for B.6 closing interview

Place-holder for B.6 closing interview

Place-holder for B.6 closing interview

Place-holder for B.6 closing interview

Place-holder for B.6 closing interview

Place-holder for B.6 closing interview

Appendix C

Sample data

This appendix contains samples of the data collected in the exploratory and main studies:

C.1 Exploratory study: sample data

Place-holder for C.1 Exploratory study: sample data

Place-holder for C.1 Exploratory study: sample data

C.2 Main study: sample data

Place-holder for C.2 Main study: sample data

Place-holder for C.2 Main study: sample data