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CHARACTERISING PERSONAL INFORMATION IN THE ENGINEERING DOMAIN

Hamish McAlpine, Ben Hicks and Steve Culley
University of Bath, UK

ABSTRACT
In recent years there has been a growing recognition of the importance of 'personal information' and there now exists a large number of personal information management tools. The concept of personal information is discussed in the context of engineering design and the shortcomings of current definitions are highlighted. To address this, an audit of the personal information used by engineers has been undertaken, showing the types used and how they are linked. The preliminary results indicate the importance of the logbook in linking and integrating information sources and it is suggested that because of this – and its importance in engineering design - it should be reconceptualised as a central tool to integrate the engineers' personal information world.

Keywords: Personal information, information use, information sources, logbooks

1 INTRODUCTION
The critical role of information in supporting the various activities of engineering design, and the ability of the designer to efficiently retrieve information has been widely reported. It has also been observed that engineers maintain and access a wide variety of information sources, which include personal information, organisational information and extra-organisational information. Whilst considerable work has been undertaken in the areas of organisational information such as PDM and document management systems, and extra-organisational information sources, such as suppliers literature, EDI and Internet resources, less attention has been given to personal information.
In the area of personal information, previous work by the authors has explored the use, content and structure of the engineer's logbook [1] revealing the variety of classes of information they contain and how information is typically structured. This study was followed by an in-depth evaluation of current and emerging technologies for supporting personal information management and specifically logbooks [2]. Both these studies revealed the prevalence and relative importance of personal information and suggested that such sources may support a much richer range of purposes than solely recording design related information such as design rationale, informal meeting notes and lessons learned. It is also suggested that personal information sources contain a large amount of potentially valuable information for the organisation. Most recently, 'informal notes' have been categorised against their content, reason for creation, use and format [3], with the authors concluding that "*such notes…are an overlooked source of knowledgeability about organizational practices*" and are a "*largely untapped source*".
To explore the concept of personal information further, a critique of current literature is presented. Based on this, an audit of the personal information of engineers is undertaken and the various types are characterised. The findings demonstrate the importance of the logbook in linking and integrating information stores. The authors propose to reconceptualise the logbook as a central tool in the engineers' personal information world, and realise its potential by developing a more integrated electronic version. By reconceptualising the logbook in this manner it is argued that wider project and organisational benefits beyond the simple sharing of information may be realised.

2 REVIEW OF PERSONAL INFORMATION

The term 'personal information' has been defined within a number of fields of research. Most commonly, the term is used to denote information about a person. An example would be a persons' address, credit history or other details held by a company. The term is also used by information researchers in the context of how people use information, and in the Human computer interaction (HCI) field where the main objective is more efficient use of such information through the use of technology. Existing work on personal information in these areas is summarised below and its relevance to personal information in engineering is discussed.

2.1 Existing definitions

Information researchers have explored the individuals' information needs, how they find the information and how they then use it [4]. Discussing 'information overload', it has been suggested that "in response to this challenge, individuals create a personalised subset of the information world that they can use when they are faced with information needs" [5]. These 'personal information collections' are further defined as consisting of various forms of content (documents, notebooks, web pages etc), structures for representing and organising the information (folders, hierarchies etc) and pointers to the information, such as bookmarks, links and people and have been described thus:

"A personal information collection is defined, therefore, as the space we turn to first when we need information to do a task or pursue an interest. It is a collection of information sources and channels that we as individuals have acquired, cultivated and organised over time and in response to a range of stimuli. The personal information collection is an organic and dynamic personal construct that we take with us into, and out of, the various events that frame our daily working and personal lives."

Others have used the terms information space [6], personal information environment [7], and personal file store [8]. However, it has been noted by a number of authors that such collections are not simply created for a specific purpose, but are created "in anticipation of some future need for that information – personal anticipated information need…" [5]. From this perspective then, personal information is anything that is collected, generated or structured for that individuals' use.

In contrast to this, personal information management (PIM) - which is often closely linked to or utilised by Human computer interaction (HCI) researchers - refers to the methods by which individuals handle, categorise and retrieve information [9]. It is "the practice of managing the information that helps us in our daily lives" [10]. From an HCI perspective, personal information has been defined as information owned by an individual and under their direct control [11] which is consistent with the definitions discussed above. In a similar way that content was been separated from structure in [5], it is also recognised in HCI that personal information may consist of items and collections [11].

As a consequence of a greater recognition of the 'knowledge worker' as an organisation's most valuable asset, there now exists a huge range of PIM tools and software. These include diaries and organisers, electronic notebooks and databases to catalogue collections of anything, from journal papers to DVD's (See [11] for an overview). However, it has been suggested by a number of authors that the sheer number of tools available to try and manage the very diverse range of personal information types has - instead of actually solving the problem – led to increased 'information fragmentation': Instead of actually providing integration "*tools such as Microsoft's OneNote™...introduce wholly new forms of information*" [12] as OneNote™ uses a proprietary file format. It has also been found that uptake of electronic PIM tools was low, and they were often used in combination with traditional 'pen and paper' tools [9]. More recently, there have been moves towards greater integration of PIM tools (see, for example, [11] [13]), although this is also not without its problems as it has been suggested that "*incorporating multiple functions into a single, computer-based device may well level out the unique properties of traditional technologies*", and that the use of multiple tools (both traditional and electronic) provides enhanced redundancy and flexibility [9].

2.2 Other dimensions of personal information

The literature also reveals that personal information may have a number of more subtle purposes for both their creation and maintenance and are not simply used to retrieve useful information when required. These purposes are summarised below:

1. As a form of *invisible innovation* to *subvert* unsuitable information systems [14], or to deal with very complex systems [3]. Examples include having 'crib sheets' due to insufficient on-screen help or unintuitive menu systems, or recording on paper intermediate results from modelling programs where no facility exists to store or print them.

2. As a means of maintaining privacy by controlling the circumstances of disclosure [15]. In this case, a personal information collection may be used to keep track on who has what information, or withhold information altogether, with good intentions or otherwise.

3. As a way of maintaining social relationships [16]. It has been suggested that keeping personal collections increases social interaction and the chance of opportunistic sharing of information that may lead to benefits such as more creative solutions or future collaboration.

4. Linked to the purpose of maintaining social relationships, using other people's personal information is a way of obtaining trustworthy information easily. Many studies of information use cite colleagues as a major source of information (see, for example, [17]) and because colleagues often share much of the same of what has been described as an 'unarticulated background' of company culture and domain knowledge, information from such sources is generally more trusted and less open to misinterpretation [18]. If information is not understood or incomplete, the recipient can question the owner directly, thus minimising effort, which is another important factor in information use [4].

5. Referring to artefacts such as filing cabinets personal information sources can also be used as 'Cognitive scaffolding' [19]. For example, it would be difficult to remember where each of a thousand customer files were located if they were merely in a single large, random pile. Artefacts such as filling cabinets and their electronic equivalents mean we need only remember the structure (e.g. they are all filed alphabetically) to locate the information.

6. To support 'self-explanation' and problem solving [20]. For some people, the act of writing information down or collecting and organising sets of documents supports retention, problem solving or understanding. In this case it was shown that the act of creating personal information (in this case in notebooks) increased the accuracy of scientific reasoning problems and the amount learned by the participants

7. As a provider of context and additional rationale [1]. For example, additional informal information such as annotations on printed CAD drawings or graphs may be provided, or links (both physical and mental) between the informal 'working out' and the formal, published document may exist.

8. In the case of paper archives of personal information, note that paper also reminds through its physical presence and is often faster to access than electronic sources. Copies of publically available information may also be kept because the reliability and permanence of external stores is not trusted [21]. This is important because it has been shown that accessibility is the single most important determinant of source use [22]

2.3 Personal information in engineering

There has also been research on what constitutes personal information in the engineering domain. A number of types of information kept in 'personal stores' have been identified, including: memos, faxes, email, meeting minutes, company reports, journal articles, calculations, collections of drawings, guideline extracts, catalogues, presentations and loose text & drawings [23]. A further questionnaire

by Lowe revealed that such personal stores of information satisfy 37% to 45% of the owners information requirements, reinforcing their importance.
In detailed studies of design practice, it has been shown that designs are often annotated or adjusted informally on paper before the changes are incorporated into the final, published design. This paper is then stored by the individual or discarded [24], again highlighting the potential importance of such sources to the organisation as well as to the individual's work practices. Similarly, [21] analyse in detail archives of paper-based information in an industrial research environment and found that personal archives are kept for a variety of reasons, both cognitive and emotional. They also draw implications for designing electronic systems for supporting personal information, suggesting that novel visual interfaces may help individuals better organise and retrieve information and that being able to retrieve information based on its contextual information is important.
As well as general PIM tools, there are also growing numbers of tools aimed specifically at supporting engineering work. There are a number of electronic logbooks aimed at engineers [2] and more attention is being paid to understanding and supporting personal information sources such as sketches, notebooks and document collections for the early stages of design, problem solving and creativity (see, for example, [25] [26]) although uptake of such tools has generally been low. It is interesting to note that in 2001 only 20% of such information was stored in an electronic format [23], supporting earlier criticism of the effectiveness of current electronic PIM tools.
There is also a body of work on design rationale capture (DRC) systems, which arguably seek to formalise or make more accessible information that has been observed to be present in logbooks and other personal sources [1]. Whilst the uptake of many other tools for managing personal information has been low, there have been some notable successes for DRC tools such as the Design Rationale editor (DRed) [27] which suggest at least some types of personal information have real organisation value.

2.4 Discussion

The above review highlights a range of perspectives on personal information, revealing its complexity and consequent difficulty in fully characterising it. Notwithstanding this, a number of observations may be made:

1. Whilst the definitions (such as that in [5]) of personal information collections and the perspectives on the purpose of personal information summarised in section 2.2 are undoubtedly useful in helping to understand its nature, they are not specific to the engineering domain.

2. Many of the lists of personal information types only consider some types of information (e.g. paper or electronic, just handwritten sources etc.) and some lack empirical grounding. There appears to be a tendency to assume that what constitutes personal information is commonly known and accepted.

3. With a few notable exceptions (e.g. [3] [24]) there exists little guidance on how best to manage or improve support for personal information use – both for the individual and especially for the wider organisation – although limited successes in the field of design rationale capture hint at the potential value of such sources.

4. As a consequence, although many tools exist for personal information management in the engineering domain, uptake has been low. Indeed, the sheer number of disconnected tools may actually have increased the problem of information fragmentation and overload.

A working definition of personal information as '*Information created by - and primarily for - the individual*' will be adopted. Note that this definition makes no reference to whether the information is formal or informal, nor whether it is electronic or paper-based. Further, the authors argue that whilst the potential value of personal information is recognised, not enough has been done to identify and characterise the full range of personal information sources, how such sources are used at present and

how they might be managed in an integrated way to allow more effective reuse, for both the individual and the organisation.

3 PERSONAL INFORMATION AUDIT

The personal information use of research engineers at Bath University and design engineers at a large aerospace engineering company has been investigated. Six participants were questioned about their personal information use in a semi-structured way. The participants were interviewed at their desks to encourage them to talk about the 'information stores' around them. It also allowed the interviewer to see samples of the information and question them in more detail about how it was used. A pro-forma was developed and refined through initial discussions with a number of engineers at Bath. Building on the previously discussed idea that personal information collections can be viewed in terms of *Form, Structure* and *Pointers* [5], topics discussed included what types of 'information stores' were used, how they were structured and organised, what contextual information was present and how the information stores linked to each other.

Identifying personal information by 'information store' (i.e. the physical or electronic medium used to hold or transmit the information) was considered appropriate for two reasons: Firstly, it was easy and natural for the participants to identify with - and reflect on - their personal information use. Secondly, identifying the information in this way allows some insight into the use of - and interaction between - multiple mixed-media sources. Participants were questioned about how the sources were used and where possible pointers existed, and were asked to show examples if possible. These pointers usually took the form of explicit links between stores or an input to another store. For example, an engineer might make reference to an electronic file store or contact information also found in another store, such as an address book. Typical comments indicated that, for example, the engineer would record in their logbook the file paths to CAD models, or paste a print-out of results in their logbook to annotate it, or that they would record messages on Post-it™ notes before transferring these to another store such as their diary, with one complementing the other. However, as noted in section 2.1, the use of multiple sources may hold benefits such as providing enhanced redundancy [9], but also cause 'information fragmentation'. The aim of questioning participants about how information stores linked together (or 'pointed' [5] to each other) was therefore to inform the design of the next generation of personal information management strategies and tools that could avoid these problems through improved integration.

The topics of structure and organisation and context were chosen because it is arguable that the first two factors dictate to a large extent accessibility (together with being able to physically access the information), which has been shown to the most important factor influencing information seeking [22]. The context-providing identifiers provided with the information arguably dictates to a large extent its value or usefulness, as far as it can be influenced (i.e. usefulness is ultimately a judgement by the end-user, all one can do is try to maximise the chances of it being useful by allowing the user to accurately assess its relevance and quality). Note that when collections of information exist, such as a collections of journal papers, their organisation is assessed under the heading 'arrangement' – recognising that collections of formal information can be considered personal information if they are collected for, and used by, the individuals. Furthermore, such personal information sources are frequently arranged in a specific way to add value. Detailed definitions of the factors investigated in the study are given in Table 1, overleaf.

Table 1 – Factors Investigated

Category	***Definition***	***Examples***
Information Store	The physical or electronic artefact used hold and/or transmit the information	Post-It notes, diaries, logbooks, email, box files, collections of journal papers or books, to-do lists etc.
Form	Characterisation - A brief description of what form the information takes	Paper-based/ electronic, printed/handwritten etc.
Structure	Subjective assessment of how the information entities are structured on the scale of low to high (see examples on right)	**Low** – freeform text that does not follow conventions of written language or graphic representation (no full sentences, paragraphs etc) **Medium** – Follows conventions of written language or diagrammatic representation. **High** – as medium but also in a widely accepted and commonly understandable format for the source, e.g. contact details arranged alphabetically by surname, with fields for address, job role, telephone number etc.
Organisation	Subjective assessment of how the information entities are arranged on a scale of low to high (see examples on right)	**Low** – No apparent organisation other than co-location **Medium** – arranged in an obvious way – e.g. chronologically or alphabetically, by project name, etc. **High** – As for medium, plus in a commonly accepted way for that type or with an index or contents page.
Arrangement (if applicable)	How collections of personal information are arranged/archived (for multiple instances of types only – e.g. collections of journal papers)	As for Organisation, if collections of a type of information exist (a collection of past logbooks or journal papers, for example)
Contextual Information	Assessment of the identifying information or metadata, such as times, dates, project names, descriptions etc that are present, on a scale of none to high.	Dates/times, title, author, description of information, etc. **Low –** Date or brief title etc **Medium –** As low, plus descriptive title and consistent across entities **High –** As medium plus description of intent or scope of information/additional background, in an accepted, structured format.
Pointers	Explicit links to other types or sources of information, whether personal or not, as assessed by the author and through examples	References to people (i.e. contact details), URLs, papers/books, electronic files, or any information held in other stores.

4 PRELIMINARY RESULTS

It has been asserted by the authors that the main barriers to effective use/reuse of personal information in the engineering design field are:

1. A lack of understanding of the number and types of personal information used by engineers,
2. The lack of understanding about the links between them and;
3. The consequent lack of guidance or strategies for managing this information and knowledge.

To address these points, the personal information stores of engineers have been investigated and the pointers (links) between them explored with a view to informing an integrated strategy and design for the next generation of engineering PIM tools.

The results from this investigation reveal a number of interesting outcomes. In total, 24 types of personal information stores were identified and characterised. These are listed in Table 2, overleaf and discussed below.

Table 2. Personal information stores

Form	Store	Description of Form	Characteristics				
			Structure	**Organisation**	**Arrangement (if applicable)**	**Contextual information**	**Pointers**
Paper-based	Logbook	Hand written, containing a variety of information from many sources	Low	Medium	Low	Low	Computer file stores, URL's, Contacts, Books, Papers, Files/folders, Emails, Diary Entries, meeting action lists
	Diary	Typically a hard-back book with a week-to-view format	Medium	High		Low	Contacts
	Post-it notes	Kept on desks, around computer monitors etc. Very brief unstructured notes, handwritten.	Low	Low	Low	None	Computer file store, Contacts, URL's, Diary entries
	Address book	A4 sheet of numbers and addresses	High	Medium		Low/Medium	
	Business cards	Kept in file in alphabetical order	High	Medium	Medium	Medium	Contacts
	To-Do list	To-do list – paper	Medium	Low/Medium		Low	Contacts, Emails, Diary entries
	Noticeboard	In office and used to store information in various formats	Low	Low		None	Diary entries
	Flipchart	A2 paper chart, used to record ideas etc or during presentations.	Low	Low		None/Low	
	Books	collections of reference material kept on or near desk	High	High	None	Low	
	Journal papers	As above	High	High	Low/Medium	Low	
	Files and folders	Various collections of a wide range of reference material such as reports etc, usually printed	NA/Various	Low	Low	Low	
	Paper bundle	As above, but stored loose on desk for accessibility	NA/Various	Low	Low	Low	
	Meeting action list	Produced from meeting minutes and used in a similar way to to-do lists	Medium	Medium		Medium	Contacts, Email
	Paper notes	Loose A4 paper notes used as a logbook, but less information from other stores. Still stored chronologically	Low	Low	Medium	Low	Computer file stores, URL's, Contacts, Books, Papers, Emails
Electronic	Diary	As for paper. Variety of programs used, most commonly Microsoft Outlook	Medium	High		Low	Contacts
	Address book	As for paper version, but often more detailed info present	High	Medium		Medium	
	To-do list	As paper, but commonly integrated with email and diary system	Medium	High		Low/Medium	Diary entries, Emails
	Tablet Notes	Used as a logbook by only 1 participant and in a similar fashion to a regular logbook	Low	Medium/High		Medium	Computer file stores, URL's, Contacts, Books, Papers, Emails, Diary Entries
	Email	Variety of programs used, commonly Outlook. Large number of files attached to incoming and outgoing mail	Low to medium	High		Medium	Logbooks, Computer file stores, URL's, Contacts, Diary Entries, to-do list
	Computer file store	Personal files on shared (network) or personal hard drive, containing large variety of information, organised in hierarchical folders	NA/Various	Medium		None/Low	Disk collections
	Browser bookmarks	'favourites' folder used to keep track of commonly used URLs. Often contained 50+ links, but less in engineering organisation	NA	Low/Medium		None/Low	
	Web history	Used in a similar way to bookmarks, above	NA	High		Medium	
	Disk collection	Collections of CDs or other media containing a large variety of electronic files including supplier catalogues and backups	NA/Various	Low	Low	Medium	
Other	Whiteboard	Used to record a variety of brief notes or sketches, often for 'working out' or in a collaborative situation	Low	Low		None/Low	Contacts, Diary entries

The number of personal information stores used by the participants varied widely, from five to 14, although all participants - even the participant using only five personal information stores - commented that it still formed an integral part of their working day. This shows that personal information was still an often used and important source of information, which is consistent with the results of previous work ([3] [21] [23]). The information also took a variety of forms, with 14 of the 24 types being paper-based. Of these 14 types, seven were handwritten and the remainder printed. Although the quantities were not accurately measured in this assessment, a large majority of the information was clearly still paper-based, echoing the findings of [23].

Most stores of personal information identified had little structure and were often organised in the most basic ways. The collections or archives were not organised, or organised in a simple chronological manner, although this may be a consequence of their relatively small size. The exceptions to this were diaries, email systems and to a lesser extent, electronic file stores, which all enforce a pre-defined method of organisation on the user. Contextual information was also limited in most cases. Dates and titles were often in evidence, but often applied inconsistently with, for example, dates lacking years or being in an ambiguous format. The exceptions to this were again largely found in electronic stores such as email and notes taken on a Tablet PC. This is because much of the contextual information was generated automatically, or the user was prompted to enter it (e.g. a subject line in an email, which also included the date, time, list of recipients, previous correspondence appended to the reply etc).

The number of pointers (links) to other sources of information also varied. The greatest number of *pointers from stores* were contained within logbooks (9) emails (6), Tablet PC notes (7), loose paper notes (6), and Post-it™ notes (4). Whilst most other sources rarely pointed to other information sources (most commonly contact details or electronic files), these stores were commonly used in conjunction with multiple sources, including journal papers, a variety of electronic files, URL's, contact details, books/journals and diary entries. The greatest number of *pointers to stores* were for Diaries (7), address books (7), computer file stores (3) and web browser 'favourites' (3). It is important to consider both *pointers from* and *pointers to* stores as both measures reflect the importance of that store.

This is illustrated in detail in Figure 1, below. Note that for the purposes of this diagram, information stores that existed in different forms but held the same information content (e.g. electronic and paper versions of diaries, and logbooks, loose paper notes and electronic notes) were grouped for clarity.

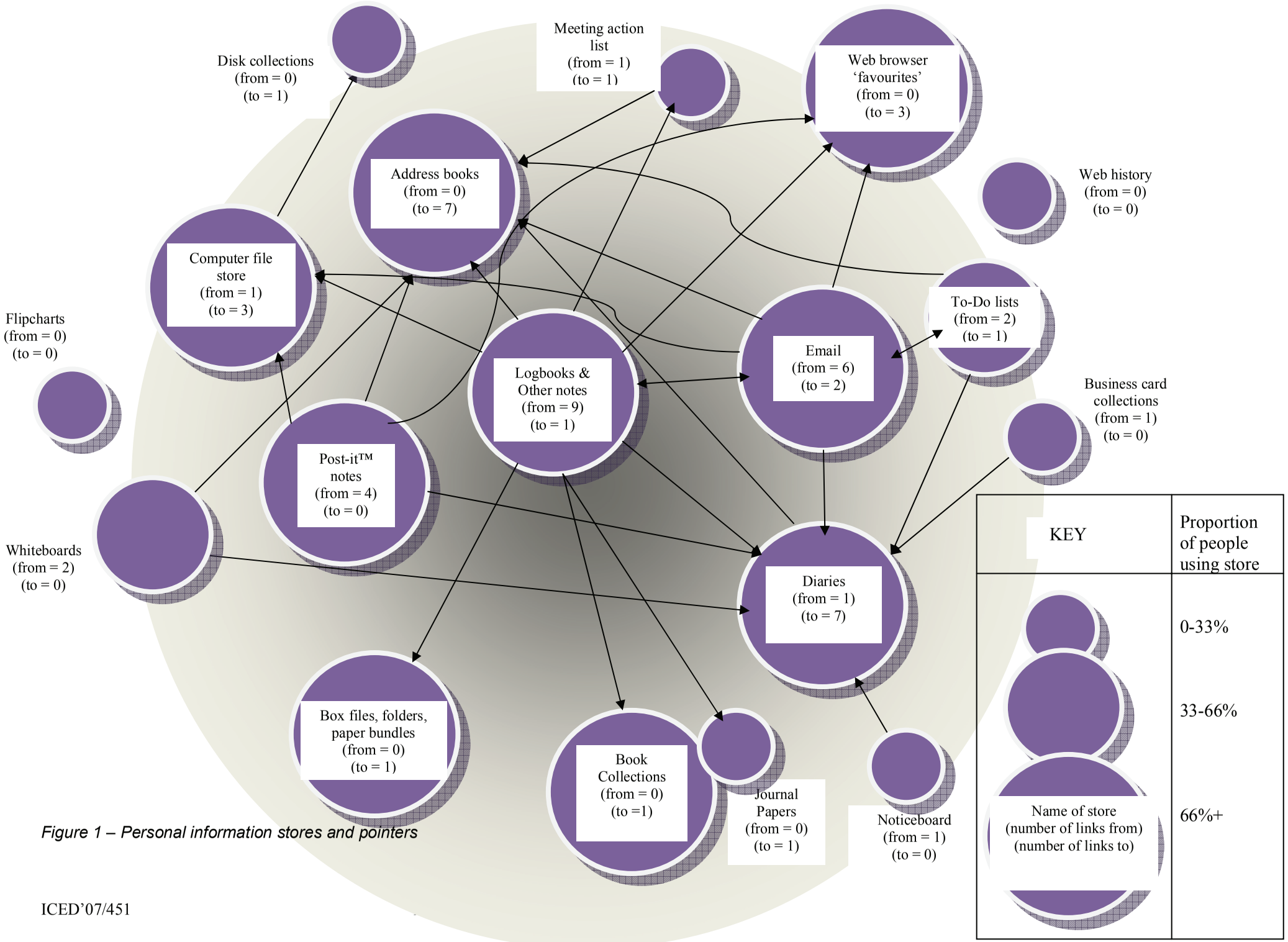

Figure 1 – Personal information stores and pointers

It can be seen that the most widely used stores (represented by larger circles) were also amongst those with the most pointers from and to other stores. The top four were: Logbooks and other notes, email, diaries and address books. It is also apparent from the audit that of these well used stores with many pointers, email, address books and diaries are all well developed: There are numerous electronic PIM tools with sophisticated organisational functions such as remote access, sharing and collaborating to fulfil these functions. Further, such electronic tools have almost universal use in large engineering organisations, with only one participant still using a paper-based diary.

In contrast, traditional paper logbooks/paper notes currently have a limited capacity for use/reuse, arguably due to their lack of structure, organisation and contextual information, and are rarely referred to after they are full or at the end of a project [1]. This is reflected through anecdotal evidence from the interviews, where participants commonly judged logbooks and other stores with little structure or context to have little or no capacity for reuse by colleagues or the wider organisation, despite containing potentially valuable information. Conversely, email and other more structured sources were judged to be most useful as personal and organisational stores of knowledge about past projects.

The authors propose that this - together with the importance of the logbook as a source of information and knowledge in engineering design [1] - means that logbooks should be reconceptualised as a central tool in the engineers' personal information world, alongside email, diaries and address books.

As well as benefiting the individual through a more integrated approach to creating, searching and sharing of their information, the authors envisage that an improved logbook which integrates more efficiently with these other key information stores could provide organisational benefits on two levels: Firstly, by exploiting pointers and other contextual information, logbooks could provide a wealth of *knowledge about* who was involved with a project, what sources of information they used and with whom they interacted. Secondly, by increasing levels of structure and organisation, large amounts of *knowledge of* engineering design-related information such as design rationale and intent, reasons for failures as well as successes, the outcome of meetings etc. could also be made more accessible.

5 CONCLUSIONS AND FUTURE WORK

The concept of personal information has been reviewed. Various definitions and eight additional dimensions have been identified and it has been shown that, in the context of engineering design, these current definitions have a number of shortcomings. To address these, a preliminary audit of engineers' personal information usage has been undertaken. Twenty four types of personal information were identified and characterised. Whilst it is recognised that this is only a starting point and more detailed work needs to be done, the audit did reveal that a large number of personal information sources are used and that they link in various ways. The authors propose that because of the importance of the logbook in linking and integrating a large number of information stores, and its importance as a source or engineering design information and knowledge, that it should be reconceptualised as a central tool in the engineers' personal information world.

However, it is argued that currently - because of a relative lack of structure, organisation and contextual information exacerbated by the fact that most logbooks are still paper-based – their potential for use/reuse by individuals and the organisation is not being fulfilled. The authors therefore intend to create a new electronic logbook that is designed to retain the well documented affordances of paper-based personal information sources whilst effectively integrating, structuring, organising and providing context to its content to make it a truly useful resource. It is proposed that a new e-logbook that integrates more closely with other key stores such as email would help to integrate the engineers' complex information world, reduce 'information fragmentation' and deliver individual and organisation benefits including the more effective reuse of engineering design information.

A crucial issue is how to design such a tool to ensure that the trade-off between individual and organisational benefits maximises the value of the information whist retaining ease and speed of creation that paper-based logbooks and other personal information stores currently provide. To that end, the authors now intend to investigate a strategy that uses both the explicit Pointers and other contextual information such as dates and project titles, to provide close integration between major information stores when necessary, and more 'lightweight' integration between other stores. Finally, it is noted that this work is based on observations in the UK. The authors intend to establish whether potential benefits may be realised internationally.

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REFERENCES

[1] McAlpine H, Hicks B, Huet G & Culley S. An investigation into the use and content of the engineer's logbook. *Design Studies*, 2006, 27 (4), pp. 481-504.

[2] McAlpine H, Hicks B & Culley S. A Review of State-of-the-Art technologies for supporting a designer's electronic logbook. In *Proceedings of Design 2006*, 15-18th May 2006, Dubrovnik, Croatia. pp. 565-572.

[3] Topi H, Lucas, W & Babaian, T. Using informal notes for sharing corporate technology know-how. *European Journal of Information Systems*, 2006, 15, pp. 486-499.

[4] Choo CW, Detlor B & Turnbull D. *Web work: Information seeking and knowledge work on the world wide web*, 2000 (Kluwer Academic Publishers, Dordrecht, The Netherlands).

[5] Bruce H. Personal, anticipated information need. *Information Research*, 2005, 10(3), paper 232.

[6] McKnight C. The personal construction of information space. *Journal of the American Society for Information Science*, 2000, 51(8), pp. 730-733.

[7] Malone TW. How do people organize their desks: implications for the design of office information-systems. *ACM Transactions on Office Information Systems*, 1983, 1(1), pp. 99-112.

[8] Lowe A, McMahon C & Culley S. Characterising the requirements of engineering information systems. *Int. Journal of Information Management*, 2004, 24, pp. 401-422.

[9] Jones SR & Thomas PJ. Empirical assessment of individuals' 'personal information management systems'. *Behaviour and Information Technology,* 1997, 16(3), pp. 158-160.

[10] Bellotti V & Smith I. Informing the design of an information management system with iterative fieldwork. In *Proceedings of the DIS 2000 conference on Designing interactive systems: processes, practices, methods, and techniques*, 2000, pp. 227-237 (New York, ACM Press).

[11] Boardman R. *Improving tool support for personal information management.* PhD Thesis, 2004, Dept. Of Electrical and Electronic Engineering, Imperial College London.

[12] Jones W. Finders, keepers? The present and future perfect in support of personal information management. *First Monday*, 2004, 9(3), Available at: http://www.firstmonday.org/issues/issue9_3/jones/index.html. Accessed January 2007

[13] Microsoft corp. *What is a Tablet PC?* Available from: http://www.microsoft.com/windowsxp/tabletpc/evaluation/about.mspx. Accessed January 2007

[14] Spinuzzi C. *Tracing genres through organizations: A sociocultural approach to information design*, 2003 (The MIT Press, Cambridge, Massachusetts).

[15] Grudin J. Desituating action: Digital representation of context. *Human Computer Interaction*, 2001, 16, pp. 269-286.

[16] Toda M, *cited in* Grudin, 2001. Common sense, emotion, and chatting, and their roles in interpersonal interactions, *SCCS Tech. Rep. No. 90–1–01*, Chukyo University, Nagoya, Japan.

[17] Ward M. A survey of engineers in their information world. *Journal of Librarianship and Information Sciences*, 2001, 33(4), pp. 168-176.

[18] Tsoukas H. The firm as a distributed knowledge system: A constructionist approach, *Strategic Management Journal*, 1996, 17, Winter Special Issue, pp. 11-25.

[19] Norman, DA. *Things That Make Us Smart: defending human attributes in the age of the machine*, 1993 (Addison-Wesley, New York).

[20] Trafton JG & Trickett SB. Note-taking for self-explanation and problem solving. *Human Computer Interaction*, 2001, 16, pp. 1-38.

[21] Whittaker S & Hirschberg, J. The character, value and management of personal paper archives. *ACM Transactions on Computer-Human Interaction*, 2001, 8(2), pp. 150-170.

[22] Fidel R & Green M. The many faces of accessibility: engineers' perception of information sources. *Information processing and management*, 2004, 40, pp. 563-581.
[23] Lowe A. *Studies of information use by engineering designers and the development of strategies to aid in its classification and retrieval.* PhD Thesis, 2002, Dept. Of Mechanical Engineering, University of Bristol.
[24] Henderson K. *Online and on paper: visual representations, visual culture and computer graphics in design engineering*, 1999 (The MIT press, Cambridge, MA).
[25] Gross MD & Do EY. Demonstrating the electronic cocktail napkin: A paper-like interface for early design. In *Proceedings of Computer Human Interaction* (CHI 96), April 13-18th, 1996, pp. 5-6.
[26] Howard TJ, Culley SJ & Dekoninck E. Information as an input into the creative process. In *Proceedings of Design 2006*, 15-18th May 2006, Dubrovnik, Croatia, pp. 549-556.
[27] Bracewell R & Wallace K. A tool for capturing design rationale. In *International conference on Engineering Design (ICED 03),* Stockholm, August 19-21st 2003.

Mr Hamish McAlpine
University of Bath
Innovative *design* Manufacturing Research Centre (I*d*MRC)
Bath, BA2 7AY
UK
Telephone +44 (0)1225 384 166
Fax +44 (0)1225 386 928
H.C.McAlpine@bath.ac.uk
http://www.bath.ac.uk/eimrc/