Enhanced Visualisation Techniques to Support Access to Personal Information across Multiple Devices

By

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Declaration

I, Simone Beets, hereby declare that the thesis for the degree Philosophiae Doctor is my own work and that it has not previously been submitted for assessment or completion of any postgraduate qualification to another University or for another qualification.

Simone Beets

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Summary

The increasing number of devices owned by a single user makes it increasingly difficult to access, organise and visualise personal information (PI), i.e. documents and media, across these devices. The primary method that is currently used to organise and visualise PI is the hierarchical folder structure, which is a familiar and widely used means to manage PI. However, this hierarchy does not effectively support personal information management (PIM) across multiple devices. Current solutions, such as the Personal Information Dashboard and Stuff I've Seen, do not support PIM across multiple devices. Alternative PIM tools, such as Dropbox and TeamViewer, attempt to provide a means of accessing PI across multiple devices, but these solutions also suffer from several limitations.

The aim of this research was to investigate to what extent enhanced information visualisation (IV) techniques could be used to support accessing PI across multiple devices. An interview study was conducted to identify how PI is currently managed across multiple devices. This interview study further motivated the need for a tool to support visualising PI across multiple devices and identified requirements for such an IV tool. Several suitable IV techniques were selected and enhanced to support PIM across multiple devices. These techniques comprised an *Overview* using a nested circles layout, a *Tag Cloud* and a *Partition Layout*, which used a novel set-based technique. A prototype, called MyPSI, was designed and implemented incorporating these enhanced IV techniques. The requirements and design of the MyPSI prototype were validated using a conceptual walkthrough. The design of the MyPSI prototype was initially implemented for a desktop or laptop device with mouse-based interaction.

A sample personal space of information (PSI) was used to evaluate the prototype in a controlled user study. The user study was used to identify any usability problems with the MyPSI prototype. The results were highly positive and the participants agreed that such a tool could be useful in future. No major problems were identified with the prototype. The MyPSI prototype was then implemented on a mobile device, specifically an Android tablet device, using a similar design, but supporting touch-based interaction. Users were allowed to upload their own PSI using Dropbox, which was visualised by the MyPSI prototype.

A field study was conducted following the Multi-dimensional In-depth Long-term Case Studies approach specifically designed for IV evaluation. The field study was conducted over a two-week period, evaluating both the desktop and mobile versions of the MyPSI prototype. Both versions received positive results, but the desktop version was slightly preferred over the mobile version, mainly due to familiarity and problems experienced with the mobile implementation. Design recommendations were derived to inform future designs of IV tools to support accessing PI across multiple devices. This research has shown that IV techniques can be enhanced to effectively support accessing PI across multiple devices. Future work will involve customising the MyPSI prototype for mobile phones and supporting additional platforms.

Keywords: Personal Information, Personal Information Management, Information Visualisation, Personal Space of Information, Information Visualisation Techniques, Multi-dimensional In-depth Long-term Case Studies

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List of Abbreviations

Abbreviation	Description
API	Application Programming Interface
ASQ	After-Scenario Questionnaire
CSS	Cascading Style Sheets
CSUQ	Computer Satisfaction Usability Questionnaire
D_3	Data-driven Documents
DoD	Details-on-Demand
DSR	Design Science Research
DUI	Distributed User Interface
GIM	Group Information Management
HTML	Hypertext Mark-up Language
ICT	Information Communication and Technology
IV	Information Visualisation
JSON	JavaScript Object Notation
MILC	Multi-dimensional In-depth Long-term Case Studies
NMMU	Nelson Mandela Metropolitan University
OOUI	Object-oriented User Interface
PC	Personal Computer
PI	Personal Information
PIC	Personal Information Collection
PIM	Personal Information Management
PSI	Personal Space of Information
SQL	Structured Query Language
SVG	Scalable Vector Graphics
TIM	Task Information Management
UI	User Interface
URL	Uniform Resource Locator
USB	Universal Serial Bus

WIMP	Windows Icons Menus Pointer
XML	Extensible Mark-up Language
ZOIL	Zoomable Object-oriented Information Landscape

Chapter 1: Introduction

1.1. Background

Personal information management (PIM) deals with the daily activities or tasks that users need to perform using a stored, organised and retrieved set of information items such as documents and calendar events (Jones and Maier, 2003). A user's volume of personal information (PI) increases constantly, and due to the current technology era, information is being stored on a number of different devices and platforms or applications (Aires and Gonçalves, 2012; Badesh *et al.*, 2014; Kolman *et al.*, 2012). This has led to a high level of dispersion of PI, referred to as the information fragmentation problem, and an increased difficulty in managing and using the information (Bergman, Beyth-Marom and Nahmias, 2006). Multiple consequences of this problem exist. Firstly, it may be difficult, or even impossible, for a user to access information stored on a different device when the device is not in the vicinity of the user. Secondly, users may have difficulty in managing the different ways in which the PI is organised on the different devices.

Effective PIM tools should unobtrusively support and assist with a person's daily activities (Weiss and Craiger, 2002). One of the key tasks performed by a user is PI organisation (Badesh *et al.*, 2014). PI should be suitably organised or structured to enable efficient information retrieval (Latif and Min Tjoa, 2006). The current method used to organise PI is to browse hierarchies (Golemati *et al.*, 2007). A hierarchical PI organisation method makes use of a tree structure to organise information items and PI collections (PICs) (Indratmo and Vassileva, 2008). The inflexible nature of existing hierarchical systems makes it difficult for users to maintain PI organisation (Evequoz and Lalanne, 2007).

Information visualisation (IV) is used to display information in a graphical and viewable manner, which should provide an effective means of observing the information (Aires and Gonçalves, 2012). Gomes, Gama and Gonçalves (2010) suggest that a meaningful visualisation technique may be the solution for the difficulty in finding information among the increasing amount of users' PI. Visualisations may assist a user in finding what s/he is searching for (Al Nasar, Mohd and Ali, 2011). Finding PI is also a key task of PIM, which could involve PI visualisation to assist in the information retrieval process (Badesh *et al.*, 2014). A PI visualisation tool should provide as much of an overview of a user's personal space of information (PSI) as possible, regardless of which device on which the PI is stored or the PI type (Jetter *et al.*, 2008). Several shortcomings were identified with the current PIM hierarchical organisation method and it was concluded that the existing hierarchical organisation method does not sufficiently support PIM, as well as PIM across multiple devices (Evequoz and Lalanne, 2007; Indratmo and Vassileva, 2008). Thus, the PI visualisation technique currently used, namely the indented list, will also not sufficiently support PIM as IV is dependent on organisation. Current PIM research provides possible solutions, such as the PI dashboard discussed by Aires and Gonçalves (2012), but these solutions are mainly limited to enhancing PIM on a single device or to focussing on a subset of PI, for example documents, images or emails (Tungare, 2007).

One of the main PIM research challenges is how to visualise the different PI items over the multiple devices on which the data is stored (Jetter *et al.*, 2008). The underlying structure of PI and the IV techniques currently used to visualise PI across multiple devices will need to be considered in order to effectively visualise PI. It remains to be investigated how PI should be visualised using the existing structure of the information to support access to PI across multiple devices.

1.2. Relevance of Research

As a user's PSI increases constantly, the need becomes greater for effective PIM. The current PI organisation methods and IV techniques do not support a user in managing his/her PI effectively. The current hierarchies used for PI organisation are inflexible and do not sufficiently support PIM across multiple devices.

Current PIM solutions are focussed on enhancing PIM on a single device or focussing on a subset of PI. This research will investigate how enhanced IV techniques can be designed and whether these techniques support accessing PI across multiple devices. The aim of this research is to improve the visualisation of PI to support a user with PIM across multiple devices.

1.3. Research Outline

The research outline describes the problem statement, which defines the problem to be addressed by this research, and the aim of the research, to identify how the research will address the problem. The research questions are defined. The research methodology used to achieve these objectives is discussed. The scope and constraints and the envisaged contribution of this research are then identified.

1.3.1. Problem Statement

Existing personal information management (PIM) organisation methods and information visualisation (IV) techniques do not support accessing personal information (PI) across multiple devices.

1.3.2. Aim of Research

To design enhanced information visualisation (IV) techniques to support access to personal information (PI) across multiple devices.

1.3.3. Research Questions

The following main research question was addressed by this research:

How should PI be visualised to support access to PI across multiple devices?

The above research question was answered by addressing the following sub-questions:

RQ 1. What are the existing problems with current PI organisation methods?

RQ 2. What are the existing problems with current PI visualisation techniques?

RQ 3. What are the requirements for an IV tool to support access to PI across multiple devices?

RQ 4. How can enhanced IV techniques be designed to support access to PI across multiple devices on a desktop device?

RQ 5. How effective are these IV techniques in supporting access to PI across multiple devices on a desktop device?

RQ 6. How can enhanced IV techniques be designed to support access to PI across multiple devices on a mobile device?

RQ 7. How effective are these IV techniques in supporting access to PI across multiple devices in a real environment using a desktop and a mobile device?

RQ 8. What are the design recommendations resulting from this research?

1.3.4. Research Methodology

A suitable research methodology was required to address the aim of the research and the research questions identified for this research. A mixed methods approach was required to address the various research questions, which are discussed in the *Research Strategies* sub-section. Limitations of the research are also identified in this section.

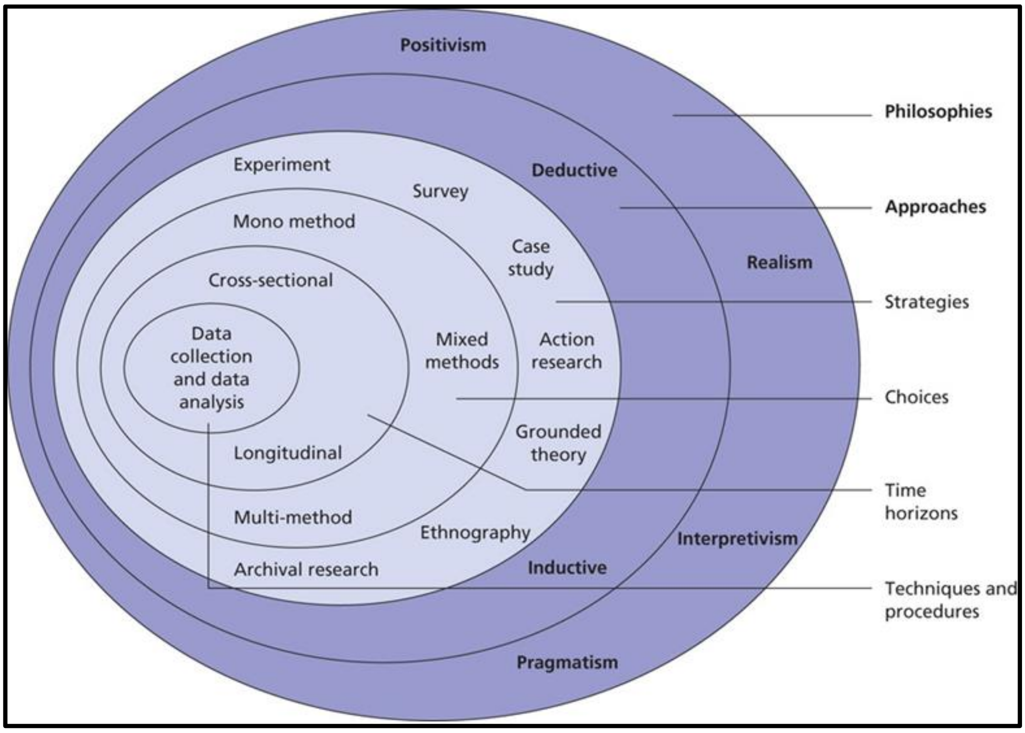


Figure 1-1 The Research Onion (Saunders, Lewis and Thornhill, 2009)

The traditional approach to research follows the philosophies, approaches and research methods shown in the research onion in Figure 1-1, which was identified by Saunders *et al.* (2009). Traditional approaches to research have explicit problems that are defined upfront. As this research describes an initial problem identified by the problem statement in Section 1.3.1, additional research methods or strategies were needed to explicitly identify and outline the problem to be addressed by this research. Thus, this research followed a combination of a positivist and an interpretivist philosophy. The research also used a combination of an inductive and deductive approach as the research was measurable and was used to address a focus with the interview study and prototype design introducing new theory. The project used descriptive and experimental research.

1.3.4.1. Design Science Research Methodology

Design Science Research (DSR) is an alternative research methodology that uses a combination of positivist and interpretivist research philosophies. The DSR methodology is widely applied in information technology- and information systems-based research, as artefacts commonly need to be designed and evaluated to address a need or to provide a solution to an existing problem identified within these fields (Johannesson and Perjons, 2012). The DSR methodology also applied to this research, where the problem was not explicitly clear upon commencing the research and whereby the processes involved within the methodology could be used to further identify the problem to be addressed.

The DSR methodology is considered to be a study of artefacts (Johannesson and Perjons, 2012). Johannesson and Perjons (2012, p.8) define the DSR methodology as:

> *"Design science is the scientific study and creation of artefacts as they are developed and used by people with the goal of solving practical problems of general interest."*

An artefact is defined as an item that is created to address a practical problem (Johannesson and Perjons, 2012). In general, examples of artefacts include physical objects, drawings, methods and guidelines. In the information systems field, artefacts could include algorithms, logic programs, systems, prototypes, models and design guidelines. This research resulted in the design of an artefact as identified in RQ 4 and RQ 6. The DSR methodology involves defining a problem statement, identifying requirements and evaluating the resulting artefact.

An artefact consists of three parts (Johannesson and Perjons, 2012). These parts are listed below:

- *Construction:* The construction of an artefact describes the components of the artefact, the relationship between these components and the interaction between these components.
- *Environment:* The environment of an artefact describes the conditions under which the artefact will function, its intended use and the target users of the artefact.
- *Function:* The function of an artefact describes the expected functionality to be supported by the artefact and the resulting benefits of using the artefact.

Table 1-1 The Activities of the DSR Methodology (Johannesson and Perjons, 2012)

	Activity	Description
1.	Explicate Problem	• Involves examining and analysing a problem. • The problem needs to be clearly identified. • Reasons for the problem can also be investigated.
2.	Outline Artefact and Define Requirements	• Involves explaining the solution to the explicated problem. • Also involves identifying requirements for the proposed artefact. • Proposed requirements are identified for the primary purpose of deriving functionality for the artefact, but construction and environment can also be included.
3.	Design and Develop Artefact	• Involves producing an artefact supporting the identified requirements and addressing the explicated problem. • Primary purpose of this activity involves identifying functionality and construction.
4.	Demonstrate Artefact	• Involves presenting the artefact to determine its feasibility, e.g. using a proof-of-concept. • Used to determine if the artefact can potentially address the explicated problem in any way.
5.	Evaluate Artefact	• Involves showing to what extent the artefact supports the identified requirements and addresses the explicated problem.

The goal of the DSR methodology is to yield an artefact and knowledge regarding this artefact (Johannesson and Perjons, 2012). Several types of knowledge exist for the DSR methodology. These knowledge types are varied, but prescriptive knowledge was gained by this research as design recommendations were identified to inform future designs of IV tools to support PIM across multiple devices (RQ 8). Several artefact types also exist. These include constructs, models, methods and instantiations. For the purpose of this research an instantiation was used, as a prototype was developed to determine whether enhanced IV techniques effectively support accessing PI across multiple devices (RQ 7).

The process of the DSR methodology comprises a number of activities (Johannesson and Perjons, 2012). These activities together with their respective descriptions are listed in Table 1-1. An overview of the DSR methodology is summarised in Figure 1-2 with the corresponding outcomes of each activity. The process involved with the DSR methodology is not necessarily conducted sequentially as an iterative approach is encouraged.

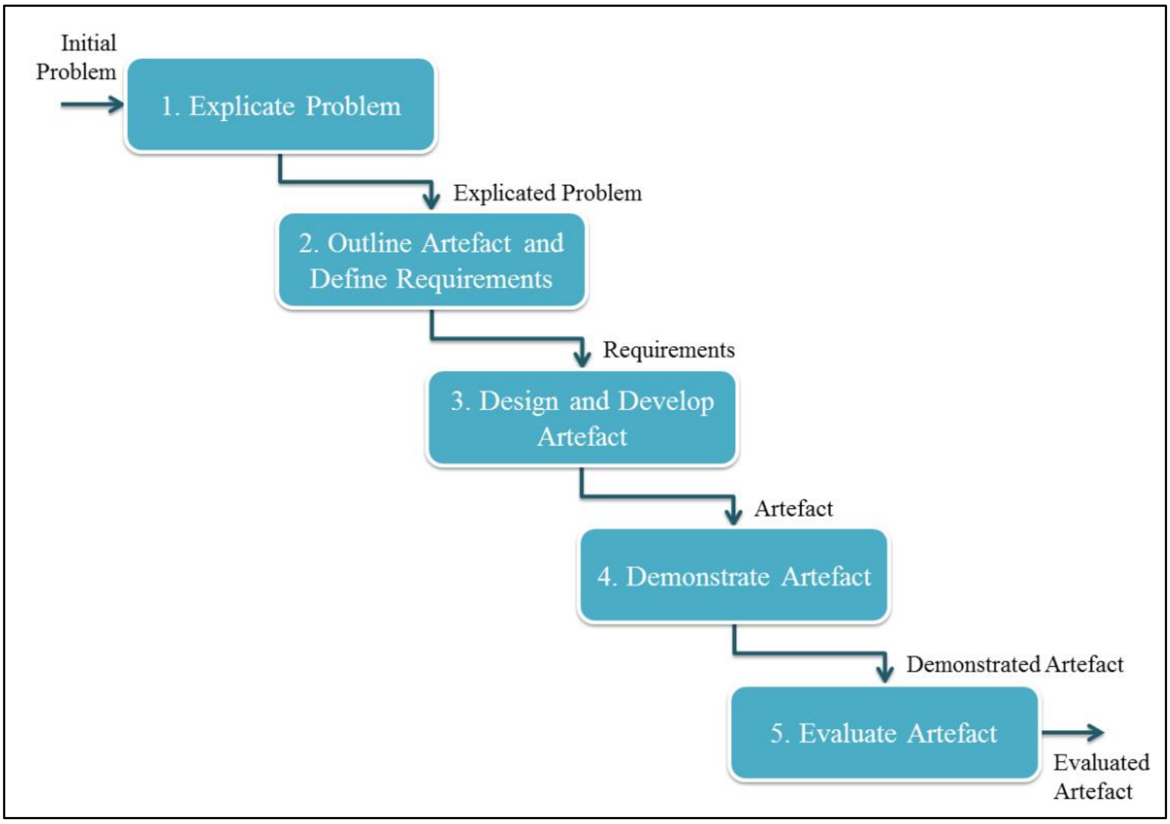


Figure 1-2 An Overview of the DSR Methodology (Johannesson and Perjons, 2012)

As stated previously, the main aim of the DSR methodology is to provide additional knowledge to an existing knowledge base (Johannesson and Perjons, 2012). The results from each activity of the DSR methodology will need to be collated to add knowledge to an existing knowledge base. The knowledge bases in this research include PIM and IV and the knowledge that was added are the design recommendations to inform future IV tools in accessing PI across multiple devices (RQ 8).

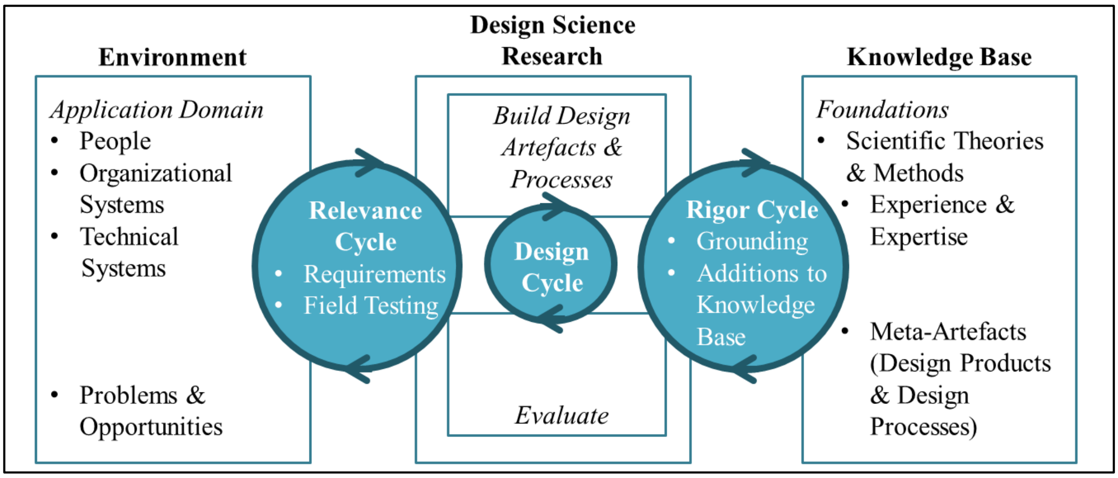


Figure 1-3 The DSR Methodology Cycles (Hevner and Chatterjee, 2010)

Three design cycles are included in the DSR methodology (Hevner and Chatterjee, 2010), as shown in Figure 1-3. These cycles include the relevance, design and rigor cycles, which are explained below (Hevner and Chatterjee, 2010):

a) Relevance

The relevance cycle relates to the environment associated with the DSR activities. The purpose of the introduction of artefacts is to improve the environment in which the explicated problem is experienced. As shown in Figure 1-3, the application domain includes the interaction of people, organisational and technical systems for a specific purpose. Problems and opportunities are identified within the environment to determine a need to be addressed. This cycle involves describing the context of the artefact by identifying the problem to be addressed, the requirements of the research, as well as the conditions under which the success of the research is determined as described in this chapter. Evaluations can be used to determine whether an artefact indeed improves the environment, by evaluating the artefact within the application domain (RQs 5 and 7). The results of the evaluation stage will determine whether further iterations are required to improve the artefact by addressing any problems identified from the evaluation or to further support the identified requirements.

b) Rigor

The knowledge base also includes the capabilities of the most advanced research in the applicable application domain as well as the existing artefacts. A requirement of this cycle is to provide a review of existing literature within the application domain and knowledge base to ensure sufficient contribution is made by the research (RQs 1 and 2). Appropriate theories and methods need to be identified to construct and evaluate the proposed artefact (RQs 3-7). Existing literature can be used to identify problems and opportunities within the application domain as well as to inform the design of the artefact. The new knowledge that is added to the knowledge base can be based on existing theories and methods in the application domain, the proposed artefact and the iterative approach applied to the construction and evaluation activities within the design cycle (RQ 8). The rigor cycle is considered successful once valuable contributions are made to the existing knowledge base applicable to the research.

c) Design

The design cycle represents the main cycle of the DSR methodology and encourages iteration between construction and evaluation to improve the extent of support for the identified requirements of the artefact. Most of the work of the DSR methodology is conducted within this design cycle, which relies on both the relevance and rigor cycles, but is conducted independently. The construction and evaluation activities need to be balanced as sufficient focus needs to be placed on both of these activities, while focussing on relevance and rigor within these activities (RQs 4-7). The evaluations that are conducted on the artefact need to be sufficiently rigorous and comprehensive in a controlled environment (RQ 5) before field studies (RQ 7) can be conducted in combination with the relevance cycle.

According to Hevner and Chatterjee (2010), certain guidelines need to be followed for the DSR methodology. These guidelines are listed and described in Table 1-2.

Table 1-2 Guidelines for the DSR Methodology (Hevner and Chatterjee, 2010)

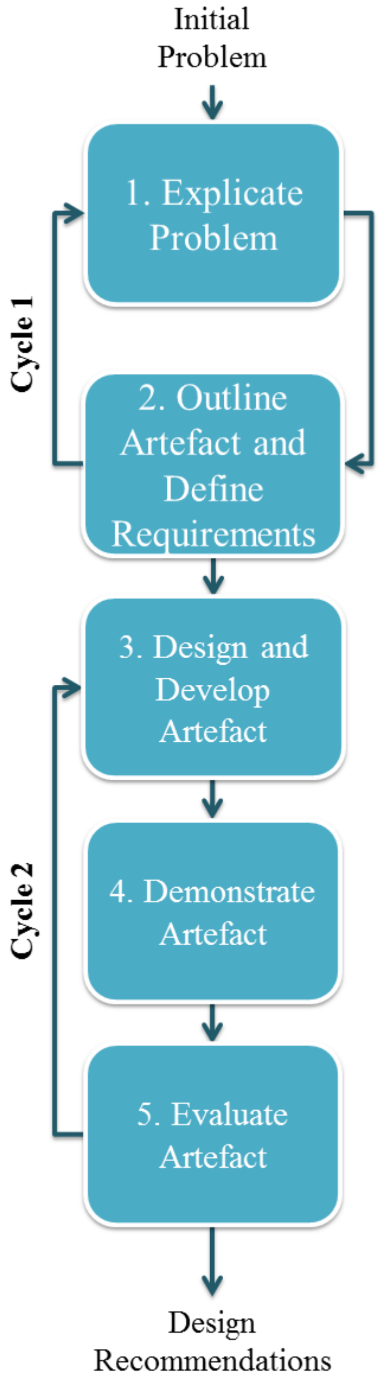
	Guideline	**Description**
1.	Design as an Artefact	DSR needs to yield an artefact as a construct, model, method or instantiation.
2.	Problem Relevance	DSR is primarily used to produce a technological solution to a real problem.
3.	Design Evaluation	The utility, quality and efficacy of an artefact need to be demonstrated in terms of rigor using thorough and in-depth evaluations.
4.	Research Contributions	The research contributions need to be strong and definitive with regards to the artefact, the design and the design methodologies used.
5.	Research Rigor	The methods applied to the construction and evaluation of the artefact need to be rigorous.
6.	Design as a Search Process	The application domain, environment and requirements need to be considered to provide an effective design of the artefact.
7.	Communication of Research	The research needs to be effectively presented to all audiences.

This research used the activities identified in Table 1-1 to address the research questions identified in Section 1.3.3. The research also followed the DSR guidelines outlined Table 1-2 to successfully apply the DSR methodology. A summary is provided in Table 1-3 regarding how the research followed the DSR methodology to address the research questions, which activities are applied to each research question and the expected outcomes of each research question.

Table 1-3 Research Questions, Activities and Expected Outcomes of Research

Research Question	**Activities**	**Expected Outcome(s)**
RQ 1. What are the existing problems with current PI organisation methods?	• Explicate Problem • Outline Artefact and Define Requirements	• Shortcomings of PI organisation methods • Requirements
RQ 2. What are the existing problems with current PI visualisation techniques?	• Explicate Problem • Outline Artefact and Define Requirements	• Shortcomings of PI visualisation techniques • Requirements
RQ 3. What are the requirements for an IV tool to support access to PI across multiple devices?	• Explicate Problem • Outline Artefact and Define Requirements	• Problems with managing PI across multiple devices • Requirements
RQ 4. How can enhanced IV techniques be designed to support access to PI across multiple devices on a desktop device?	• Design and Develop Artefact • Demonstrate Artefact	• Artefact – desktop version of proposed IV tool
RQ 5. How effective are these IV techniques in supporting access to PI across multiple devices on a desktop device?	• Evaluate Artefact	• Results from preliminary user study & any problems found with artefact
RQ 6. How can enhanced IV techniques be designed to support access to PI across multiple devices on a mobile device?	• Design and Develop Artefact • Demonstrate Artefact	• Artefact – mobile version of proposed IV tool
RQ 7. How effective are these IV techniques in supporting access to PI across multiple devices in a real environment using a desktop and a mobile device?	• Evaluate Artefact	• Results from field study & any problems found with artefact (both versions)
RQ 8. What are the design recommendations resulting from this research?	• *Addition to Knowledge Base*	• Design Recommendations

From Table 1-3, the process that was followed using the DSR methodology, including the application of the DSR activities to the corresponding research questions with the respective expected outcomes, is shown in Figure 1-4. An iterative approach, as encouraged by the DSR methodology, was followed for the design cycle, incorporating two iterations within this cycle.



Cycle 1			
Iteration	Explicate Problem	Outline Artefact and Define Requirements	
1	Shortcomings of PI organisation	Requirements for PI organisation	Outcomes
2	Shortcomings of PI visualisation	Requirements for PI visualisation	
3	Problems with managing PI across multiple devices	Requirements for IV tool	

Cycle 2			
Iteration	Design and Develop Artefact & Demonstrate Artefact	Evaluate Artefact	
1	Desktop version of prototype	Results from preliminary user study	Outcomes
2	Mobile version of prototype	Results from field study	

Figure 1-4 The DSR Activities Applied to this Research

1.3.4.2. Research Strategies

A research strategy is defined as a description of how the research will be conducted (Johannesson and Perjons, 2012). Several research strategies will be used to address the research questions for this work, following the DSR methodology. These research strategies include a literature study, survey, design, prototyping, experiment and critical thinking strategies.

a) Literature Study

Literature studies are used to provide a synopsis of a topic in a certain research area (Hofstee, 2009). A literature study research strategy, along with the survey discussed below, was used to conduct the *Explicate Problem* and *Outline Artefact and Define Requirements* DSR activities. A literature study was used to introduce the PI and PIM topics and to identify the need for accessing PI across multiple devices. A literature study was also used to investigate the shortcomings of current PI organisation methods. Existing PI organisation strategies, methods and systems were discussed in detail. Shortcomings were then identified for each PI organisation method and system discussed. Finally, requirements for PI organisation were derived.

A literature study was also used to determine the shortcomings of current PI visualisation techniques. Several PI visualisation techniques and systems were discussed and the shortcomings of each of these IV techniques and systems were identified. Requirements for PI visualisation were identified.

b) Survey

Surveys are used to gather information and perceptions from individuals regarding a specific topic (Hofstee, 2009; Johannesson and Perjons, 2012). As described above, this research strategy addresses the *Explicate Problem* and *Outline Artefact and Define Requirements* DSR activities. A semi-structured interview study was used to identify how users currently manage PI across multiple devices. The interview study was also used to determine problems experienced with PIM across these devices. A pilot study was needed to ensure that there were no problems with the interview study process. The interview method was discussed in detail to ensure transparency and to allow the process to be replicated by other researchers. From the results of the interview study, requirements were identified to inform the design of an IV tool discussed in the following sub-section.

c) Design

A design strategy can be used to create novel artefacts for a specific purpose (Vaishnavi and Kuechler, 2004). The design research strategy was used to conduct the *Design and Develop Artefact* and the *Demonstrate Artefact* DSR activities. The current organisation method and IV technique commonly used, as well as the derived requirements for PI organisation, visualisation and those resulting from the interview study discussed above, were used as design implications influencing which IV technique(s) were the most suitable to support PIM across multiple devices. Existing IV techniques were not sufficient to support PIM across multiple devices, and so, enhanced IV technique(s) were needed to be designed specifically for PIM across multiple devices. These IV technique(s) were designed based on the shortcomings of existing PI organisation methods and systems as well as the shortcomings identified from the review of existing IV techniques and systems. The design was also based on the requirements identified for PI organisation and visualisation. PIM tasks were identified that need to be supported by the designed IV techniques. The main task that these IV techniques were required to support is accessing PI across multiple devices.

d) Prototyping

A prototype can be used to convey research in a constructive way (Olivier, 2009). Prototyping was used in combination with the Design research strategy to conduct the *Design and Develop Artefact* and the *Demonstrate Artefact* DSR activities. A prototype was used to implement the enhanced IV technique(s) designed for PIM across multiple devices. Initially, the design was focussed on a desktop device. A sample PSI was used for this prototype for evaluation purposes. Appropriate implementation tools were identified to implement the IV techniques. The prototype was used to determine to what extent enhanced IV technique(s) can be used to effectively support accessing PI across multiple devices using an experimental research strategy. Following this process, the design of the prototype was transferred to a mobile device. Similarly, suitable implementation tools were identified to incorporate the selected IV techniques on the mobile device. This version of the prototype was also evaluated using the experimental research strategy discussed in the next sub-section.

e) Experiment

An experiment is conducted to assess a theory or to observe the result of a particular intervention (Hofstee, 2009; Johannesson and Perjons, 2012). The theory to be assessed in this research is how the proposed IV techniques support accessing PI across multiple devices. The experimental research strategy addresses the *Evaluate Artefact* DSR activity.

A preliminary user study was used to determine the suitability of the enhanced IV technique(s) designed to support accessing PI across multiple devices on a desktop device. The preliminary user study was also used to identify any problems with the IV techniques and the prototype. The evaluation method to be followed for the preliminary user study was discussed. Participants of the evaluation needed to use multiple devices to access their PI. The preliminary user study initially used a sample PSI and the prototype accessed the participants' PSI at a later stage in the field study. Evaluation metrics, captured using questionnaires, were used to determine the usefulness of these enhanced IV technique(s) in supporting PIM across multiple devices.

Following the preliminary user study to evaluate the prototype on a desktop device, the design was transferred to a mobile device. Both versions of the prototype were evaluated using a field study, which supports testing the prototype in the user's own environment using his/her own PSI. The appropriate evaluation approach to be followed was selected for the field study. The field study provided in-depth results to determine the effectiveness of the enhanced IV techniques to support PIM across multiple devices.

f) Critical Thinking

Critical thinking makes use of evidence to justify a belief by identifying the "inferential connections" that exist between different statements, ultimately developing an argument into an explicit conclusion (Mulnix, 2012). Critical thinking can thus be used to analyse results or outcomes of specific research to confirm the contributions of the work. Requirements were identified for PI organisation and visualisation in Chapters 2 and 3 respectively. The critical thinking research strategy enabled the addition of valuable knowledge to the existing knowledge bases, namely PIM and IV. Requirements were also identified from the results of the interview study. These requirements were compared to determine the resulting requirements for PIM across multiple devices. The field study also provided results that may be useful to inform similar future research. The resultant requirements together with the results of the field study were critiqued to identify design recommendations, transformed from the requirements, to inform the design of future IV tools to support PIM across multiple devices. These design recommendations form the additional knowledge added to both the PIM and IV knowledge bases.

1.3.4.3. Limitations

A limitation of this research is that not all problems relating to PIM were addressed. Only those problems relating to PI organisation and visualisation were considered. Privacy of information, while not the focus of the research, was taken into account with regards to the evaluations conducted. The representativeness of participants of the evaluations conducted throughout this research were clearly identified. Ethics approval was obtained to conduct preliminary user studies and field studies.

1.3.5. Scope and Constraints

It is not possible to provide an overall view or organisation of the complete PSI as the extent of a user's entire PSI is unknown (Jetter *et al.*, 2008). The research was limited to the type of PI that will be organised, visualised and accessed across multiple devices. A subset of PI was supported in this research including document files and media, such as images and videos. These PI types were determined in literature to be the key information types that need to be visualised over multiple devices. Additionally, not all PICs need to be kept on all devices (Tungare and Perez-Quiñones, 2008). Systems involving ontology or data mining to organise or visualise PI were not considered for this research.

The research visualised PI on a personal computer (static device) and a tablet device (portable device). Non-traditional devices were excluded from the focus of the research. Laptop, desktop and mobile phone devices were determined to be the most popular devices, with usually one other additional portable device, used by participants in a user study conducted by Dearman and Pierce (2008). Tungare and Perez-Quiñones (2008) reinforced this conclusion as laptops and mobile phones were used more than desktop computers, although these were also highly used. Accessing PI across multiple devices is an important aspect to consider (Dearman and Pierce, 2008).

1.3.6. Envisaged Contribution

The existing organisation methods and visualisation techniques used for PIM do not support access to PI over multiple devices. The current hierarchical organisation of PI is not necessarily the most suitable method to organise this information. The existing technique used to visualise this hierarchical organisation does not support the user in viewing and accessing this information.

The envisaged contribution of this research included the enhanced IV technique(s) that were designed to support PIM across multiple devices. These enhanced IV technique(s) were designed to support accessing PI across multiple devices. Multiple evaluations of these IV technique(s) determined to what extent the proposed technique(s) support accessing PI across these devices. This resulted in design recommendations that were derived to assist in the design of IV tools to support accessing PI across multiple devices for future developers to address the current lack of support for accessing PI across these devices.

1.4. Chapter Outline

The research questions outlined in the corresponding chapters and addressed by the above-mentioned research strategies are summarised in Table 1-4. Chapter 1 introduced the topic of the research and motivated the rationale of this research. The problem statement, research questions and objectives and aim of the research were outlined in this chapter. The research methodology to be used for the research was described. Scope and constraints were identified and the envisaged contribution was discussed.

Table 1-4 Summary of Research Questions, Strategies and Chapters

Research Question	Research Strategy	Chapter
RQ 1. What are the existing problems with current PI organisation methods?	Literature Study	Chapter 2
RQ 2. What are the existing problems with current PI visualisation techniques?	Literature Study	Chapter 3
RQ 3. What are the requirements for an IV tool to support access to PI across multiple devices?	Survey	Chapter 4
RQ 4. How can enhanced IV techniques be designed to support access to PI across multiple devices on a desktop device?	Iterative Design Prototype	Chapter 5
RQ 5. How effective are these IV techniques in supporting access to PI across multiple devices on a desktop device?	Experiment	Chapter 6
RQ 6. How can enhanced IV techniques be designed to support access to PI across multiple devices on a mobile device?	Iterative Design Prototype	Chapter 7
RQ 7. How effective are these IV techniques in supporting access to PI across multiple devices in a real environment using a desktop and a mobile device?	Field Study	Chapter 8
RQ 8. What are the design recommendations resulting from this research?	Critical Thinking	Chapter 9

The literature study will be discussed in Chapters 2 and 3. Chapter 2 will address the first research question (RQ 1), by introducing PIM and the need for accessing PI across multiple devices. PI organisation will be described in terms of current PI organisation strategies, methods and systems. Shortcomings will be identified for existing PI organisation methods and systems. Requirements will be identified for PI organisation to support accessing PI across multiple devices.

PI visualisation will be discussed in Chapter 3, which will address the second research question (RQ 2). The need for PI visualisation will be identified. The current PI visualisation techniques will then be described. The shortcomings of these PI visualisation techniques will be identified. Existing PI visualisation systems will also be described. The benefits and shortcomings of these systems will then be discussed. Requirements will be identified for PI visualisation to support accessing PI across multiple devices.

Chapter 4 will address the third research question of this work (RQ 3). An interview study will be conducted to determine how users currently manage PI across multiple devices. The interview method and results will be described. Requirements will then be identified for an IV tool to provide access to PI across multiple devices.

Chapter 5 will discuss the design of enhanced IV technique(s) to support accessing PI across multiple devices on a desktop device. This chapter will address the fourth research question (RQ 4). The sample PSI that will be used for PI visualisation will be described as well as the design rationale. The Functionality to be supported by the prototype will be identified in this chapter. Suitable IV techniques will be identified to determine if the IV techniques can be used as they are, or if the techniques need to be enhanced for PIM across multiple devices. Requirements verification to confirm the requirements and the design of the prototype, in terms of a conceptual walkthrough, will then be described. The selection of suitable implementation tools will be discussed. The implementation of the prototype will be described in terms of functionality and interaction. A discussion section will be used to identify any design issues relating to the design and implementation of these enhanced IV technique(s).

Chapter 6 will discuss a preliminary user study to determine the suitability, effectiveness and usefulness of the enhanced PI visualisation technique(s) selected to support PI across multiple devices, which were described in Chapter 5. Chapter 6 will address the fifth research question (RQ 5). The participant sample, evaluation metrics captured and the evaluation procedure will be discussed. The results of the preliminary user study will be discussed in terms of the effectiveness, user satisfaction and qualitative results. A discussion section will conclude the chapter identifying any issues experienced with the prototype.

Chapter 7 will describe the design of the prototype incorporating the enhanced IV techniques on a mobile device, addressing the sixth research question (RQ 6). The chapter will follow a similar chapter structure to Chapter 5. The updated data design will be discussed to allow a user to upload his/her own PSI to be visualised by the prototype. The design rationale, functionality, IV techniques and prototype design will be discussed. The implementation tools used to map the desktop design of the prototype to a mobile device will be identified and the implementation of the selected storage system and IV techniques will be described. A discussion section concludes this chapter, which will discuss any problems experienced with the implementation of the mobile version of the prototype.

Chapter 8 will describe the method and results of a field study used to evaluate both versions of the prototype. Chapter 8 will address the seventh research question (RQ 7). The evaluation method will be described in terms of the evaluation approach followed, the aims and objectives of the field study and the participant sample. Additionally, the evaluation metrics, tasks and procedure will be discussed. The field study results will be described in terms of effectiveness, user satisfaction and qualitative results. A discussion section will also conclude this chapter, which will discuss the results of the field study and any problems encountered by the participants.

Chapter 9 will integrate the results from the previous chapters to outline design recommendations. This chapter will address the eighth and final research question of this work (RQ 8). The design recommendations will be identified to guide the design of future IV tools to support accessing PI across multiple devices. The support provided by the prototype for the requirements identified in Chapters 2 and 3 will be discussed. These requirements will then be mapped to the requirements resulting from the interview study. Design recommendations will then be identified and discussed in terms of the results of the field study.

Chapter 10 will conclude the thesis. The achievements of the research will be described to determine to what extent the research questions were addressed. The theoretical and practical contributions of the research will be discussed. Limitations and problems encountered with the research will be identified and the chapter will conclude by discussing ideas for future research to be completed. The chapter will show to what extent the enhanced IV technique(s) effectively support accessing PI across multiple devices. A summary of the chapter outline is shown in Figure 1-5.

1.5. Conclusion

As a user's volume of PI is increasing constantly, the need becomes greater for an effective method of managing this PI. PI organisation and visualisation are identified as two key tasks of PIM. The inflexible nature of current PI organisation methods and visualisation techniques do not sufficiently support PIM across multiple devices.

This research will determine whether enhanced IV techniques can be designed for visualising PI across multiple devices. This research will also determine to what extent these IV techniques support access to PI across multiple devices. The aim of this research is to improve the visualisation of PI to support PIM across multiple devices. The research will follow the DSR methodology, which is focussed on providing an artefact to improve practical problems within an application domain, in this case PIM. The methodology also requires that a definitive contribution be made to the existing knowledge base, which, in this research, will be in the form of design recommendations to inform the design of future IV tools to support PIM across multiple devices.

The following chapter will address the first research question, namely "*What are the existing problems with current PI organisation methods?*" PIM will be described and current PI organisation methods will be discussed. The chapter will identify problems with the current PI organisation methods and describe requirements for PI organisation across multiple devices.

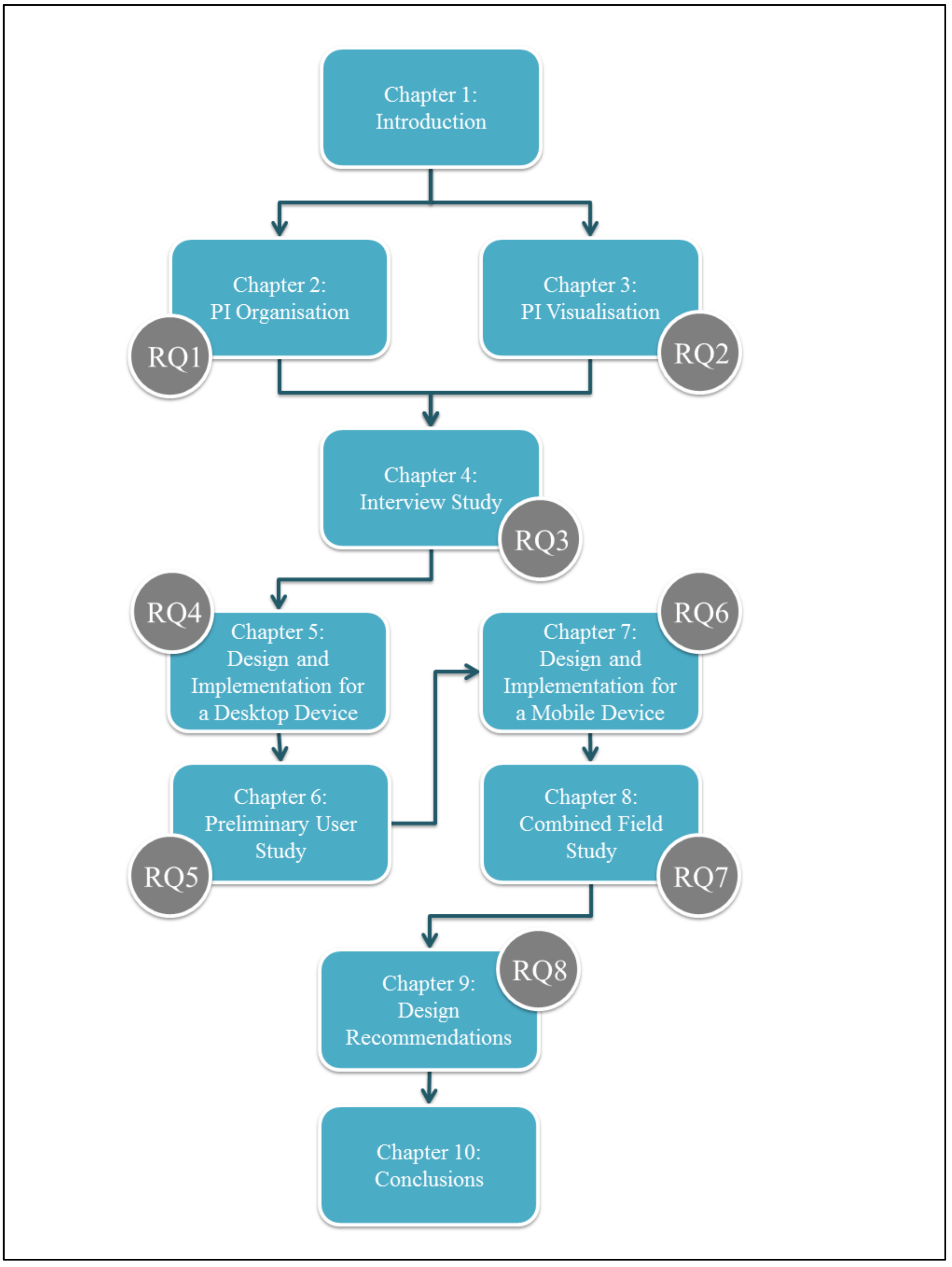


Figure 1-5 Chapter Outline

Chapter 2: Personal Information Organisation

2.1. Introduction

Organisation of personal information (PI) is a key task of personal information management (PIM). An introduction needs to be provided of PIM in general to provide a background to the research. Problems with existing PI organisation methods need to be identified to determine how enhanced visualisation techniques can be designed to support PIM. This chapter addresses the first research question, RQ 1, identified in Chapter 1, namely *"What are the existing problems with current PI organisation methods?"* This research question was addressed by conducting the *Explicate Problem* and *Outline Artefact and Define Requirements* design science research activities.

The following section provides an introduction to PIM. Current PI organisation methods are discussed including the organisation strategies used, the organisation methods employed and the current organisation systems or tools proposed in research. The shortcomings of these organisation methods and systems are then identified. The need for supporting PIM across multiple devices is discussed. Requirements for PI organisation are identified from the shortcomings of the organisation methods and systems.

2.2. Personal Information Management

PI is defined as the information owned or acknowledged by a user including documents, emails, media and calendar event information types. An effective PIM tool should allow a user to collect, store and retrieve relevant information from his/her personal space of information (PSI). Two key problems exist with PIM, namely the information fragmentation problem and the difficulty in accessing PI across multiple devices.

2.2.1. Defining Personal Information

An information item is a representation of information, such as an email, web page bookmark or electronic file. Information is considered to be "personal" if it is information that has been encountered before and information that is of interest (Jones and Maier, 2003). Jones and Maier

(2003) identified that PI includes information about the user. Indratmo and Vassileva (2008) contradict this statement by identifying that PI does not refer to user information, but rather information that a user owns or controls. Relevant PI can be stored “anywhere and nowhere in particular” (Jones, 2011). Aires and Gonçalves (2012) define PI as information that is sent to or from a user that is not necessarily owned or managed by the user. Jones (2008) identifies PI to be inclusive and describes the following six senses of how information can be considered personal:

- Controlled by a user;
- About a user;
- Directed towards a user;
- Sent by a user;
- Experienced by a user;
- Relevant to a user.

Tungare (2007) similarly, but more simplistically, defines PI as:

- Information kept for personal use (e.g. files);
- Information about a user kept under the control of another user (e.g. health information);
- Information a user experienced, but not in the user’s control (e.g. browsed web sites);
- Information directed to a user (e.g. email).

Different types of PI exist including location and social information, information regarding other users and information of other users (Komninos, Baillie and Barrie, 2008). PI also includes calendar entries, emails, electronic files, web browsing history, to-do lists, contacts or address books, other communication data such as phone calls and chat sessions, media such as images, videos and music, and bookmarks (Komninos *et al.*, 2008; Jones, 2008; Schraefel, André and Van Kleek, 2008; Lee, Gong and Lee, 2009; Katifori, Vassilakis, *et al.*, 2008; Tungare and Perez-Quiñones, 2009; Latif, Mustofa and Min Tjoa, 2006). PI can also be considered to be ephemeral (temporary), working and archived (dormant) (Voit, Andrews and Slany, 2009). It is suggested that users store information that they find useful simply because they have the means to store the information (Gwizdka, 2006). A subset of related PI is referred to as a PI collection (PIC) (Indratmo and Vassileva, 2008). Gwizdka (2006) identifies that a PIC can play a role in the following:

- Shaping information needs;
- Determining the organisation of retrieved information;

- Informing the keeping decision;
- Influencing relationships with new information.

The combination of a user's PICs is referred to as a PSI (Gwizdka, 2006). Each user has a unique PSI containing the six senses of PI illustrated in Figure 2-1 (Jones, 2008). A PSI contains the PI, collected by a user, that is required to perform general tasks or "knowledge work" (Sauermann, van Elst and Dengel, 2007). A PSI is considered to span digital and physical information items (Jetter *et al.*, 2008). A PSI influences the mode in which a user views and interacts with the digital world (Jones, 2008). A user is also considered to have a public space of information, containing the information and resources that a user has collected, that can be made public and shared among users (Gwizdka, 2006). These personal and public information spaces have an influence on each other but are not regarded to be associated with each other.

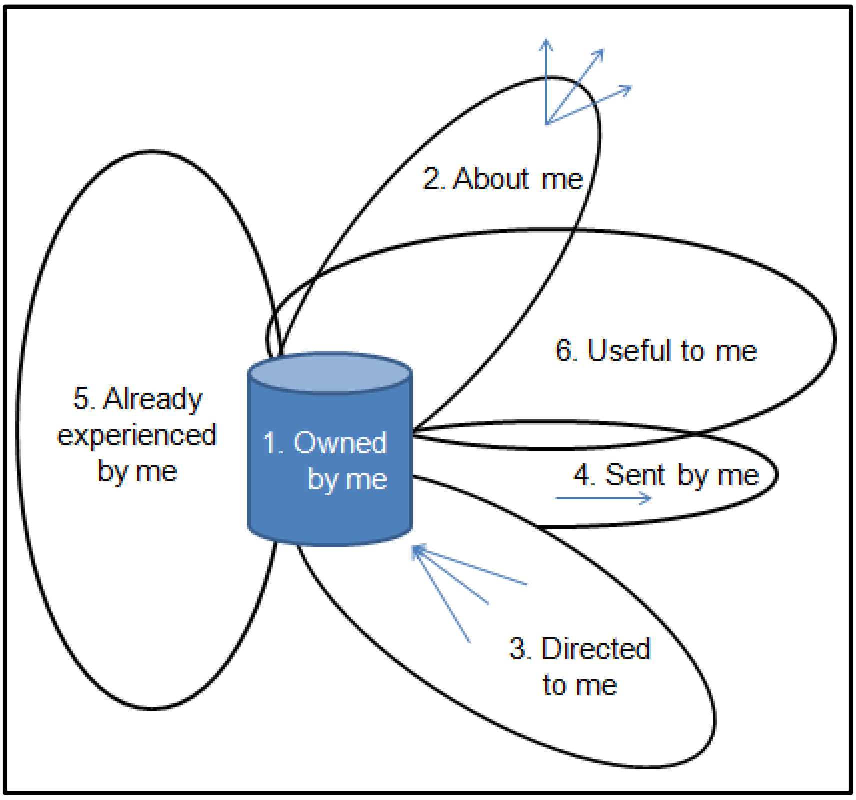


Figure 2-1 The PSI of a User Illustrating the Six Senses of PI (Jones, 2008)

PSI tasks that a user performs such as storing, organising, retrieving and processing of PI is referred to as PIM (Indratmo and Vassileva, 2008). A user needs to be able to filter relevant, location-dependent information in his/her PSI with limited interaction (Komninos *et al.*, 2008). PIM stems from the need for effective information retrieval (Katifori, Torou, *et al.*, 2008). PIM provides many research challenges and various benefits. PIM research can be broken down into PI and social activities (Indratmo and Vassileva, 2008). An extension of PIM research deals with the social activities element, referred to as group information management (GIM) (Indratmo and Vassileva, 2008). GIM includes collaborative PIM and file sharing among multiple authorised users.

2.2.2. Benefits of Personal Information Management

PIM is a large, active area of research (Jones and Maier, 2003; Indratmo and Vassileva, 2008). The PIM research area is growing constantly, resulting in the development of PIM tools and methodologies (Evequoz and Lalanne, 2006). The idea of PIM is for a user to have access to his/her PI which is location-relevant, in the most appropriate form, complete and of a high quality to effectively perform daily user tasks (Jones *et al.*, 2008). PIM should allow a user to effectively collect, store and retrieve relevant information from his/her PSI (Lepouras *et al.*, 2006).

Research regarding PIM is aimed at enabling users to expand their control over their PSIs (Jones, 2008). PIM tools and techniques have been developed to support this intention, but need to be more personal in order to be useful (Schraefel *et al.*, 2008). PIM tools focus primarily on an individual user's activities or requirements, but these tools should also support collaborative PIM (Indratmo and Vassileva, 2008). PIM tools will need to be improved to positively affect user experience.

Jones, Munat and Bruce (2005) identified that improvements in PIM could assist users with improving their use of resources such as time, funds, energy and attention, leading to a better quality of life and increased employee productivity within organisations. PIM provides various additional benefits for users dealing with their PICs (Jones and Maier, 2003; Jones *et al.*, 2005). These benefits include increased employee expertise and team-work in organisations; improvements in information literacy and increased support for mature users.

2.2.3. Information Fragmentation Problem

A key problem relating to PIM is described as the information fragmentation problem (Collins and Kay, 2008). Tungare (2007) identifies the information fragmentation problem as follows:

> *"…the condition of having a user's data in different formats, distributed across multiple locations, manipulated by different applications, and residing in a generally disconnected manner…"*

The amount of PI in a PSI is increasing constantly, leading to large volumes of PI that need to be managed resulting in information overload (Singh, 2006). Information is distributed at a faster rate than what users can manage (Tungare, 2007). PI is stored on a number of devices, applications and services and is intensified by the popular use of mobile technology and Internet services (Kim, 2012; Jones, 2011). A trade-off occurs between an improvement in PI accessibility and share-ability and the amount of PI an individual user needs to process (Kim, 2012). Information overload and information fragmentation have received research attention as PIM issues (Tungare and Perez-Quiñones, 2009).

The ideal PSI would allow a user to accumulate information without the need to delete older information (Latif and Min Tjoa, 2006; Voit *et al.*, 2009). The current technology storage capabilities also encourages users to keep their PI (Evequoz and Lalanne, 2009). The number of devices used to store PI is also growing (Dearman and Pierce, 2008). Current PIM tools do not sufficiently support a user in accessing and managing related PI stored on these multiple devices. Even a user that makes use of a single digital device to manage PI has information stored in different locations on the device (Jones *et al.*, 2008). Information relating to a single task can even be distributed over several devices and applications (Stenmark, Espenkrona and Svensson, 2010). This leads to time-consuming and error-prone PIM (Jones *et al.*, 2008). Users fail to remember where to find information and this influences timely retrieval of the PI (Peters, 2001). Current tools developed to address this issue have added to this problem rather than improving the situation (Jones *et al.*, 2008).

When users work on a project, their information is collected from various sources (Indratmo and Vassileva, 2008). A variety of PIM tools, such as email clients and file systems, are used to store and manage this information. These tools do not necessarily support each other's storage and organisation methods to merge the project information, which leads to information fragmentation. Structures are then duplicated and maintained across different tools (Jones, Whittaker and Anderson, 2012). This problem results in the difficulty of managing the different collections used by the PIM tools (Indratmo and Vassileva, 2008). Users are thus required to navigate through the separate collections in different locations to retrieve the relevant information. The numerous PI types increase the difficulty in finding a feasible PIM solution (Dearman and Pierce, 2008). The multitude of devices used, increased by the popularity of mobile and portable devices such as cell phones, portable digital assistants and laptops, increase the information fragmentation problem as PIM may be stored on a combination of devices (Dearman and Pierce, 2008; Tungare and Perez-Quiñones, 2009). As the number of devices used for PIM increases, information fragmentation proliferates (Jones, 2011).

A fragmentation problem exists when a user who may work on a single project manages the information used for this project in a format-related collection, i.e. according to PI type (Bergman *et al.*, 2006). Users typically store PI in different collections according to the PI type as existing PIM tools encourage this organisation. The disadvantages of this storage include time-consuming PIM, increased cognitive load in managing separate PICs, difficulty in maintaining consistency between these collections and the use of multiple PIM tools to manage these collections. Identifying important and relevant information in a PSI is an important task of PIM tools in order to address the information fragmentation problem (Singh, 2006).

An email overload problem occurs when users use the email system to support subordinate tasks resulting in PIM problems and overwhelmed users (Dearman and Pierce, 2008). Email is used as a memory system and as a task management tool leading to large organisation structures and full inboxes (Peters, 2001). This problem may lead to email being integrated into, or supported by, other applications, as users increasingly need to share and communicate (Dearman and Pierce, 2008).

Other general issues that exist relating to PI include the following: information security, virus protection, privacy issues, version control, delivery notifications, information retrieval methods and filtering relevant information (Jones, 2008). These issues need to be addressed in order to successfully support PIM.

2.3. Access to PI across Multiple Devices

According to Weiss and Craiger (2002), computers and software should unobtrusively support users with their daily activities. The ideal is to use computer systems without considering these systems (Weiss and Craiger, 2002). The multiple devices a user owns and uses for PIM need to be considered rather than focussing on a single device (Dearman and Pierce, 2008). With the increasing popularity of mobile devices as well as the move towards GIM and file sharing, accessing personal or group information across multiple devices becomes an important aspect of PIM to consider (Tungare and Perez-Quiñones, 2008). This has encouraged the provision of cloud-based storage systems, such as Dropbox and Google Drive, so that a user has direct access to his/her PI and is provided with alternative storage space. Additionally, a user’s tasks span multiple devices (Dearman and Pierce, 2008). A PIM tool requires smooth PI and device integration, an easy user interface (UI) and should be able to scale well with increasing volumes of PI (Voit *et al.*, 2009).

Limited research has been conducted regarding supporting access to PI across multiple devices (Tungare, 2007). Seamless and effective access to PI across multiple devices is required to fully support PIM (Indratmo and Vassileva, 2008). A user should be supported in accessing PI irrespective of location or device (Jetter *et al.*, 2008). PIM research is thus extending towards a holistic approach (Indratmo and Vassileva, 2008). Task management of a user should be supported, enabling access of different types of information from multiple devices. As the volume of PSIs increase over multiple devices, PI is becoming increasingly dispersed over these devices.

Not all PI items can be accessed in a single system, as an overall view of the entire PSI is difficult to support (Jetter *et al.*, 2008). Capra (2009) identified that email is the link that connects PI stored in different locations and on different devices and plays an important role in PIM research. Evequoz and Lalanne (2007) re-enforced this idea by using personal email archives as the main PI source in their research aligning other PI types including documents, images and media with the email archive. Viégas, Golder and Donath (2006) identified that email is considered by many researchers to be the most important and most commonly used form of PI to support PIM. A limitation of current PIM research is that existing research only focusses on a single subset of PI, or PI type, either email, web bookmarks or files, or on a single device (Indratmo and Vassileva, 2008; Tungare, 2007).

This research will focus on document files, and media such as images, email and calendar events. These PI types and subsets have been used in various PIM studies including, Collins and Kay's research (2008) regarding collaborative PIM on interactive tabletop devices, research conducted by Bergman *et al.* (2006), which determined how users store PI, and by Aires and Gonçalves (2012), who developed a dashboard to view PI. PI regarding the user’s activities can be collected from various applications such as the social networking website, Facebook (Aires and Gonçalves 2012). Applications such as Gmail, Facebook, Twitter, Flickr and Panaramio can also be used to retrieve additional user information. Information on the device and on the Internet can be used to retrieve additional user information including other social networking websites, and Wi-Fi connections for location and calendar information (Schraefel *et al.*, 2008). Secondary information such as sensory data, for example temperature and location, may be included in PIM tools to assist the user with additional queries or to provide additional information (Latif and Min Tjoa, 2006).

2.4. Current PI Organisation and Management

One of the key tasks performed by a user when managing PI is organisation (Stenmark *et al.*, 2010). PIM research spans different sub-areas and so it is difficult to gain an overview of the approaches used to address PIM issues (Indratmo and Vassileva, 2008). This section describes the need for effective PI organisation and the current strategies, methods and systems used for PI organisation.

2.4.1. The Need for PI Organisation

PI should be suitably organised or structured to enable efficient information retrieval (Latif and Min Tjoa, 2006). The type of PI organisation has a large impact on the visualisation technique used to support information retrieval (Golemati *et al.*, 2007). Task management can be facilitated if PI is logically organised (Indratmo and Vassileva, 2008). As PI becomes more complex and distributed over multiple devices, the need becomes greater for PI organisation and retrieval (Al Nasar *et al.*, 2011).

2.4.2. PI Organisation Strategies

Voit *et al.* (2009) discuss the research of Malone (1983) who identified different PI organisation strategies employed by users. The two main organisation strategies included files, where information is arranged in logically organised PICs, and piles, where PI is organised according to physical location. Piling is used when users find PI classification difficult. Henderson (2009) identified that periodic reorganisation is common. Users mostly employ a combination of filing and piling (Hardof-Jaffe *et al.*, 2009).

Hardof-Jaffe *et al.* (2009) identified the PI organisation strategies of students. The organisation strategies used included piling (files are kept in the root directory), one folder filing (files are kept in one folder), small folders filing (files are kept in many small folders) and big folder filing (keeping most files in different folders with one sub-folder holding many files, or a combination of piling and filing).

Voit *et al.* (2009) also discussed research conducted by Whittaker (1996), where email PIM strategies included no filers, where users do not use folders, frequent filers, where users organise email messages in folders regularly, and spring cleaners, where users organise email messages in folders at regular intervals. Managing PICs of different PI types involves different organisation strategies depending on each PIC, for example files are the most organised where emails and bookmarks contain more unfiled PI items. Tungare (2007) hypothesises that filing/piling behaviour is determined by a user's personal characteristics.

2.4.3. PI Organisation Methods

When users make the decision that information is relevant, they need to choose how to store and retrieve this information (Gwizdka, 2006). Users tend to store and retrieve information regarding a project in a project folder when the design of the PIM tool encourages this organisation, but store and retrieve this information according to a format-related organisation if the PIM tool encourages this organisation instead, such as email PIM tools (Bergman *et al.*, 2006). The PI type and structure informs how users organise their PICs (Gwizdka, 2006). The Internet plays an important role in accessing PI from multiple devices (Jetter *et al.*, 2008). Currently, users email themselves attachments as a way to support accessing PI across multiple devices (Capra, 2009). This leads to PI transfer problems including compatibility problems, problems with large file sizes and problems with version control. Capra (2009) determined that the PI type's file size may influence the choice of file transfer method.

The current method used to organise PIM is in hierarchies of files and/or folders (Golemati *et al.*, 2007; Voit *et al.*, 2009; Badesh *et al.*, 2014). Files and folders have been the primary method used for PI organisation since paper-based PIM (Civan *et al.*, 2008; Bergman *et al.*, 2013). A PI hierarchical organisation method makes use of a tree structure to organise information items and PICs (Indratmo and Vassileva, 2008). Hierarchies have received considerable research attention as a hierarchy is one of the most frequent and significant PI structures used for organisation (Golemati *et al.*, 2007). Hierarchical structures are widely used in software systems such as file and email systems (Indratmo and Vassileva, 2008). Hierarchies are popular for PI organisation as they are not only used for organisation, but also for project problem decomposition (Jones *et al.*, 2005).

Advantages of using hierarchies include the following (Indratmo and Vassileva, 2008):

- **Familiarity:** Hierarchies are a familiar means for users to organise information. Existing systems largely use hierarchies to manage and organise information.
- **Understanding:** An effectively organised hierarchy can assist users in understanding a PIC easier. The logical structure of a hierarchy can assist a user in determining relationships between different information items.

- **Support for Task Management:** As the volume of task or project-based information increases, the hierarchy can provide support for task management, which is an important aspect of PIM.
- **Structure Re-use:** Structure re-use is supported by using hierarchies to assist in task management. The structure of a project in a hierarchy can be copied for another project.
- **Information Search and Retrieval:** Users are able to search for relevant PI in a hierarchy, which eliminates ambiguous terms referring to different contexts. The branches of the hierarchy refer to different topics and within these branches the topics relate only to the parent topics.

A commonly used application of a hierarchical organisation method is Windows Explorer, which facilitates file browsing using an indented list visualisation (Golemati *et al.*, 2007). Files are visualised according to the tree structure organisation of folders and files in the folders. Other methods used for PI organisation, although not as popular as the hierarchy, include flat (assigning tags to PI items), linear (PI items are arranged in a list), spatial (used commonly on the computer desktop) and network (PI items are linked to one another) methods (Indratmo and Vassileva, 2008).

2.4.4. Shortcomings of PI Organisation Methods

Users have difficulties in organising and retrieving PI (Evequoz and Lalanne, 2009). Several shortcomings of existing organisation methods have been identified (Badesh *et al.*, 2014). These shortcomings will be used to inform the design for PI organisation.

The inflexible nature of existing hierarchical systems makes it difficult for users to maintain sufficient PI organisation (Evequoz and Lalanne, 2007). Users may not be able to select relevant classification schemes to organise their PI, which leads to ineffective information retrieval and user frustration (Evequoz and Lalanne, 2007; Kolman *et al.*, 2012). Voit *et al.* (2009) state that the problems involved with hierarchical organisation include a difficulty in defining unambiguous folder names, complexity to identify mutually-exclusive folder naming for child categories under a parent folder, the difficulty in completely sub-dividing the parent folder into child folders, multiple folder classification may be necessary but is not supported and a result of a potentially unbalanced hierarchy as more PI items may be kept in a certain folder than in another. Sajedi, Afzali and Zabardast (2012) also note storage-time ambiguity as a problem as a file can only be accessed at one path even though it may be suitable at multiple paths. The deeper a file is stored in the hierarchy, the more difficult it becomes to retrieve the file (Hsieh and Sun, 2008). Although hierarchies are powerful for PI organisation, a hierarchy requires continuous management of PI (Bade, Nitsche and Nürnberger, 2012).

Evequoz and Lalanne (2007) identify that the hierarchical organisation is the main reason for these problems. Hierarchies do not provide explicit links between various information items relating to the same project or task. This implies that information needs to be searched repeatedly using different applications to find relevant PI. The existing organisation method does not effectively represent the structure of PI to support information retrieval. Sajedi *et al.* (2012) also identify that the volume of files and folders is the main problem with PI organisation.

An additional shortcoming regarding the current hierarchical organisation method is that considerable effort is required to manually classify each PI item without support for links between the PI items (Gomes *et al.*, 2010). PI is thus dispersed in different locations, which leads to complex information retrieval.

Sauermann *et al.* (2007) identify two key problems with current organisation methods. Firstly, the structure of the information is either taxonomy or keyword-oriented. Rajamanickam (2009) also identified that an additional cognitive load is required to classify PI items. Secondly, separate structures exist to organise different PICs of unlike PI types in separate applications, such as email and file systems (Sauermann *et al.*, 2007). There is limited support for linking these separate PICs in a single organisational structure leading to inconsistencies between different PICs. Jones *et al.* (2009) identify that different, separate systems are used to organise different PI types. For example, Windows Explorer does not necessarily support the organisation of an email archive other than enabling the user to store a copy of an email item in a folder in the hierarchy. An additional limitation of Windows Explorer is that collaborative PIM is not supported.

Further limitations of the current hierarchical PI organisation method include the following (Indratmo and Vassileva, 2008; Bergman *et al.*, 2013):

- **Additional cognitive load:** Creating a hierarchy and classifying PI items requires additional cognitive load.
- **Single classification option:** A PI item may relate to multiple tasks but may only be classified under a single category.
- **Support for information fragmentation:** PI items relating to a single project are scattered in multiple PIM tools further compounding the information fragmentation problem.

- **Inconsistency:** Due to the support provided for information fragmentation, it becomes difficult to sustain consistency in related hierarchies.

2.4.5. PI Organisation Systems

PIM systems are tools that are provided to users to assist in finding, categorising and re-finding their PI (Badesh *et al.*, 2014). Various PIM tools exist that attempt to address the PIM issues. Several systems relating to PIM were excluded from this discussion as they were either limited to supporting a subset of PI types, including TheMail (Viégas *et al.*, 2006), MemoMail (Elsweiler, Ruthven and Ma, 2006), PhotoMemory (Elsweiler, Ruthven and Jones, 2005) and PhotoLand (Ryu, Chung and Cho, 2010). Some of the key PIM tools that support multiple PI types are briefly discussed in this section.

2.4.5.1. LifeStreams (1996)

LifeStreams (Fertig, Freeman and Gelernter, 1996) makes use of a continuous "time-ordered stream" to organise PI (Jones, 2011; Jones and Anderson, 2011). This tool is not reliant on a hierarchical organisation, but is largely search-reliant (Bergman *et al.*, 2006; Collins and Kay, 2008).

2.4.5.2. Haystack (1999)

Haystack (Adar, Karger and Stein, 1999) was developed as a PIM tool which uses a single UI to manage various PI types using an ontology (Collins and Kay, 2008). The tool supports association between PI items as well as annotation, but is also search-reliant.

2.4.5.3. MyLifeBits (2002)

MyLifeBits (Gemmell *et al.*, 2002) is a PIM tool developed by Microsoft Research (Al Nasar *et al.*, 2011). The aim of this PIM tool is to provide multiple visualisations of different PI types with support for annotation and search, based on item name or annotation. With this tool, the user is not restricted to a hierarchical organisation.

2.4.5.4. Stuff I've Seen (2003)

Stuff I've Seen (Dumais *et al.*, 2003) is a PIM tool also developed by Microsoft Research similar to the MyLifeBits tool and, like MyLifeBits, is also not reliant on the hierarchy (Al Nasar *et al.*, 2011). The system makes use of information indexing in a unified manner supporting multiple PI types (Dumais *et al.*, 2003). Contextual cues such as time and author are used to search and filter to find PI items (Dumais *et al.*, 2003; Al Nasar *et al.*, 2011).

2.4.5.5. Phlat (2006)

Phlat (Cutrell *et al.*, 2006) is used to enhance searching for PI, combining searching and browsing using association and context, and was developed by Microsoft Research (Al Nasar *et al.* 2011). Users can create metadata, which Phlat transforms to a flat organisation. Phlat can also tag the metadata to the PI where tags are directly linked to the files. The tool makes use of the Windows Desktop Search engine to allow access to the PI.

2.4.5.6. ProjectFolders (2006)

Bergman *et al.* (2006) conducted a study on users' organisation habits. The results indicated that users organise their information according to projects when the organisation structure encourages this task-based organisation. Based on this result, a single hierarchical solution, ProjectFolders, was developed, extending the existing hierarchical organisation method. ProjectFolders supports documents, emails, web sites, tasks and contacts and organises this information in a single hierarchy, which is separated by tabs. Each tab corresponds to a PI type.

2.4.5.7. Email Archive (2007)

Email is considered to be an important PI type for PIM (Evequoz and Lalanne, 2007). Evequoz and Lalanne (2007) developed a PIM tool that indexes and visualises email PI with links to other PI items aligning the structure of emails with the remaining PI. The system supports browsing, clustering email according to different types of metadata to organise PI, aligning other PI items with the email organisation and visualising this organisation.

2.4.5.8. Facet Folders (2008)

Facet Folders (Weiland and Dachselt, 2008) makes use of nested hierarchies, which are derived from the existing hierarchical organisation method. Facet Folders makes use of metadata and filtering to adapt the hierarchies according to the user's need. Folders are used by the system, which can dynamically change, offering users flexible views of their PI using metadata and filtering facilities. Metadata can include time, location, person, event, classification and so on. Persistent hierarchies are used to allow the user to create dynamic views over a number of facets of his/her PI.

2.4.5.9. Zoomable Object-oriented Information Landscape (2008)

The Zoomable Object-oriented Information Landscape (ZOIL) (Jetter *et al.*, 2008) provides a web-based UI which unifies local and remote PI items, including functionality and relationships, to a single interface not reliant on the current hierarchical PI organisation system. This system is designed for multiple devices, also including mobile devices, and is platform and application independent. ZOIL is motivated in terms of moving away from the current file system and desktop metaphor and replacing it with a versatile database. The domain model of ZOIL incorporates a design principle relating to object oriented UIs, where a PI item is considered an object and classes represent different objects with attributes.

2.4.5.10. Planz (2010)

Planz, formerly known as the Personal Project Planner (Jones *et al.*, 2008), is a PIM tool providing a "single, integrative document-like overlay to a folder hierarchy through dynamic on-demand assembly of Extensible Mark-up Language (XML) fragments" (Jones *et al.*, 2010). The goal of the Universal Labeler, a similar tool to Planz from which Planz evolved, was to attempt to support unified PI organisation and visualisation providing a single PI organisation for different PI types using a project-centred approach (Jones *et al.*, 2005).

Context and different PI types are supported, including files, email messages, web pages and notes. An editable document is displayed with user tasks, where PI organisation is supported by the ability to drag PI items in the document, providing a link to the PI item. Tasks and sub-tasks relate to a file system of files and folders. Planz can be used as an alternative file manager to create, edit, or delete folders/files. XML fragments are used to create the document overlay.

The Cross Tool Mark-up Language (XooML) was developed as an extension of the Planz prototype. XooML attempts to avoid requiring the user to reorganise or relocate his/her PI (Jones, 2011). The goal of XooML is to provide integrative organisation of PI for use in multiple PIM tools using a directed graph instead of a hierarchy.

2.4.5.11. File Concept Browser (2012)

Sajedi *et al.* (2012) proposed a file manager, the File Concept Browser, that supports multiple categorisations. The structure is similar to the conventional hierarchical structure used, but files can be maintained through different paths avoiding redundancy, ambiguity and multi-versioning. A folder is considered to be a "concept" as the folder does not own the file or determine the location of the file, but rather provides associations to one or more concepts to access the file. A flat repository is used for back-end storage. The goal of this tool is to allow a user to access a file at the first attempt and as fast as possible.

2.4.5.12. PI Dashboard (2012)

The PI Dashboard (Aires and Gonçalves, 2012) is a web application to provide a graphical overview of a user's life patterns using a dashboard metaphor. Information is sourced from email messages, instant messages, web pages visited, documents and other information sources. Information is currently gathered from various sources including Facebook, Twitter, Flickr and Panaramio.

2.4.5.13. InfoMaps (2012)

InfoMaps (Kolman *et al.*, 2012) is described as an interactive tool which makes use of a spatial organisation to organise PI using a landscape similar to ZOIL. InfoMaps is provided in the form of a web application. Multiple PI types are considered, including documents, email, calendar events, tasks and web pages.

2.4.5.14. Dropbox (2007)

Current tools, such as Dropbox (Houston and Ferdowsi, 2007) and TeamViewer (TeamViewer GmbH, 2005), attempt to bridge the link between PIM and accessing PI across multiple devices. Dropbox is a tool which promotes accessing information from any device at any time while supporting collaboration with shared folders (Houston and Ferdowsi, 2007), thus providing an extension of the hierarchy.

2.4.5.15. TeamViewer (2005)

TeamViewer provides remote support by allowing a user to access a device through another device, and allows for online meetings between team members (TeamViewer GmbH, 2005). TeamViewer supports the hierarchy by providing this remote support.

2.4.6. Shortcomings of Current PI Organisation Systems

All systems supported different combinations of PI types. Context, association, annotation, and temporal organisation are the aspects most supported by the PI organisation systems. Indexing and tagging is also supported in several organisation systems.

Table 2-1 depicts the structures used by each system. None of the systems discussed were restricted to a hierarchy. Several systems extended the hierarchy (6), in some way, but most systems omitted using the hierarchy completely (9).

Table 2-1 Structure Used by Systems

#	System	Year	Extends the Hierarchy	Replaces the Hierarchy
1.	LifeStreams	1996		Abandons hierarchy in favour of time-based visualisation
2.	Haystack	1999		Makes use of an ontology
3.	MyLifeBits	2002		Uses collections and search to replace the hierarchy
4.	Stuff I've Seen	2003		Does not rely on hierarchy
5.	TeamViewer	2005	Extends the hierarchy allowing remote access	
6.	Phlat	2006		Independent of hierarchy
7.	ProjectFolders	2006	Single hierarchy solution incorporating tabs	
8.	Email Archive	2007		Multiple visualisations
9.	Dropbox	2007	Extends the hierarchy using a cloud storage system	
10.	Facet Folders	2008	Adaptable hierarchy using faceted metadata	
11.	ZOIL	2008		Single UI not reliant on current hierarchy
12.	Planz	2010	Hierarchical document overlay to support current hierarchy organisation	
13.	File Concept Browser	2012	Allows multiple categorisations viewed as a hierarchy using concepts instead of folders with the support of a flat storage system	
14.	PI Dashboard	2012		Dashboard of information
15.	InfoMaps	2012		Landmarks with various layouts

One of the main problems of current PIM systems is that these systems focus on a single device or on a subset of PI (Tungare, 2007). The organisation systems are either device-dependent, do not support collaboration (identified to be an important aspect of PIM) or are focussed on a specific type of PIC, for example an email PIC. Although Dropbox and TeamViewer attempt to address the lack of support for PIM across multiple devices, these systems suffer from the same hierarchical organisation problems as discussed in Section 2.4.4.

A general problem of PI organisation systems is that users seem to be disorganised and it may be attributed to inadequate PIM system design (Bergman *et al.*, 2008). Jones *et al.* (2009) identify five reasons that PIM tools are abandoned, namely lack of visibility, integration, co-adoption, scalability and return on investment. Dearman and Pierce (2008) argue that current PIM tools focus on the device rather than being user-centric. Tungare (2007) identifies that PIM tools, although useful, are not sufficient as they are greatly individualised leading to tool inconsistency.

Using time to organise PI is useful, but it should not be the only aspect used for PI organisation (Latif and Min Tjoa, 2006). Several PI organisation systems, such as the File Concept Browser, are search-reliant (Al Nasar *et al.*, 2011). PIM research has indicated that location-based finding, or browsing, is used more frequently for PI retrieval than search (Jones *et al.*, 2010). Systems such as MyLifeBits focus only partially on PI.

2.5. Requirements for PI Organisation

Users have a need for organisation and being organised (Henderson, 2009). The above-mentioned shortcomings of the hierarchical organisational structure currently used for PI organisation highlights that the current organisation method does not sufficiently support PIM. Changes need to be made to the hierarchical organisation structure currently used for PI organisation to overcome the issues identified (Sajedi *et al.*, 2012). Certain requirements can be identified to assist in improving PI organisation. These requirements are outlined in Table 2-2.

Table 2-2 Requirements for PI Organisation

	Requirements
1.	Organisation-Dependent Visualisation
2.	Context Awareness
3.	Support for Multiple Hierarchies
4.	Association of PI Items
5.	File Sharing
6.	User-Centred Approach
7.	Access to PI across Multiple Devices

2.5.1. Organisation-Dependent Visualisation

The current hierarchical PI organisation method does not sufficiently support PIM. Several systems in Section 2.4.5, including Phlat, InfoMaps and the PI Dashboard, replaced the hierarchy with other structures such as temporal organisations and only a number of systems supported extending the hierarchy. The IV technique(s) used to visualise PI will depend largely on how the PI is organised. Shneiderman (1996) identified a taxonomy of IV techniques according to data type. Thus, the IV technique(s) used to visualise PI will depend on the structure of the PI. For example, if the PI is organised according to a network, a node-link network IV technique or a square matrix may be suitable to visualise this network depending on the support provided for the required tasks. Indratmo and Vassileva (2008) suggest that the current organisation method used for PIM be extended rather than replaced. The proposal to extend the hierarchical organisation method has been well-supported (Xiao and Cruz, 2005; Bergman *et al.*, 2006; Sajedi *et al.*, 2012).

2.5.2. Context Awareness

Due to the move towards supporting Task Information Management (TIM), PIM research is moving towards a more holistic approach (Indratmo and Vassileva, 2008). Currently, PI is stored in different locations or PIM tools and on multiple devices. Context is a dynamic environment property that is influenced by user presence and actions (Morales-Aranda and Mayora-Ibarra, 2007). Context also depends on the user activities, devices that the user accesses and the mode in which the devices are available (Singh, 2006). Context can assist in task awareness, and thus assist with the TIM aspect of PIM. A PIM tool needs to use contextual information to effectively support a user's tasks (Latif and Min Tjoa, 2006).

2.5.3. Support for Multiple Hierarchies

Users have a need for PI integration (Jones, 2011). It is important to have some type of structure for effective information retrieval (Sauermann *et al.*, 2007). The choice of organisation structure is not always clear and so more than one type of structure may be suitable (Latif and Min Tjoa, 2006). A single hierarchy solution where all PI currently stored in multiple hierarchies are kept in a single folder irrespective of the PI type may also be considered (Bergman *et al.*, 2008). Multiple hierarchies need to be considered as multiple PI types exist over a number of user devices within their own hierarchies.

2.5.4. Association of PI Items

A shortcoming of the existing methods used to organise PI was that there was no method of linking related PI items. Latif and Min Tjoa (2006) discuss the original suggestion of Bush

(1945), which is to use "trails" for PI organisation as users follow an "association of thoughts". A user should be able to retrieve PI items in more than one location (Voit *et al.*, 2009). Inter-relation and inter-linking between PI types are important for PIM (Latif and Min Tjoa, 2006; Stenmark *et al.*, 2010). Multiple associations of PI items should be facilitated in an effortless manner (Indratmo and Vassileva, 2008). Additionally, allowing multiple classifications of a single PI item is considered useful (Bergman *et al.*, 2013). A PI organisation method will need to consider the relationships between PI items to sufficiently support PIM. Tagging could possibly be used for this association process (Evequoz and Lalanne, 2007). A tag acts as metadata by describing a PI item using a keyword (Bergman *et al.*, 2013). Tagging filters are considered to be important to assist with filtering of a search space (Al Nasar *et al.*, 2011).

Lee *et al.* (2009) used semantics to provide relationships between events and related PI items in ontology. Xiao and Cruz (2005) provide a semantic ontology-based framework to support PIM using annotations, associations and representation. The application of semantic web technology for PIM allows the creation of semantically-rich PIM tools which can use the structure and semantics of a user's PSI as metadata (Indratmo and Vassileva, 2008).

As mentioned in Section 2.3, users use email to allow access to files, but they also use email and version control systems, to keep record of different versions of the same PI item (Dearman and Pierce, 2008). Association of PI items could possibly also support version control. Making use of item similarity, as used by Adams, Phung and Venkatesh (2006), and/or the use of association can assist a user with managing different versions of the same PI item.

2.5.5. File Sharing

As discussed in Section 2.2.1, an extension of PIM is GIM (Whalen, Toms and Blustein, 2008). Users often communicate and interact electronically, thus collaborative PIM is an important aspect to consider. File sharing is defined as making a file or PI item available to another user or user group with certain rights to the item. File sharing, GIM and the issues that these aspects involve, such as privacy, will need to be considered when designing a PI organisation method as other users may need to access PI items in a user's PSI (Indratmo and Vassileva, 2008). Thus, shared organisational structures may need to be created and negotiated to provide effective collaboration (Jones *et al.*, 2012).

2.5.6. User-Centred Approach

Bergman *et al.* (2008) state that a user who stores and organises his/her PI is usually the same user that will retrieve this information. Most PIM research focusses on developing PIM tools, or is tool-oriented, rather than user-centred (Kim, 2012). Tool-oriented approaches have not been as successful due to the large number of PIM tools currently available and so a user may find it difficult to choose a suitable tool for PIM. Only a few PIM tools have been adopted long-term which involves a "tool-switching cost" for the remaining tools. Kim (2012) argues that a user should be guided in enhancing PIM behaviour rather than developing and evaluating new PIM tools, i.e. user-centred versus tool-centred. PIM guidance provided to users should assist in providing a mental model of a user's PI as users may become overwhelmed by PIM tools as they are not entirely sure how to effectively use their PI using these PIM tools. Additionally, as a user's needs change, PIM habits change as well (Evequoz and Lalanne, 2009). A PIM tool should be developed based on an understanding of the users' needs (Peters, 2001). Dearman and Pierce (2008) suggest that the PIM research focus should be on the users rather than the PIM tools. Users' organisation strategies also need to be taken into account when organising PI.

2.5.7. Access to PI across Multiple Devices

PI is increasingly being distributed over multiple devices (Tungare and Perez-Quiñones, 2008). This highlights the need for a holistically designed PIM tool considering the PI on these devices as well. A limited number of PI organisation systems supported accessing PI across multiple devices. Mobile devices have different constraints and design considerations from a desktop or notebook computer and these considerations need to be considered when selecting an appropriate organisation method or visualisation technique. Synchronisation becomes an issue to be taken into consideration.

2.6. Conclusion

Information fragmentation is a growing issue of PIM. As a user's PI increases, the information becomes distributed over a number of PICs and devices. This problem highlights a need for an enhanced method of organising PI to support accessing this information across multiple devices.

Users tend to organise PI using a filing or piling approach and the user's organisation behaviour should be considered when selecting a PI organisation method. Most PIM research focusses on the tools being developed rather than focussing on the user.

The current method used to organise PI, namely the hierarchical organisation structure, is inflexible and provides additional limitations such as the inability of associating different PI items and lack of support for collaborative PIM.

The current hierarchical structure used for PI organisation provides limited or no support for accessing PI across multiple devices. Certain PICs and PI types are stored on multiple devices, including mobile phones and tablets. Thus, there is a need to provide access to this information across these multiple devices.

A number of PIM tools exist that attempt to address different PI organisation problems. Unfortunately, these tools suffer from several shortcomings, mainly focussing on improving PI organisation on a single device or replacing the hierarchy.

Several requirements were identified from the shortcomings of the existing PI organisation methods and systems. These requirements included providing an organisation-dependent visualisation extending the hierarchy, the provision of context-aware organisation, support for multiple hierarchies, the provision of association between multiple PI items, support for file sharing and collaboration, focussing on the user rather than the tool and providing access to PI across multiple devices.

The next chapter will discuss the visualisation of PI following on from this chapter. The current visualisation techniques used for PIM will be discussed to determine the shortcomings of existing techniques that will be used to inform the design of the enhanced PI visualisation techniques to support access to PI across multiple devices.

Chapter 3: Personal Information Visualisation

3.1. Introduction

Another main task of personal information management (PIM) is personal information (PI) visualisation. Visualisation can be considered to be an important aspect of PIM as the user interacts with the user interface (UI) of the PIM tool. Similarly to the PI organisation chapter (Chapter 2), problems of existing PI visualisation techniques need to be determined to identify how enhanced visualisation techniques can be designed to support PIM. Chapter 3 addresses the second research question (RQ 2) identified in Chapter 1, namely "*What are the existing problems with current PI visualisation techniques?"* This research question was addressed using the *Explicate Problem* and *Outline Artefact and Define Requirements* design science research activities.

The need for PI visualisation is described in the following section. This chapter then discusses the current techniques used for PI visualisation and identifies shortcomings of these visualisation techniques. Various PI visualisation systems are discussed and shortcomings of these systems are outlined. An existing PI visualisation solution is then described and issues of this system are discussed. Requirements for PI visualisation are identified from the shortcomings of the visualisation techniques and systems and from information visualisation (IV) in general.

3.2. The Need for PI Visualisation

A visual representation of information is more effective than a textual representation (Aires and Gonçalves, 2012). Visualisations are required to display information in a graphical and viewable manner, which should provide a novel means of observing the information. IV is also generally used to provide insight, to support the sense-making process and to amplify cognition using these visualisations (Pousman, Stasko and Mateas, 2007; Heer, 2008).

An advantage of using IV is that multiple attributes of a PI collection (PIC) can be viewed simultaneously to enable users to explore, compare and analyse this PIC in various ways (Indratmo and Vassileva, 2008). IV tools can positively assist with information retrieval and data analysis (Balakrishnan, Fussell and Kiesler, 2008). Gomes *et al.* (2010) suggest that a meaningful visualisation technique may be the solution for the difficulty in finding information among the increasing amount of users' PI. Visualisations may assist a user in finding what s/he is searching for (Al Nasar *et al.*, 2011). Additionally, visualisations provided to a group of users can encourage collaboration (Balakrishnan *et al.*, 2008).

A number of PIM tools exist to organise and visualise PI, but these tools remain largely unused as they do not effectively support access to PI across multiple devices (Rajamanickam, 2009). An interface needs to be designed to support accessing PI across multiple devices, which unifies content and functionality to assist a user in developing his/her own processes, structures and views of his/her personal space of information (PSI) (Jetter *et al.*, 2008). To make effective use of an appropriate PI organisation method, the method should be considered a "view" (Indratmo and Vassileva, 2008). If a PI organisation method is designed, it needs to be visualised to effectively communicate with the user (Rajamanickam, 2009).

Together with the requirement to support multiple PI types, PI visualisation systems should also provide multiple IV techniques and support the tasks related to information retrieval:

3.2.1. Support for Multiple IV Techniques

Dumais *et al.* (2003) suggest that a list view representation may not be suitable for PIM and state that an improved IV technique may be needed. Sequential grid layouts for media PI items may not be sufficient for information retrieval (Ryu *et al.*, 2010). Ryu *et al.* (2010) identify that the UI is important for photo management as this is what the user interacts with. If an ontology is used for PI organisation it needs an effective UI and visualisation, otherwise it may become difficult for the end-user to use (Katifori, Vassilakis, *et al.*, 2008; Katifori, Torou, *et al.*, 2008). There has also been research interest in using the visualisation of email archives in order to discover patterns (Viégas *et al.*, 2006).

In addition to the visualisation dependence on the PI organisation, the IV technique(s) used will also depend on the PI types and PICs within a user's PSI. Each PI type may require a different IV technique (Jetter *et al.*, 2008). Alternatively, a user's PICs may require different IV techniques. Multiple or nested IV techniques may be needed, as used in the development of the Zoomable Object-oriented Information Landscape (ZOIL) tool for nomadic cross-platform PIM (Jetter *et al.*, 2008), and by Evequoz and Lalanne (2007), who used a network and a TreeMap to visualise an email archive. It will need to be determined which IV techniques will be suitable for which PI type or PIC, or whether these IV techniques may need to be enhanced to support PIM.

The different devices used will also provide unique challenges for visualisation (Jetter *et al.*, 2008). For example, a mobile phone has different constraints from a static device. The IV techniques used will need to be customised for these devices. Additionally, if multiple visualisations of PI are provided, these visualisations need to be co-ordinated (Aires and Gonçalves, 2012). Thus, if a user filters on certain PI, then the other visualisation will be updated to reflect the filtered information.

Indratmo and Vassileva (2008) suggested providing a user with multiple views or perspectives of his/her PSI so that s/he is provided with several visualisation options. This may assist in allowing a user to customise the PIM tool to his/her needs; for example, a user may require visualising his/her PI according to device, PI type, time and so on.

3.2.2. Support for Information Retrieval Tasks

A PI visualisation system needs to support tasks identified for visualisation and tasks identified specifically for PIM. Shneiderman (1996) identified a well-known and commonly used mantra for IV:

"Overview first, zoom and filter, then details-on-demand..."

Several IV tasks were identified that need to be supported when designing an IV tool, namely:

- **Overview:** Provide an overview of the information.
- **Zoom:** Allow the user to zoom in on information of interest.
- **Filter:** Filter out irrelevant information.
- **Details-on-Demand (DoD):** Provide details of items of interest when required.
- **Relate:** View the associations between information items.
- **History:** Provide a history of actions to support exploration.
- **Extract:** Provide a method of extracting the information.

There are various methods for supporting the above-mentioned tasks, for example, an overview can be provided by either providing an interactive overview to assist a user in navigating his/her PI, or by using a fisheye strategy directly over the visualisation. This mantra should be followed when designing visualisation techniques for PIM. A user should be supported in the above tasks when retrieving information using IV. A user should be supported in browsing, searching and filtering to find information items.

In addition to the visualisation tasks mentioned above, tasks specific for PIM need to be supported by the PI visualisation tool as well. The goal of PIM is to enable a user to access his/her PI relevant to his/her location, in the most appropriate form, while supporting the tasks of PIM (Jones and Bruce, 2005). Barreau (1995) originally identified PIM tasks to include the following tasks:

- Acquiring;
- Organising;
- Storing;
- Maintaining;
- Retrieving;
- Producing.

PIM tasks were then later simplified to include the following (Jones and Bruce, 2005):

- Keeping (storing);
- Managing (organising and maintaining);
- Finding (searching and browsing for retrieval).

More recently, the key activities for PIM were identified as the following four activities (Indratmo and Vassileva, 2008):

- Acquiring;
- Organising;
- Retrieving;
- Processing.

Lower-level PI tasks for each PI item in the PSI include the following tasks (Jones and Bruce, 2005):

- Creating;
- Sorting;
- Moving;
- Naming;
- Assigning properties;
- Copying;
- Distributing;
- Deleting;

- Transforming.

The keeping (storing), organising and finding (viewing and retrieving) PIM tasks across multiple devices form the focus of this research. Support for the general PIM tasks as well as the lower-level tasks for each PI item need to be provided by the design of a PI visualisation tool. Additionally, the PI visualisation tool could adapt to allow the user to view newly added PI items, which are different from his/her previous usage of the tool.

3.3. Current PI Visualisation Techniques

A PI visualisation tool should provide an overview of a user's PSI, regardless on which device the PI is stored or the PI type (Jetter *et al.*, 2008). The visualisation of hierarchies is an important aspect of PIM (Golemati *et al.*, 2007). As discussed in Section 2.4.3, hierarchies are the most common PI organisation method used. Thus, hierarchies need to be visualised to facilitate user interaction. Golemati *et al.* (2007) identify the general categories of hierarchy visualisations as follows:

- **Indented List:** Used most commonly in Microsoft Windows Explorer.
- **Node-link Trees:** Use a top-bottom or left-right layout, such as a Cone Tree or SpaceTree.
- **Zoomable UIs (ZUIs):** Provide a zoom feature to zoom in and out of specific sections in the hierarchy, e.g. Grokker.
- **Space-Filling:** Effectively use screen-space by sub-dividing node space between its children, e.g. TreeMap.
- **Context + Focus:** Distort the view of the hierarchy for context and focus, e.g. StarTree.

Golemati *et al.* (2007) and Kolman *et al.* (2012) identify that the indented list is most commonly used for file browsing. The advantages of this IV technique are that it provides good performance levels in most environments and users are familiar with this technique (Golemati *et al.*, 2007). Figure 3-1 illustrates the document and media hierarchy visualisation of Windows Explorer using the indented list.

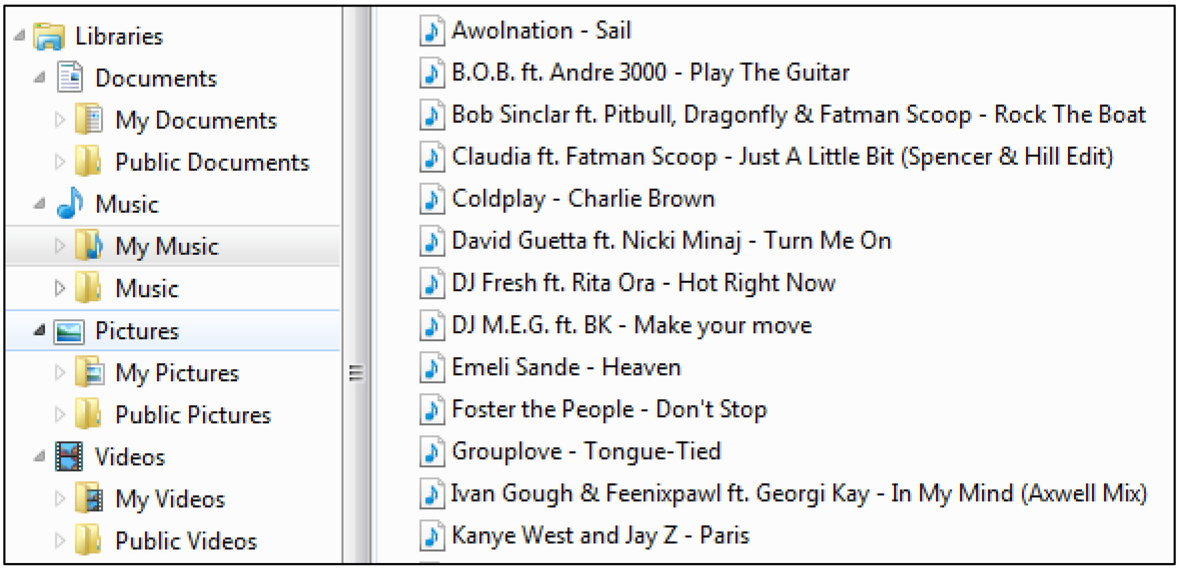


Figure 3-1 The Indented List Visualisation of Windows Explorer

3.4. Shortcomings of Existing PI Visualisation Techniques

Several shortcomings were identified in Section 2.4.4 regarding the current method of PI organisation. It can be concluded from Section 2.4.4 that the existing hierarchical organisation method does not sufficiently support PIM. Thus, the PI visualisation technique used to visualise the hierarchical organisation may not support PIM as it will suffer from the same limitations as the organisation method it visualises.

Golemati *et al.* (2007) identified from a user study that the presentation of the hierarchy used by Windows Explorer is insufficient. Golemati *et al.* (2007) evaluated the use of Windows Explorer and determined that the participants of the study did not use the system as they found it confusing, time-consuming and redundant. The participants noted that Windows Explorer does not provide an overview and does not use effective screen-space. Navigation, information retrieval (in terms of file and folder visibility), colour-coding and interaction were also problems experienced with Windows Explorer. Although the familiarity of the indented list may be an advantage of this visualisation technique, a hierarchical organisation method and visualisation technique may be too limited for PIM especially if associations between PI items (Section 2.5.4) need to be supported by the PI organisation method.

Jones *et al.* (2009) identified *visibility* to be one of the main reasons why project-related PIM tools are not used. Filing systems and email archives, such as Microsoft Outlook, were abandoned as the systems did not support effective PIM since the PI was not always available and visible.

3.5. PI Visualisation Systems

PIM has been researched since Bush's vision of the Memex (Bush, 1945) as a "*device in which an individual stores all her books, records, and communications, and which is mechanized so that it may be consulted with exceeding speed and flexibility*" suggesting the use of trails to assist a user with information retrieval. Previous research has identified the importance of visualising PI to enable effective information retrieval. Various visualisation systems have been developed for PIM and these systems are discussed in this section. Some systems discussed in Chapter 2 are also discussed in this section as these systems focussed on both PI organisation and visualisation. These systems at least partially supported the information retrieval tasks (Section 3.2) and either extend the hierarchical organisation method or support multiple IV techniques. None of the systems discussed in Section 2.4.5 support both the extension of the hierarchy and multiple IV techniques.

3.5.1. Systems Extending the Hierarchy

This section describes visualisation systems that extend the hierarchical organisation method and support multiple PI types. Visualisation systems discussed in this sub-section include ProjectFolders, Facet Folders, Planz and the File Concept Browser.

3.5.1.1. ProjectFolders (2006)

ProjectFolders (Bergman *et al.*, 2006) is an extension of current hierarchical PI organisation systems and suggests that PI items of various types, e.g. documents, emails, web pages, tasks and contacts, but related to the same project, should be clustered together (Section 2.4.5.6; Figure 3-2). Thus, all project-related information can be found in the same location.

This system is considered a single hierarchy solution which replaces the need for multiple hierarchies. Tabs are provided within a folder, which each contain a specific PI type. Although this system may improve the current hierarchical system used for PI organisation by incorporating different PI types within a single location, folders, and their related issues, still remain. Additionally, this system is designed for a desktop computer device. While tabs are used to improve the current hierarchical system, the same indented list is used to visualise the folder hierarchy.

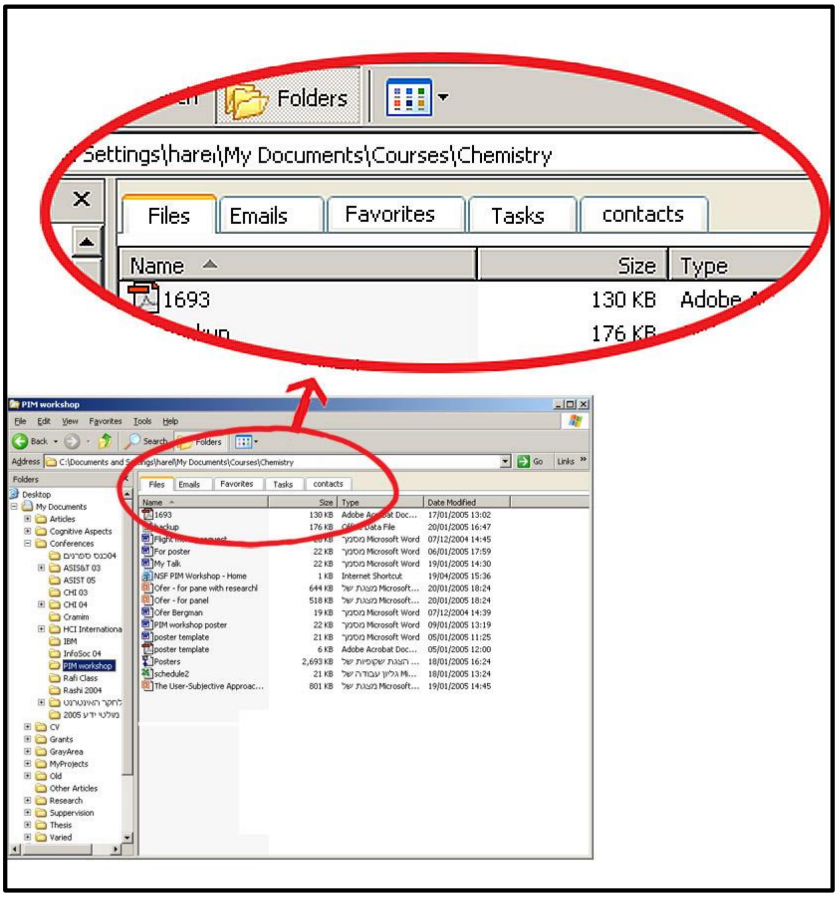


Figure 3-2 The ProjectFolders User Interface (Bergman *et al.*, 2006)

3.5.1.2. Facet Folders (2008)

Facet Folders (Weiland and Dachselt, 2008) is an interactive visualisation system to assist users in filtering PI (Section 2.4.5.8; Figure 3-3). One of the goals of this system is to display the metadata of each information item to support filtering and adapt the hierarchies when the user's needs change. Persistent hierarchies are used to allow the user to create dynamic views over a number of facets of his/her PI. Folders are used by the system, which can dynamically change, offering users flexible views of their PI using metadata and filtering facilities. Metadata can include time, location, person, event, classification and other aspects.

Figure 3-3 shows images of holidays ordered by year and location, in this case country, with work documents ordered by location, in this case continent. Facet Folders is designed similar to current hierarchical organisation systems using thumbnails to represent different types of PI. Folders are displayed as rectangles, labelled with the filter attribute and making use of colour-coding to differentiate between facet types. Folders located on the same hierarchy level are represented by positioning them above each other, grouping these folders by filter attributes where groups are indicated using dashed lines. Each group is assigned a facet handle located at the top-right of the group with the label indicating the granularity of the facet. Parent folders contain sub-folders, which are connected using dashed lines as well. Scrolling the hierarchy supports navigation and folders can be expanded or contracted, showing thumbnails of contained items when the folder is contracted. Not all items are represented as thumbnails at the same time as this would increase on-screen clutter, but rather the system allows the user to select when to view more items.

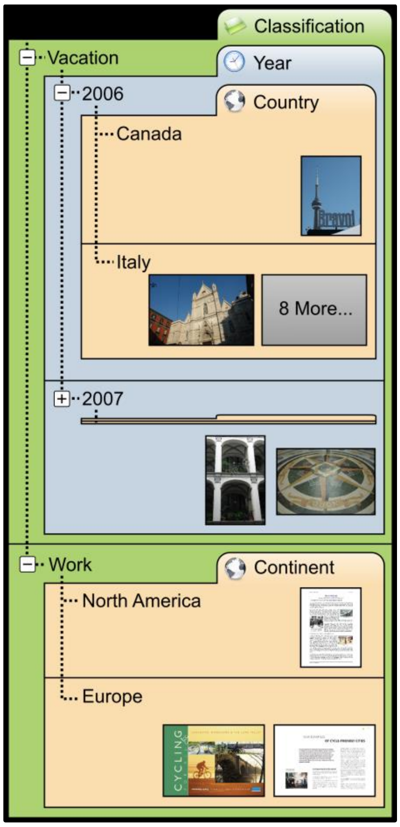


Figure 3-3 The Facet Folders Hierarchical User Interface (Weiland and Dachselt, 2008)

This system was designed for desktop computers and also for hierarchies where the metadata can be organised hierarchically. The system is still limited to some type of hierarchy and not all PI items are visualised by the system. Due to the layout of the system, deep hierarchies may be difficult to visualise.

3.5.1.3. Planz (2010)

Planz (Jones *et al.*, 2010) provides a document-like overlay to the current hierarchical organisation using compiled Extensible Mark-up Language (XML) fragments (Section 2.4.5.10). The system is intended to visualise multiple PI types, including documents, calendar events as well as website content and links. Planz makes use of a document that a user can edit to display a user’s tasks as illustrated in Figure 3-4. High-level projects are represented by headings with sub-tasks listed below the headings. *Drag and link* support is provided, allowing users to drag PI items into the document, and *in-context create* support, allowing the user to create a PI item from within the document and providing a link to the item where the cursor was positioned. Users can type in the document, modify the hierarchy of headings, expand or collapse headings and swop notes and headings. The file system is then created according to the Planz document.

A preliminary evaluation of Planz was encouraging (Jones *et al.*, 2010). It can be deduced that the Planz system supports a hierarchy, and thus still suffers from the shortcomings of the current hierarchical systems. The indented list visualisation may also not be the most suitable visualisation technique for visualising PI. Similar to MyLifeBits, time may not be sufficient as the only attribute taken into account for visualisation (Latif and Min Tjoa, 2006).

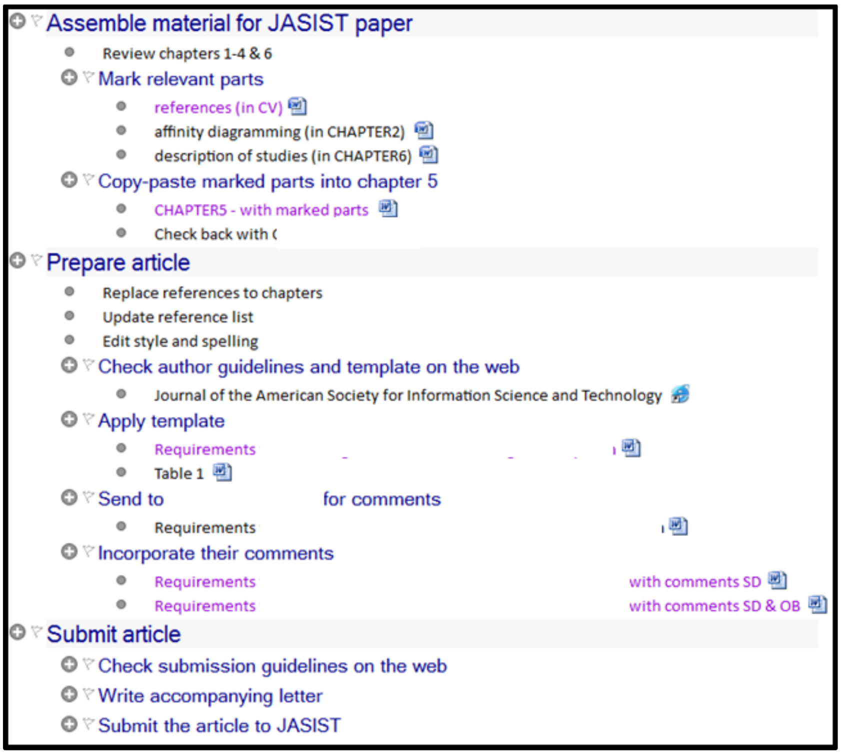


Figure 3-4 The Planz User Interface (Jones et al., 2010)

3.5.1.4. File Concept Browser (2012)

The File Concept Browser (Sajedi *et al.*, 2012), described in Section 2.4.5.11, is a file manager, similar to Windows Explorer, that supports multiple categorisations (Figure 3-5). Files can be maintained in different locations without causing problems involved with current hierarchical organisation systems. The main idea is to support the user in retrieving a specific file in one attempt.

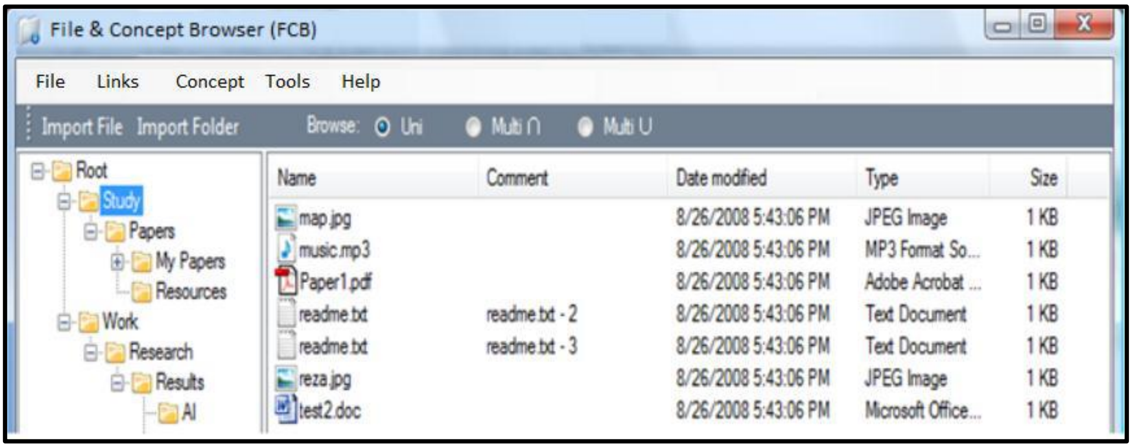


Figure 3-5 The File Concept Browser User Interface (Sajedi *et al.*, 2012)

As explained in Section 2.4.5.11, folders do not contain files as a folder only represents a concept. A file can be associated with one or more concepts. Concepts are represented using an indented list, similar to Windows Explorer, while the files are stored in a flat organisation. Browsing is improved to support exploration of files represented by multiple concepts. Other functionality provided by a typical hierarchical file manager is supported by the File Concept Browser.

A limitation of this system is that the indented list was used for visualising the concept hierarchy, while other IV techniques may be more suitable to support PIM. The system also does not currently provide support for email information types.

3.5.1.5. Dropbox (2007)

Dropbox (Houston and Ferdowsi, 2007) is available as a web-based application or an installed desktop application. The desktop application is embedded in the existing file manager on the relevant device, thus making use of the list-based visualisation to view PI (Section 2.4.5.14; Figure 3-6). Dropbox also suffers from the issues associated with hierarchical organisation and visualisation. Additionally, a user needs to remember to upload the information, and, once uploaded, it is not clear on which the device the information originally resided.

Figure 3-6 The Dropbox User Interface

3.5.1.6. TeamViewer (2005)

TeamViewer (TeamViewer GmbH, 2005) allows users to transfer PI items from one device to another, making use of each device's hierarchical organisation and visualisation (Section

2.4.5.15; Figure 3-7). Limitations of TeamViewer include displaying only the two devices' information. When transferring information between devices shown in a drill-down structure, a user is required to know beforehand on which device the necessary information is stored. Additionally, it also has the same hierarchical organisation and visualisation issues as Dropbox, since TeamViewer only supports accessing another device if the user was using the other device as an additional hard drive.

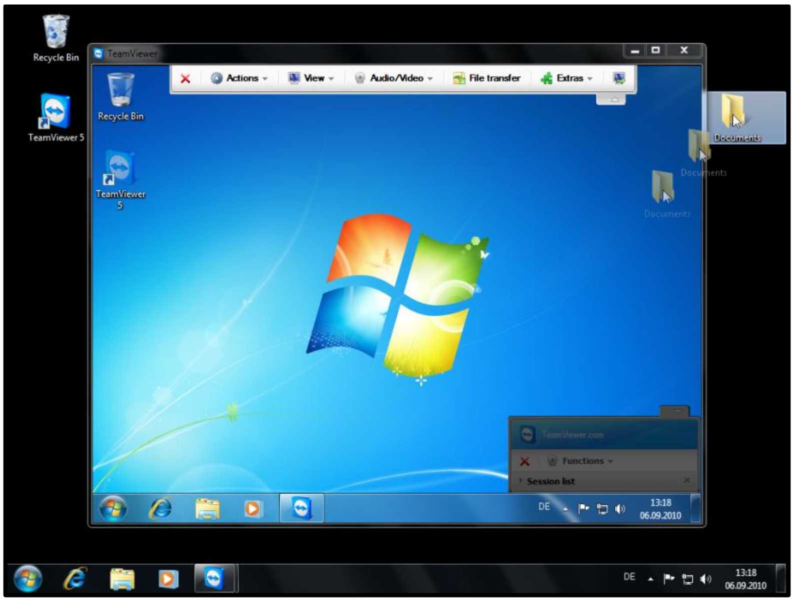


Figure 3-7 The TeamViewer User Interface

3.5.2. Systems using Multiple IV Techniques

This section describes visualisation systems that incorporate multiple IV techniques to visualise multiple PI types. Visualisation systems discussed in this sub-section include MyLifeBits, the Email Archive, ZOIL, PI Dashboard and InfoMaps.

3.5.2.1. MyLifeBits (2002)

MyLifeBits (Gemmell *et al.*, 2002) is a system used to store media and documents in a Structured Query Language (SQL) Server database. MyLifeBits, as described in Section 2.4.5.3, is focussed on using collections (i.e. annotations) and search to replace the current hierarchical organisation. Thus, MyLifeBits supports PIM using multiple visualisations, annotations for non-text media and transclusion for authoring. Transclusion refers to the authoring tools used that allow "two-way links to media that they include in new media" such that a link represents one PI item annotating another PI item (e.g. a photo being used in a presentation) (Gemmell *et al.*, 2002; Evequoz and Lalanne, 2007).

Searches in a user's PIC can be visualised using a timeline view (Figure 3-8), a clustered-time view, a detailed view and a thumbnail view. Time and date information as well as a possible location or descriptor of a media item is stored. The detailed view provides a list of PI items with each attribute. The thumbnail view displays reduced images of the PI items using a grid. The timeline view (Figure 3-8) displays these thumbnails over a timeline which can be adjusted. The clustered-time view allows grouping thumbnails by time.

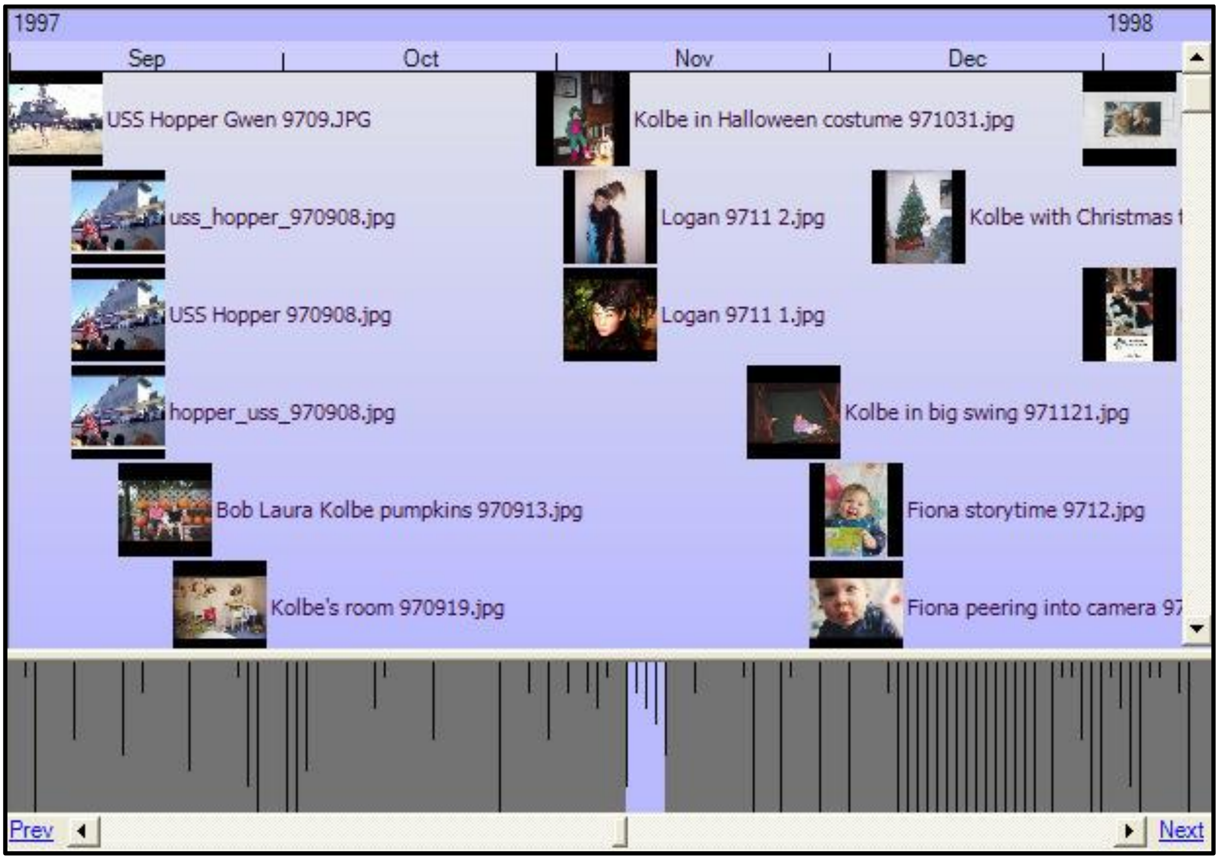


Figure 3-8 The Timeline View of MyLifeBits (Gemmell *et al.*, 2002)

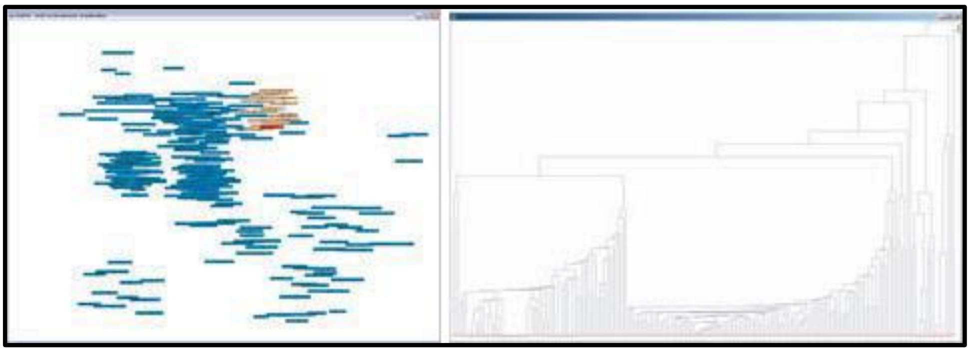
The design of the UI in MyLifeBits focusses on information density, reducing the need of the user to have to find hidden information, minimising the requirement of identifying what an item represents using thumbnails, modifying the size of the thumbnail upon selection and providing preview and other optional windows for displaying additional information about a certain PI item. Annotation is one of the primary goals of MyLifeBits as items may be annotated in a group, providing support for audio annotations and providing a toolbar in the web browser to record visited web pages.

MyLifeBits makes use of stories providing an *Interactive Story By Query* interface to allow a user to search and create stories from items in the search result. Stories are shown using a slide show or a time sheet. These stories are used to annotate each PI item included within them.

While time is an important aspect of PIM, it should not be the only consideration (Gemmell *et al.*, 2002). Although a timeline-based visualisation with annotation support may be useful for media PI items, the UI is search-based (Latif and Min Tjoa, 2006). No user studies have been conducted to determine to what extent these visualisations support PIM. An observation that can be made relates to the possibility of limited scalability of the timeline visualisation technique used in MyLifeBits (Figure 3-8).

3.5.2.2. Email Archive (2007)

Evequoz and Lalanne (2007) designed a PIM tool consisting of visualisation techniques to visualise a user's digital memory (Section 2.4.5.7). Browsing is supported by this tool to allow a user to find specific items of information. Email is used as the primary source of metadata to group information according to social, thematic and temporal organisations. The aim was to provide multiple visualisation techniques to visualise PI to support visual query refinement, such as filtering, with each organisation requiring its own visualisation. Simple visualisation techniques were implemented to visualise the groupings of information as can be seen in Figure 3-9.



(a) **(b)**

Figure 3-9 The Email Archive Visualisation Techniques (a) A Social Network Graph (b) Thematic Hierarchical Clustering (Evequoz and Lalanne, 2007)

At the time of publishing, thematic grouping was visualised by a treemap, where social grouping was visualised by a social network graph using a spring layout with limited functionality. This research seems to be still in progress and so visualisations were only created for two of the clusters. Additionally, only email was supported at the time and only browsing was supported by the visualisation system. Limited functionality was supported by the system. It remains to be determined to what extent these visualisations support PIM.

3.5.2.3. Zoomable Object-Oriented Information Landscape (ZOIL) (2008)

ZOIL (Jetter *et al.*, 2008) follows the following design principles with the domain model incorporating these principles: *object oriented UIs (OOUIs),* a PI item is considered an object and classes represent different objects with attributes; *semantic zooming,* zooming in to reveal more content and supported functionality, zooming out to view an icon; *nested IVs,* representing PICs as portals and allowing selection of sub-portals within a portal and visualising this sub-portal; *information space as an information landscape,* providing all PI items on the screen as an infinite space; and *nomadic cross-platform UIs,* allowing access to multiple devices using a web-application (Section 2.4.5.9).

Jetter *et al.* (2008) identified a need for ZOIL to be extensible and customisable. PI items are considered as objects with properties, with each PI type representing a class containing attributes, metadata, links, functionality and how the item should be viewed. PICs are arranged according to the activity where the user selects the items in a portal, the location of the portal on the screen and the visualisation technique to be used, thus integrating different types of PI in a single PIC. Additional visualisation techniques can be downloaded as plug-ins. ZOIL allows for panning to browse the information landscape (Figure 3-10). In 2009, Gerken *et al.* moved the ZOIL UI to surface computing. Surface computing, in this case, referred to collaborating on mobile, tabletop or wall-sized devices using ZOIL; and Squidy, another software tool developed as an interaction library to unify different device toolkits.

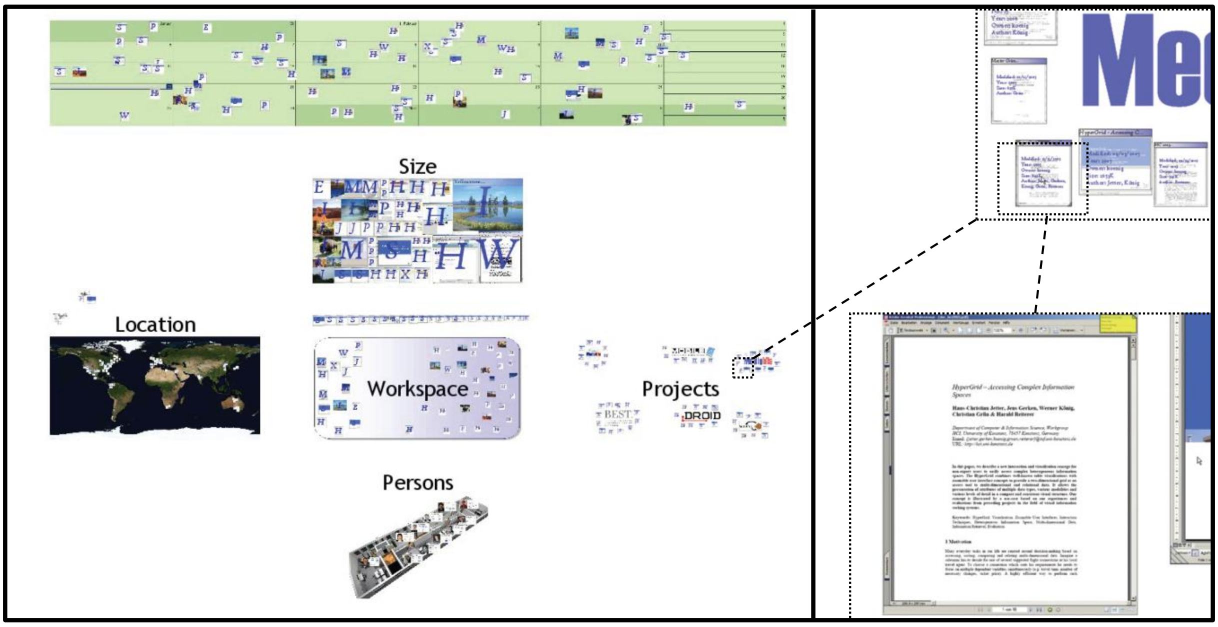


Figure 3-10 The ZOIL User Interface (Jetter *et al.*, 2008)

Two key features of ZOIL were highlighted, namely OOUIs and ZUIs. OOUIs were considered to support organising and visualising co-operative objects, which can be used for direct manipulation using touch and gestures. ZUIs were identified as being useful as they use a natural presentation to display large volumes of information without needing WIMP (Windows Icons Menus Pointer) principles.

Sources of information for ZOIL include objects in a digital library, a file system, emails in a web-based email account, calendar dates and users of a social networking website (Gerken *et al.*, 2009). The landscape is referred to as a *virtual canvas* of unlimited size and resolution. Searching, by means of a keyword search with the possibility of creating a portal with the search results, and browsing, using panning and zooming, are supported. The main strength of ZOIL is contributed to its flexibility in distributed and collaborative situations (Zöllner, Jetter and Reiterer, 2011). A client is provided with the opportunity to select a section of the landscape to view and also select which visualisation to use.

The latest definition of ZOIL refers to ZOIL as a "novel design approach and software framework for post-WIMP DUIs (Distributed UIs) in interactive spaces" (Jetter *et al.*, 2012). A DUI is an interface that distributes components among different monitors, devices, platforms, displays and users.

This system is one of the only systems that unifies PI from multiple devices and different PICs. Currently, ZOIL only supports the *Microsoft Windows* platform and is not entirely multi-platform. Additionally, the UI only scales for multiple devices to enable viewing and so the UI is not customised to support the constraints and considerations of each type of device. One of the key issues with ZOIL is that it is not clear on which device the PI items are stored. It is also not clear which types of visualisation techniques are supported for PIM.

Although user studies were conducted, these studies were mainly focussed on determining to what extent the ZOIL framework supports developing applications and not whether the visualisation techniques support PIM. It also needs to be determined how the spatial orientation of the landscape may be perceived by the user and whether the selected visualisation techniques are the most appropriate techniques to visualise the different types of information. It is not clear how personal and shared information spaces will be supported using ZOIL for surface computing. Finally, the framework seems to focus on collaboration on a large display and not for other devices such as a mobile phone except for "cooperative" devices, for example using a tablet to define the interaction and a tabletop for collaboration.

3.5.2.4. PI Dashboard (2012)

The PI Dashboard (Aires and Gonçalves, 2012) makes use of a dashboard metaphor (Section 2.4.5.12; Figure 3-11). This system supports the use of plug-ins so that a user can personalise his/her dashboard with each plug-in using a visualisation. Plug-ins are correlated so that selecting an item in one plug-in updates the display in all other related plug-ins. Each plug-in provides interaction ability so that a user can select different items, update time ranges, find out more information of an information item by hovering over the item, and so on. The system is extensible in that new plug-ins can be created and new types of PI can be added as sources.

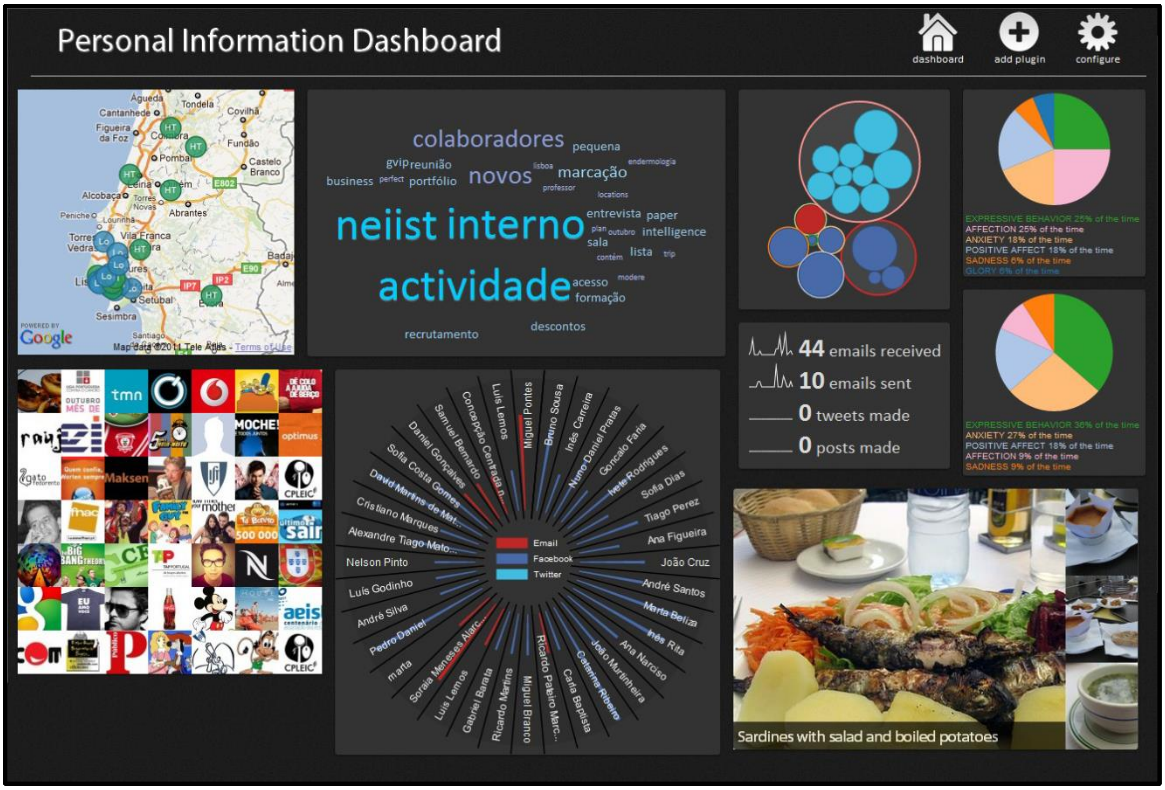


Figure 3-11 The Personal Information Dashboard User Interface (Aires and Gonçalves, 2012)

Different types of visualisations exist in the PI Dashboard. For example, a tag cloud visualisation, called *Keyword Cloud*, is used to display the most prominent words from emails, posts and tweets and is shown in the top-middle of the interface in Figure 3-11. Bubbles are used to display email messages shown as the third plug-in, called *You've Got Bubbles*, at the top of the interface in Figure 3-11. In the bottom-middle of the interface is the *Who&How* plug-in, that displays activities with each contact that a user has, arranged using a circle with edges connecting concentric areas. Bars represent activities such as emails received from a contact and posts on Facebook. Filtering is supported, with the addition of fadeouts and highlighting to encode filter results. The Details-on-Demand task is supported using tooltips to provide additional information of a specific item on the screen.

A usability evaluation of the PI Dashboard provided positive results (Aires and Gonçalves, 2012). Cross-referencing information from multiple sources, plug-in communication and the number and type of sources were identified as positive features of the system. Participants identified the need for accessing and creating email from the system, which the system does not currently support.

The system is used as a tool to only visualise information of a user. Although the system provides a web interface, information stored over multiple devices was not considered. From the design of the UI displayed in Figure 3-11, it seems that the system was not designed to consider constrained devices such as a mobile phone. The sources of information primarily focus on social networks to view patterns, and even though email was considered, documents, media and calendar information do not form part of the focus of the visualisations.

3.5.2.5. InfoMaps (2012)

Background images can act as landmarks for familiarity or in relation to the PI items' metadata in InfoMaps (Section 2.4.5.13; Figure 3-12) (Kolman *et al.*, 2012). A background image can be selected by the user upon which the user can spatially place PI items to relate these items to the background image. Queries and keyword filters can be used to group related information on the screen and searching is also supported. A PI item is described by its URL (Uniform Resource Locator), title, description and data published/modified attributes. PI items are represented by a thumbnail image. Hovering over a PI item will display a popup information window displaying the PI item's metadata. A PI item can also be opened by double-clicking on the item, where a web page will open to view the item. Various layouts are provided including grid, horizontal, vertical, cascaded and radial layouts. A complementary framework, referred to as Weave, is used to provide co-ordinated and different views using visual tools.

Currently, only RSS feeds and PDF documents are supported. No documented evaluations could be found on the InfoMaps UI and there is no evidence indicating what devices are supported. The sources of the information items are also unclear. There is also no discussion on the suitability of the IV techniques incorporated within the tool.

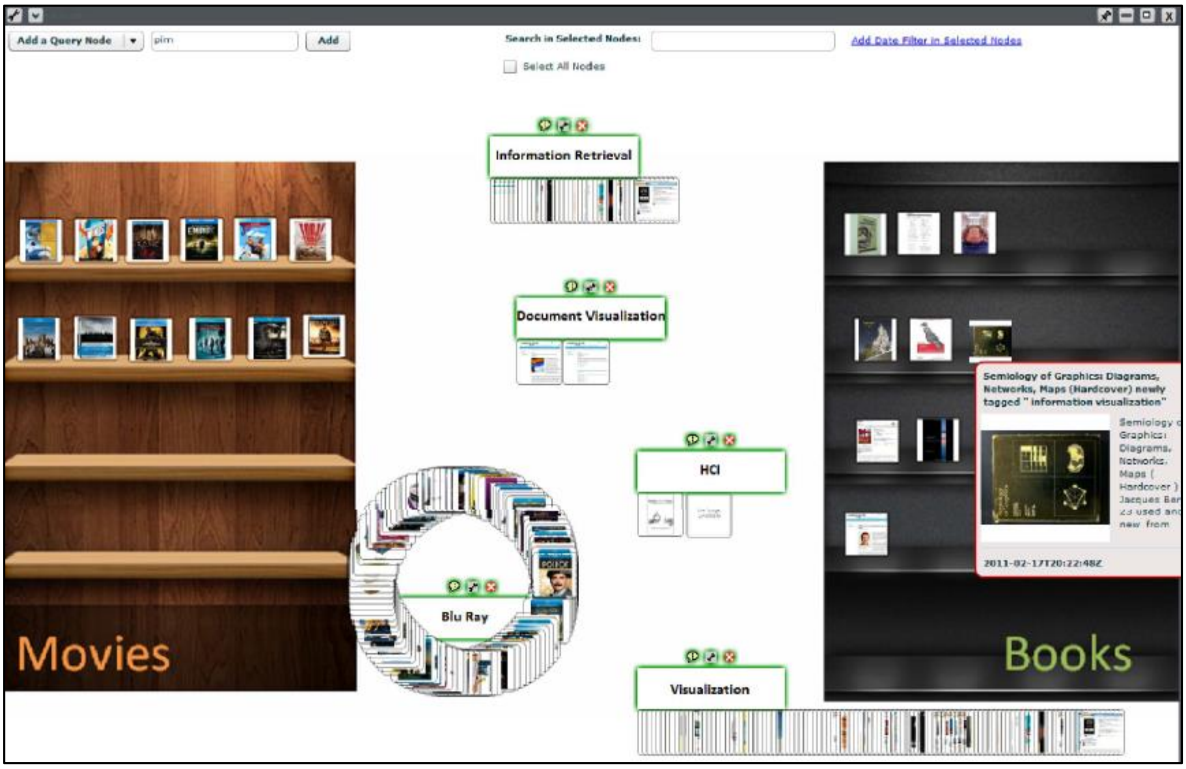


Figure 3-12 The InfoMaps User Interface (Kolman *et al.*, 2012)

3.6. Shortcomings of PI Visualisation Systems

The PI visualisation systems were discussed in terms of their support for extending the hierarchy or providing multiple IV techniques. The PI visualisation systems were analysed to determine what IV techniques were used to visualise PI, or a subset thereof, by each system. Table 3-1 lists the number of systems relating to a specific visualisation (Appendix A). The indented list, most commonly used to visualise a hierarchy, was the most popular technique used by the PI systems (5). A list may not be the most suitable technique to view PI (Dumais *et al.*, 2003). MyLifeBits and the Email Archive used multiple visualisation techniques to provide different views of a user's PI. ZOIL and InfoMaps used landscapes using several visualisation techniques. Other visualisations included the use of a dashboard with plug-ins, each with their own visualisation, and a nested, treemap visualisation.

The PI visualisation systems described in the previous section each possess benefits and shortcomings. All the PI visualisation systems possess varied shortcomings. Shortcomings are mainly attributed to the systems focussing only on visualising PI on a single device, mainly a desktop or a mobile device. Most systems can be considered to be "offline" as the PI visualised cannot be accessed from a different device for which the system was designed. Multiple hierarchy visualisations are also not supported.

Table 3-1 IV Techniques Used by Systems

	IV Technique	Freq.
1.	Indented List	5
2.	Multiple Visualisations (Different Combinations of IV Techniques)	2
3.	Landscape (Multiple Visualisations)	2
4.	Dashboard (Multiple Visualisations)	1
5.	Nested (Treemap)	1
	Total	**11**

It is unknown to what extent these different tools have been adopted in users' daily lives as it seems that hierarchical systems, such as Windows Explorer, still dominate PIM tool usage. This result may be due to the overwhelming number of PIM tools made available to a user with the user not being able to select the most appropriate tool with which to manage their PI.

Some of the tools discussed still visualised PI using a list view as shown in Table 3-1 and also focussed on visualising search results rather than the entire PSI. It was determined in Chapter 2 that users prefer to browse rather than search. Other systems, such as the email archive, only support browsing, which may be an issue for large datasets. Additionally, some systems, such as the PI Dashboard, are mainly limited to viewing patterns of information usage rather than providing support for accessing PI. Various systems, including Planz, rely on time to visualise and support finding PI, but other aspects of PI also need to be considered. Systems such as MyLifeBits use a database to store a user's PI, but this may not be useful as it forces a user to install a separate storage application for PIM. MyLifeBits also does not focus on the UI design. It is also not clear what functionality and information retrieval tasks are supported by each system, and whether PI can be accessed from within the systems, which is a required feature of such a system (Aires and Gonçalves, 2012). For those systems that support accessing PI across multiple devices, such as Dropbox and TeamViewer, it is also not clear on which device the original PI is stored.

Lastly, there is no clear consistency between the different types of PI that were visualised. There is also limited consistency in which IV techniques were used and the motivation for using these techniques was not given, thus it is not clear which IV techniques are most suitable to visualise

PI, especially for visualising PI across multiple devices. The next section describes requirements for visualising PI across multiple devices.

3.7. Requirements for PI Visualisation

The PI visualisation technique(s) that will be designed need to support the organisation method(s) used. Due to the existing ineffective organisation method used for PIM, the visualisation technique used for PIM does not sufficiently support PIM. Certain requirements can be identified from the shortcomings discussed previously. These requirements are listed in Table 3-2.

Table 3-2 Requirements for PI Visualisation

	Requirements
1.	Browsing Support
2.	Provide a Temporal View
3.	Allow a User to View an Overview, Set of Topics and Entire PSI
4.	Visually Represent PI Items
5.	Interactivity Support

3.7.1. Browsing Support

Users prefer browsing PICs than searching to retrieve PI items (Voit *et al.*, 2009). Re-finding is an important task for PIM, and users prefer to browse to find PI items such as documents (Jones, Wenning and Bruce, 2014; Bergman *et al.*, 2012). Users prefer browsing a PSI hierarchy because they are able to view the available PI items at each level and select the required item (Voit *et al.*, 2009). Although advances have been made in improving search engines, users still prefer browsing over searching their PSI. A visualisation system should primarily support browsing and searching as a secondary task. Additionally, the search facility should incorporate advanced filtering and sorting to refine a search.

3.7.2. Provide a Temporal View

A number of existing PI visualisation systems visualised PI by replacing the current hierarchical organisation in favour of using a temporal visualisation, including LifeStreams (Fertig *et al.*, 1996). Other systems, such as the Email archive (Evequoz and Lalanne, 2007), used a timeline visualisation as one of multiple visualisation techniques provided by the system. Time was identified in Chapter 2 as being one of the most important aspects of PIM. It was identified in Section 3.6 that although time is important, it should not be the only aspect considered for PIM

(Latif and Min Tjoa, 2006). Additional support such as association, annotations, tagging and different perspectives can support the temporal PIM attribute.

3.7.3. Allow a User to View an Overview, Set of Topics and Entire PSI

The main problems with existing systems that need to be addressed include effective use of screen space, focussing on multiple PI types, supporting multiple PICs, focussing on browsing rather than searching to find relevant PI and making use of a single UI to visualise multiple PI types and PICs across different devices. The IV techniques also need to support large PSIs, thus supporting the problem of the ever increasing volume of PI owned by a user. Several IV techniques were carefully selected to be incorporated in the MyPSI prototype, a tool to support access to PI across multiple devices, to support these requirements. These IV techniques need to be enhanced to support PIM across multiple devices. An *Overview* will use an interactive nested circles layout; a *Tag Cloud* will represent the tags in the PSI; and the set-based technique, hereafter referred to as the *Partition Layout*, will be used to visualise the folder structures for each user device:

a) The Overview

One of the first tasks in the visual information seeking mantra (Shneiderman, 1996; Heer, Bostock and Ogievetsky, 2010) taxonomy is to provide an overview, which is not entirely possible with Windows Explorer. None of the PI visualisation systems discussed in Section 3.5 provided an explicit Overview. The *Overview* can be visualised using a nested circles layout, which is considered to be an enclosure diagram (Heer *et al.*, 2010). A nested circles layout provides a general view of the data that it represents, which clearly represents the hierarchy. An example of the nested circles layout is shown in Figure 3-13. An *Overview* should provide an overall view of the PSI supporting the *Overview* task in the visual information seeking mantra (Shneiderman, 1996). The *Overview* should be interactive, which can assist in filtering.

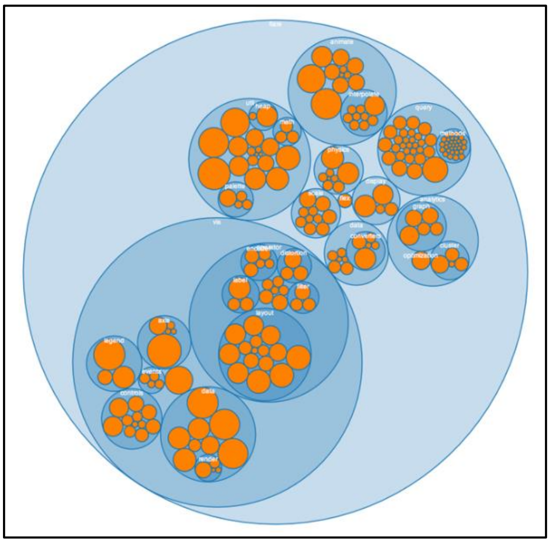


Figure 3-13 An Example of a Nested Circles Layout (Heer *et al.*, 2010)

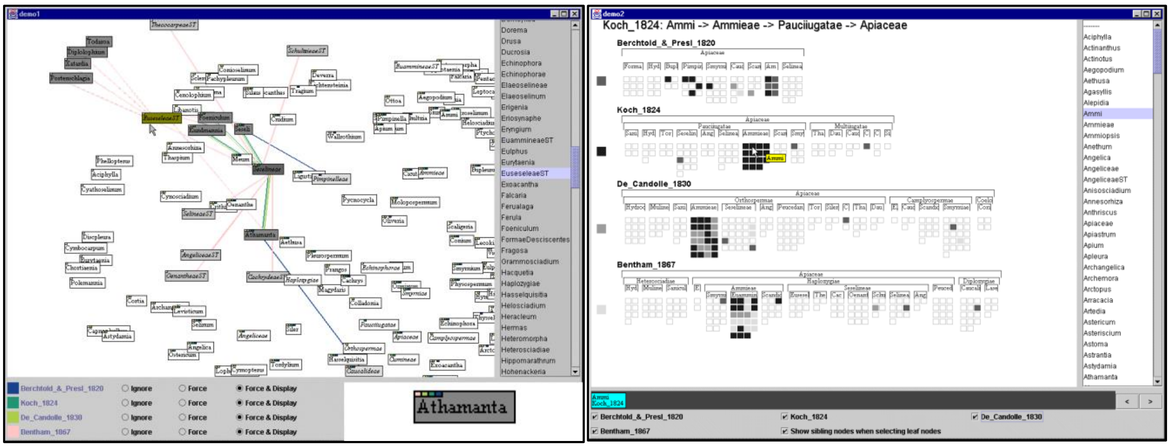
b) The Tag Cloud

Association of PI items was identified in Section 2.5 as one of the main requirements for PI organisation. A tagging facility is provided by Windows Explorer, but the functionality is not fully exploited by the tool. Most of the PI visualisation systems discussed in Section 3.5 support tagging in the form of associating PI items. None of these systems, however, provide a visualisation of the assigned tags within a PSI. The existing tags in the PSI should be represented by a *Tag Cloud*, which is typically used for a general information-seeking task (Sinclair and Cardew-Hall, 2008), and can also assist with filtering. An example of a *Tag Cloud* is shown in Figure 3-14.

Figure 3-14 An Example of a Tag Cloud (Sinclair and Cardew-Hall, 2008)

c) The Partition Layout

Multiple hierarchies need to be considered in order to view PI across multiple devices and according to each PI type. Limited research was found regarding the visualisation of multiple hierarchies to support information retrieval. Graham and Kennedy (2010) compared existing IV techniques with respect to the visualisation of multiple hierarchies, such as a matrix and a union tree. The survey identified that a preference exists to keep the hierarchies part of the multiple hierarchical structure separate. Graham and Kennedy (2008) also identified that a combination of views may be necessary to support all the required tasks of a tool supporting a combination of the *Overview*, *Partition Layout* and *Tag Cloud*.



(a) **(b)**

Figure 3-15 (a) A Graph-based IV techniques versus (b) a Set-based IV Technique (Graham, Kennedy and Hand, 2000)

The use of a graph-based or network IV technique and a novel set-based IV technique visualising a botanical taxonomy were also compared and are displayed in Figure 3-15 (Graham, Kennedy and Hand, 2000). The comparison revealed that the set-based IV technique was the preferred IV technique to visualise the plant classification scheme as it provided a more structured visualisation technique, which was representative of the data taxonomy, and minimised clutter. The set-based IV technique also provided better ordering and minimised overlapping nodes. This IV technique provides an alternative to the pure hierarchical list-based IV technique by showing groups of similar PI types per device.

3.7.4. Visually Represent PI Items

It was observed from the LifeStreams visualisation system discussed in Section 3.5 that it may be difficult to distinguish between different PI items placed sequentially within the temporal visualisation as the PI items were visually similar. Systems, such as MyLifeBits and Stuff I've Seen, effectively represented PI items as thumbnails to avoid this issue (Al Nasar *et al.*, 2011). Providing a preview of a PI item, similar to Stuff I've Seen displaying an icon, title, attributes and the first few lines of text content (if the item is a document), could be useful to support a user in finding PI effectively.

3.7.5. Interaction Support

IV is comprised of representation, the visualisation of data, and interaction, how the user makes use of a system or visualisation to find information (Yi *et al.*, 2007). The representation and interaction components of IV need to be combined to support the user in finding relevant insight or information within a dataset. Although representation has been widely researched, interaction has become secondary to the visualisation used by a system but is considered as important, as the interaction indicates how a user can use the representation in a system.

Following the requirement of supporting information retrieval tasks, the tasks that need to be supported require interaction to support the user in exploring his/her PICs. The visual information seeking mantra identified by Shneiderman (1996) is only one of many interaction taxonomies identified to support IV, but has been widely adopted. From reviewing many interaction taxonomies and IV systems, Yi *et al.* (2007) identified interaction categories for IV systems, which included the following:

- *Select:* Highlight an interesting object.
- *Explore:* View another object of interest.
- *Reconfigure:* Organise the data differently.
- *Encode:* View the data using a different visualisation.
- *Abstract / Elaborate:* Zoom in or out to view details.
- *Filter:* Using conditions to view certain information.
- *Connect:* Viewing related objects.

Many of the PI visualisation systems discussed in Section 3.5 use interaction to involve the user in the information retrieval process. Visual cues and interactive visualisations are required to support and motivate the user to find relevant information items within his/her PSI.

3.8. Conclusion

The aim of Chapter 3 was to identify the shortcomings of existing PI visualisation systems and identify requirements for a PI visualisation tool. This chapter addressed the second research question, namely "*What are the existing problems with current PI visualisation techniques?*"

Large datasets benefit from using a visualisation technique to represent the data. Visualisations were determined to provide better insight into large volumes of information than textual representations. This result also applies to PIM, as users are not able to sufficiently perform information retrieval tasks on their PI due to not having an overview of their PSI. As a user's PICs increase, it becomes difficult for a user to be able to view his/her information in these different PICs and over different devices. IV can thus be used to provide this overview to a user while supporting access to the user's PI across multiple devices.

Different visualisation techniques have been used to visualise PI, but the current hierarchical PI organisation method is mainly visualised using an indented list. The indented list suffers from the same shortcomings as the hierarchical structure as well as not making effective use of screen-space, making it difficult for a user to view an overview of his/her PI. Thus, this hierarchical PI organisation method and visualisation technique does not support a user in viewing his/her PSI.

The key requirements of PI visualisation systems include supporting the information retrieval tasks, providing multiple IV techniques and providing support for extending the hierarchy. Various PI visualisation systems have been developed to address a number of PI visualisation issues. None of the IV systems supported both multiple IV techniques and extending the hierarchy. These visualisation systems were also limited to visualising single hierarchies on one device. Therefore, these systems do not support access to PI across multiple devices. Additional shortcomings involved not knowing how these systems have been adopted in daily computing, still making use of a list to visualise the PI supported, and focussing on searching and displaying search results. Only the ZOIL, Dropbox and TeamViewer systems were intentionally designed to be used across multiple devices.

From the shortcomings of the PI visualisation techniques and systems and also from general IV ideas, several requirements for PI visualisation were identified. These requirements included providing browsing support, incorporating a temporal view, allowing a user to view an overview, set of topics and his/her entire PSI, supporting visual representations of PI items and supporting interaction in addition to visualisation. These requirements, together with the requirements for

PI organisation identified in Chapter 2, need to be considered when designing a visualisation tool to support access to PI across multiple devices.

The requirements for PI organisation and visualisation need to assist the user in visualising his/her PICs over multiple devices. The selected IV techniques to support PIM across multiple devices include an *Overview*, a *Tag Cloud* and a *Partition Layout* IV technique. These IV techniques will need to support the identified requirements. Only a few systems discussed in this chapter provided some support for accessing PI on multiple devices, but not necessarily across multiple devices. Thus, it is not clear what is currently used to manage PI across these multiple devices. The next chapter will discuss an interview study conducted to determine how users currently manage their PI across these different devices and also to identify problems experienced in managing PI from a user's perspective.

Chapter 4: Interview Study

4.1. Introduction

Limited research has been conducted on supporting access to personal information (PI) across multiple devices (Tungare, 2007). With the increasing popularity of mobile devices as well as the move towards group information management (GIM) and file sharing, accessing personal or sharing group information across multiple devices has become an important aspect of personal information management (PIM) to consider (Tungare and Perez-Quiñones, 2008). A user should be supported in accessing his/her PI irrespective of location or device (Jetter *et al.*, 2008).

The PI organisation and visualisation systems discussed in Chapter 2 and 3 provided limited or no support for accessing PI across multiple devices. It was thus difficult to determine the current status of PIM and how users deal with this. An interview study was conducted to determine how users currently manage their PI across multiple devices (see Appendix B for Research Ethics Approval) (Beets and Wesson, 2013a). The problems experienced in managing PI across multiple devices were also identified from this interview study. This chapter assists in addressing the third research question of this research, RQ 3, namely *"What are the requirements for an IV tool to support access to PI across multiple devices?"* This research question was addressed by using a combination of the *Explicate Problem* and *Outline Artefact and Define Requirements* design science research activities.

The method of the interview study is described in the following section discussing the interview objectives, participants, questions asked, analysis procedure, interview setup, the interview process and the pilot study. The results of the interview study are then described in terms of the four main questions asked during the interviews. A discussion section follows the results. Based on the results of the interview study, the initial requirements for PI organisation, visualisation and functionality as discussed in Chapters 2 and 3 are confirmed.

4.2. Interview Method

Each participant was asked four questions relating to PIM. Face-to-face, one-on-one, in-person, informal, semi-structured interviews were conducted with 10 participants for this study

(Creswell, 2009). Thematic analysis, in combination with coding techniques, was used to analyse the interview data.

4.2.1. Interview Study Objectives

Empirical studies, including interviews, can serve as a pre-design step to inform the design process of information visualisation (IV) techniques and tools (Brehmer *et al.*, 2014). The interview study was used to establish how PI is currently being managed across multiple devices. The aim of the interview study was to identify problems experienced when managing PI across these devices. The outcomes of the interview study, together with the results of Chapters 2 and 3, informed the design of a PI visualisation tool incorporating enhanced IV techniques to support access to PI across multiple devices.

4.2.2. Participants

The interviews were conducted with 10 academic staff and postgraduate students (five academic staff, five postgraduate students) from the Department of Computing Sciences at the Nelson Mandela Metropolitan University (NMMU). Participants were required to have advanced computing knowledge and experience, and were also required to currently be using more than one device to manage their PI. Figure 4-1 illustrates that participants ranged between 21 and 50+ years of age.

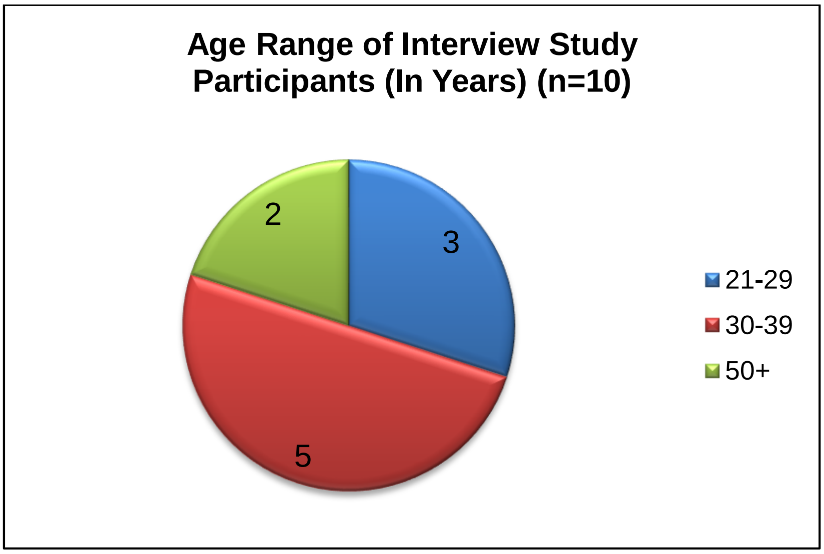


Figure 4-1 Age Ranges of Interview Study Participants (n=10)

All participants had at least six years of computer experience and all but one participant managed their PI daily using a digital device. The other participant managed his PI infrequently.

4.2.3. Interview Questions

Biographical information was provided by the participants. This biographical information included the following:

- Gender;
- Age range;
- Staff or postgraduate student;
- Experience using computers;
- Frequency in managing PI using a digital device.

Four main questions were asked in the interview regarding PIM across multiple devices. Each participant was asked the following questions:

1. How many digital devices do you currently use to store PI?
2. How do you currently manage your PI across these devices?
3. What problems have you experienced with managing your PI across these different devices?
4. Do you have any ideas on how better to manage your PI across these different devices?

Additional questions were asked following the responses to the above-mentioned questions.

4.2.4. Data Analysis

The data analysis involved using thematic analysis, in combination with coding techniques, to analyse the interview data (Creswell, 2009). Thematic analysis involves identifying and analysing patterns or themes within data and reporting on these themes. The analyser needed to perform a process of coding and analysis to identify themes within the data, following Creswell's suggested data analysis procedure for qualitative research (Creswell, 2009). The data was analysed using the NVivo 10 analysis software (QSR International, 2012). The following steps were taken during the data analysis stage of the interview:

Step 1: The interviews, captured using a voice recorder, were transcribed into text.

Step 2: The transcripts were then read to ensure no mistakes were made.

Step 3: The data was organised according to the different questions in NVivo for all participants.

Step 4: The data was then iteratively analysed further and divided into further smaller sections to identify codes/categories within the data for each question.

4.2.5. Interview Setup

An email was sent out to potential participants requesting their participation in the interview study. A face-to-face, one-on-one, semi-structured interview was used as the collection instrument for this study. The interview was captured using a voice recorder and written notes. The interview with each participant was conducted in the lecturers' offices, and a separate interview room for postgraduate students, to avoid possible interruptions.

4.2.6. Interview Procedure

The duration of the interview was approximately 20 minutes. The process followed a similar sequence to the interview protocol identified by Creswell (2009). Creswell's interview protocol includes recording the date, place, interviewer and participant involved in the interview, following a standard interview process for each interview conducted, asking the identified questions, requesting participants to explain or elaborate on the responses to the respective questions, allowing space between questions to record answers and thanking the participant for participating in the interview.

This interview study additionally included several other steps. Upon conducting the interview, the participant completed a consent form. The participant was then provided with an information sheet to remind the participant of the intention of the interview. The participants were asked to provide biographical information and were then asked the four questions relating to PIM.

4.2.7. Pilot Study

The interview was conducted with a single participant before the interview study took place to ensure that the full process, including the actual interview, capturing of the interview responses and analysis of the interview data, avoided any problems that may have arisen. The pilot study interview was included in the final results, due to no major changes being made to the procedure of the interview study following the pilot study. The only change incorporated was to specifically include "digital devices" instead of any device in the first interview question.

4.3. Interview Results

The transcripts of each interview were analysed using NVivo 10 software (QSR International, 2012). The results of the analysis are described in this section.

4.3.1. Devices Used for PIM

Most participants of the interview study used at least four devices for PIM, with three participants using five devices for PIM. Two participants used two devices for PIM and one participant used three devices as can be seen in Figure 4-2.

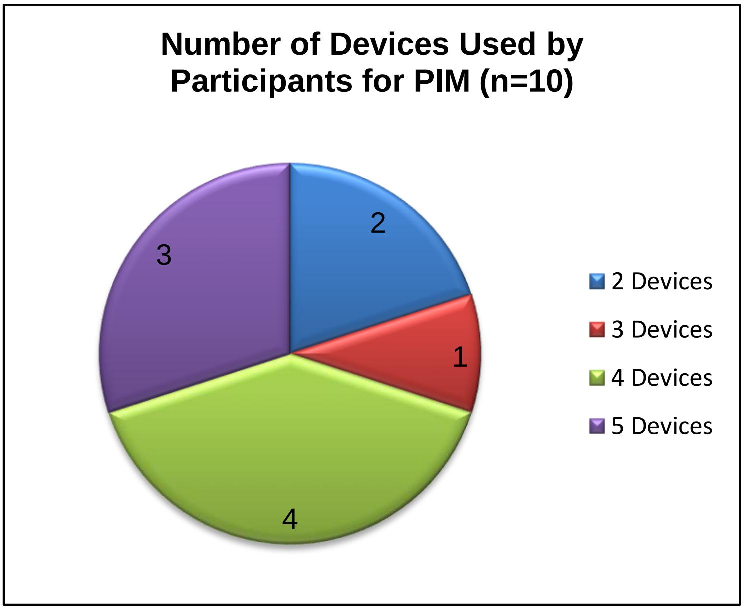


Figure 4-2 The Number of Devices Used by Participants of the Interview Study (n=10)

Table 4-1 shows the distribution of devices used for PIM. All participants of the interview study used a desktop computer provided by the university for PIM or work-related activities. Additionally, all participants commented on using their devices for a combination of personal- and work-related activities. Most participants (9) used their mobile phone for PIM and had a desktop computer at home that they used for PIM (8). Six participants used a laptop for PIM.

Most participants (9) had a combination of devices, which used of different platforms. For example, one of the participants, who used five devices for PIM, possessed a mobile phone using the Blackberry operating system, a tablet which used Android, a laptop which used both Windows and Ubuntu, a desktop computer at home, which used Ubuntu and a desktop computer at university, which used the Windows platform. The other participant used two devices and both used the Windows platform.

Table 4-1 Devices Used by Participants for PIM (n=10)

	Device	Number of Participants Using this Device
1.	Work / University Desktop Computer	10
2.	Mobile Phone	9
3.	Home Desktop Computer	8
4.	Laptop	6
5.	Tablet	2
6.	Netbook	1
7.	Playstation	1
8.	Secondary Home Desktop Computer	1

Five participants considered their desktop computer at the university as their main device used for PIM and work-related tasks. Four participants considered a combination of devices as their main devices for different purposes. One of the participants mentioned that his mobile phone is his main device for reminders and his laptop is the main device for viewing and working with his information:

> *"I'd really say, that, for being reminded about stuff, my blackberry. And then looking at stuff and thinking about stuff and writing stuff, my laptop."*

Four participants used their laptop when travelling and accessing their PI. Two participants travelled with their mobile phones and another two travelled with their netbook computers. One participant noted that, depending on the need when travelling, he would either travel with his mobile phone or his tablet device. Another participant did not have a mobile device with sufficient capabilities to take with him when travelling:

> *"I'm sort of stuck, because I don't really have a mobile device, but if I'm going somewhere where I know there's a computer then, I can just put whatever I need on Dropbox, or on a flash disk."*

The participants of the interview study used multiple devices to manage their PI. Thus, the number and combination of devices used and different platforms employed by each device may exacerbate the current PIM situation discussed in Section 2.3 and provides a motivation for the need to access PI across multiple devices. The next sub-section discusses how the participants of the study managed their PI across these different devices.

4.3.2. How Users Manage PI across Multiple Devices

Participants mainly used different combinations of methods to manage their PI across their different devices. Table 4-2 displays the methods mentioned by participants for managing their PI across different devices with the number of participants who mentioned the method.

Most participants (9) used email to ensure that they are able to access a PI item on another device. Six participants still currently use email to transfer information from one device to another, either for transferring large files, using the emailed version as a back-up, as a convenience for transferring a certain type of PI, or as a transfer method in addition to using another method, such as a flash drive.

Table 4-2 Methods Used by Participants of the Interview Study to Manage their PI (n=10)

	Method Used	Number of Participants Using this Method
1.	Email	9
2.	Flash Drives	9
3.	Windows Explorer Folder Structure	9
4.	Dropbox	6
5.	Servers	1
6.	Annotations	1
7.	Cloud Storage (Other than Dropbox)	1
8.	USB Connection of Device	1
9.	External Hard Drive	1

Most participants (9) also mentioned using flash drives, also referred to as universal serial bus (USB) drives, either continuously or at some stage for managing PI across different devices. Participants used flash drives when emailing became impractical to transfer information (2), for the file transfer process (2), as a back-up to the items stored on Dropbox, to store documents currently being used or worked on, as an alternate mechanism to using the phone's hard drive for transferring images and as the sole transfer tool due to not having Internet connectivity at home. One participant used an external hard drive instead of a flash drive.

All participants used the Windows Explorer folder structure provided on their desktop computers and laptop devices to manage their PI. The folder structure provides an order to the information stored on these devices. Six participants used Dropbox, either as their primary mechanism for accessing information across different devices or as a back-up tool. Dropbox makes use of a similar hierarchical structure, except that the overview of the structure is not provided as in Windows Explorer. Another difference between Windows Explorer and Dropbox is that Dropbox provides an indication of whether the folders and files have been synchronised or not. One participant mentioned that he used the same folder structure on each device to "not get lost", using a flash drive for transferring information between devices in addition to using email and using Dropbox merely as a back-up of this information:

> *"I mainly use my desktop and my laptop. So what I do, since the desktop is the main device because I have Internet access and everything, and then if I need something on my laptop at home, so I just copy, whatever I need and then I just put it on. And I have the same folder structure, basically. It's more or less the same. So when I take something in, my 'paper' folder, I just put it on my 'paper' folder at home. Basically, I have that, in order not to get lost, you know, because if you have a general folder structure, you will be confused at a certain point of time. So for the important stuff, like work and stuff like that, so if I have the same structure, I know, ok when I copy something here, I just put it there, and then I won't get lost."*

Other methods used to manage PI included the use of a server to back-up what is stored on Dropbox, adding annotations to PI items to compliment the hierarchical structure used for PI organisation, making use of other cloud storage methods, such as Microsoft SkyDrive (Microsoft Corporation, 2007), instead of Dropbox for PIM, or making use of a mobile phone's USB connection to transfer media to another device.

4.3.3. Problems Experienced

Participants noted various problems in managing their PI across different devices, ranging from problems with the folder structure of Windows Explorer and Dropbox, to general issues experienced with information fragmentation and problems with using flash drives for PIM (Table 4-3).

Table 4-3 Problems Identified by Participants of the Interview Study in Managing their PI (n=10)

	Problem	Number of Participants Noting this Problem
1.	Folder Structure Problems	9
2.	Dropbox Problems	8
3.	Prior Knowledge Required to Ensure Access to PI	7
4.	Separate Structures and Applications	5
5.	Version Control / History	4
6.	Connectivity	4
7.	Information Fragmentation	4
8.	Email Problems	3
9.	Synchronisation Issues	2
10.	Flash Drive Issues	2
11.	Not Being Sufficiently Organised	2
12.	Lack of Cross-Platform Programs	1
13.	Learning Curve Expected in using a New Operating System	1
14.	Cost of Connectivity Using a Mobile Phone	1
15.	Effort Required to Use Tagging	1

Six participants identified that the hierarchical folder structure and classification scheme is restrictive mainly due to a user being limited to categorise a file in a single folder even though it may be suited to other folders as well. Additionally, participants classify PI items in certain folders but are not able to find these items again when needed, thus resulting in organisation issues, as identified by one participant:

> *"Well look, I mean, I'm used to the folder structure so it's not an issue, but finding stuff sometimes can be a problem, or, 'I know I took a photo of this, but now where did I put it.' I actually had that problem the other day, because when I take the stuff off my phone, and then I don't always put it into the correct place and then, if I want to do something fast, it goes on the desktop and I don't save it in my media folder and then I was looking for it. I know it was on my computer, but I can't find it in my media folder, oh it's on my desktop. That is a pain."*

Four participants experienced problems with naming folders appropriately, especially when backing up information and storing and organising different versions of PI items. Other issues identified involve versioning issues (2), having to remember to update folders with the latest files (2) and problems with inconsistent structures between different devices (2). Participants also noted that organising information hierarchically is restrictive, that the inability to link email with the folder structure is an issue, that considerable effort is required to manage PI using the hierarchy, having different folder structures on different drives on a single device is an issue and synchronisation becomes a problem when using different hierarchies on different devices. One participant also mentioned not being able to view information in different ways:

> *"I organise my photos by dates and events and places, but that gets mixed up sometimes, but I do typically do that. But if I want to have it sort of, by date and by location it's difficult. If, for example, I've taken photographs of our holiday trips to Knysna, but I can't remember what year it was, then it's a pain to go and search each year, and check the photos, but that's a common issue. And then, of course, if you do it by location, then if you want to find everything that happened last year then you have the other problem, or with people. 'View all the photos that have my, my little girl in it, that's my bulldog.' Then you have to go and search all the folders…"*

Eight participants identified problems with Dropbox. Dropbox mainly suffers the same limitations as the Windows Explorer folder structure (4). Three participants identified that they needed to remember to upload the necessary information to Dropbox to be able to access this information from another device. Additional issues that were identified include synchronisation issues (2), the limitation of free space provided to each user after which the user needs to pay for added space (2) and connectivity issues (2), which could be experienced by any cloud storage mechanism. While Dropbox provides support for file sharing, users are required to share folders instead of sharing files directly with other users. Once a file is uploaded to Dropbox, it is no longer clear on which device the item was originally stored. When downloading an item from Dropbox, a copy is stored on the device, which is not linked to the item in Dropbox and Dropbox assumes that a single device, single user relationship exists and has problems recognising different users' accounts on one device.

Seven participants identified that a problem with using various methods to transfer files or provide access to files across different devices is that the user is required to know beforehand what information is needed to be accessed, to either upload the PI items to Dropbox, or copy onto a flash drive. One participant noted that he would like all his information to be available:

"…I will most certainly not know beforehand, and I would prefer, like, everything to be available."

Five participants found problems with the limitation of the email structure and other file structures not being able to communicate, and that email items and other items cannot be linked or associated, as one participant explained:

"It would be quite a cool thing if you had this integrated view of all your information, because here you've got the email system, which is one system, and then you've got your file structure on a particular device, which is another system, and yet there could be connections between individual emails and a topic. So, it would be like cool if you could have all your emails that have got to do with a thing, living together with the files which go with them…"

Four participants identified that it was difficult to keep record of the different versions of the same PI item. Connectivity was also identified as a problem in managing PI between different devices (4). One participant described a problem he had recently experienced involving connectivity issues:

"You know, for instance, the other day I needed a file. So now I had to sit at home and my Internet was giving me hassles. Now I can VPN from home into this PC, fairly easily, it's easy, if I have the Internet connection. So now, my Internet was giving me hassles, and there I'm sitting; now I can't get hold of that file. So, I had to drive in from Walmer to come and fetch a file here, to go back and work on it. So, that's the kind of problem: having no real time, online access to certain information."

Four participants mentioned the information fragmentation problem, some in terms of examples, including the following scenario explained by one of the participants of the interview study:

"Well ok, here is where things get a bit tricky, because, I've got photographs that are living on here, I've got photographs which are living on the office PC, and I've got photographs which are living on my laptop. In addition, my wife's netbook has got photographs on as well, and one can't actually easily aggregate them together. I mean you can try and bundle them together but they are so massive, you can't really forward them easily by emailing, so you've got to use a memory stick. Even working across my WiFi network at home, would be a bit slow."

Connectivity, limitations in file sizes for attachments and having to download multiple attachments were problems experienced with using email to transfer PI (3). Two participants mentioned problems with synchronisation. Unreliable flash drives was the main problem identified with this method used for PIM (2). Two participants admitted to not being well-organised, which hindered their ability to find and access their PI when required. Other problems experienced by the participants included a lack of cross-platform programs when using devices with different operating systems, the expected learning curve that is involved when upgrading operating systems and managing PI using the new system, the increasing cost of using multiple applications on a mobile phone for PIM, and the time and effort required by the user to effectively use tagging to annotate PI items to assist in finding these items when needed.

4.3.4. Ideas on Improving PIM across Multiple Devices

Nine participants were positive about the suggestion of a tool that provided a single user interface (UI) that would visualise a user's PI, which resides on different devices and in separate applications, to provide access to this information. One participant identified that while this tool may be desirable for most users, he would like to implement his own cloud storage mechanism tailored to his unique needs. Four participants noted that if there was such a tool, they would like it to provide some sort of automation in organising their PI. Seven participants preferred the tool to be a native application, similar to Dropbox, installed on each device as a browser may provide limitations for such a tool.

When asked about any ideas on how better to manage their PI across their different devices, participants provided various suggestions. Participants have a need for version control support (3) and for immediate access to their information (4). Two participants suggested a search tool, which is capable of searching across different devices' PI collections (PICs) and applications to find information. One participant suggested a tool which would intelligently "think" for the user:

> *"…Maybe also it would remember the things that I did the most, and kind of pre-fetch stuff for me, so, that would actually cut down a lot of traffic as well. Rather than saying, 'ok I'm going to give you this entire 4 gigabytes of stuff' but 'ok I'm rather going to give you pre-fetched stuff, that I'm kind of watching you and seeing what you're doing', and that would be a cool kind of thing. But, once again, to actually see what's there, which I can't do, I can't access the stuff, and I also can't see what's there. I can't picture it. In fact…I can't visualise it."*

Two participants identified the need to view PI using IV techniques to assist a user with PIM. Nine participants expressed the need for the suggested tool to provide support for file sharing and/or collaboration, but two of these participants noted that permissions and privacy would need to be considered.

Various additional suggestions were made including creating cross-platform programs to allow users to edit PI items on different devices, to display on which device the PI is stored, to provide some sort of offline accessibility when Internet connectivity is a problem, including facilities, such as a birthday calendar, that are provided on mobile phones but cannot be used because of cost implications, and the use of tagging to assist in PIM. Other suggestions involve providing intelligent searching, support for association between PI items that are linked, creating a virtual server in the Cloud for oneself according to one's needs, providing the functionality associated with the PI items in addition to being able to view the items, providing a view for a user and a view for the users s/he collaborates with, enabling support for "pre-fetched information" to assist a user with PIM, sharing PI items with a contact and not a folder as is the case with Dropbox, possibly providing an application on top of Dropbox to address its issues, linking the email structure with the file structure, and the need to consider each device's constraints when designing such a tool as the one suggested. One participant also suggested the use of a non-file file system, where PI items are considered objects moving away from the desktop metaphor.

4.4. Discussion

Participants of the interview study used a number of different devices to manage their PI and different combinations of devices were used by each participant. Participants also used different combinations of methods to manage their PI. Email, the Windows Explorer folder structure, flash drives and Dropbox were the main methods identified for managing PI. The results of the interview study support the identification of the information fragmentation problem as a key problem in PIM (Chapter 2). Four participants directly mentioned the information fragmentation problem or described a scenario relating to this problem.

The results provided further evidence of the problems experienced with the hierarchical organisation method and indented-list visualisation technique currently used for PIM (Chapters 2 and 3). Almost all participants used Windows Explorer, and most of the participants experienced numerous problems with this folder structure, mainly due to its restrictive nature. Six participants confirmed that the hierarchy is inflexible and has a restrictive classification scheme, as identified in Chapter 2. In addition to the problems described in Chapter 2 and 3, several other problems were identified by the participants. These problems include issues with naming PI items especially when dealing with different item versions (4), inconsistent structures between devices (2) and hard drives resulting in synchronisation issues, the effort required to classify a PI item and only having one view of the PIC, i.e. the list visualisation. Two participants confirmed that the list visualisation technique may not be suitable for visualising PIM and that they need more useful visualisation techniques to view their PI to support information retrieval as identified by Dumais *et al.* (2003) in Chapter 3.

Several participants used Dropbox as a tool for accessing PI across multiple devices, but also noted that this tool suffers from the same limitations as the hierarchical folder structure (4). Participants confirmed that they needed to remember to upload or synchronise information they required to access (3) and that, once a file was uploaded, it was not clear on which device the original version was stored. Participants identified additional issues with Dropbox including experiencing synchronisation issues (2), the limitation of free space (2), connectivity issues (2), problems with file sharing and that Dropbox assumes a single device, single user relationship.

Although flash drives are widely used, these devices are considered an unreliable tool to use for PIM (3). Problems were also experienced with using email for file transfer (3). Participants also identified that it is difficult to know beforehand which PI items need to be accessed (7), confirming the issue of the "push" nature of the Dropbox and TeamViewer tools. Participants also confirmed that the lack of support for linking different PICs in separate applications, i.e. documents versus email, and limited support for associating linked PI items, are problems that need to be addressed (5). A general lack of support for version control (4), connectivity issues (4) and admitting that they are not well-organised (2) were other problems identified by the participants.

4.5. Requirements for a PI Visualisation Tool

Based on the results of the interview study and related research, several requirements were identified for the visualisation tool suggested in Section 4.4. These requirements were categorised according to implications for organisation, visualisation and interaction.

4.5.1. Organisation

4.5.1.1. Provide a Virtual Storage Solution which Aggregates PI in a Single Location

PI is restricted to the device on which the information is stored because of the increasing information fragmentation problem (Section 2.2.3). There is currently limited support for storing a user's entire PSI in a single location to perform tasks across the PSI (Sections 2.3, 2.5.3 and

2.5.7). The virtual storage solution could allow the PI to reside on the original device but aggregate references to the PI items, which could be accessed when the different user devices are connected. This could address the issues identified by participants that they are unsure beforehand which PI items are needed to be accessed and that inconsistent structures exist between devices.

4.5.1.2. Provide Support for Association of Linked PI items

Allowing users to link PI items could assist with version control of PI, which is not currently supported by the hierarchical organisation method (Section 2.4.4). The current hierarchical organisation method is restrictive as it does not support association between PI items, which could be useful for information retrieval. Support for PI item association could also address the issue of not being able to link items in PICs in separate applications (Section 2.5.4). Assisted organisation in terms of semi-automatic PI organisation could support users who are not well-organised and decrease the effort required to classify PI items.

4.5.1.3. Provide Tagging to Assist in Information Retrieval

Tagging of PI items could also assist with information retrieval and version control (Sections 2.5.4 and 3.8.3). Manually and/or automatically tagging PI items could assist with re-finding information when searching. Tags could also address the restrictive and inflexible hierarchical organisation method to assist with classifying PI items (Section 2.4.4).

4.5.1.4. Include Additional Facilities Other than General PI types

In addition to the common PI types, such as documents and media, email and contacts were regularly mentioned in the interview study. The proposed tool should consider these additional PI types to support PI organisation (Section 2.3). Providing support for additional PI types could assist with the ability to link PICs in separate applications, such as email and documents.

4.5.2. Visualisation

4.5.2.1. Use a Single UI to Visualise PI across Different Devices

Participants described scenarios where they experienced information fragmentation problems and welcomed the suggestion of a tool that provides a single UI to visualise a personal space of information (PSI) across several devices. The current hierarchical organisation method does not provide an overview and does not provide support for consistent structures between the different devices (Sections 2.4.4 and 3.4). Additionally, current PIM solutions focus on a single device

(Section 3.6). A tool visualising PI across several devices could address these issues. Participants preferred that the tool be implemented as a native application installed on each device.

4.5.2.2. Visualise the PI using Suitable IV techniques

Both the literature study and the interview study identified that the list visualisation currently used to visualise PI may not be suitable for this type of information (Sections 3.4). Making use of suitable IV techniques could address the restrictive nature of the hierarchy and the ineffective use of screen space provided by the indented-list visualisation technique (Section 3.7.3).

4.5.2.3. Provide Different Views of the PSI

Participants noted that only having one view of their PI is not sufficient. The proposed tool could provide different views of the PSI, for example viewing the PSI according to a timeline, using tag clouds, by device, by folder or by contacts (Sections 3.7.1 and 3.7.2). These different views support browsing to find information (Section 3.7.1). Sorting is also a capability commonly used to support browsing (Jones *et al.*, 2014), and this could also provide alternative views of a user's PSI.

4.5.2.4. Consider Each Device's Physical Constraints

Most participants managed their PI across at least three devices, but each device uses its own method for organising and visualising this information. The proposed IV tool needs to be designed to consider the user's different devices, i.e. a mobile device has different constraints when compared with a desktop computer (Section 2.5.7). Additionally, the tool needs to use a device's information to distinguish between these different devices and allow for more than one user per application by using a secure access mechanism, for example, a log in process.

4.5.3. Interaction

4.5.3.1. Provide Intelligent Searching Across Devices

In addition to the IV techniques used to support browsing the PSI, intelligent searching of the PSI also needs to be facilitated to support information retrieval (Section 3.7.1). A combination of keyword and in-text searching and filters could be used to allow searching PI across different devices.

4.5.3.2. Provide Support for File Sharing and Collaboration

The current hierarchical organisation method, with the exception of tools such as Dropbox, does not support file sharing or collaboration (Sections 2.3 and 2.5.5). Although the focus of the proposed IV tool is on PIM, the tool needs to support file sharing with other users, while considering the issues associated with this sharing, such as privacy. The support for file sharing should address the problems that the participants experienced when sharing files.

4.5.3.3. Provide Functionality Associated with PI items

Due to the information fragmentation problem, if an item cannot be viewed, it cannot be accessed. Although the proposed tool will allow a user to view his/her entire PSI, the functionality of each PI item should be supported, such as allowing the user to open and edit a document (Section 3.2). Additionally, the tool should provide support for common information retrieval tasks, including browsing and searching to find information, and viewing metadata (Sections 3.7.1 and 3.7.4).

4.5.3.4. Support Immediate Access to PI items

As a user's PI is fragmented across different devices, it becomes difficult to find and access required PI items immediately (Sections 3.2 and 3.7.5). The proposed tool should provide instant access to PI items on a certain device if that device is available, and could possibly include offline accessibility of certain PI items if certain devices are not always available, for example providing a recently-accessed list of PI items, regardless on which device these items are stored.

4.6. Conclusion

Dropbox and TeamViewer are two tools currently available to support accessing PI across multiple devices. Each tool possesses its own advantages and shortcomings. Dropbox is mainly limited to the same shortcomings of the current hierarchical organisation method and TeamViewer also suffers from these limitations in addition to only being able to transfer information between two devices at a time.

An interview study was conducted to determine how users currently manage their PI across different devices and the problems that they experience with PIM. The interview was conducted with 10 participants and each interview was captured using a voice recorder. Steps were taken in the data analysis procedure to prepare the interview data for analysis and also for performing the analysis according to the procedure identified by Creswell (2009).

Participants of the interview study used several devices to manage their PI. Additionally, these participants used various combinations of methods to manage their PI across these different devices. The most popular methods included the use of email, the Windows Explorer folder structure, flash drives and Dropbox. The participants of the interview study identified a number of problems in managing their PI, mainly due to not being able to view and access their PI across their different devices. The suggestion of an IV tool to support access to PI across multiple devices received a positive response. The results of the interview study were used to propose several requirements for organisation, visualisation and interaction to guide the development of the proposed IV tool.

Chapters 2, 3 and 4 provided requirements for the design of a visualisation tool to provide access to PI across multiple devices. The next chapter will outline the design of this visualisation tool using these chapters as a guide for the design of this tool.

Chapter 5: Design and Implementation for a Desktop Device

5.1. Introduction

The interview study, discussed in Chapter 4, was conducted to determine how users currently manage their personal information (PI) across multiple devices. The results of the interview study, together with the literature review, assisted in identifying requirements for a tool to visualise PI across multiple devices. These requirements will need to be transformed into functionality to be supported by a personal information management (PIM) tool incorporating appropriate information visualisation (IV) techniques to visualise this PI within a single user interface (UI) (Beets and Wesson, 2013b; Beets and Wesson, 2014). Thus, this chapter addresses the fourth research question (RQ 4), namely "*How effective are these IV techniques in supporting access to PI across multiple devices on a desktop device?"* This research question was addressed in the first iteration of the *Design and Develop Artefact, Demonstrate Artefact* and *Evaluate Artefact* design science research activities.

The next section describes the design of the PI visualisation tool for a desktop device in detail, including a description of the data design, the design rationale, functionality derived from the requirements of the interview study, the enhanced IV techniques incorporated in the tool, an overview of the prototype and requirements verification in terms of a cognitive walkthrough. The implementation of the tool is then discussed comprising the implementation environment, the data, the selected implementation tools and the incorporated IV techniques. A discussion section, describing the support of the proposed visualisation tool for the design and implementation requirements, concludes the chapter.

5.2. Design

The prototype was designed from the requirements obtained from the literature review and the interview study. The design of the prototype is focussed on desktop design and will be web-based as discussed in the Design Rationale sub-section. Functionality was derived from the requirements and appropriate visualisation techniques were selected and enhanced to support this functionality.

5.2.1. Data Design

In order to evaluate the initial versions of the prototype, a personal space of information (PSI) needed to be visualised by the prototype. A sample of a real PSI was used to provide a data space for the designed prototype. The PSI used is an actual representation of a user's information, but is considered a sample as it is not a user's own data source and so participants of subsequent evaluations may not be able to rely on association with the data to assist with relevant PI retrieval.

JSON (JavaScript Object Notation) is an alternative method to XML (Extensible Mark-up Language) to store and exchange large amounts of data using a structured notation (W3Schools, 2014). JSON does not rely on any specific programming language and the notation it uses is considered to be easily understandable. Several visualisation toolkits and libraries, such as D3 (Bostock, Ogievetsky and Heer, 2011) and the JavaScript InfoVis Toolkit (Belmonte, 2009), also support the use of JSON as an input to the IV techniques provided. The sample PSI that was used for the prototype is illustrated in Figure 5-1, depicting the devices and the folders or libraries included for each device. Email was not included in the libraries.

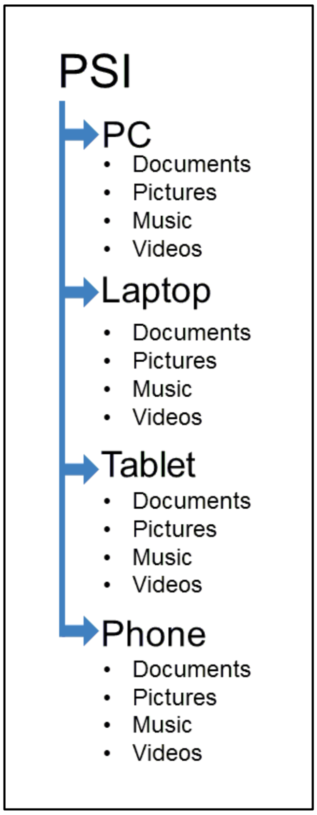


Figure 5-1 Sample PSI used for the Prototype

It was identified from the interview study discussed in the previous chapter that most participants owned at least three devices (Section 4.3.1). Thus, four devices were included in the data design and supported by the prototype, namely a *PC* (Personal Computer), *Laptop*, *Tablet* and *Phone*. Each device contained the same four libraries, namely Documents, Pictures, Music and Videos, which were captured from the respective locations on each device. Therefore, a total of 16 different PI collections (PICs) will need to be visualised by the prototype.

The Windows API (Application Programming Interface) Code Pack for the .NET framework (Microsoft Developers Network, 2009), in combination with .NET, was used to retrieve the PI stored on the different devices. The PICs stored on the phone and tablet devices were copied off the devices and stored on the desktop computer to then be read into the JSON files. A call was made to each *Libraries* folder to read in the different PICs. A folder or file was contained within a *File* object with a folder containing a *Descendants* array, representing the sub-folders and files contained within that folder. Recursion was used to maintain the hierarchical structure of the PICs. Sub-folders and files were then recursively stored in their own *File* objects, but added to the *Descendants* object of their immediate parent. Files do not possess a *Descendants* array, and properties and extended properties of each file were captured using the Windows Shell32 object in the Code Pack. The following file properties were stored for each *File* object:

- Name;
- Path;
- Type, i.e. folder or file;
- File type, i.e. a document, image, music or video file;
- Size of the file in bytes;
- Thumbnail (as a base64 string to be stored in a JSON file);
- Date Created;
- Date Accessed;
- List of tags;
- Descendants (if the object is a folder).

JSON.NET (Newton-King, 2006) was then used to serialise these *Library* objects into separate JSON objects to be stored in the respective text files representing each PIC.

5.2.2. Design Rationale

The interview study in Chapter 4 identified that a desktop computer was the main device used to manage personal- and work-related information (Section 4.3.1). Thus, a decision was made to focus the design and implementation process on desktop or laptop devices. This will allow the prototype and the IV techniques to be designed and evaluated to determine whether the prototype, as well as the selected IV techniques, support PIM across multiple devices on larger screens before shifting the focus towards devices with smaller screen sizes. The design and implementation cycle followed a two-step development process outlined in Table 5-1.

Table 5-1 Two-Step Development Process

	Device	**Interaction**	**Data**
Step 1	Desktop	Mouse-based	Sample PSI
Step 2	Tablet	Touch-based	Cloud Storage System

The main requirement of the prototype was to support accessing PI across multiple devices (Sections 2.3 and 2.5.7), thus the device on which the PI is visualised, or the device on which the prototype is used, needs to have a connection to the Internet. Therefore, the prototype was designed as a web application, whereby connecting to the application will be via an URL (Uniform Resource Locator).

It was determined in Chapters 2 and 3 that the hierarchy, as well as the indented list used to visualise it, suffer from various limitations (Sections 2.4.4 and 3.4). Thus, a hierarchy may not be the most appropriate means to organise, visualise and access PI. This result was also enforced by the results of the interview study in Chapter 4 (Section 4.3.3) as participants also identified that the file manager suffers from various limitations such as ineffective use of screen space. Chapter 2 dealt with the strengths and weaknesses of the existing PI organisation systems found in literature. The prototype will focus on most of the features identified in Section 2.4.6, such as browsing, annotation, association, and support for, but not limited to a temporal organisation (Sections 2.5 and 3.7). Weaknesses of existing systems (Section 2.4.6) that will be addressed include systems being search-reliant and the focus on the IV technique rather than the PIM and PI visualisation for information retrieval. Other shortcomings that will be addressed include focussing on limited PIM concepts, not providing a useful visualisation and being limited to a single device.

While it was identified that the hierarchical organisation method is restrictive, the prototype will use the existing hierarchy of PI available on a user's device. The prototype will support a temporal view, identified as an important feature of existing IV systems (Section 3.7.2). Similar shortcomings were identified in Section 3.6 relating to PI visualisation systems, which will be addressed by the design of the prototype.

An additional key requirement of the prototype is to support viewing all PI of a user stored and managed over multiple devices, within a single UI (Section 4.5.2.1). The PI distributed across multiple devices should preferably be displayed within a single UI using an appropriate IV technique to view each device's hierarchy. Visualising PI across multiple devices thus requires multiple hierarchy visualisations supporting functionality, as discussed in the following sub-section.

5.2.3. Functionality

Similar functionality provided by current file managers, such as Windows Explorer, need to be supported by the prototype. Core functionality to be supported by the prototype was derived from the requirements outlined in Chapter 4 (Section 4.5). These functions were categorised according to the main tasks to be supported, namely manipulation, sorting, intelligent browsing, intelligent searching, filtering, tagging and linking. Linking is not currently supported by file managers and is an additional function that needs to be supported (Latif and Min Tjoa, 2006; Stenmark *et al.*, 2010). The prototype will also need to support the visual information seeking mantra identified by Shneiderman (1996): Overview first, Zoom and Filter, then Details-on-Demand.

The functionality to be supported is described in the following sub-sections.

5.2.3.1. Manipulation

The general manipulation functions support the requirement to provide full access to the PI items (Section 4.5.3.4) and include the following:

- Add/delete a new PI item or folder;
- Name/rename a PI item or folder;
- Select (view/preview PI item);
- Open a PI item;
- Move/copy PI item(s) or folder(s).

5.2.3.2. Sorting

Allowing a user to sort the PSI supports the requirement to provide different PI views (Section 4.5.2.3) and also supports browsing (Section 4.5.2). This functionality should include the following:

- Sorting the PI on a specific device;
- Sorting a specific type of PI on a specific device.

A user should be provided with a default primary and secondary sort order and should also be able to sort by date, author, title, tag, folder, type and the size of the PI items.

5.2.3.3. Intelligent Browsing

Intelligent browsing should support browsing across multiple devices, i.e. as a user browses for a certain item, similar folder(s) should be expanded and related or similar PI item(s) should be visible on other devices (Section 4.5.2).

5.2.3.4. Intelligent Searching

Similar to intelligent browsing, intelligent searching should support searching across multiple devices (Section 4.5.3.1). A user should also be able to select in which fields to search, including within the content, title, author, tags and folder names or be able to search within all of these fields.

5.2.3.5. Filtering

Filtering could support the search facility or be used independently of the search facility. A user should be able to filter the PSI by device, PI type, timeframe, author, tag and/or by a size range.

5.2.3.6. Tagging

Tagging should be supported in MyPSI (Section 4.5.1.3) by allowing the user to tag PI items in the following ways:

- Tag PI item(s) with a new tag;
- Tag PI item(s) with an existing tag.

A *Tag Cloud* should be provided to display the existing tags within the overall PSI. A user should be able to select a tag in the *Tag Cloud* and the collections within the PSI should filter and display PI item(s) annotated with this tag.

5.2.3.7. Linking

Linking is a newly added function compared to existing file managers (Shneiderman, 1996; Evequoz and Lalanne, 2007). A user should be able to link related PI items in different collections or within the same collection by selecting the items and linking these items.

5.2.4. Visualisation Techniques

Suitable IV techniques were proposed in Section 3.7.3 to support access to PI across multiple devices. These IV techniques include an *Overview*, a *Tag Cloud* and a *Partition Layout*.

5.2.4.1. The Overview

The *Overview* supports the requirements of the visual information seeking mantra (Shneiderman, 1996), as well as the visualisation requirements (Section 4.5.2), and is displayed in Figure 5-2. The outer circle represents the entire PSI, where the different types of PI, including documents, pictures, music, email and video, represent the next level of circles. Within these second-level circles are circles which represent the different devices on which the PI is stored. The size of each circle represents the size of the PIC with respect to other devices and PI types. The *Overview* supports the requirement to provide different views (Section 4.5.2.3) as it provides an overall view of the PSI across multiple devices.

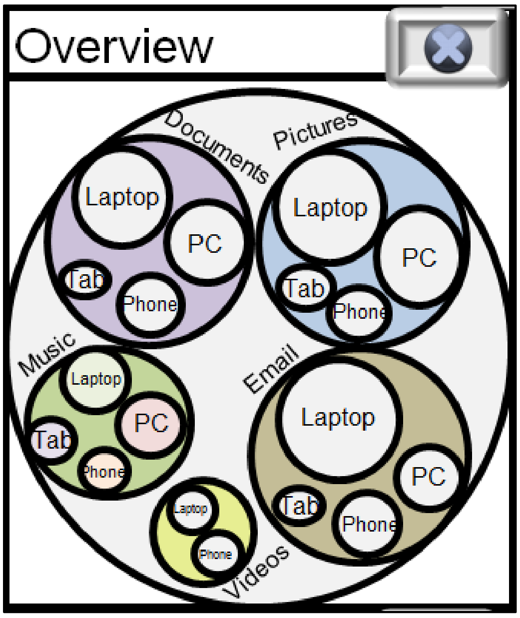


Figure 5-2 The Overview

5.2.4.2. The Tag Cloud

The *Tag Cloud* supports the tagging requirement identified in Section 4.5.1.3. The *Tag Cloud* in MyPSI, as illustrated in Figure 5-3, will represent existing tags assigned to PI items within the user's PSI.

Figure 5-3 The Tag Cloud

5.2.4.3. The Partition Layout

An enhanced version of the set-based IV technique, the *Partition Layout*, was implemented in the prototype as the technique facilitates a structured method to visualise multiple hierarchies. The set-based technique was enhanced and implemented in the prototype to support information retrieval. The *Partition Layout* supports the browsing requirement to visualise PI across different devices in a single UI while using suitable IV techniques (Section 4.5.2). Each device has its own hierarchy displayed using the set-based layout (Figure 5-4). The *Partition Layout* is displayed similar to a space-filling IV technique, such as a treemap (Heer *et al.*, 2010). Folders used for visualisation include the user's *Libraries* folder where the *Documents*, *Music*, *Pictures* and *Videos* sub-folders can be found, as illustrated in Figure 5-4. The entire folder structure for a device is represented by the *Partition Layout*, where different PI hierarchies within the same device are displayed horizontally next to each other, sub-folders within a PI type are displayed vertically under parent folders and PI items are displayed below their immediate parent folders. Device folder structures are displayed below one another in separate hierarchies. The way in which the PI is displayed on the screen allows for maximum visibility while supporting scalability by providing browsing support in terms of hidden folders.

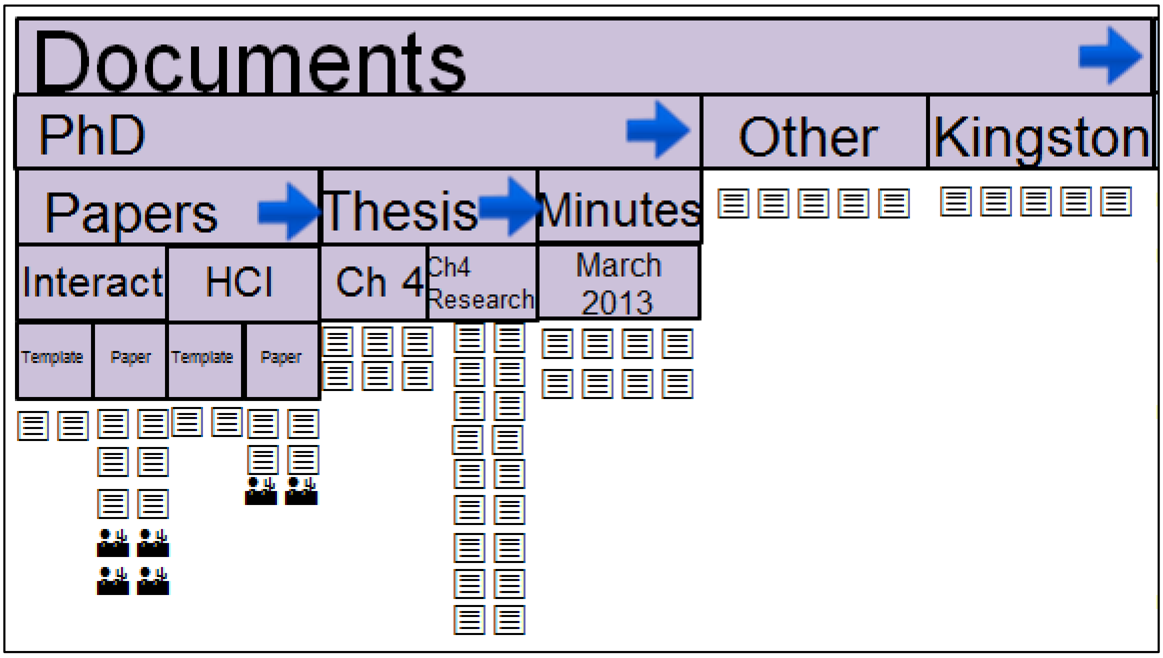


Figure 5-4 A Folder Structure in the Partition Layout

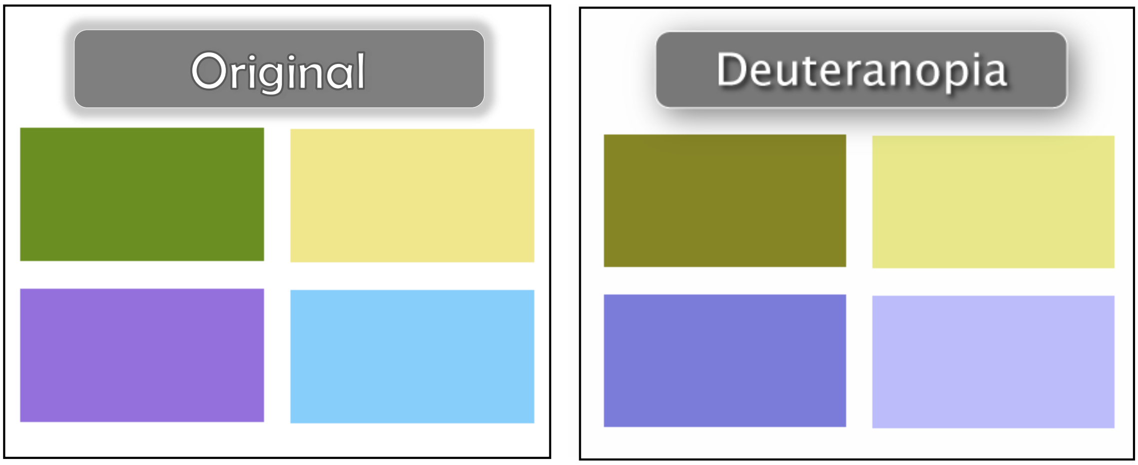
5.2.5. Prototype

The initial MyPSI prototype is illustrated in Figure 5-7. Depending on the available screen space, the user is presented with three windows to the left representing the *Overview*, the *Dashboard* and the *Tag Cloud* (Figures 5-7 A-C), and a toolbar at the top of the screen providing general navigation support, the search, filter and sort facilities (Figure 5-7D). The *Partition Layout* providing a view of all of the user's PI over the different devices occupies most of the screen space (Figure 5-7E). The prototype provides interactive IV techniques, which are co-ordinated, i.e. when a selection is made within one IV technique it is reflected within the other techniques.

The *Dashboard* (Figure 5-7B) provides a summary of the newly added PI items since the last use of the system, supporting the filtering requirement of providing different PI views (Section 4.5.2.3). A user will be able to select any of these items to view their respective folder locations, which will be highlighted in the relevant folders. A user can also select to view the most recently accessed items, which will be also be highlighted.

Figure 5-7E represents the *Partition Layout* used to visualise the folder structures on the respective devices. A folder structure will be displayed for each user device. Each device is represented by the device name and each device's folder structure is represented by a window, which can be collapsed or maximised. To enable access to PI on a certain device, the device needs to be connected to the Internet. An icon represented by a tick or cross will indicate whether a device is connected to the Internet or not. If a device is not connected to the Internet, a user will be able to view the PI items on the device, but will not be able to access the items other than those in the recently accessed list, which will be cached.

The PI types will be colour-coded to distinguish between the different types. The colours that will be assigned to the respective PI types are: purple for documents, blue for images, olive green for music and yellow for videos. The colour scheme also supports the blue-yellow contrast used by Vizster, an IV tool used for social network analysis (Heer and Boyd, 2005). This colour-coding addresses the most common colour vision deficiency, referred to as red-green colour blindness or Deuteranopia displayed in Figure 5-5 (Bernhard and Kelso, 2007).



(a) **(b)**

Figure 5-5 (a) Original Colour Coding for MyPSI with (b) Deuteranopia Colour Blindness

Semantic zooming will be supported similar to that provided by the Zoomable Object-oriented Information Landscape (ZOIL) (Jetter *et al.*, 2008) as displayed in Figure 5-6. As a user zooms into a specific folder or PI item (Figure 5-6a), the item will enlarge, revealing a label of the type of PI item (Figure 5-6b), the title and the first page of the item if the item is a document, i.e. a preview of the item (Figure 5-6c and d). The MyPSI tool will therefore support all of the common manipulation tasks identified in Section 4.5.3.3.

The intelligent searching requirement (Section 4.5.3.1) will be supported by performing a search and/or filter (Figure 5-7D), making an *Overview* filter selection (Figure 5-7A) or a selection in the *Tag Cloud* (Figure 5-7C), thereafter only displaying relevant PI. The remaining PI items will be de-saturated, as used in Shneiderman's SocialAction tool (Perer and Shneiderman, 2006). MyPSI will utilise the highlighting visual cue to show similar PI items.

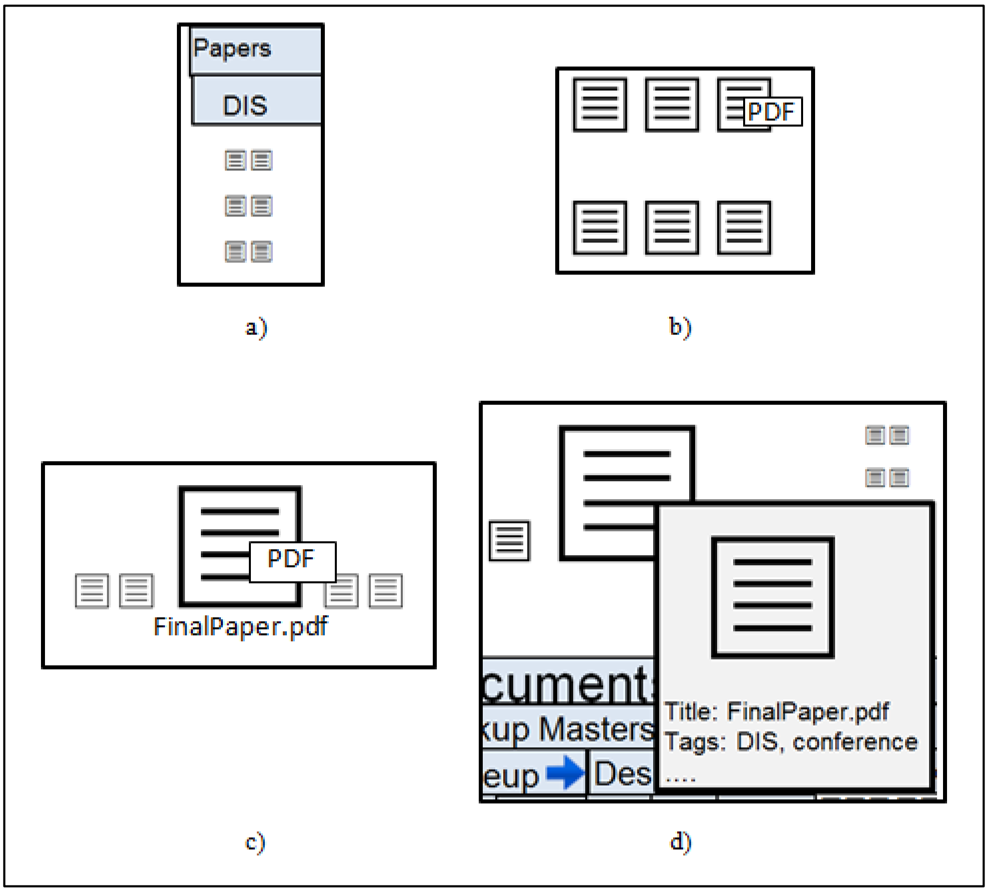


Figure 5-6 Levels of Semantic Zooming to be Supported by MyPSI

The toolbar provided at the top of the screen to the left of the search bar (Figure 5-7D), will provide general functionality. The Home button will clear any sort, search, filter, selection, and/or highlights displayed on the screen, and return the folder structures to the original display. A user will be able to Undo or Redo actions, refresh the PSI to include newly added items, and zoom in and out. The last button on the toolbar will be used for linking, supporting the requirement to facilitate association of linked PI items (Section 4.5.1.2), and will be enabled once multiple items are selected.

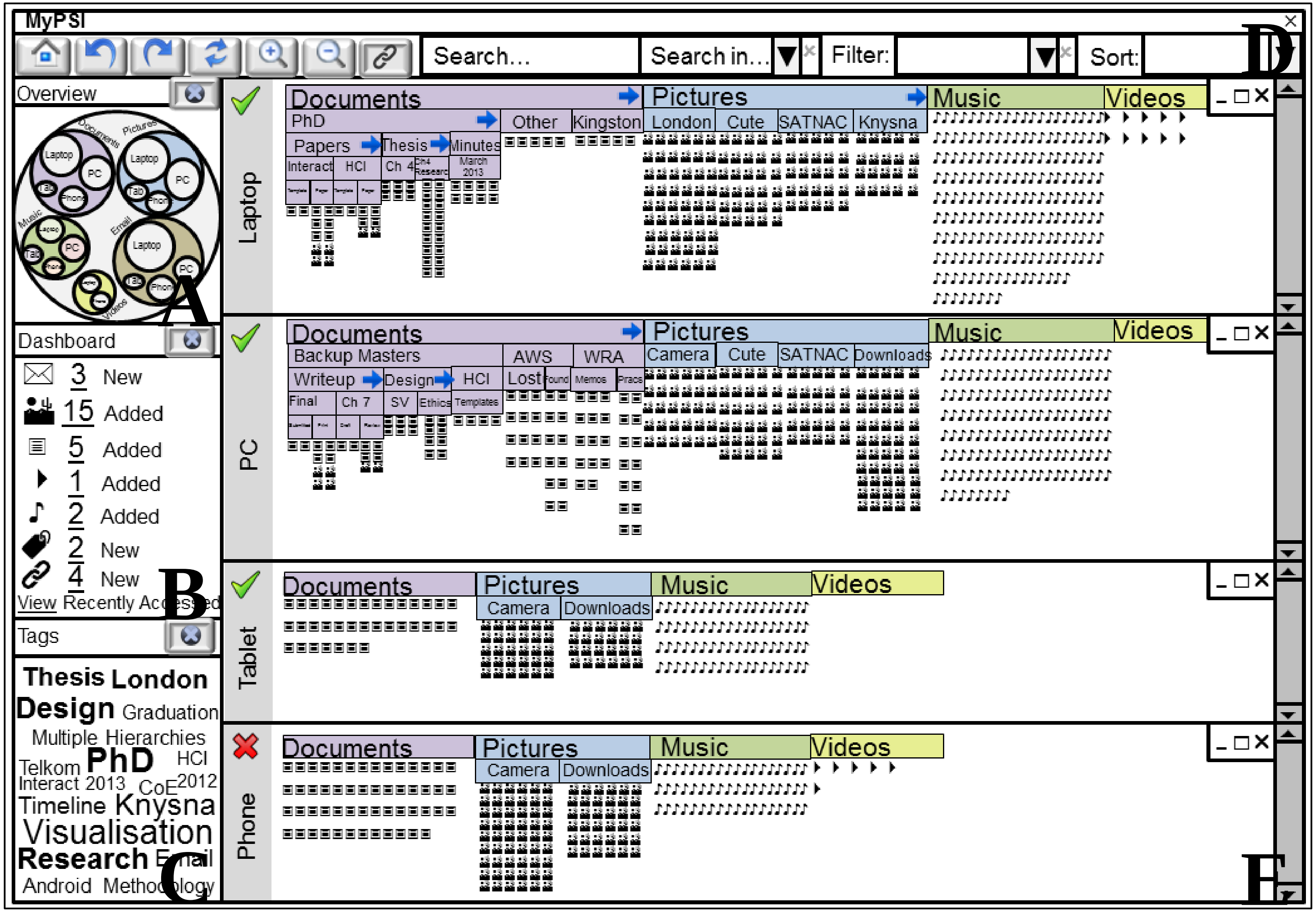


Figure 5-7 The UI Design of MyPSI

5.2.6. Requirements Verification

A cognitive walkthrough, which was used as a means of requirements verification, was conducted with six participants who took part in the interview study (Chapter 4) (Kerne, 2002). The participants of the walkthrough were provided with the requirements as discussed in Chapter 4 and the design of the MyPSI prototype with the proposed interaction.

Results of the cognitive walkthrough were generally positive, verifying all requirements except those relating to the need for support for collaboration and file sharing and visualising email. Participants identified that they use other tools for file sharing and email. Therefore, these two requirements were removed and the focus was shifted towards PIM for a single user. The design of the MyPSI prototype, the suitability of the visualisation techniques, and the proposed interaction, were also confirmed.

Participants found the IV techniques in MyPSI to be interesting and potentially useful for information retrieval. A participant particularly mentioned that s/he liked the *Partition Layout* as s/he had not seen anything similar to it before. One participant suggested using a Treemap instead of the circle packing layout for the *Overview*, which was subsequently implemented. Using a comparison, the circle packing layout was selected as it provided a better overall view than the Treemap. The only concern that a number of the participants noted was the lack of focus on mobile design, but this was clarified as the mobile design will be addressed at a later stage in the second step of the Design and Implementation cycle and will be discussed in Chapter 7.

5.3. Implementation

D_3 (Data Driven Documents) (Bostock *et al.*, 2011) was selected as the most appropriate visualisation library to implement the MyPSI prototype. The sample PSI discussed in Section 5.2.1 was read into the D_3 layouts used for the respective IV techniques. The IV techniques identified in Section 5.2.4 were implemented in MyPSI similar to the proposed design. The IV techniques needed to be modified and enhanced to support all the required functionality outlined in Section 5.2.3.

5.3.1. Implementation Tools

An analysis was conducted to determine the most appropriate visualisation toolkit or library to implement the MyPSI prototype including Raphael (Baranovskiy, 2008) and the JavaScript InfoVis Toolkit (Belmonte, 2009). Processing.js (Fry and Reas, 2008), while a powerful library, focusses on supporting images for visual art, animation and gaming to assist in learning programming languages rather than focussing on IV and is limited to desktop applications. Raphael (Baranovskiy, 2008) provides support for vector art drawing and only supports limited chart visualisations. The JavaScript InfoVis Toolkit (Belmonte, 2009) is primarily used to create interactive visualisations for the Internet. This toolkit provides support for charts, icicle layouts, treemaps and other IV techniques, but the customisation capabilities are somewhat limited. Protovis (Bostock, Heer and Ogievetsky, 2009) is another toolkit for providing visualisations for viewing in a web browser and provides various types of visualisations, but it is no longer under active development as the D_3 visualisation library has evolved from this toolkit. TufteGraph (Shay, 2009) makes use of jQuery and CSS (Cascading Style Sheet) to create graph visualisations, but from the documentation it seems that it only supports charts. jqPlot (Leonello, 2009), a library that works alongside jQuery, and Google Charts (Google Inc., 2009), an API assisting in visualising timelines and treemaps and is highly flexible, provide support for visualising charts, but they both have a limited range of available charts. ManyEyes (IBM, 2007) provides interactive visualisation of data that is uploaded or publicly available. Vis.js (Almende, 2010) is capable of visualising large amounts of data in the browser, but is limited to providing IV techniques such as a network and a timeline. Several other visualisation libraries and toolkits exist, but they are mainly limited to supporting only a few IV techniques or are limited in customisation capability.

The D_3 visualisation library provides an extensive and powerful means to visualise large datasets on the Internet using HTML (Hypertext Markup Language) (W3C, 2014a), CSS (W3C, 2014b) and SVG (Scalable Vector Graphics) (W3C, 2014c) with a data-driven approach. Thus, D_3 was selected as the preferred visualisation library to support the implementation of the MyPSI prototype. D_3 provides the widest range of available IV techniques and examples of applied IV techniques. Additionally, D_3 provides the most powerful customisation facilities of these IV techniques. IV techniques visualised using the D_3 library are also scalable as these IV techniques are capable of providing responsive views of large datasets.

As identified in Section 5.2.2, the MyPSI prototype requires that each device needs to have an Internet connection to enable access to the PI stored on the different devices. The MyPSI prototype was developed as a web-based application using a combination of the D_3 JavaScript visualisation library (Bostock *et al.*, 2011), HTML, to structure the UI of the web application, CSS, to format the UI, and Bootstrap (Otto and Thornton, 2010), a framework that works with HTML and CSS to provide a responsive front-end layout for a web application. Additionally, jQuery (The jQuery Foundation, 2006) and jQueryUI (The jQuery Foundation, 2007) were used to provide added support to the UI and JavaScript, the Font Awesome JavaScript library (Gandy, 2013) was used to provide the icons, the Select2 plugin library for jQuery (Vaynberg, 2012) was used to support the multi-selection, modification and removal of tags in the *Tag Cloud*, and d3-tip (Palmer, 2012), which provides tooltips to be used by D_3 visualisations, was used to provide suitable tooltips.

5.3.2. Data

JSON files are well-supported by the D_3 visualisation library. The *Partition Layout* is visualised using an *icicle* layout within D_3. The *Partition Layout* deals directly with the PICs and thus each *icicle* layout requires the file location string of where the related JSON file can be found. The JSON files for each PIC of each device are read into separate arrays which are read by the *icicle* layouts. The *root* of each *Partition Layout* is represented by the respective *Library* folders. A *value*, in this case the *size* attribute, is assigned to each PI item within the array to assist in the pre-calculation of positioning and sizing of each folder, sub-folder and file. The *size* of a folder is determined as an aggregate of its immediate *children's* sizes, a sub-folder's *size* as its *children's* sizes and so on. Thus, the layout is built using a bottom-up process. Additionally, the *children* also need to be assigned appropriately, where the *descendants* array for each folder (and sub-folder) is assigned to that specific folder as its *children*.

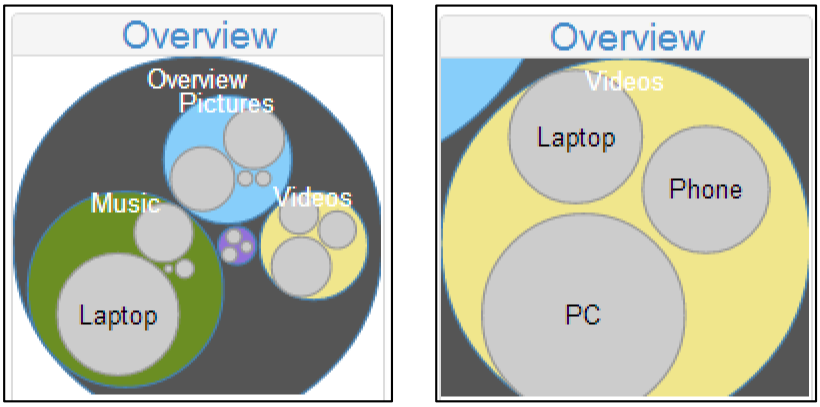
The *Tag Cloud* represents an array of tags, which are aggregated from each PI item's tag array. The tag name, the PI items associated with the tag and a count of the number of PI items associated with this tag are stored for each tag in the tag array. The *Overview* is represented by an array, which aggregates the sizes of each PIC, including each *Library* folder on each device. The names of the device or folder, as well as the summation of the sizes for each PIC, are stored to visualise the *Overview*.

5.3.3. Visualisation Techniques

The MyPSI prototype was implemented following the design described in Section 5.2.4. The following sub-sections describe the implementation of the *Overview*, the *Partition Layout* and the *Tag Cloud*.

5.3.3.1. The Overview

The *Overview* shown in Figure 5-8 is interactive and co-ordinated with the *Partition Layout*, so that, if a device is selected within the *Overview*, the *Partition Layout* will filter and collapse the other devices, only displaying the selected device's information. Additionally, if the *Overview* is reset, any devices collapsed within the *Partition Layout* will be expanded again. A user can also determine the total size of a PI type or PI on a specific device by viewing the tooltip on hover.



(a) **(b)**

Figure 5-8 (a) The Overview implemented in MyPSI and (b) Zooming on Selection showing the Labels

5.3.3.2. The Partition Layout

The initial *icicle* layout enhanced for MyPSI is illustrated in Figure 5-9. Parent and leaf nodes are handled in a similar way by allocating the space below each parent according to the size of its children.

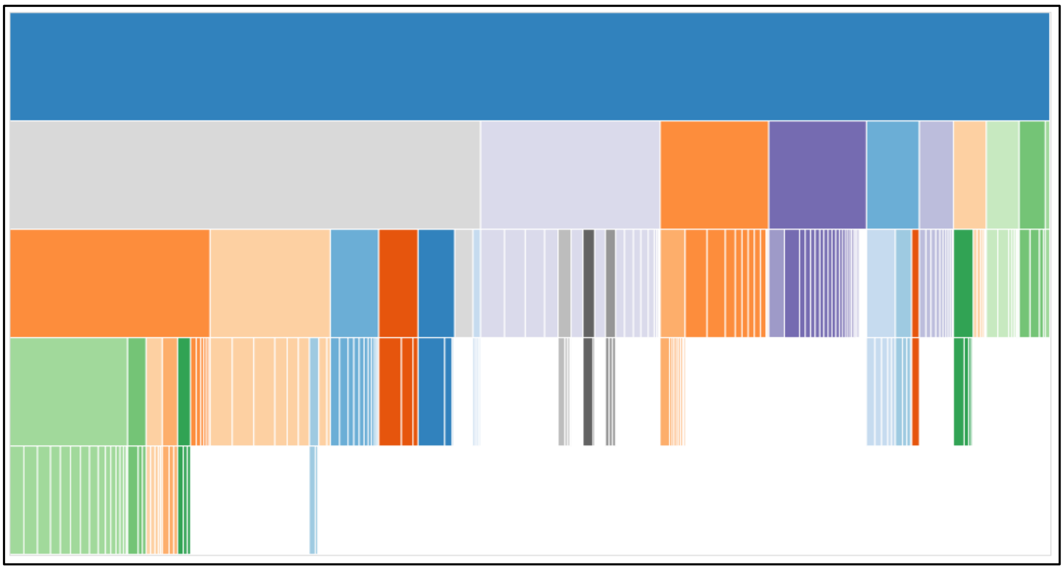


Figure 5-9 The Original Icicle Layout Enhanced for the Partition Layout

The *Partition Layout* is used to visualise the folder structures on the different devices (Figures 5-10 and 5-12). Recently accessed PI items are usually those items that users access the most (Bergman *et al.*, 2012). By default, the most recently accessed sub-folders within the root PI folders will be displayed according to screen space availability. An initial filter is applied to the

Partition Layout, but no more than three sub-folders are displayed at a time within the *Library*, and the first three sub-folders within parent folders, due to space constraints and to minimise clutter. The folders are also sorted by date accessed as a user may need to access recently used files and folders within such a tool. In the ZOIL tool (Section 3.5.2.3) different PICs were clustered but unstructured, whereas the MyPSI prototype is clustered as well as structured.

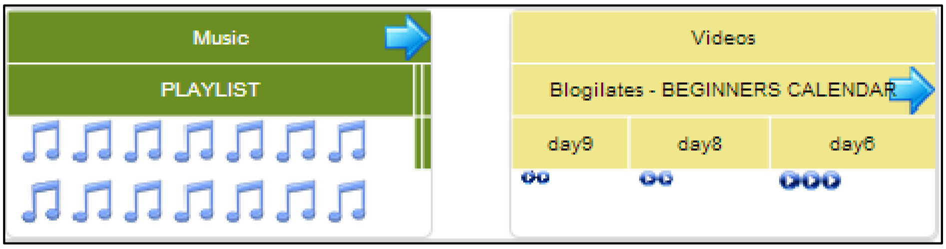
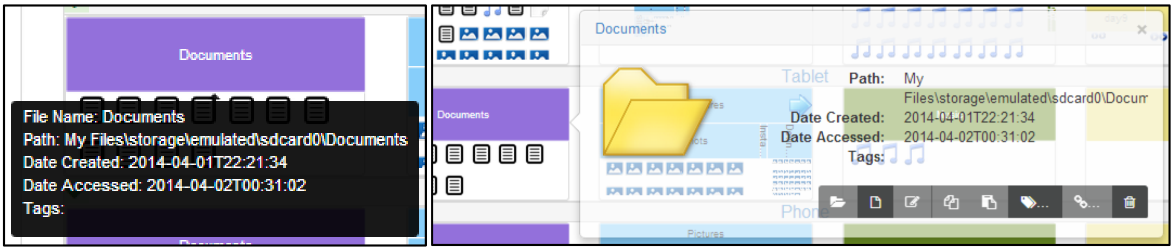


Figure 5-10 The Partition Layout implemented in MyPSI

An arrow will be displayed on the folder label if the folder contains hidden sub-folders. If a user would like to view a hidden sub-folder, s/he can scroll back and forth using the arrow keys. In a user study conducted by (Bergman *et al.*, 2012), participants accessed PI items faster using the *Icons* view of Windows Explorer than the *Details* view. Thus, all PI items will, by default, be initially represented by icons on the first zoom level, where icons identify the type of file. Hovering over or clicking on a file or folder will display a tooltip or popover respectively, to provide more information about the PI item, as shown in Figure 5-11.



(a) **(b)**

Figure 5-11 (a) A Tooltip and (b) a Popover in MyPSI

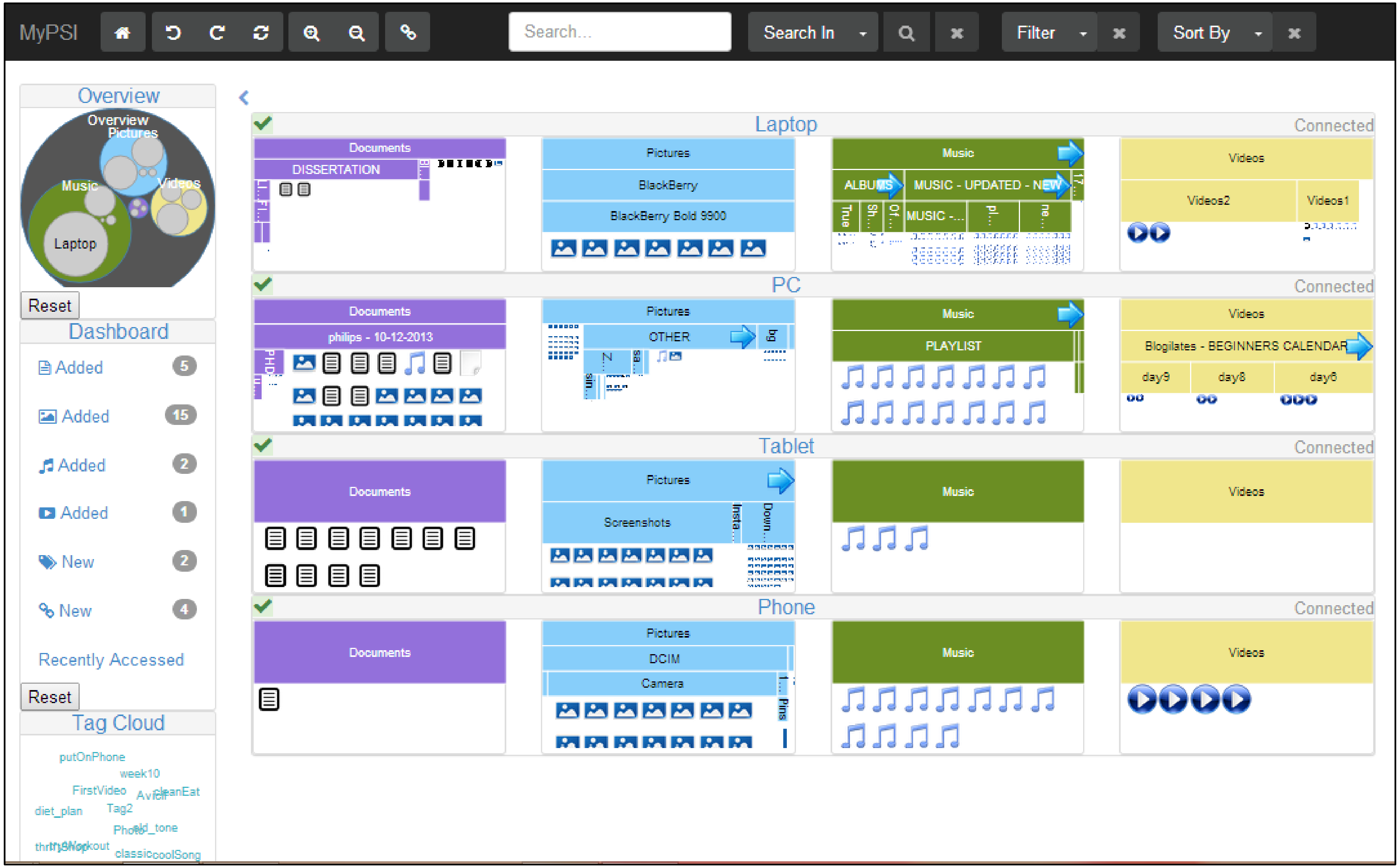


Figure 5-12 Implementation of the MyPSI Prototype

An example of co-ordination with the *Overview* as discussed in the previous section is displayed in Figure 5-13. The example shows that when the *Tablet* device is selected in the *Overview*, the other devices are collapsed within the *Partition Layout*, only showing the PI on the relevant device.

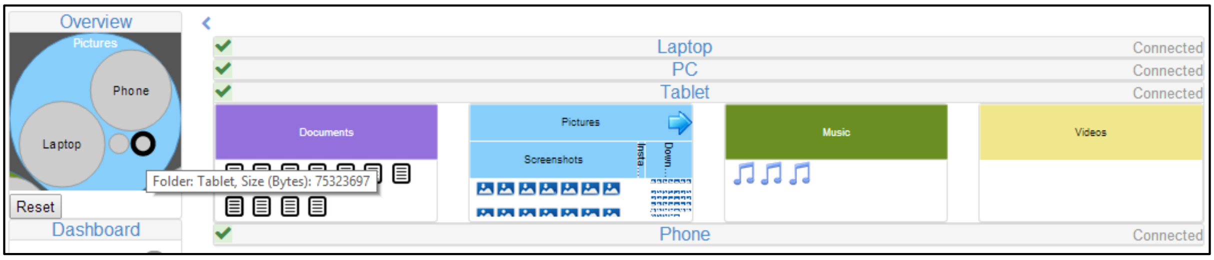


Figure 5-13 Co-ordination between the Partition Layout and the Overview

Figure 5-14 illustrates the desaturation that commences as a user starts typing in the search bar at the top of the screen. Relevant items will remain in the original colour, while irrelevant PI items will be de-saturated to a lighter colour.

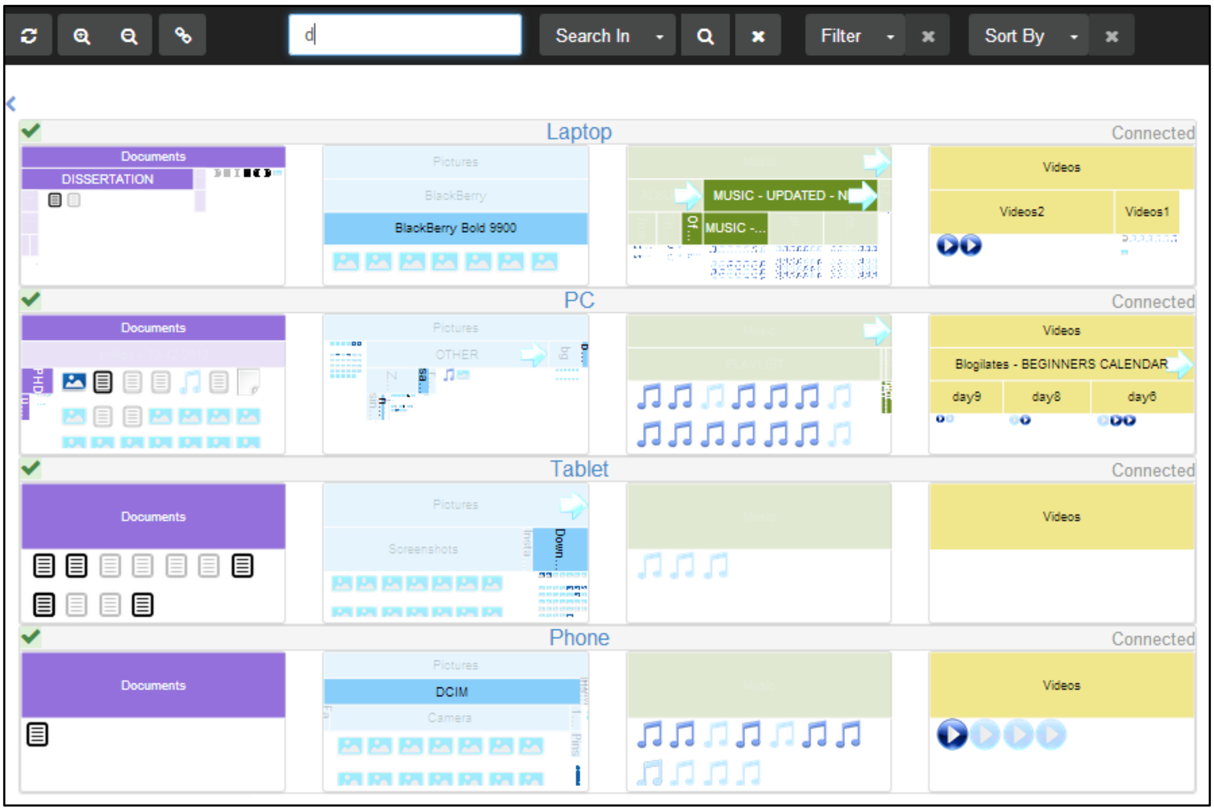


Figure 5-14 Performing a Search in MyPSI

5.3.3.3. The Tag Cloud

The *Tag Cloud* (Figure 5-15) provides a separate filtering facility and is co-ordinated with the *Partition Layout*. When a PI item is annotated with a new tag that does not appear in the *Tag*

Cloud, this tag will be added to the *Tag Cloud*. The *Tag Cloud* can assist in refining a search or be used independently of a search query, by selecting a tag in the *Tag Cloud* to only display those PI items that are annotated with the specified tag. Tags can also be edited and deleted, updating and deleting the associations with the related PI items.

Figure 5-15 The Tag Cloud implemented in MyPSI

5.4. Discussion

It was possible, to a large extent, to incorporate the selected IV techniques in the MyPSI prototype. The IV techniques incorporated in the MyPSI prototype could be implemented similar to the proposed design. This achievement emphasises the extensive capability of the D3 visualisation library. Existing IV techniques and examples are highly customisable and can be extended to support required functionality. The input of JSON files or arrays as a data source allows a simple means of including the necessary data to be visualised by the IV techniques. Searching, filtering and other selection tasks across a large dataset results in responsive performance. Colour-coding, highlighting, applying tooltips and other supporting tasks are also well-supported by the D3 library. Various IV techniques can be incorporated within the same UI with ease and these techniques can also be co-ordinated. D3 also works well together with other JavaScript libraries, such as Bootstrap.

Some difficulties were experienced in implementing the proposed design of MyPSI. These difficulties included:

- The required browsing functionality;
- Co-ordination with information popups;
- Transposing the information to view the information from a different perspective using specific layouts;
- Issues relating to the *Tag Cloud* implementation;

- Scaling of files;
- Difficulties with sorting;
- Semantic zooming;
- Label overlap.

Due to the large volume of PI contained within the sample PSI, files and folders were hidden according to a certain threshold (Section 5.2.4). This required the hiding and showing of files and folders on demand, i.e. when an arrow is selected triggering browsing. If the entire PIC is passed to the *icicle* layout, where filtering is performed thereafter, then due to the pre-calculation of positions and sizes, the visualisation would display an area reserved for initially hidden folder(s) and/or file(s). Thus, a need existed for two different data structures or layouts: one used initially, which only included the folder and file items to be displayed on load, and a second layout, which is used the first time hidden files and folders are browsed. The primary layout consists of all the PI items that meet the initial threshold. Once browsing has commenced the second layout is used from that point onward. Thus, a filter is performed before passing the data to the layout. Upon commencing the browsing task, the appropriate sub-folders and files are added to the containing array and then this array is passed to the second layout to be visualised to support a scrolling browse function. This ensures that the layout calculates positions and sizes only for those folders and files to be displayed on-screen initially.

While D_3 provides tooltips to support the Details-on-Demand (DoD) task and the implementation thereof is simple, the DoD requirement is not fully supported. Bootstrap provides simple panels, which can be converted into more complex popovers to provide additional information of a selected item. Thus, it was difficult to keep the information updated as the PI items' properties changed. This could also be due to the popovers being more primitive and less developed by Bootstrap.

At the time of implementation there existed only a single example of the *Tag Cloud* using the D_3 visualisation library on the official available website (Bostock, 2013). This example was used as it would otherwise have been difficult to create the required *Tag Cloud* technique. This example was highly modified to support the requirements of the *Tag Cloud* in MyPSI. The *Tag Cloud* needed to use the Select2 JavaScript jQuery plugin to support multi-select or multi-entry of the tags and to support editing and deleting of tags.

The *Partition Layout* required converting the default divisions used to visualise leaf nodes, i.e. files, to icons. This introduced a scaling problem as small (in size) parent folders with a large number of files made it difficult to visualise these files in the allocated space beneath the folder.

A minor difficulty existed while implementing the sorting functionality. Initially, it was desired to sort across all devices and PI types, but this resulted in a rather lengthy delay in performance as each section of the *Partition Layout* needed to be updated each time a sort was performed. Thus it was decided to only allow sorting over a specific device or PI type to avoid this problem.

Zooming is well-supported by D_3 and is provided in two ways within MyPSI, i.e. either by a double-click, which focusses on a specific folder or by scrolling into or out of the *Partition Layout.* Semantic zooming, however, needed to be implemented manually to some extent as changes were made based on the zooming level at which the PIC was being viewed.

Label overlap affected all three IV techniques implemented in MyPSI. The *Overview* and *Partition Layout* were affected by circles or partitions being too narrow or small compared to the label length. Hence additional functionality, namely displaying portions of the labels according to the available space, needed to be included to handle label overlap. Also, it was difficult to handle overlapping tags within the *Tag Cloud* especially as the *Tag Cloud* does not consider different font sizes.

While a number of difficulties were experienced with the implementation of MyPSI using the D_3 library, most of these difficulties were successfully addressed. D_3 can therefore be considered as a powerful library to visualise information, and specifically PI across multiple devices.

5.5. Conclusion

The existing hierarchical folder structure and indented-list IV technique does not provide support for accessing PI across multiple devices. Requirements for PIM across multiple devices were identified from an interview study to determine how participants currently manage PI across multiple devices and these requirements were converted into functionality to be supported by a prototype, called MyPSI. MyPSI was developed as an interactive visualisation tool to support PIM across multiple devices, using a *Partition Layout*.

A sample PSI was visualised in MyPSI, and captured in JSON files maintaining the original hierarchical structure of the PI. The focus of the design was on the first step of the design and implementation process, i.e. desktop / laptop devices, referred to as static devices, using a web-based application. Three IV techniques were incorporated in MyPSI, namely an *Overview*, a

Partition Layout and a *Tag Cloud*. A conceptual walkthrough confirmed the prototype design, the selected IV techniques and the proposed interaction. The selected IV techniques were implemented in MyPSI using the D_3 visualisation library, which provides a wide range of IV techniques that are highly customisable. The MyPSI prototype was successfully implemented similar to the proposed design showing that, while D_3 provided some difficulties with implementation, most, if not all, of the functionality could be implemented as required in D_3.

The MyPSI prototype needed to be evaluated in a user study to determine whether the tool provides effective support for PIM across multiple devices (Plaisant, 2004). An evaluation discussed in the following chapter was used to determine the effectiveness of the implemented IV techniques.

Chapter 6: Preliminary User Study

6.1. Introduction

Chapter 5 outlined the design and implementation of the MyPSI prototype using enhanced information visualisation (IV) techniques to support personal information management (PIM) on a desktop device. An evaluation was needed to determine the effectiveness of these enhanced IV techniques as well as the usefulness of the MyPSI prototype (see Appendix B for Research Ethics Approval) (Beets and Wesson, 2014). This chapter addresses the fifth research question, RQ 5, namely "*How effective are these IV techniques in supporting access to PI across multiple devices on a desktop device?"* This research question was addressed in the first iteration of the *Evaluate Artefact* design science research activity.

A preliminary user study was conducted to address the previously-mentioned requirements (Chapters 4 and 5). The next section describes the evaluation method including the aims and objectives, the participants involved, a description of the evaluation environment, collection methods and evaluation metrics, the tasks completed and the evaluation procedure. The results of this preliminary user study are then discussed relating to the usability of the MyPSI prototype and the implemented IV techniques. A discussion section follows the results section identifying limitations, usability problems identified and suggestions for improvement.

6.2. Evaluation Method

A preliminary user study (see Appendix B for Research Ethics Approval) was conducted to determine whether MyPSI contained any usability problems. Usability metrics captured included effectiveness (task completion) and user satisfaction. Effectiveness was captured for each task using a task list together with participant observation. Satisfaction was captured using a post-test questionnaire (Appendix F). Efficiency was not captured in this user study. The task list for the user study consisted of seven main tasks with a training task included for each of these tasks (Appendix E). The evaluation used a within-subjects experimental design. Ten participants completed the preliminary user study of the MyPSI prototype.

6.2.1. Aims and Objectives

Usability evaluations are considered as a useful tool to identify any usability problems with IV techniques and tools (Plaisant, 2004). Thus, the aim of the preliminary user study was to determine the effectiveness of the IV techniques incorporated in the desktop version of the MyPSI prototype described in Sections 5.2 and 5.3. Additionally, the purpose of the preliminary user study was also to determine the usefulness of the desktop version of the MyPSI prototype in general (Section 5.2). The preliminary user study was also used to identify any usability problems with the MyPSI prototype, and specifically problems or issues with the IV techniques.

6.2.2. Participants

Participant information was captured using a biographical questionnaire (Appendix D). A convenience sample of 10 postgraduate students from the Department of Computing Sciences at the Nelson Mandela Metropolitan University (NMMU) was used for the user study. The selected participants regularly use multiple devices for PIM and were thus considered representative users. Participants were in the age range of 21-39 years. Seven participants had at least six years computer experience. The remaining three participants had 3-5 years computer experience. Most participants (7) managed their personal information (PI) on a daily basis as shown in Figure 6-1. The remaining participants managed their PI on a weekly (2) and monthly basis (1).

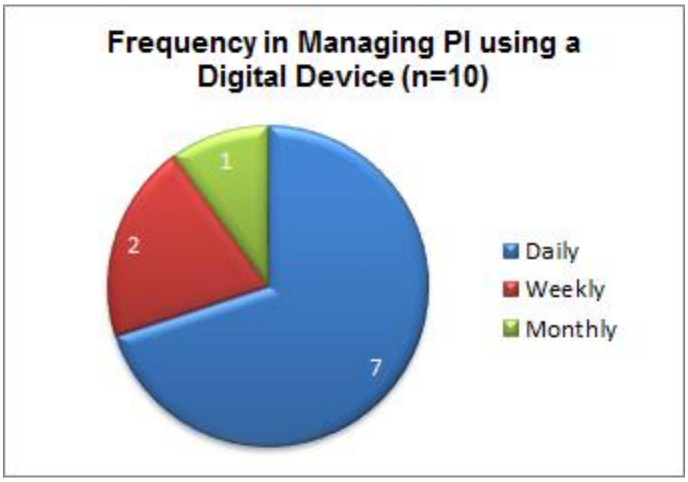
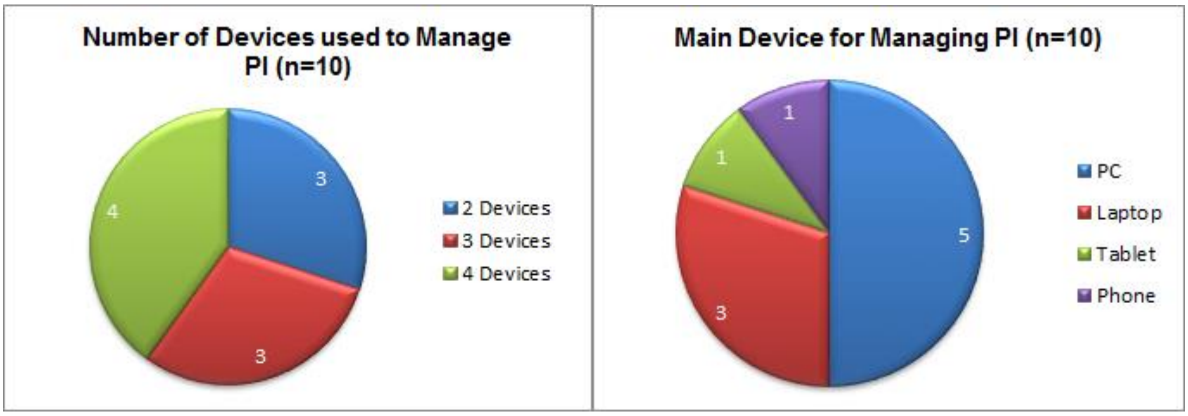


Figure 6-1 Frequency in Managing PI Using a Digital Device (n=10)

Figure 6-2 illustrates that seven participants used at least three devices to manage PI. This reinforces the design decision in Section 5.2.1 to support four devices. The main device used by participants to manage PI was either a desktop computer (5) or a laptop (3). One participant considered his/her mobile phone as his/her main device for managing PI and one participant considered his/her tablet as the main device.



(a) **(b)**

Figure 6-2 (a) The Number of Devices used to Manage PI and (b) the Main Device for Managing PI

6.2.3. Evaluation Metrics

Evaluation metrics considered for this preliminary user study included effectiveness and user satisfaction. Efficiency was excluded as an evaluation metric in this evaluation as it is not considered to be relevant when evaluating IV techniques (Freitas *et al.*, 2002; Brehmer *et al.*, 2014). Users of IV techniques are encouraged to explore datasets using the incorporated IV techniques, rather than performing a specific task as quickly as possible.

Effectiveness was used to measure task success, i.e. whether a participant was able to complete a task or not. User satisfaction was captured using a post-test questionnaire (Appendix F), which used a combination of the NASA-TLX form (Hart and Staveland, 1988) and the Computer Satisfaction Usability Questionnaire (CSUQ) (Lewis, 1995). The purpose of the NASA-TLX form was to measure cognitive load. The CSUQ was used to measure overall satisfaction and usability and to capture general comments. The general section required participants of the user study to note the most positive and most negative aspect(s) of the system and to provide general comments relating to the system or suggestions for improvement. Additional questions were asked specifically relating to the different visualisation techniques and included the following:

- *Technique X* provided a good overview of…;
- *Technique X* was useful;
- *Technique X* was easy to use;
- The (zoom and) filter of *Technique X* was easy to use;

- The (zoom and) filter of *Technique X* was useful.

Regarding the last two questions, both the *Overview* and *Partition Layout* provided a type of zoom, where the *Tag Cloud* did not support zooming. A final question was added for the *Partition Layout*, namely "*The zoom feature of the Partition Layout enabled me to obtain more information on a file*". All questions in the post-test questionnaire were rated using a 7-point Likert scale. The original questions relating to cognitive load from the NASA-TLX form were re-arranged to standardise the method of response for the participants of the preliminary user study and to minimise confusion (Section 1 in Appendix F).

6.2.4. Tasks

Seven main tasks were included in the task list, which related closely to the required functionality discussed in Section 5.2.3 (Appendix E). Three sub-tasks were included in the *Manipulation* task, thus the user study had a total of nine tasks. The participants were also required to complete a training task before each actual task. The tasks that were included in the user study are listed in Table 6-1.

Table 6-1 Tasks Included in the Preliminary User Study

	Task	**Description**
1.	The Overview	Find information within the *Overview* as well as making use of the co-ordinated view with the *Partition Layout.*
2.	Data Manipulation: Rename a Folder	Select the label of a folder to edit the label.
3.	Data Manipulation: Add a File	Add a file to a specific folder.
4.	Data Manipulation: Delete a File	Delete a specific file from a particular folder.
5.	The Tag Cloud	Manipulate the *Tag Cloud* to edit the tag name and also to determine particular files assigned a tag or vice versa.
6.	Search	Use the search facility to find specific files.
7.	Filter	Use the filter facility to find specific files, in addition to the expanding/collapsing ability of the *Partition Layout*.
8.	Semantic Zooming	Zoom in on a specific file to determine more information at certain zoom levels.
9.	Browsing	Use the file navigation arrows provided in the *Partition Layout* to find hidden folders.

Table 6-2 MyPSI Functionality Compared with the Visual Information Seeking Mantra (Shneiderman, 1996)

Aspect	**The Overview**	**The Partition Layout**	**The Tag Cloud**
Overview	• Overview of total size of collections per device and PI type	• Overview of content of different *Libraries* within different devices	• Overall view of all tags in *Tag Cloud*
Zoom	• Selecting PI type or device to zoom in	• Semantic zooming • Folder focus on double click • Collapse & Expand for Devices	
Filter	• Selecting a PI type or device to filter *Partition Layout* (i.e. co-ordinated views)	• Overall filter • Overall search (with Search By) • Initial filter to minimise clutter by only displaying a certain number of sub-folders within a folder	• Selecting a tag to filter *Partition Layout* with specific tag
Details-on-Demand	• Tooltip to show more information	• Tooltip to show some file/folder information • Popover displays detailed information	• Selecting a tag to filter *Partition Layout* with specific tag
Relate	• Co-ordinated with *Partition Layout*	• Linking • Tagging • Searching • Filtering • Distinguish files by file type icon • Structured to easily view sub-folders and files within a folder	• Co-ordinated with *Partition Layout* • Tagging
History	• Undoing and Redoing Actions	• Undoing and Redoing Actions	• Undoing and Redoing Actions
Extract		• Open a file	

A heuristic evaluation is regarded as an alternative method to evaluate IV techniques and tools (Forsell and Johansson, 2010). According to Forsell and Johansson (2010) and Zuk *et al.* (2006), one of the heuristics used to measure IV techniques and tools is the visual information seeking mantra identified by Shneiderman (1996). Table 6-2 illustrates the support that the functionality of MyPSI provides for each aspect of the mantra. As can be seen from the table, the functionality provided by each IV technique incorporated in the MyPSI prototype supports most of the IV aspects. It is not necessary for the *Overview* and *Tag Cloud* to support the Extract aspect. Additionally, as mentioned previously, the *Tag Cloud* does not currently support any type of zooming facility.

6.2.5. Procedure

The preliminary user study took place in the PhD Lab of the NMMU Department of Computing Sciences using a desktop computer with the Windows 8.1 operating system. The PhD lab was considered to be a quiet setting to conduct the user studies and well-suited as the desktop computer used for the evaluations was the same computer on which the MyPSI prototype was developed. Due to the web implementation of the MyPSI prototype, the prototype was run in the Google Chrome web browser (Google Inc., 2008). Prior to the commencement of the user study, each participant completed an informed consent form (Appendix C). The participant then completed an electronic background questionnaire (Appendix D). The evaluation procedure was then explained and an introduction to the user interface (UI) of MyPSI was provided. Participants were then encouraged to interact with the prototype before commencing with the task list. The participants then completed the training and actual tasks within the task list (Appendix E). The last part of the user study required the participants to complete an electronic post-test questionnaire (Appendix F).

6.3. Evaluation Results

The results of the preliminary user study are discussed in terms of results for effectiveness and satisfaction. Qualitative results captured from the post-test questionnaire are also presented in this section.

6.3.1. Effectiveness Results

The participants were required to answer a question relating to each task, which was used to measure effectiveness. Additionally, participant observation was used to identify any issues that the participants might have had during the completion of any of the tasks. A rating of 0-2 was assigned to each task with notes to determine with which interactions the participants had problems. The value of the ratings included the following:

- Rating of 0: The participant was not able to complete the task.
- Rating of 1: The participant was able to complete the task with some problems.
- Rating of 2: The participant was able to complete the task without any problems.

The percentage of correct answers, together with the ratings from the observations, were used to determine the effectiveness performance metric.

Table 6-3 Effectiveness Results Comparing Task List Answers with Participant Observations (n=10)

Task #	Task List Answers (% of Correct Answers)	Participant Observation (% of Observations with value >1)
1.	100%	100%
2.	100%	**90%**
3.	**90%**	**90%**
4.	100%	100%
5.	**80%**	**80%**
6.	100%	100%
7.	100%	100%
8.	100%	100%
9.	100%	100%

Most tasks received 100% task success except for Task 3 (90%) and Task 5 (80%), as can be seen in Table 6-3. Task 3 required participants to add a file to a specific folder and answer how many documents were contained in that folder. Participant observation revealed that one participant identified the documents in the folder but answered the question incorrectly. Task 5 involved clicking on a specific tag in the *Tag Cloud* and hovering over the file related to this tag to determine the number of tags related to this file. Both participants who answered this task answered incorrectly similarly to the training task, which required participants to determine how many files were associated with a specific tag.

According to the participant observation ratings for each task, Tasks 3 and 5 received a similar task success rating of 90% and 80% respectively, with the addition of Task 2 (90%). Task 2 required participants to select the label of a folder to rename the folder. Although one of the participants answered correctly, he clicked on another folder's label and became confused with the task thereafter. Although there were a small number of tasks that received lower effectiveness ratings, no major problems were identified with the IV techniques or the MyPSI prototype in general. Thus, based on the above results, the IV techniques and the MyPSI prototype can be considered to be effective for PIM across multiple devices.

6.3.2. Satisfaction Results

The satisfaction results were divided into several sub-sections, namely cognitive load, overall satisfaction, usability and the sections relating to each IV technique. A section was also provided to identify the most positive and negative aspect(s) of the prototype and to allow any general comments. Each value of the 7-point Likert scale had an associated meaning, i.e. 1: Strongly Disagree and 7: Strongly Agree. Thus, a mean rating with a value of greater than 5.29 indicates that the respective result is strongly positive, i.e. equivalent to either a five, six or seven rating on the Likert scale.

6.3.2.1. Cognitive Workload

The mean ratings were all positive (< 2.0) for cognitive load, which indicated that the required mental workload was low (Figure 6-3). All the mean ratings were less than 2.71, i.e. equivalent to either a one or two rating on the Likert scale. Participants did not feel discouraged or unsuccessful when completing the tasks using the MyPSI prototype.

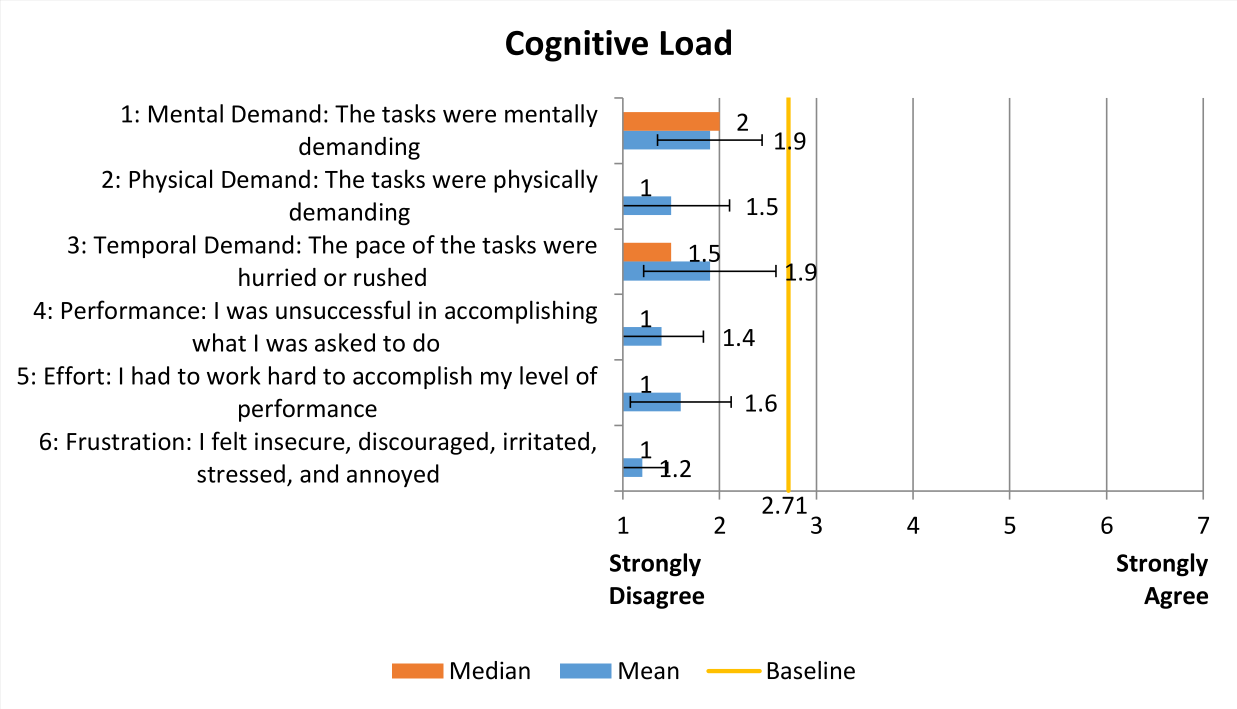


Figure 6-3 Mean Ratings for Cognitive Load using a 7-point Likert Scale (n=10)

6.3.2.2. Overall Satisfaction

The mean overall satisfaction ratings were all rated highly (> 6.0), as shown in Figure 6-4. The overall satisfaction received the highest ratings from the participants. Participants found the MyPSI prototype easy to use, easy to learn and simple.

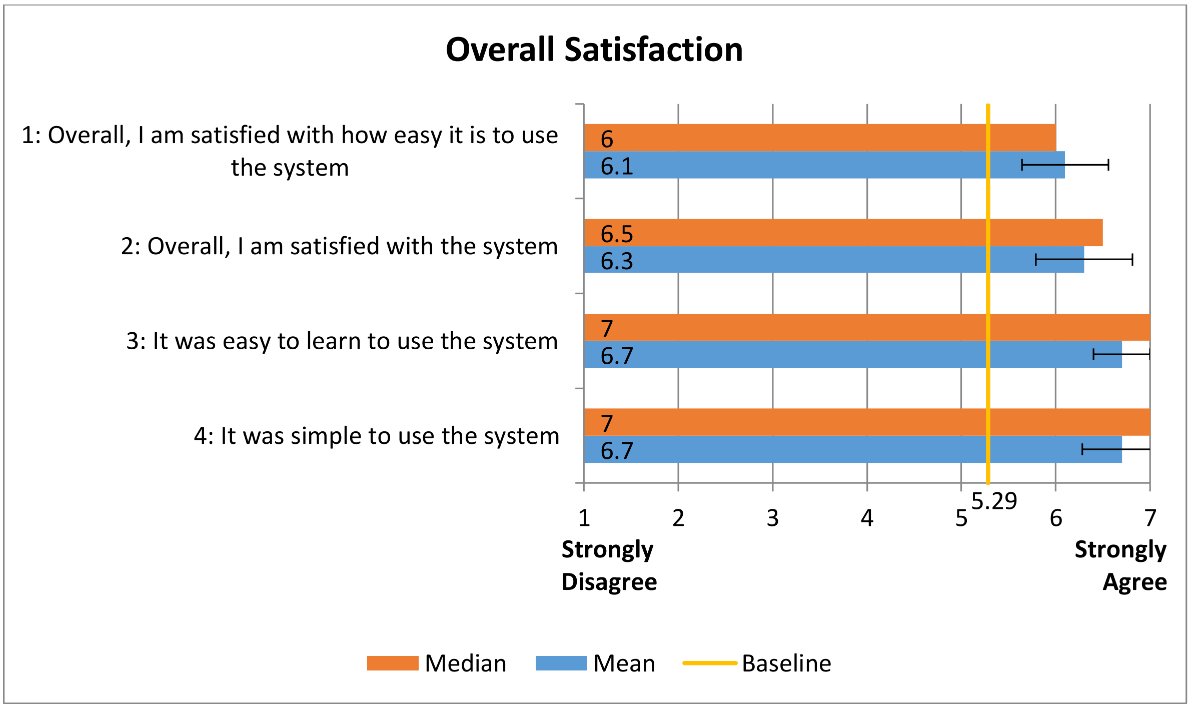


Figure 6-4 Mean Ratings for Overall Satisfaction using a 7-point Likert Scale (n=10)

6.3.2.3. Usability

The mean usability ratings for the MyPSI prototype were also high (> 5.5) (Figure 6-5). Participants perceived that they became productive quickly using the MyPSI prototype and that they could easily find items and browse the system.

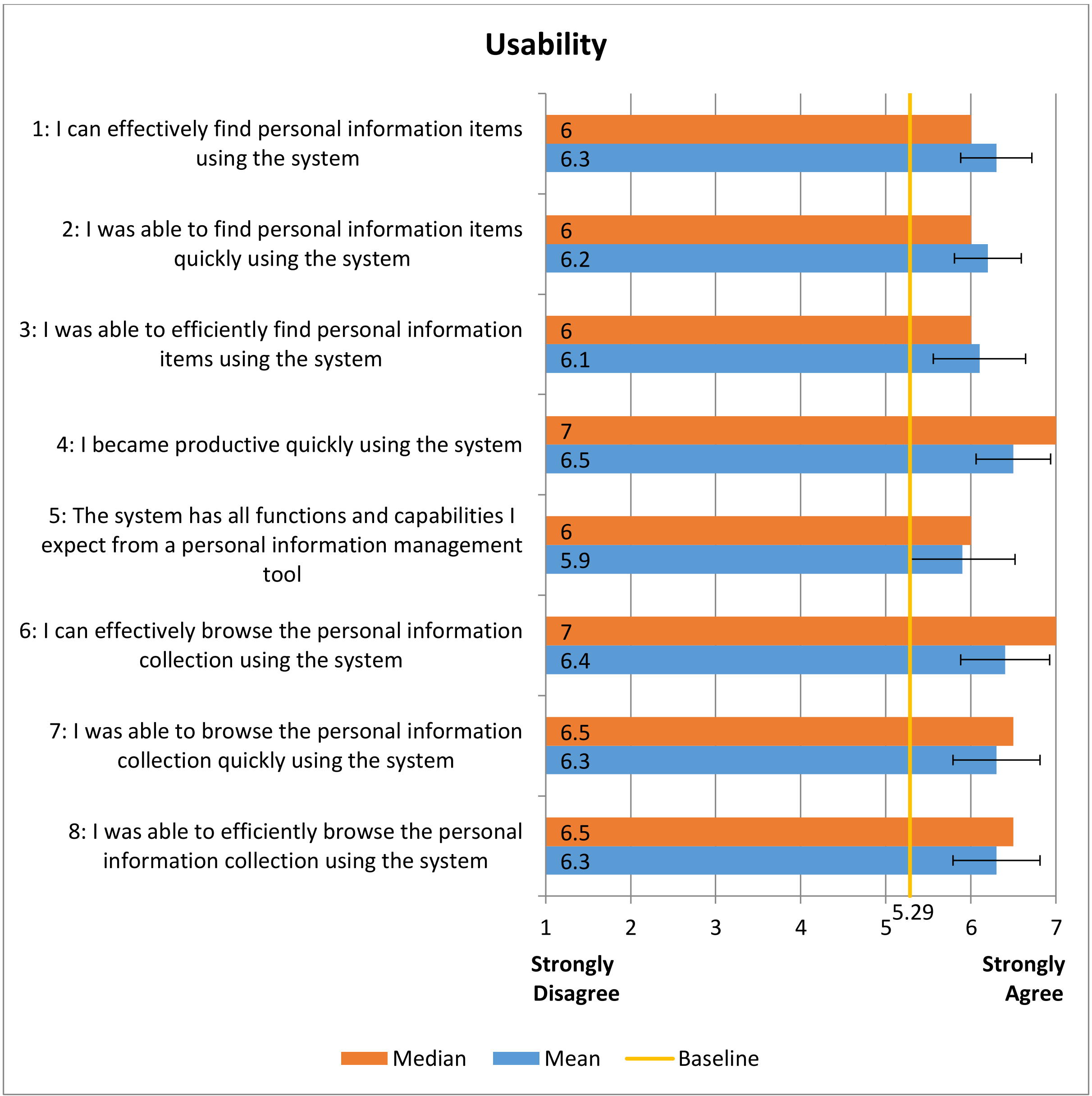


Figure 6-5 Mean Ratings for Usability using a 7-point Likert Scale (n=10)

6.3.2.4. Visualisation Techniques

Separate sub-sections were provided in the post-test questionnaire relating to the *Overview*, the *Tag Cloud* and the *Partition Layout*. The following sub-sections describe the results relating to each of these respective IV techniques.

a) The Overview

The *Overview* IV technique also received high ratings (> 6.0) (Figure 6-6). Participants found that the *Overview* was useful, easy to use and provided a clear view of the different types of PI.

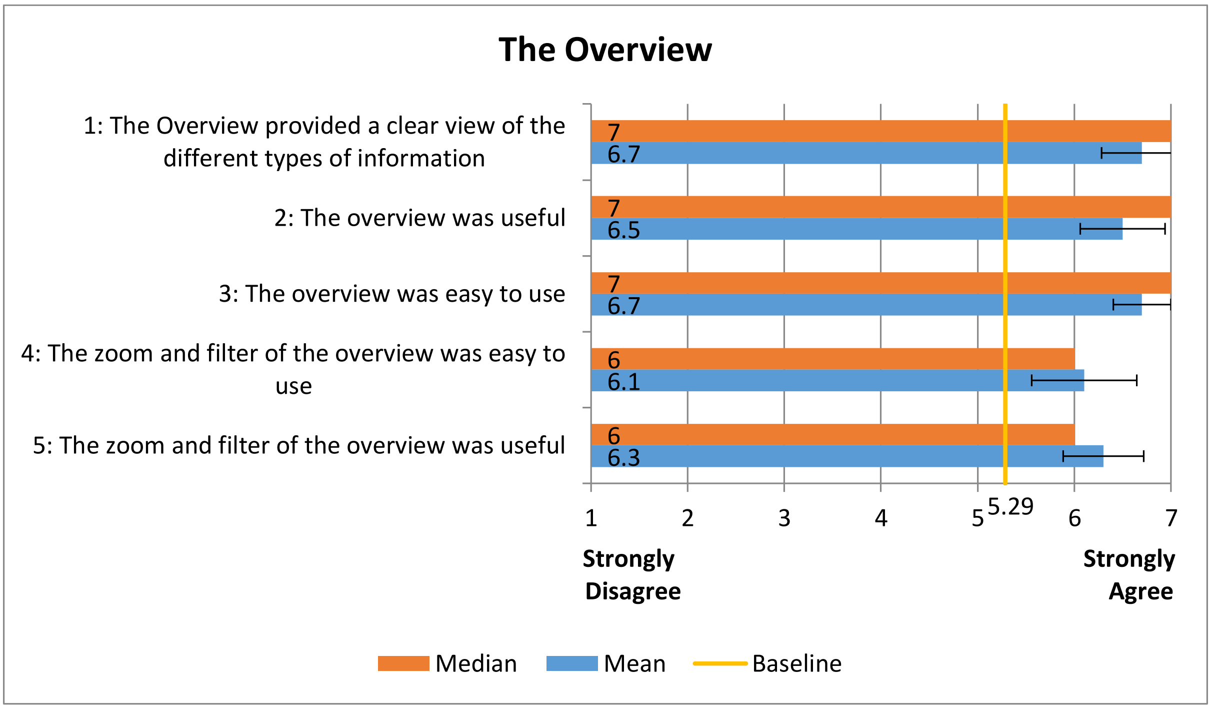


Figure 6-6 Mean Ratings for the Overview using a 7-point Likert Scale (n=10)

b) The Tag Cloud

The *Tag Cloud* also received high ratings for the questions relating to this visualisation technique (> 5.5), as shown in Figure 6-7. The participants found the *Tag Cloud* and *Tag Cloud* filter easy to use and useful.

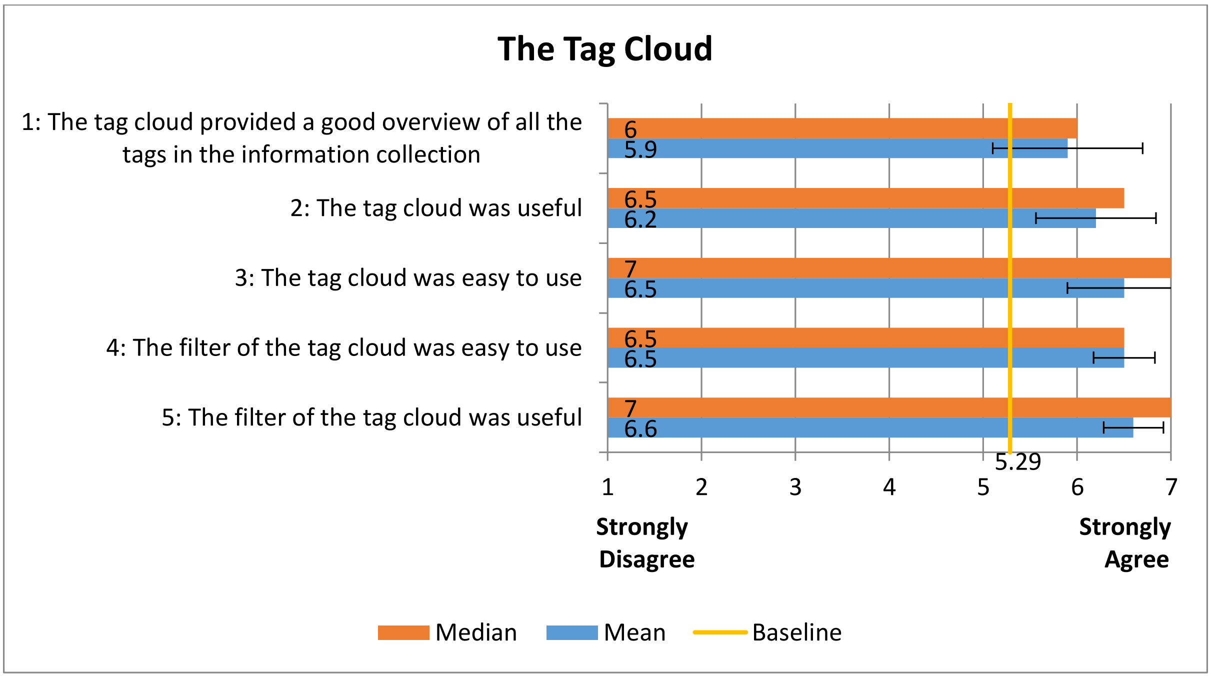


Figure 6-7 Mean Ratings for the Tag Cloud using a 7-point Likert Scale (n=10)

c) The Partition Layout

The mean ratings for the *Partition Layout* also received high ratings (> 6.0) (Figure 6-8). Participants found the *Partition Layout* useful and easy to use. Participants also found that the layout provided a good view of the information in the different collections.

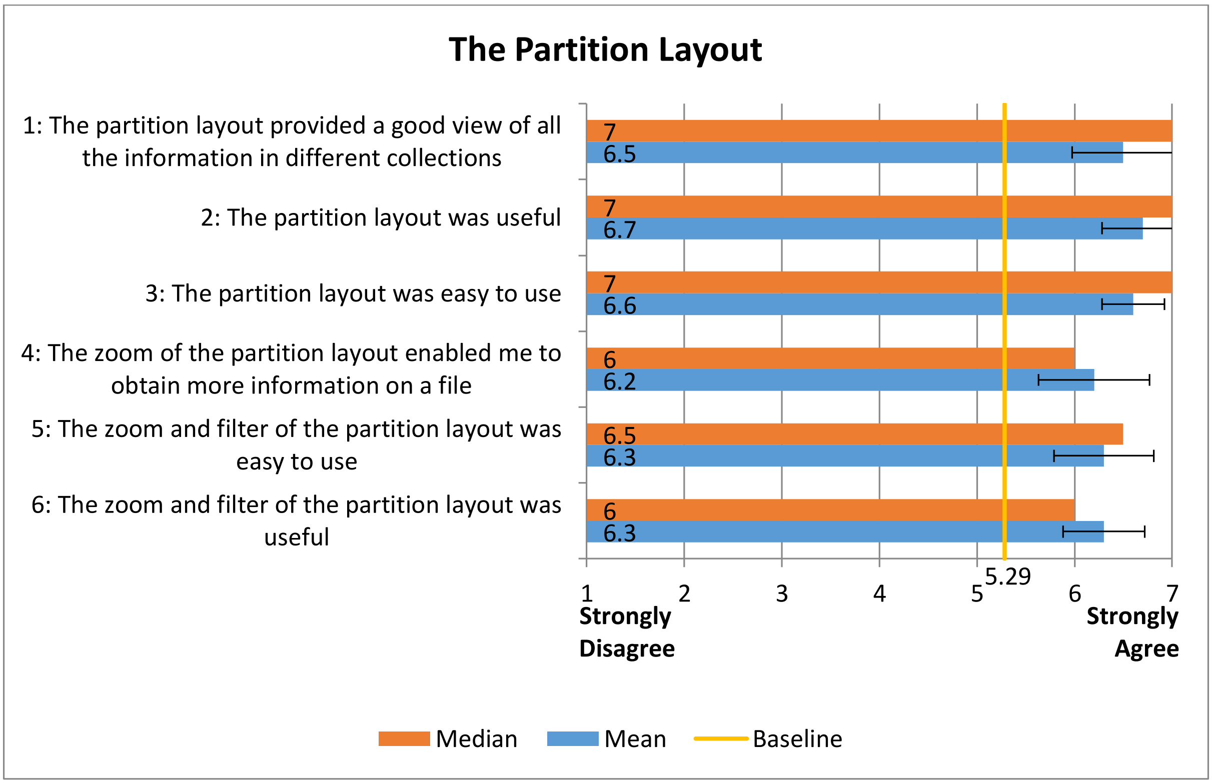


Figure 6-8 Mean Ratings for the Partition Layout using a 7-point Likert Scale (n=10)

6.3.3. Qualitative Results

The post-test questionnaire provided sections at the end of the questionnaire to note the most positive and negative aspects of the MyPSI prototype. A section was also provided for any general comments regarding the prototype or any suggestions that the participants might have for improvement.

6.3.3.1. Most Positive Aspect(s)

Participants were asked to note the most positive and negative aspect(s) of the MyPSI prototype. Table 6-4 identifies that several participants (5) indicated the *Overview* as the most positive aspect of MyPSI as it was intuitive and easy to use. Participants also had positive responses to the UI design layout (4) and found the features that were provided, such as filtering, to be useful (4). Three participants identified the *Partition Layout* as the most positive aspect.

Table 6-4 Most Positive Aspects of the MyPSI Prototype (n=10)

	Positive Aspect	Freq.
1.	Overview interaction was intuitive and easy to use.	5
2.	Good layout of components and design of system interface. Simple, yet elegant system design.	4
3.	Options such as filtering and searching.	4
4.	Different partitions of the various devices and their collective information stored.	3
5.	Visually appealing.	2
6.	Different usage of colours to distinguish between different file types.	2

6.3.3.2. Most Negative Aspect(s)

The most negative aspect was related to the small file icons (4) as shown in Table 6-5. A second negative aspect was that the *Tag Cloud* was difficult to use when there were many tags as these could overlap (2). Two participants suggested differentiating results that were part of a search or filter from the rest of the information items more obviously.

Table 6-5 Most Negative Aspects of the MyPSI Prototype (n=10)

	Negative Aspect	Freq.
1.	Cannot clearly see small files.	4
2.	Tag cloud items not easy to read.	2
3.	Slight difficulty in easily identifying which files are relevant to a performed search/filter and those that are not.	2

6.3.3.3. General Comments

Five participants noted that MyPSI was a good prototype, which they would consider using in the future, as shown in Table 6-6. General suggestions related to the differentiation of results as described above and allowing a user to maximise a folder to support easier browsing.

Table 6-6 General Comments of the MyPSI Prototype (n=10)

	General Comments	Freq.
1.	Very nice system, would like to have such a system to sync all files and media on my different devices.	5

6.4. Discussion

While the MyPSI prototype was in the early stages of development, participants agreed that the IV techniques, namely the *Overview*, *Tag Cloud* and *Partition Layout*, provided a good view of PI across multiple devices. Participants also found the IV techniques to be effective, easy to use and useful. From the comments, the participants also found the MyPSI prototype generally useful. Although these results are promising, a few usability problems were identified. The problems that need to be addressed included the following:

- Modify the icon scaling according to the file's parent folder to account for small file icons;
- Differentiate more obviously between the files and folders that result from a filter, from those that are not part of the results;
- Improve on the layout, positioning and tags visualised by the *Tag Cloud* to make it easier to read, including zooming capability within the *Tag Cloud*;
- The need to control the transitions more appropriately when browsing, which were not fluid.

A few usability problems were further identified from the participant observation of both the training tasks and the actual tasks. These problems included the following:

- Problems when selecting a tag in the *Tag Cloud*, i.e. when a tag is selected that has tags assigned to it, no files are shown as part of the results;
- Problems in distinguishing between the different types of files;
- The need to provide a breadcrumb or information bar to assist users with current folder/file location status;
- The lack of information within a folder regarding the files it contains;
- More visual feedback is needed;

- Provide a separation between selecting a label and a folder to address issues with renaming;
- Ensure that a folder deletes correctly as it did not all of the time.

Limitations of these results include the small sample size (n=10) that was used for the study. An additional limitation was due to the sample PSI that was used as described in the previous chapter (Section 5.2.1). In future, the prototype will be tested using a field study with the users' own data. Lastly, the design and implementation of the MyPSI prototype was limited to a desktop computer. A subsequent step following this evaluation was to include support for multiple devices. Thus, it was necessary to design a mobile version of the MyPSI prototype for mobile devices.

6.5. Conclusion

The preliminary user study of the MyPSI prototype was used to determine the effectiveness and usefulness of the *Overview*, *Tag Cloud* and *Partition Layout* IV techniques. The MyPSI prototype was developed to allow demonstration and evaluation of the proposed techniques. Effectiveness, in terms of the task list, participant observation and user satisfaction were captured for each participant of the evaluation. It was also determined that the tasks provided by the MyPSI prototype supported the visual information seeking mantra used for the design of IV techniques and tools.

The results of the user study yielded highly positive results. Effectiveness ratings showed that participants could easily interact with the IV techniques. The prototype received positive ratings for cognitive load, overall satisfaction and usability. Results of the user study showed that participants found that the proposed IV techniques provided a good overview of PI across different devices within a single UI. Participants rated the system as simple, easy to use and easy to learn. The participants also found the *Overview*, *Tag Cloud* and *Partition Layout* easy to use and useful. Only a few usability issues were found with the prototype, which were addressed. The next chapter will discuss the design of a touch-based interface to support PIM on a mobile device.

Chapter 7: Design and Implementation for a Mobile Device

7.1. Introduction

Chapter 5 and 6 discussed the design, implementation and evaluation of the MyPSI prototype on a desktop device. The preliminary user study described in Chapter 6 identified no major issues with the user interface (UI) or information visualisation (IV) techniques in the MyPSI prototype. The aim of this chapter is to discuss the design of the MyPSI prototype to support access to personal information (PI) across multiple devices on a tablet device. Thus, this chapter addresses the sixth research question, RQ 6, as outlined in Chapter 1, namely *"How can enhanced IV techniques be designed to support access to PI across multiple devices on a mobile device?"* This research question was addressed in the second iteration of the *Design and Develop Artefact, Demonstrate Artefact* and *Evaluate Artefact* design science research activities.

The following section details the design of the MyPSI prototype on a mobile device. The data design, design rationale, functionality and IV techniques are discussed in this section. The implementation section then follows describing the implementation tools, data and IV techniques with regards to the implementation of the prototype on the mobile device. This chapter concludes with a discussion section relating to the design and implementation of the MyPSI prototype on the tablet device.

7.2. Design

The MyPSI prototype was extended to support mobile devices in addition to desktop and laptop devices. The design of the MyPSI prototype for the tablet is similar to the design of the desktop version. The sample personal space of information (PSI) used for the desktop version was replaced to allow users to upload their own PI. The mobile version of the prototype supports the same functionality and makes use of the same IV techniques as the desktop version to provide consistency across the devices and to evaluate the effectiveness of these IV techniques across multiple devices.

7.2.1. Data Design

The desktop version of the MyPSI prototype used a sample PSI using JavaScript Object Notation (JSON) files to allow the prototype to be evaluated. The evaluation was a controlled study, and so the MyPSI prototype needed to be evaluated "in the wild" so that it can be tested within a user's own environment. To allow evaluation in a real environment, a real PSI needs to be provided for each user of MyPSI. Although the focus of this research is on the IV techniques designed for the MyPSI prototype and not the back-end storage system, a user will need to be able to upload their own PI to use MyPSI in their own environment. Thus, a cloud storage back-end was provided to allow a user to upload his/her own PSI visualised using the MyPSI prototype. The hierarchy is still preserved as shown in Figure 5-1 and thus the JSON files were replaced by a cloud storage system. An overview of this back-end support is displayed in Figure 7-1. From Figure 7-1, it can be seen that the process of the data storage for the MyPSI prototype involves a user uploading his/her PSI to the cloud storage system, the MyPSI prototype then retrieves the PSI from the cloud, the user can then interact with his/her PSI using MyPSI, and any updates or modifications to the information are then updated in the cloud storage system.

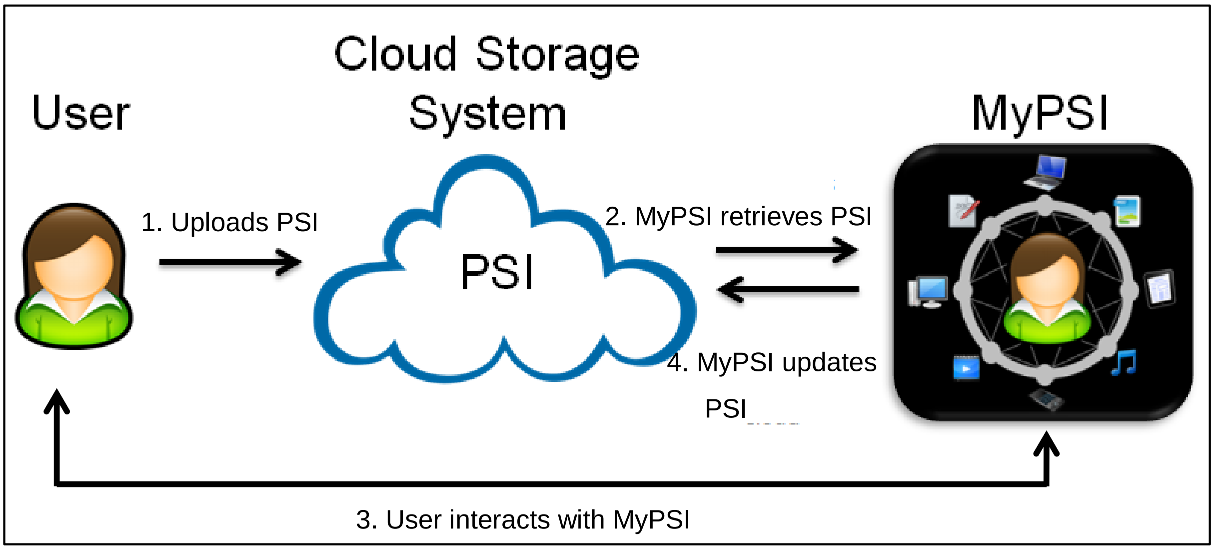


Figure 7-1 Updated Data Process of MyPSI

7.2.2. Design Rationale

The main requirement of the prototype, as identified in Section 5.2.2, is to provide access to PI across multiple devices. Thus, this chapter discusses the second step in the development process described in Table 5-1 (Section 5.2.2). The second step of the development process is focussed toward providing the MyPSI prototype on a mobile device with touch-based interaction using a user's own PSI stored within a cloud storage system.

The design of the MyPSI prototype on the mobile device followed a similar design rationale as the design of the desktop version described in Section 5.2.2 to provide consistency across the devices. The selection of what type of mobile device to support comprised, firstly, a choice between a tablet device and mobile phone, and secondly, which platform to support.

One of the main distinctions between a mobile phone and a tablet device is the significant difference in screen size and screen space availability. A larger screen size is better suited for interacting with an IV tool especially on a device using touch-based interaction. Additionally, a mobile phone is considered to be a constrained device and as such the design of the MyPSI prototype would need to be modified significantly to suit the mobile phone whereas the current design could be mapped onto a tablet device.

Tablet devices are also gaining popularity for everyday and business tasks. Both the mobile phone and tablet devices are portable, but the screen size, power and storage space provided on tablet devices may be more conducive to encourage personal information management (PIM) "on the go". Mobile phones are also mainly used for email updates and browsing the Internet (Tech Talk Africa, 2013), but the MyPSI prototype focusses rather on PI in terms of documents and media, which are stored more commonly on a tablet device than a mobile phone. Lastly, tablet devices are increasingly used by users for business purposes and because the users of the MyPSI prototype are expert users, a tablet device may be more suited to be selected as the mobile device supported by MyPSI.

In July 2013, iOS was the most popular operating system for tablet devices in South Africa, followed closely by Android (BusinessTech, 2013). Tablet device sales were also on the increase and were expected to surpass personal computer (PC) sales by 2015. In the first six months of 2013, Samsung sold more tablet devices in South Africa than Apple. According to Gartner (2014), Android became the top tablet operating system in the global market in 2013. In the first quarter of 2014, Samsung received the highest market share in tablet sales globally for the first time, surpassing Apple, with Android the dominant operating system for all sales (PCWorld, 2014). These statistics show that Android is one of the most popular and widely used operating systems for tablet devices. Additionally, iOS is somewhat difficult to develop applications for as various permissions need to be obtained before a specific application can be created and to register as an iOS application developer is a lengthy process, whereas Android is less restricted in this aspect. Thus, Android was selected as the most suitable platform on which to design and implement the tablet version of the MyPSI prototype.

7.2.3. Functionality

The same functionality is supported in the tablet version of the MyPSI prototype as in the desktop version (Section 5.2.3). The functionality is supported in the same manner as implemented in the desktop version of the MyPSI prototype, but using touch-based interaction. The functionality that is supported comprises the following:

- Manipulation;
- Sorting;
- Intelligent Browsing;
- Intelligent Searching;
- Filtering;
- Tagging;
- Linking.

7.2.4. Visualisation Techniques

Identical IV techniques are used in the tablet version of the MyPSI prototype as in the desktop version. The IV techniques include an *Overview*, using a nested circles layout, a *Tag Cloud*, and a *Partition Layout*, using the set-based IV technique. These IV techniques were discussed in detail in Section 5.2.4.

7.2.5. Prototype

Due to the availability of 10.1” Android tablet devices, a feasibility study was conducted on the suitability of mapping the design of the desktop version of the MyPSI prototype to a tablet device. The 10.1” screen space of the tablet devices allowed enough screen space to use the design of the MyPSI prototype directly onto the tablet devices with no issues experienced. Thus, the design of the tablet version of the MyPSI prototype follows the design described in Section 5.2.5, with the addition of a sign in functionality provided by the cloud storage system to authenticate each user and ensure that only a specific user can access his/her uploaded PSI.

7.3. Implementation

The design of the MyPSI prototype was implemented on the tablet device using PhoneGap (Adobe Systems Inc., 2014). Users will be able to upload their own PSI using Dropbox using MyPSI to visualise each PSI secured using sign in functionality. The same IV techniques were implemented in the tablet version of MyPSI as in the desktop version of the prototype.

7.3.1. Implementation Tools

The D_3 (Data-driven Documents) JavaScript library was used to design and implement the selected IV techniques within the MyPSI prototype. Currently, D_3 is the most powerful library or toolkit to design customised IV techniques. The selection of implementation tools for the tablet version of the MyPSI prototype was limited by the requirement to use the D_3 JavaScript library. Due to the visualisation library being a JavaScript library, a true native Android application could not be developed as Java and JavaScript are incompatible. Thus, an interim or middleware application needed to be selected to map the design of the desktop version of the MyPSI prototype to the tablet device.

Three possible middleware applications were reviewed to determine which tool would be suitable to implement the tablet version of the MyPSI prototype. These applications included Xamarin (Xamarin Inc., 2014), PhoneGap (Adobe Systems Inc., 2014) and Titanium (Appcelerator Inc., 2014). Xamarin, created in 2011, is used to create mobile applications that appear native across different platforms using the C# programming language, reducing the amount of code needed to create each mobile application as well as minimising the knowledge needed regarding each platform. Xamarin allows for code reuse across platforms, and applications appear more native (Whetton, 2014a). Xamarin suffers from the disadvantage that some features may not be supported by all platforms, loading delays and the learning curve experienced with creating mobile applications using the framework. Xamarin is also not entirely free, although a starter version is available and Xamarin Indie is available free for students.

PhoneGap, created in 2008, is a framework that makes use of Hypertext Mark-up Language (HTML), JavaScript and Cascading Style Sheets (CSS) to support cross platform applications, which are viewed through a web view component, basically wrapping a web application to appear as a native application (Mobile Dev Resources, 2014; Whetton, 2014a). Thus, transferring the original design to the tablet application is a simple process, code reuse is taken advantage of, and several platforms are supported (Whetton, 2014a; Adobe Systems Inc., 2014). One of the most negative aspects of PhoneGap is the slow performance of PhoneGap applications (Whetton, 2014a). PhoneGap applications also do not support truly native applications.

Appcelerator Titanium also makes use of JavaScript to create applications, but instead of using HTML and CSS it makes use of Extensible Mark-up Language (XML) or a custom Application Programming Interface (API) resulting in a more native-like, hybrid application (Whetton, 2014a). Thus, making use of Appcelerator Titanium to transfer the existing design to the MyPSI tablet application would involve a more complex process. Advantages of this framework include better performance and reuse of code across platforms. Disadvantages of the Appcelerator Titanium framework include a possibility of lack of support for all features across different platforms, an increased processing requirement, slight delay in loading of the application and that the framework is free for development but requires payment for deployment to an application store, and only iOS and Android platforms are supported.

PhoneGap provides a wrapper for web-based applications where Xamarin and Appcelerator Titanium makes use of cross-platform tools to create a native application (Mobile Dev Resources, 2014). PhoneGap was selected as the most suitable implementation tool using the Cross Platform Mobile Development Model provided in Appendix L (Whetton, 2014b). This selection was made as there existed a requirement to use JavaScript, the preference of performance and UI responsiveness over cost, familiarity of JavaScript using HTML and CSS, and that a cross-platform application was not required. PhoneGap also provided a much simpler method to transfer the design of the desktop version of the MyPSI prototype to the tablet version as no extensive work needed to be carried out to complete this mapping. Thus, PhoneGap was selected as the most appropriate implementation tool.

7.3.2. Data

In addition to the primary implementation tool required to map the design of the desktop version of the MyPSI prototype to the tablet version, a suitable cloud storage system needed to be selected to allow a user to upload his/her PSI to be visualised by MyPSI, as shown in Figure 7-1. Three cloud storage systems, which provided APIs, were analysed to determine which cloud storage system would be the most suitable system to use as the back-end of the MyPSI prototype. These APIs included Dropbox-js API (Dropbox Inc., 2012), Google Drive API (Google Inc., 2013) and OneDrive API (Microsoft Corporation, 2012).

A feasibility study was conducted with each cloud storage system, where each system was used to connect to the MyPSI prototype to determine which features were supported and to identify the limitations of each system for comparison purposes. The full comparison is outlined in Table 7-1 and continued in Table 7-2.

Six main requirements were identified to compare the cloud storage APIs. These requirements included security, support for syncing, file properties supported, methods provided, whether the file hierarchy was maintained and finally whether the API works seamlessly with PhoneGap. The issues that were found are highlighted in Tables 7-1 and 7-2. All three APIs provide OAuth2 authentication, which provides a one-time sign in functionality to ensure security, but problems were experienced with the sign in process using Google Drive through PhoneGap. OneDrive was eliminated as a possible cloud storage API when it was discovered that the API does not support polling or syncing changes. There were some file properties that were not provided by both Dropbox and Google Drive, but these properties were not critical in determining which API would be most suited to provide a back-end system to the MyPSI prototype. Neither Dropbox nor Google Drive preserved the hierarchy of files stored within their storage systems and retrieved files were returned in a flat list, which needed to be rebuilt into a hierarchical structure. Dropbox was thus selected as the most suitable cloud storage API to support the tablet version of the MyPSI prototype as it was the most advanced API, provided the most functionality and as PhoneGap was not fully supported by Google Drive. Dropbox provides a JavaScript API specifically for handling applications created by frameworks such as PhoneGap.

7.3.3. Visualisation Techniques

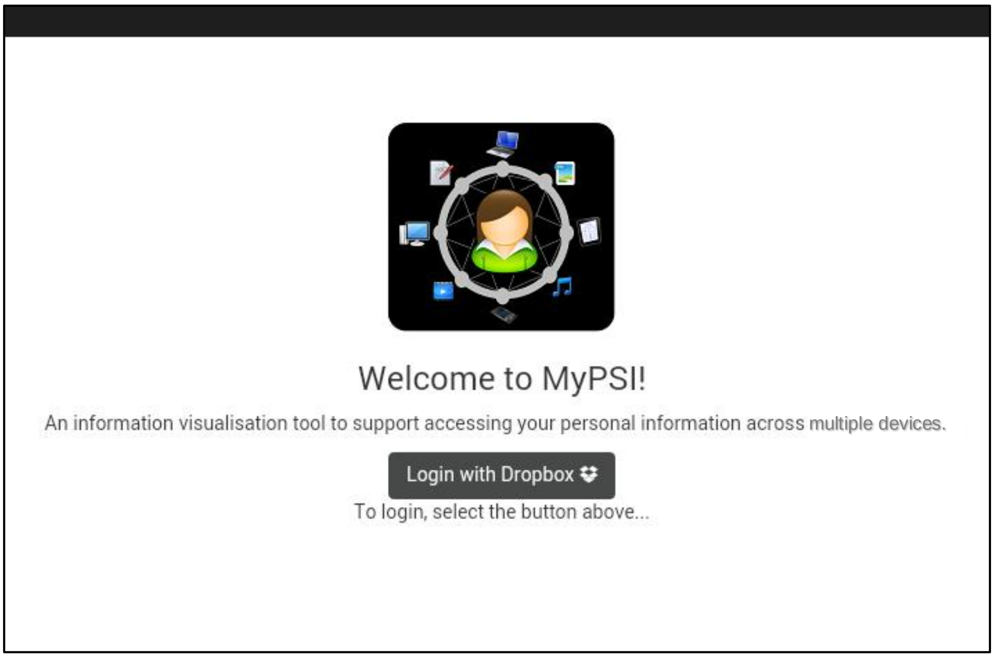
The implementation of the MyPSI prototype on the tablet device using PhoneGap resulted in a similar look and feel to the design on the desktop version. The tablet version, as well as the desktop version, initially display a welcome screen for MyPSI (Figure 7-2a), a sign in screen provided by Dropbox on *Login with Dropbox* selection (Figure 7-2b), which, upon successful log in, is redirected to the MyPSI UI. Once signed in, the user’s name is displayed in the toolbar on the top-right of the screen (Figure 7-2c). A dropdown was provided, as shown in Figure 7-2c, so that if a user was to touch, or click in the case of the desktop version, on his/her name, the prototype would provide an option to sign out of the application.

Table 7-1 Comparison of Cloud Storage Systems

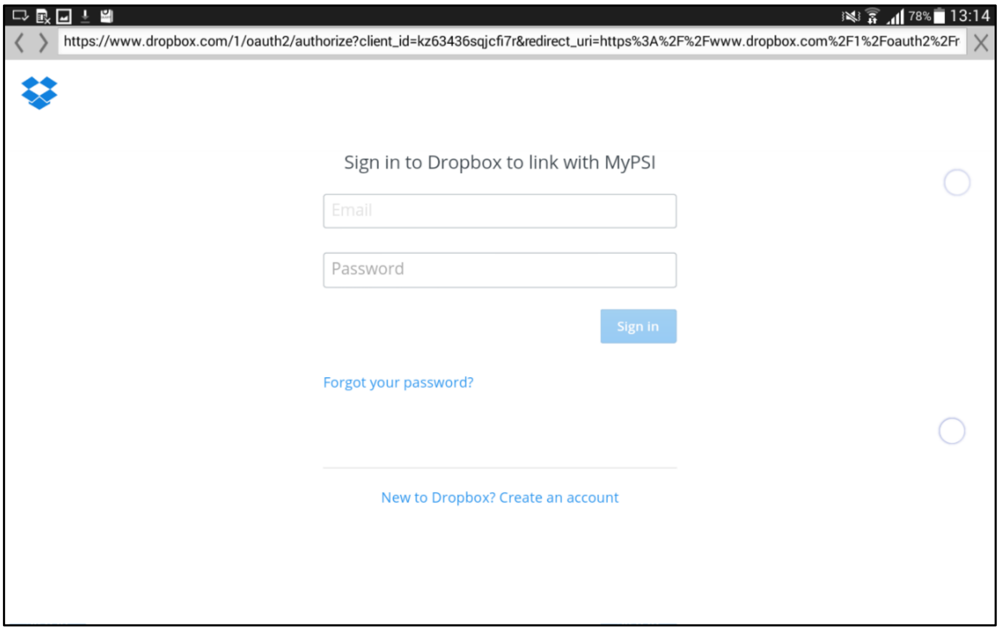
Criteria	**Dropbox**	**Google Drive**	**OneDrive**
1. Security	Uses OAuth2 to authenticate user (Works well)	Uses OAuth2 to authenticate user (Issues experienced)	Uses OAuth2 to authenticate user (Works well)
2. Syncing	"Pollforchanges" and "Pullchanges" Pulls all information on first pull and only changes on subsequent pulls	"Watch" and "Changes" list Pulls all information on first pull and only changes on subsequent pulls	None – no push notifications of changes
3. File Properties:			
3.1. Name	X	X (title)	X
3.2. Path	X		Only link
3.3. Folder / File	X		X
3.4. Type	X	X (mimeType / File extension)	X
3.5. Size	X	X (fileSize)	X
3.6. Thumbnail	X	X	Not clear
3.7. Date Created		X	Not clear
3.8. Date Accessed	X	X	X
3.9. Tags			X
3.10. Contents (for Preview)	X	X (Indirect method of downloading document and getting file content)	X

Table 7-2 Comparison of Cloud Storage Systems (Continued)

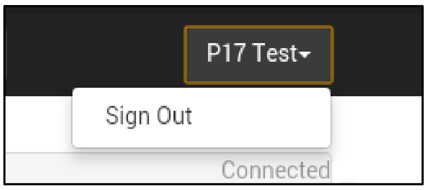
Criteria	**Dropbox**	**Google Drive**	**OneDrive**
4. Methods			
4.1. Create	X (writefile)	X	X
4.2. Copy	X	X	X
4.3. Move	X	X (with copy and delete)	X
4.4. Delete	X	X	X
4.5. Rename	X (metadata / stat)	X (update)	X
4.6. Open	X (by providing URL)	X	X (with download)
4.7. Save / Update	X	X	X
5. Maintain File Hierarchy?	No (flat list but can build hierarchy using path attribute – will need to separate into PI arrays)	No (flat list, but does have parent ID with which to associate children and to build hierarchy – can also access specific paths to create separate PI arrays)	Partially (Stored in JSON object)
6. Works with PhoneGap?	X	Not fully supported	X



(a)



(b)



(c)

Figure 7-2 Sign In Process for MyPSI

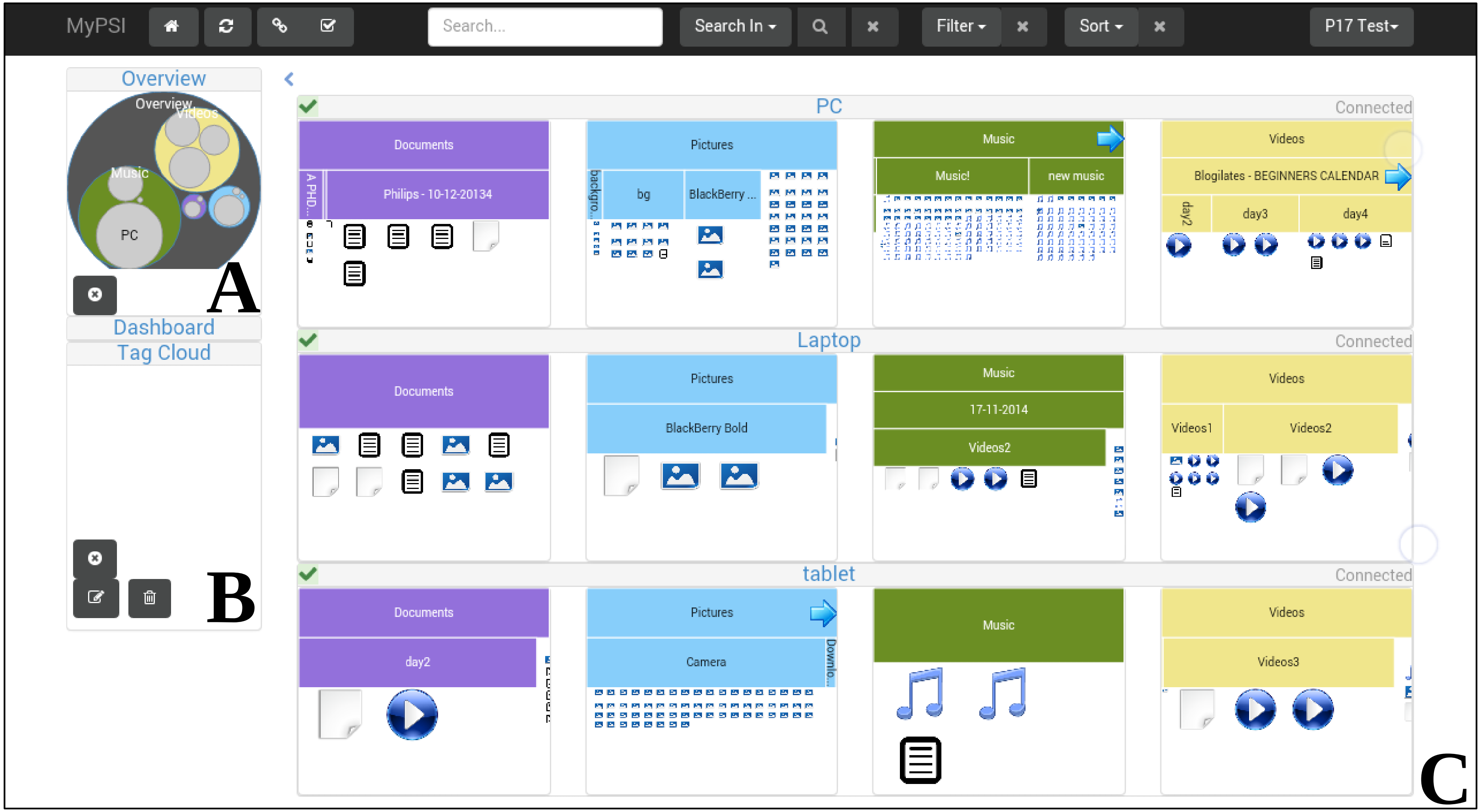


Figure 7-3 MyPSI User Interface on the Tablet Device

The UI of the tablet version of the MyPSI prototype is displayed in Figure 7-3. The screen design display is similar to the desktop version. The *Overview* is displayed in the collapsible sidebar on the left of the screen (Figure 7-3A), the *Tag Cloud* is shown in the same sidebar on the bottom left of the screen (Figure 7-3B) and the *Partition Layout* makes up the remainder of the screen (Figure 7-3C).

The icons indicating whether a device is connected or not were not removed, but no functionality was attached to these icons as the devices are simulated using the Dropbox folders. Additionally, if a user has less than four devices, only these devices will be displayed on the screen and will use up the entire available screen space. The popup information window was reduced in size to reduce the amount of information that is covered when viewing a file or folder's information using this window, as shown in Figure 7-4.

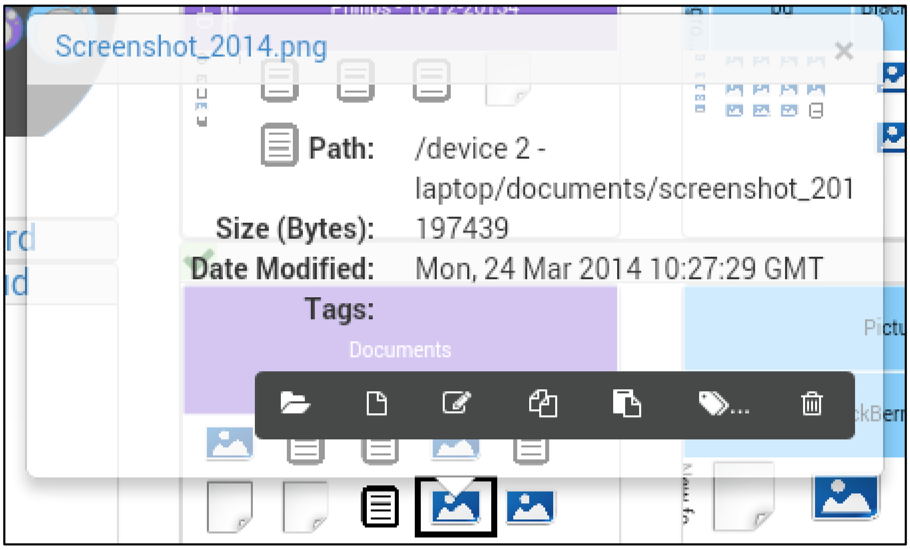


Figure 7-4 Popup Information Window on the Tablet Device

An improvement implemented after the preliminary user study involved desaturating the PI items that are not part of the search or filter results so that the results are clearer. Figure 7-5 shows an example of the updated search results.

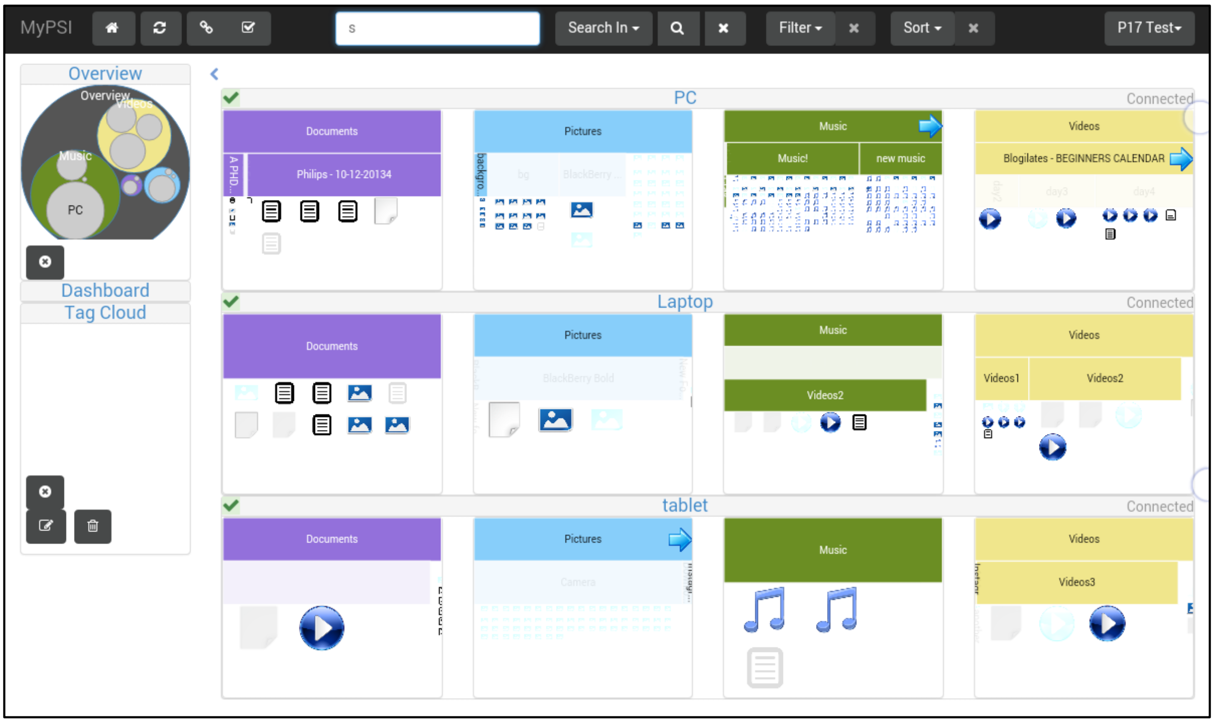


Figure 7-5 Updated Search / Filter Results

Highlighting was added to each PI item, when hovered over, for the desktop version with the mouse, or selected (clicked or tapped), on either device. This will assist the user to identify what item was focussed on or selected. An example of highlighting can be seen in Figure 7-6.

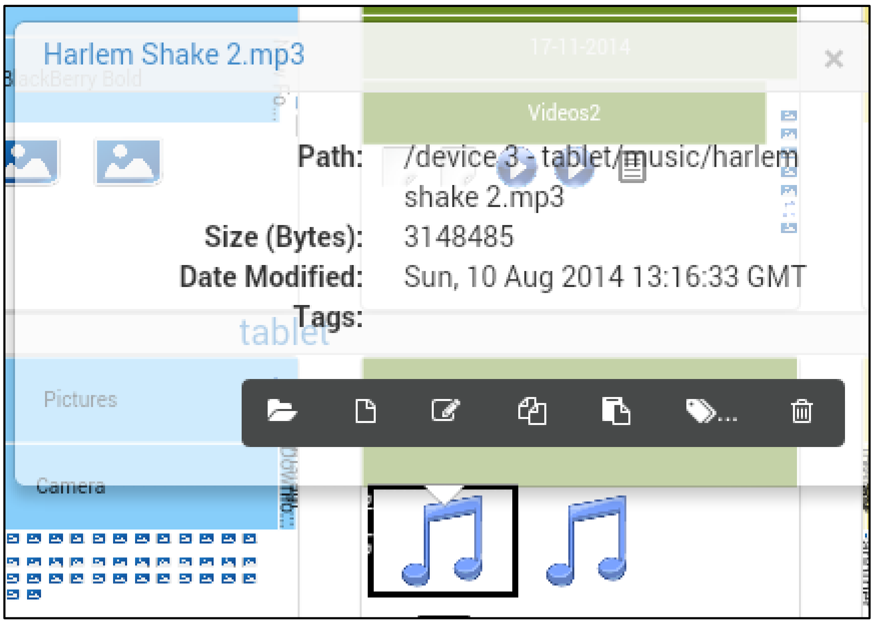


Figure 7-6 Highlighting of a PI Item in MyPSI

The library for the multi-select functionality when adding or editing tags was also modified. The Select2 plugin used to support the multi-select functionality no longer worked properly post-evaluation and so a different JavaScript library, Selectize.js (Reavis, 2013), was used to provide this functionality. The problem regarding the lack of smoothness of the transitions when browsing hidden folders, identified in Section 6.4, was also addressed.

7.4. Discussion

As shown in Figure 7-3, the design of the desktop version of the MyPSI prototype could be successfully mapped onto the tablet version. The tablet version of MyPSI resulted in a similar look and feel as the desktop version. All the functionality outlined in Section 5.2.3 was supported in the tablet version. The tablet version also included the improvements and modifications discussed in the previous section. No major issues were encountered in the process of transferring the desktop version of the MyPSI prototype to the tablet version.

PhoneGap provided a simple means of mapping the code behind the desktop version of the MyPSI prototype to the tablet version. Only minor changes needed to be included in the tablet version to allow the application to run on the device. Initially, it was decided to convert the desktop version of the MyPSI prototype to a Windows application. This conversion could not be successfully completed as Windows applications do not support the jQuery library, and even though a custom jQuery library was found that supported Windows, major issues within the library resulted in remaining with the original desktop version in terms of a web application. The mapping to an Android application, however, was a simple process. The main problem experienced with PhoneGap was the slow response time within PhoneGap applications on mobile devices. The MyPSI tablet version was tested against the functionality outlined in Section 5.2.3, and no obvious delays were experienced. Currently, PhoneGap provides a 300ms delay on selection, which is thought to provide a user the chance to either only provide a single selection, or a selection on double tap (similar to a double-click). A JavaScript library, FastClick (FT Labs, 2012), exists where this delay can be removed, but the double tap capability was then unavailable. Another problem was identified upon introducing the FastClick library, namely that the pinch zooming used for semantic zooming, where two fingers are used to zoom in or out of a PI collection, became unresponsive. Thus, this library had to be removed from the application as the semantic zooming functionality was a key capability in the MyPSI prototype and was already supported by the desktop version of the prototype. Additionally, PhoneGap applications use a *WebView* component for the tablet version, as discussed in Section 7.3.1, which requires an *inappbrowser* plugin to be added, otherwise the application will not work. Thus, Android guidelines could not be followed and the application does not look and feel like a native application, although both the desktop and tablet versions look similar. Lastly, it was difficult to trace implementation errors as PhoneGap provides a more primitive way of error checking, i.e. by means of logging into a console application.

No major issues were experienced in combining D_3 and PhoneGap and no major changes were required to support D_3 within a tablet application. The functions that related to click events of a mouse in the desktop version were initially changed to support *touchstart* and *touchend* events for touch interaction. This modification worked sufficiently, but the same problems were experienced as the incorporation of the FastClick library, and so the touch events were changed to the original click events. These click events transformed into touch events well.

There were also a small number of issues experienced in incorporating Dropbox within a PhoneGap application. The OAuth authentication of Dropbox worked well within the desktop and tablet versions. One problem that would possibly impact the future evaluation of such a tablet application was the problems experienced when polling for changes and pulling those changes. During testing, the *pullChanges* method would not call all of the data stored in Dropbox, even though the count of the data items was less than the method's limit. Polling for changes returned a positive result in the sense that there were items still to be pulled, but it was difficult to retrieve these items. Other issues of Dropbox, not limited to PhoneGap, related to a missing file property, namely date created, that was required, so this was removed from both versions of the prototype, and the date accessed property was used anywhere that required the date created property. Tags are also not stored for files in Dropbox and so a separate text file was kept to store tags for each file. Lastly, only a preview of contents could be provided for plain text files, i.e. with mimeType text/plain.

7.5. Conclusion

Following the preliminary user study of the desktop version of the MyPSI prototype, it was determined that the selected IV techniques were suitable for PIM across multiple devices. No major issues were identified with the desktop version of the prototype. As the aim of this research was to support accessing PI across multiple devices, this chapter discussed the design and implementation of the MyPSI prototype on a mobile device, addressing the sixth research question (RQ 6), namely *"How can enhanced IV techniques be designed to support access to PI across multiple devices on a mobile device?"*

The sample PSI was replaced in order to enable "testing in the wild", where a user makes use of MyPSI to visualise and manage his/her own PSI in his/her own environment. A cloud storage system was used to enable the user to upload his/her PSI to be visualised by MyPSI. This chapter described the second step in the development process discussed in Section 5.2.2, with a similar design rationale. Tablet devices are gaining popularity among general and business users, provide a larger screen space and are not as constrained as a mobile phone. Therefore a tablet device was selected as the mobile device on which the prototype would be implemented. Android has recently become the top operating system, and was therefore selected as the most suitable operating system to support a tablet application. The same functionality and IV techniques were supported by the tablet version of the MyPSI prototype.

The tablet version of the MyPSI prototype could not be implemented as a native mobile application, as the tablet application needed to be supported by the D_3 JavaScript visualisation library. A middleware framework was required to implement the tablet version of the MyPSI prototype. Several frameworks, including PhoneGap, Xamarin and Appcelerator Titanium, were reviewed and PhoneGap was selected as the most suitable framework to map the desktop version of the MyPSI to the tablet version. A cloud storage API needed to be selected to provide a back-end to both versions of the prototype. The Dropbox API, Google Drive API and the OneDrive API were reviewed using several criteria. The OneDrive API has not yet been fully developed for the required functionality and problems were experienced with the Google Drive API within the PhoneGap application with regards to authentication. The Dropbox API was thus selected as the most suitable cloud storage API to use with the MyPSI prototype as it was the most developed and provided the most support for the required aspects. The PhoneGap mapping provided the same look and feel on the tablet version as the desktop version, with the addition of support for touch interaction. While some problems were experienced with D_3, Dropbox and PhoneGap, the tablet version of the prototype was successfully implemented. The next chapter will discuss a field study, which was used to evaluate the effectiveness of the enhanced IV techniques incorporated in the MyPSI prototype on both the desktop and tablet versions of the prototype.

Chapter 8: Combined Field Study

8.1. Introduction

Following the design, implementation and evaluation of the MyPSI prototype on a desktop device in Chapters 5 and 6, the design and implementation of the tablet version of the MyPSI prototype was discussed in Chapter 7. A limitation of the evaluation of the desktop version of the MyPSI prototype was that a controlled study was used as the evaluation method. Thus, a field study was required to evaluate the MyPSI prototype "in the wild" to determine the effectiveness of the information visualisation (IV) techniques incorporated in MyPSI across multiple devices (Shneiderman and Plaisant, 2006), specifically focussing on both the desktop and tablet versions of the prototype (see Appendix B for Research Ethics Approval). This chapter addresses the seventh research question, RQ 7, namely *"How effective are these IV techniques in supporting access to PI across multiple devices in a real environment using a desktop and a mobile device?"* This research question was addressed in the second iteration of the *Design and Develop Artefact, Demonstrate Artefact* and *Evaluate Artefact* design science research activities.

A field study was used to evaluate the MyPSI prototype on both desktop and tablet devices and serves as a more in-depth evaluation method in comparison to the preliminary user study (Chapter 6). This chapter is structured similarly to Chapter 6, where the next section describes the evaluation method in detail including discussions on the aim of the field study, participants involved, evaluation metrics captured, tasks required and the evaluation procedure. Section 8.3 discusses the results of the field study comparing the results of the desktop and tablet versions of the MyPSI prototype. A discussion section then follows identifying to what extent the development tools supported the implementation of the prototype on multiple devices and improvements to be made.

8.2. Evaluation Method

A field study (see Appendix B for Research Ethics Approval) was used to evaluate the effectiveness of the IV techniques incorporated in the MyPSI prototype across multiple devices, specifically desktop and tablet devices. The field study followed a specific approach designed for evaluating IV techniques and tools. Metrics captured for the field study included effectiveness (logging), satisfaction, errors and qualitative comments. The field study used a within-subjects design similar to the preliminary user study (Chapter 6). While 20 participants agreed to participate in the field study, only 13 participants completed the evaluation.

8.2.1. Approach

IV evaluation provides various challenges (Riche, 2010), but there is a need for alternative evaluation methods (Shneiderman and Plaisant, 2006). Although controlled experiments, such as usability evaluations, are useful for identifying usability problems, these experiments do not support evaluating the effectiveness of data exploration and are also not specifically focussed on IV evaluation (Riche, 2010; Shneiderman and Plaisant, 2006). Eye tracking is commonly used to support these usability evaluations especially for providing a better understanding of exploration approaches (Goldberg and Helfman, 2010), but the evaluations are still controlled.

Various methods have been developed and/or applied for the specific purpose of evaluating IV techniques and tools. These methods include grounded theory and/or evaluation, focus groups, crowdsourcing and a customised case study approach.

8.2.1.1. Grounded Theory / Evaluation

Grounded evaluation makes use of qualitative analysis to make sure that the actual, further evaluation of IV techniques and tools considers the intended use of these IV techniques and tools (Isenberg *et al.*, 2008). The process of this evaluation method includes understanding the context of the intended use of the proposed IV techniques and tools in terms of data, tasks, current techniques used and the process of its use, and then deriving the initial design, identifying which interim evaluation methods would be appropriate and identifying evaluation criteria from this. This evaluation method is used to develop theory based on subjective experiences from users and is user-centred (Faisal *et al.*, 2008). Grounded evaluations are targeted towards the early stages of development of IV techniques and tools (Isenberg *et al.*, 2008). Thus, at this stage of this research, an alternative and more suitable evaluation approach is needed.

8.2.1.2. Focus Groups

Focus group evaluations are used to gather qualitative data and identify unexpected problems (Mazza and Berre, 2007). Focus group interviews are conducted by a facilitator, making use of open-ended questions, with a group of users whereby the users identify any concerns about the IV tool. The facilitator provides questions to the users relating to the usefulness of the system and cognitive tasks. Advantages of focus groups include the possibility of simultaneously capturing a number of user perspectives and therefore users can feed off other users' comments and ideas. A shortcoming of this evaluation method is that the users do not actually interact with the IV techniques and tools themselves, and thus may not be able to identify problems and features that they would not be able to identify without interacting with the actual system (Kinnaird and Romero, 2010).

8.2.1.3. Crowdsourcing

A recent development in IV evaluation involves crowdsourcing (Heer, 2010). Crowdsourcing provides an alternative lightweight approach to IV evaluation, where participants are gathered online to complete small tasks with an IV technique or tool. Potential crowdsourcing advantages have been identified for evaluating IV techniques and tools, including reducing evaluation costs and conducting more practical evaluations. Unfortunately, this evaluation method suffers from a number of challenges and shortcomings, such as the unreliability of participants and results, and crowdsourcing has not yet been widely applied in the IV field. Additionally, specific to this field study, the mobile application needed to be installed on each tablet device, thus crowdsourcing for the tablet version was not possible.

8.2.1.4. Multi-dimensional In-depth Long-term Case Studies Approach

The Multi-dimensional In-depth Long-term Case Studies (MILC) approach makes use of observations, interviews, questionnaires and system logging to evaluate performance and user interface (UI) efficiency and utility (Shneiderman and Plaisant, 2006). This evaluation method focusses on using case studies to gather detailed results from a few users making use of their own data with an IV technique or tool within their own environment, i.e. "in the wild", over an extended period of time. The MILC approach follows an ethnographical approach whereby IV designers collaborate with expert users to analyse the expert's own data over a period of time (Riche, 2010).

From the above evaluation methods, it can be concluded that the MILC evaluation approach provides the closest evaluation method to the requirement of evaluating "in the wild" in terms of a field study. Additionally, the literature that exists relating to the MILC evaluation approach is extensively detailed and can be easily applied and replicated within this research. Although the qualitative evaluation methods such as the MILC and grounded evaluation suffer from limitations such as the time required to capture and analyse data, bias possibly introduced by the observer and the difficulty in reproducing and generalising results (Riche, 2010), these limitations can be addressed so that they are avoided.

8.2.2. Aims and Objectives

The aim of the field study was to determine the usefulness of the IV techniques incorporated in the MyPSI prototype in supporting access to personal information (PI) across multiple devices, specifically on desktop and tablet devices, over a two-week period, due to time constraints. The field study was also used to analyse subjective experiences when using the MyPSI prototype.

8.2.3. Participants

Each participant of the field study completed an electronic biographical questionnaire similar to the preliminary user study (Appendix D). The requirements of participants for the field study included that the participants needed to currently be managing PI across at least two devices. Additionally, each participant was required to be available for one of the available two-week periods.

The field study was conducted with students and staff from the Department of Computing Sciences and the School of Information Communication and Technology (ICT) at the Nelson Mandela Metropolitan University (NMMU). Initially, 20 participants agreed to participate in the field study, although only 13 participants completed the entire field study. Table 8-1 outlines the distribution of the participants in terms of completion.

Table 8-1 Distribution of Participants in Terms of Completion

	Number of Participants
Completed	13
Started but did not finish	3
Did not start	4
Total	**20**

Three participants commenced the evaluation and participated in the first few days of the field study, but two participants withdrew from the study due to work commitments. One participant withdrew from the field study after completing the evaluation for the desktop device as s/he perceived that the MyPSI prototype contained several usability problems and thus did not wish to continue. Upon inspection, it was determined that this participant did not view any of the video tutorials beforehand and so did not know what the proposed interaction was for each function within the prototype. Four participants completed the informed consent form as well as the biographical questionnaire, but did not complete any of the tasks or log book diaries and then subsequently withdrew from the study.

Participants were in the age range of 21-49 years of age. Most participants (10) had at least 10 years computing experience, while three participants had 6-9 years computing experience. Figure 8-1 shows that most participants (9) managed their PI daily, where the remaining participants (4) managed their PI weekly using a digital device.

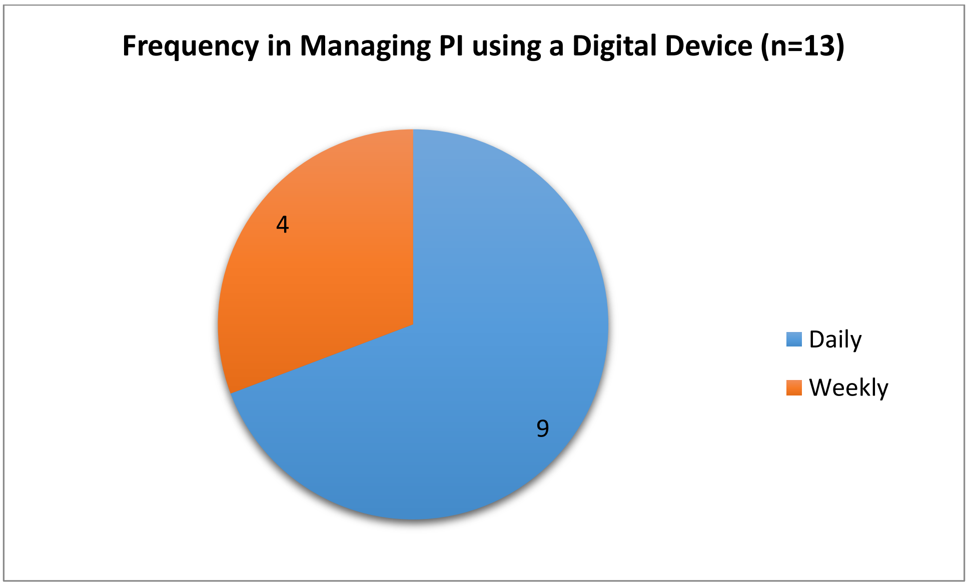
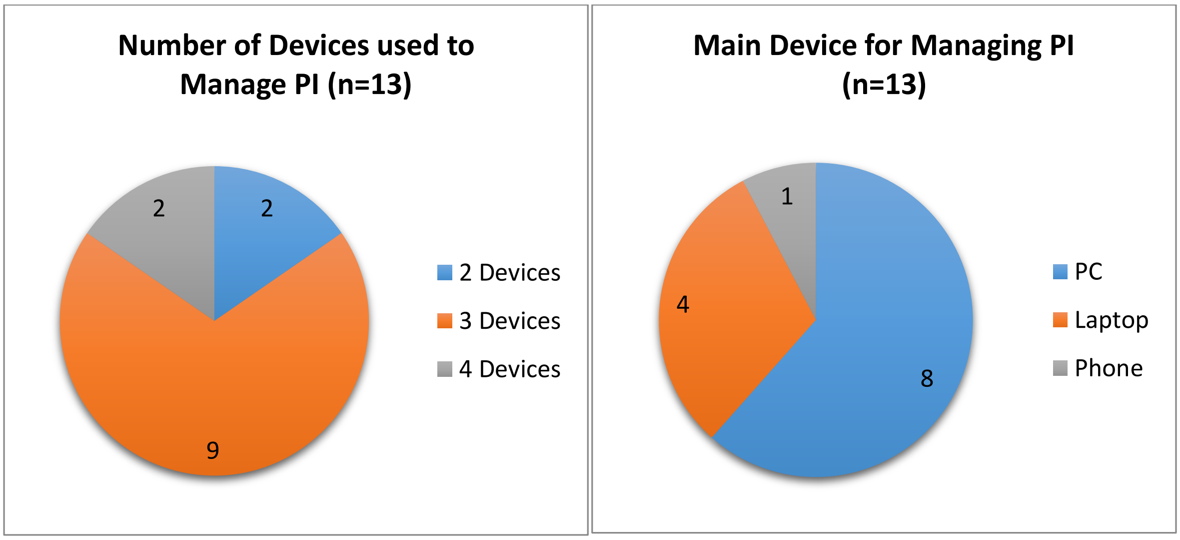


Figure 8-1 Frequency in Managing PI Using a Digital Device (n=13)

Figure 8-2 depicts the number of devices each participant use to manage PI as well as which device each participant considers as their main device to manage PI. Nine participants use four devices to manage their PI, while two participants manage their PI across three devices and the remaining two participants use two devices to manage their PI (Figure 8-2a). Most participants (8) consider their desktop personal computer (PC) as their main device to manage PI, while the remaining participants consider their laptop (4) and mobile phone (1) as their main device (Figure 8-2b).



(a) **(b)**

Figure 8-2 (a) The Number of Devices used to Manage PI and (b) the Main Device for Managing PI

8.2.4. Evaluation Metrics

The MILC approach makes use of various means to capture data within an evaluation. These means include participant observation, interviews, surveys and system logging. This field study, following the MILC approach, used system logging, participant logging and questionnaires to capture various types of data. IV techniques and tools are focussed on data exploration, thus user performance in terms of efficiency was excluded from the field study. The following metrics and associated data capture methods were used for the field study:

a) Effectiveness – Log Book Diaries and System Logging
b) User Satisfaction – Questionnaires
c) Qualitative comments – Log Book Diaries & Questionnaires

System logging was identified as one of the key methods for capturing data using the MILC approach (Shneiderman and Plaisant, 2006). System logging is useful to determine user behaviour and exploration (Pohl, Wiltner and Miksch, 2010). Logging was used to identify errors within the interaction and whether participants were able to complete their tasks.

Participant observation may be considered an intrusive evaluation method especially when participants are managing PI (Brehmer *et al.*, 2014). Thus, alternative methods, such as log books and system logging, can be used to address this issue. One of the guidelines of the MILC approach is to provide a log book to participants for identifying problems and insights as well as general comments. After completing each task, a participant was required to complete a log book diary in the form of an electronic questionnaire, which was the same for each day of the field study as well as for each device evaluation. The log book diary used the After-Scenario Questionnaire (ASQ) (Lewis, 1995), with the addition of the participant number for administration and capturing purposes as well as an open-ended section for general comments.

Forsell and Cooper (2012) proposed the idea of creating standard questionnaires for IV and noted that more focus needs to be placed on subjective measures for evaluating IV techniques and tools. At the time of the commencement of the field study, no questionnaires could be found specifically for IV evaluation. Thus, user satisfaction and qualitative comments were captured using a similar post-test questionnaire to the preliminary user study (Section 6.2.3). A post-test questionnaire was provided for both the desktop and tablet devices. The post-test questionnaire used the NASA-TLX form (Hart and Staveland, 1988) to measure cognitive load and the Computer Satisfaction Usability Questionnaire (CSUQ) (Lewis, 1995) to capture overall satisfaction, usability and general comments. The same questions were used for each IV technique incorporated in the MyPSI prototype as in the preliminary user study (Section 6.2.3). These questionnaires used 5-point Likert scales for simplification purposes in order to make it easier and simpler for participants to complete the questionnaires. An additional question was added to the post-test questionnaires for the field study, i.e. *Would you consider using this system in future?*

All questions included in the electronic log book diaries and the post-test questionnaires used a 5-point Likert scale. Descriptive statistics, including the mean and median, were calculated for each question. Each value of the 5-point Liker scale had an associated meaning, i.e. 1: Strongly Disagree, 2: Disagree, 3: Neutral, 4: Agree and 5: Strongly Agree. Thus, a mean rating with a value of greater than 3.4 indicated that the respective result was strongly positive, i.e. equivalent to either a four or five rating in the Likert scale.

8.2.5. Tasks

Several main functions were identified in Section 5.2.3. Similar tasks were identified for the field study as the preliminary user study derived from Section 5.2.3, with the addition of linking functionality. These high-level tasks were mapped directly from the required functionality and included the following:

- Data manipulation;
- Semantic Zooming;
- Sorting;

- Intelligent Browsing;
- Intelligent Searching;
- Filtering;
- Tagging;
- Linking.

It needed to be determined whether a predefined set of tasks should be provided in the field study versus allowing users to explore. According to Stone *et al.* (2005), there exists various levels to controlling the participants' tasks. These levels of control include ensuring each task is predefined by the facilitator, participants can comment on suggested tasks and participants can add additional tasks, participants are offered a choice between predefined tasks and their own tasks, and participants are required to suggest their own tasks. Allowing participants to create their own tasks restricts the evaluation in not being able to compare results from different participants and thus ventures into an explorative domain. Providing a predefined set of tasks to the participants may allow increased control and ensure that participants evaluate each aspect, but there is little room to explore with the system and thus it is too restrictive. Offering participants a choice between task lists also makes it difficult to compare results between participants. Thus, the alternative and most appropriate level of task control was to provide participants with a task list and encourage participants to further explore the prototype, as the functions of the MyPSI prototype are well-defined. Additionally, this control level is the most balanced, as it ensures that each aspect of the prototype is evaluated and comparison is possible between participants.

Similar tasks were identified for the desktop and tablet versions of the MyPSI prototype. The tasks were kept direct, but as vague as possible, as the structure of each participant's data was unknown and so the tasks were described such that each participant could complete the tasks with their own data. The main tasks were included at least twice within an evaluation on a device, to ensure that the participant was not influenced by unfamiliarity. Each main task included sub-tasks, which required participants to use the appropriate IV techniques to complete the tasks.

Table 8-2 Main Task Groupings per Day for both the Desktop and Tablet Devices

	Main Functions
Day 1	Data Manipulation Semantic Zooming
Day 2	Browsing Sorting
Day 3	Searching Filtering
Day 4	Tagging Linking

The grouping of the main tasks is shown in Table 8-2. The detailed task list for each day of the field study is provided in Appendix H.

8.2.6. Equipment

All participants had access to a desktop or laptop computer with which to complete the tasks relating to the desktop version of the MyPSI prototype in the first week of the field study. Two participants used their own tablet devices to complete the tasks in the second week of the field study, one used an older Android tablet device and the second participant used a Samsung Galaxy Tab 4. The remaining participants used loaned tablet devices. Two of these devices were Samsung Galaxy Tab 4 tablets and the rest were older tablets, specifically Samsung Galaxy Tab 2 devices.

8.2.7. Procedure

An email, detailing the procedure of the field study, was sent out to potential participants requesting their participation in the study. The field study consisted of two subsequent two-week periods (Monday – Thursday). As soon as participants agreed to participate in the field study, they were sent their specific participant information, including an assigned participant number to be used throughout the field study for reference and to ensure confidentiality and anonymity within the results. The participants were required to consent to participate in the study by completing an electronic consent form (Appendix G). The participants were also requested to complete a biographical questionnaire similar to the preliminary user study (Appendix D). Each participant was forwarded an instruction manual on how to sign in and upload his/her PI to Dropbox prior to commencing the field study tasks. A requirement of the MILC evaluation approach was to provide training on the MyPSI prototype to each participant (Shneiderman and Plaisant, 2006). To maintain as unobtrusive a field study as possible, video tutorials were created relating to each day of the field study. The first day of the field study additionally included video tutorials relating to the sign in process and describing the UI of the MyPSI prototype. Each day of the field study required participants to view the relevant video tutorials, and then commence the tasks for the day. After the day's tasks were completed, the respective log book was completed. At the end of each week, which represented an evaluation of either the desktop or tablet devices, the link to the electronic post-test questionnaire (Appendixes J and K) for that week was provided to the participants. The desktop version was evaluated first as it was identified as the main device used to manage PI for most participants (Figure 8-2b). Table 8-3 depicts each week and the version of the prototype evaluated in the field study. After the second week of the field study, each participant was thanked for their participation and any loaned tablet devices were returned.

Table 8-3 Field Study Weeks with the Relevant MyPSI Version Evaluated

	MyPSI Version
Week 1	Evaluate the web page using https://www.mypsi.co.za on a desktop or laptop device with mouse-based interaction
Week 2	Evaluate the PhoneGap application on an Android tablet device with touch-based interaction.

8.3. Evaluation Results

The field study results are discussed in terms of effectiveness and satisfaction. The qualitative results captured through the log books as well as the post-test questionnaires conclude the Results section.

8.3.1. Effectiveness Results

The system logging for both the desktop and tablet versions of the MyPSI prototype did not reveal any interesting results. Unfortunately, for some participants, the logging was also not captured correctly, as there currently exists no Append function to add new information to a particular file, thus the method to append to the log file read the file to capture its existing contents, added the new information to the contents and then wrote this content back to the file, overwriting the existing content. Some of the time, the reading function was unreliable and could not retrieve existing content and thus the new information overwrote the file's contents. For those participants whose files were captured correctly, it could be seen that participants only completed the required tasks and did not explore the system further. Additionally, the participants followed similar processes to complete the tasks as the participants closely followed the steps in the video tutorials provided for training.

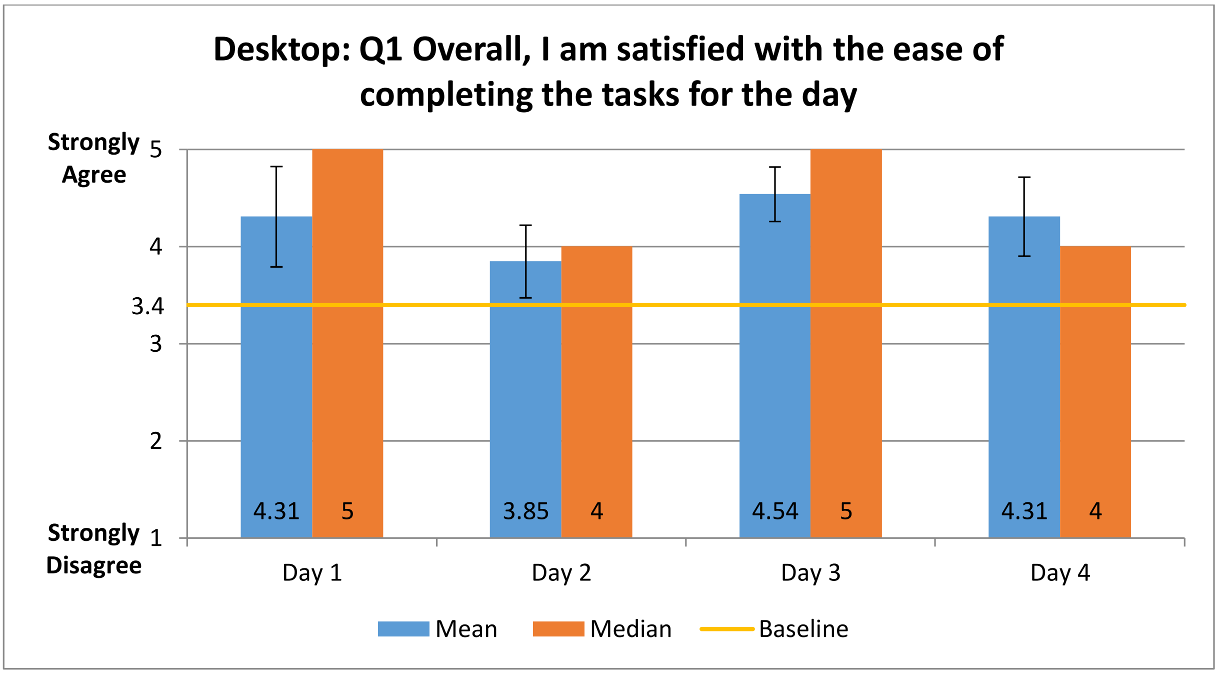
Fortunately, the log book diaries provided detailed information for each set of tasks completed on each day of the field study. All participants fully completed the log book diaries for each day of the field study. The groupings of the high-level tasks are repeated in Table 8-4 for ease of reference within this section.

Table 8-4 Main Task Groupings per Day for both the Desktop and Tablet Devices

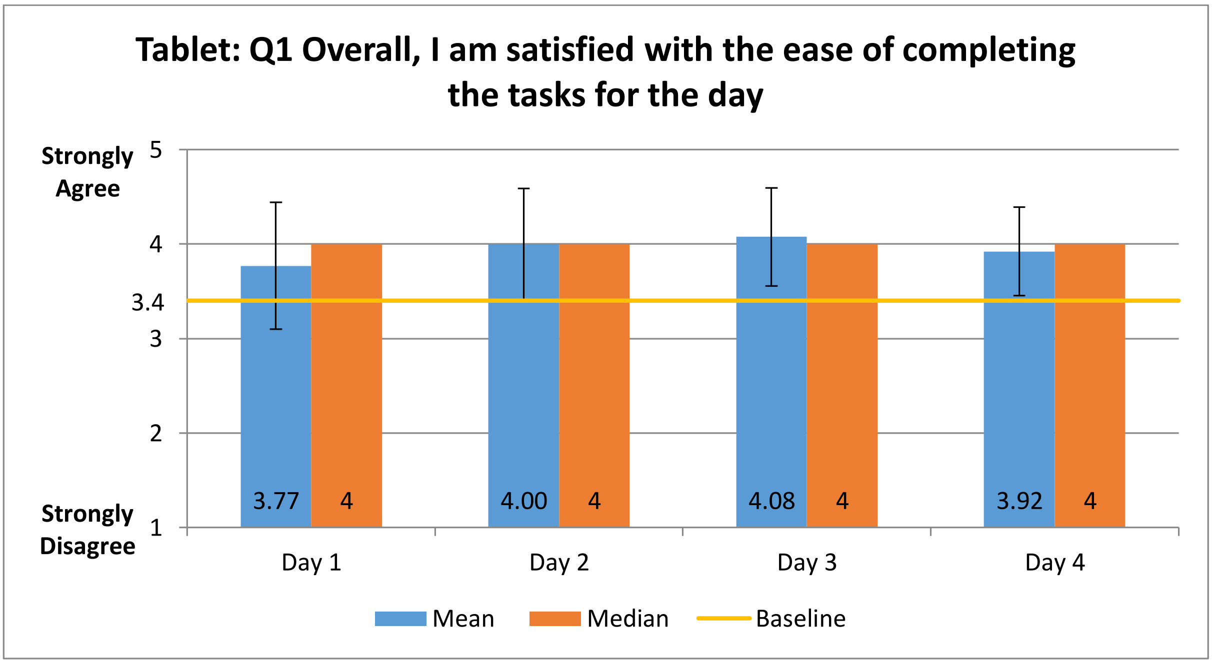
	Main Functions
Day 1	Data Manipulation & Semantic Zooming
Day 2	Browsing & Sorting
Day 3	Searching & Filtering
Day 4	Tagging & Linking

The first question in the log book diaries for both versions of the MyPSI prototype related to the ease of completing the tasks for that day. The mean ratings for the each day of the field study for both the desktop (Week 1) and tablet (Week 2) versions of the MyPSI prototype for the first question of the log book diaries are displayed in Figure 8-3.

The set of tasks for each day of the field study received positive ratings in terms of ease of use (Figure 8-3). From Figures 8-3(a) and (b), it can be seen that the desktop version of the MyPSI prototype was easier to use for data manipulation and zooming, searching and filtering, and tagging and linking. Participants found browsing and sorting slightly easier using the tablet version of the MyPSI prototype (Figure 8-3b).



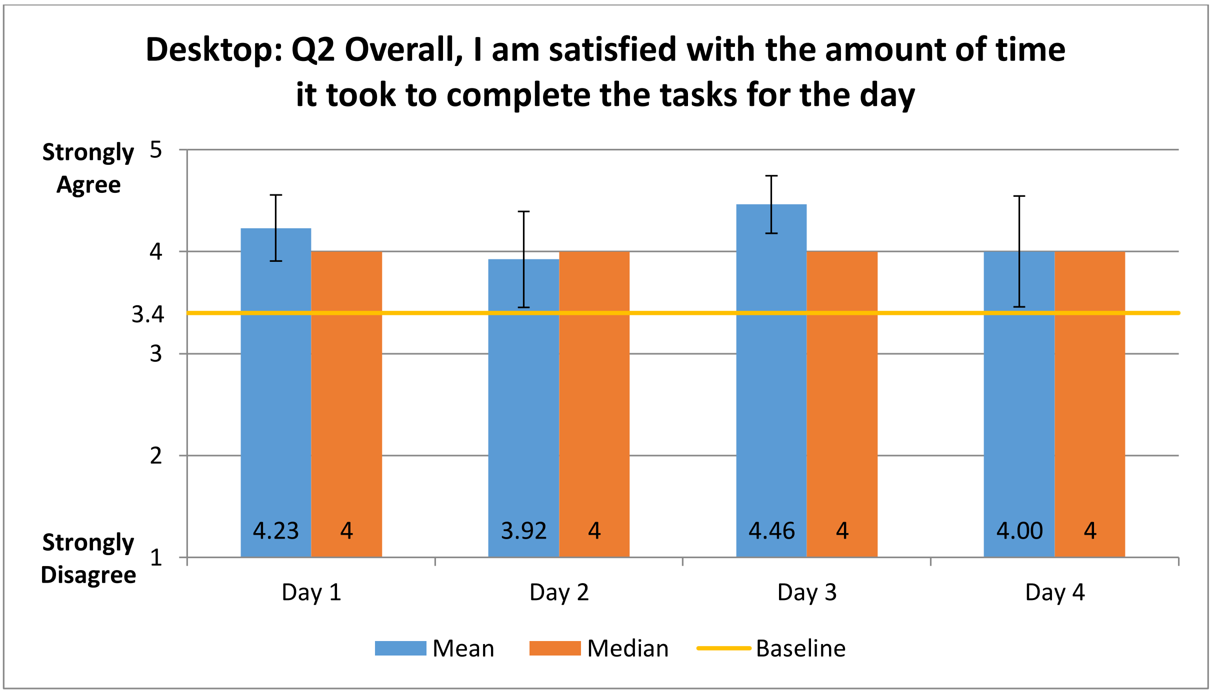
(a)



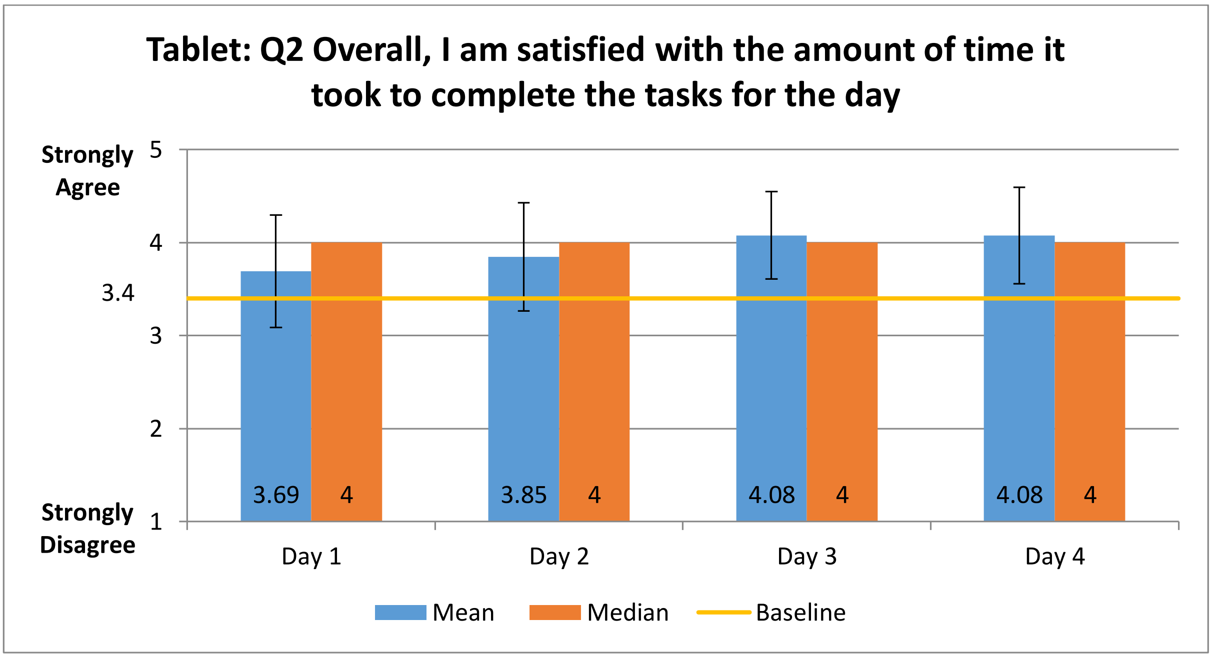
(b)

Figure 8-3 Mean Ratings for the Log Book Diaries for Q1 (n=13)

Figure 8-4 displays the mean ratings for the log book diaries for the second question, which related to the time taken to complete the sets of tasks for each day of the field study. Participants were generally satisfied with the time taken to complete each task on both versions of the prototype. Participants found the desktop version of the MyPSI prototype faster for all the sets of tasks except for tagging and linking, where participants perceived that these tasks were slightly faster on the tablet version of the MyPSI prototype.



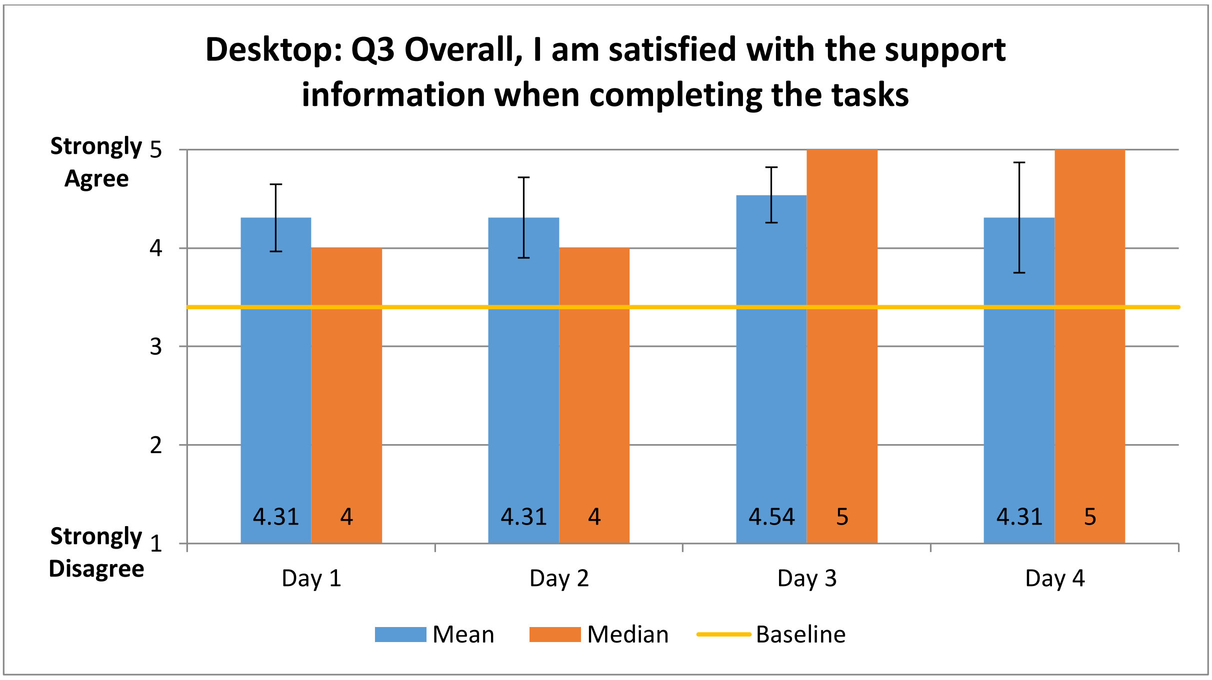
(a)



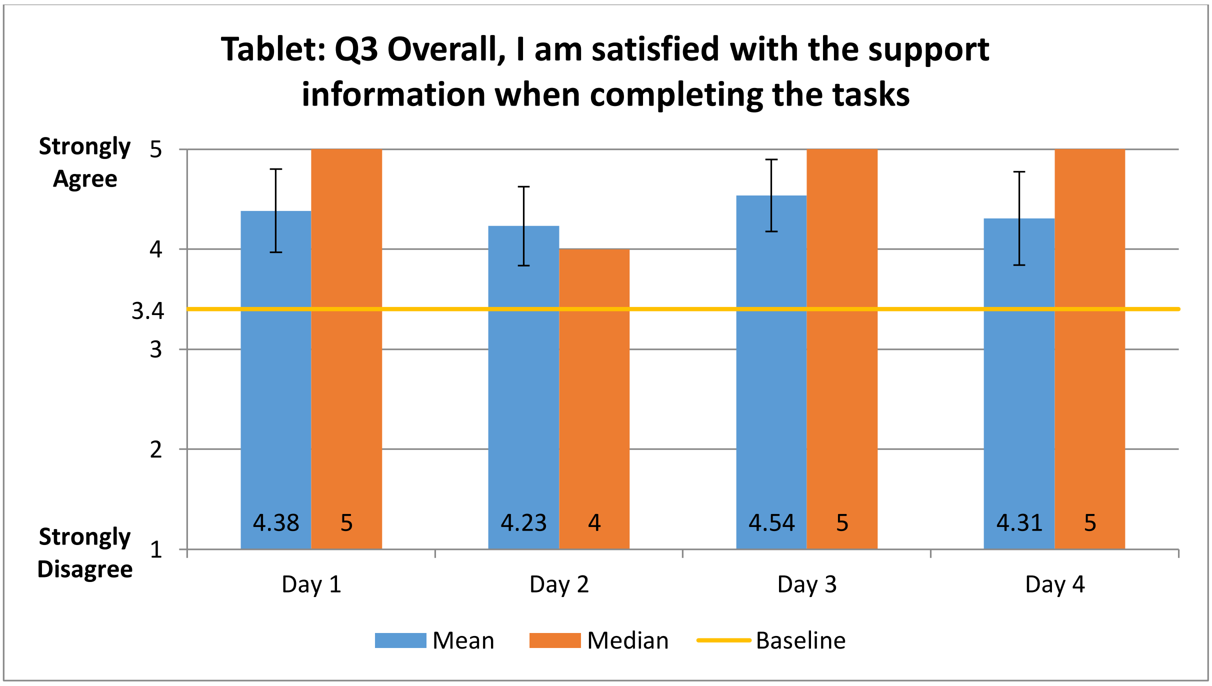
(b)

Figure 8-4 Mean Ratings for the Log Book Diaries for Q2 (n=13)

The third question of the log book diaries related to the support information provided within the MyPSI prototype. Participants were highly satisfied with the support information provided in both versions of the MyPSI prototype (Figure 8-5). The ratings were similar for both the desktop and tablet versions of the prototype for all the tasks of the field study.



(a)



(b)

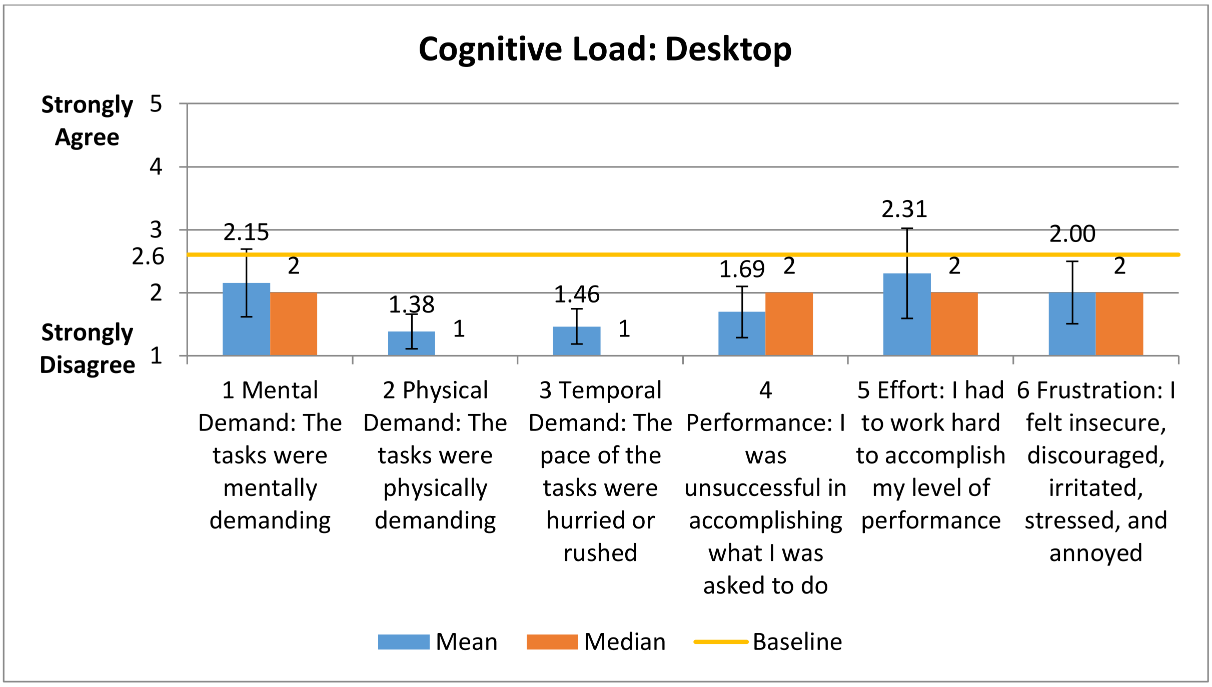
Figure 8-5 Mean Ratings for the Log Book Diaries for Q3 (n=13)

During the field study, no major errors or problems were identified with the MyPSI prototype. Two participants experienced problems in the display of the prototype on the desktop versions, as one device would display twice and the last device would then not display. Upon inspection, it was identified that the name of a device could not include a period, i.e. ".", and the device could not start with a number. Once these naming issues were addressed, all the devices for these participants displayed correctly. One of the participants found it difficult to complete the tagging and linking tasks (the last tasks for the field study) on the tablet and thus rated these tasks lower for Day 4 on the tablet. It was identified that the tablet (Samsung Galaxy Tab 2) provided to the participant was slow and not as responsive as the other tablets used. Other than these two issues, it can be concluded that both versions of the MyPSI prototype were successful in providing effective IV techniques to manage PI across multiple devices.

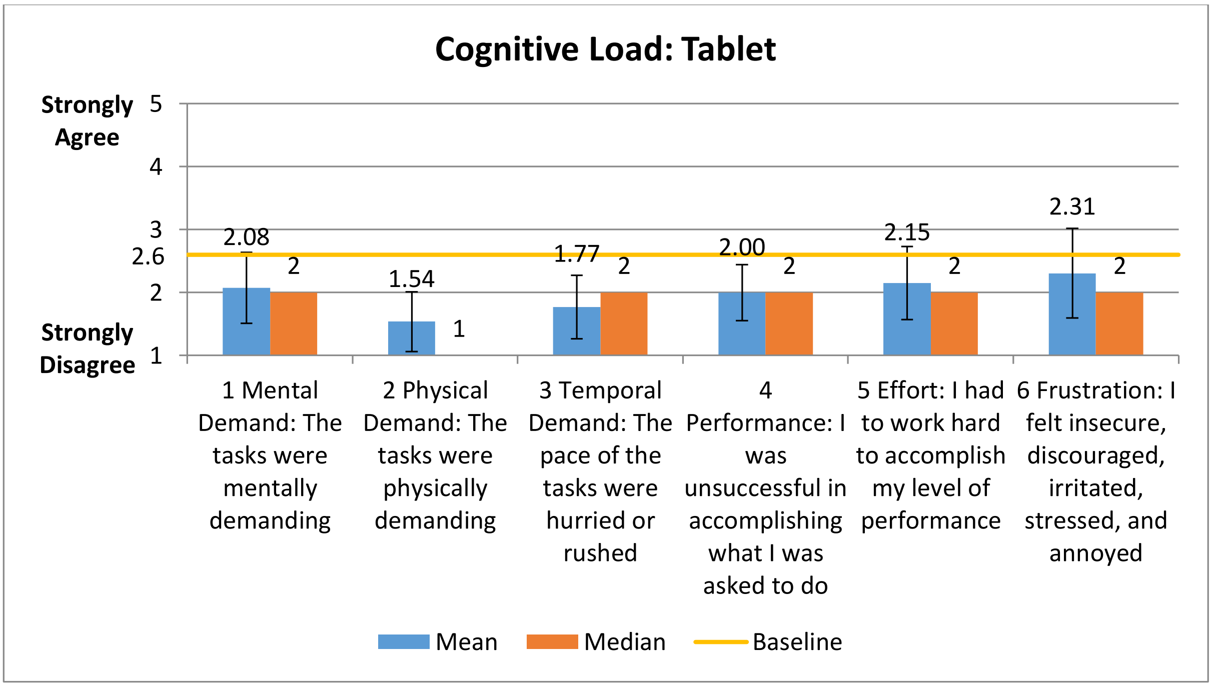
8.3.2. Satisfaction Results

Satisfaction was measured using a combination of the NASA-TLX form for cognitive load and the CSUQ for capturing overall satisfaction, usability and qualitative comments (Section 8.3.3). Sub-sections were added for each IV technique, including the *Overview*, the *Tag Cloud* and the *Partition Layout*.

Figure 8-6 depicts the mean ratings for cognitive load for both the desktop and tablet versions of the MyPSI prototype. All ratings for both versions of the prototype were low. All the mean ratings were smaller than 2.6, i.e. equivalent to either a one or two rating on the Likert scale. Most questions for cognitive load, except for the question relating to frustration, received slightly higher ratings for the tablet as expected. This could be due to participants being familiar with using the desktop and the interaction of the mouse in comparison with the newer method of using a mobile device and touch-based interaction. Some of the participants had never used a tablet before this field study and thus were learning to use the tablet device as well as the MyPSI prototype.



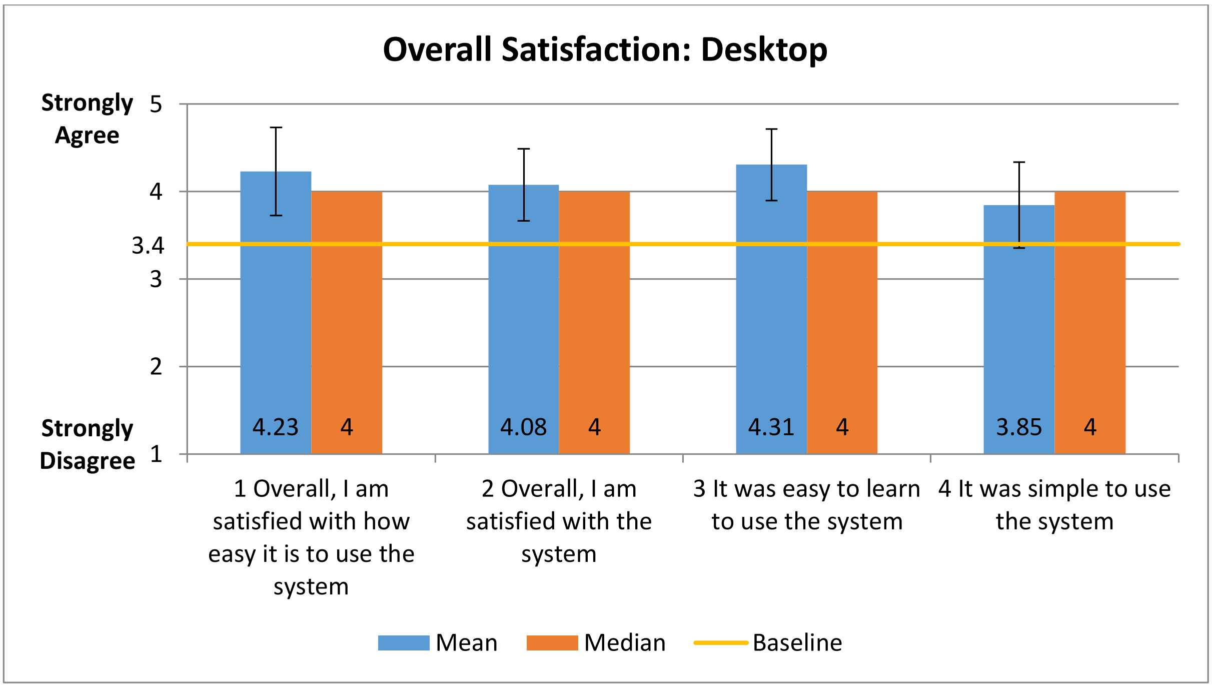
(a)



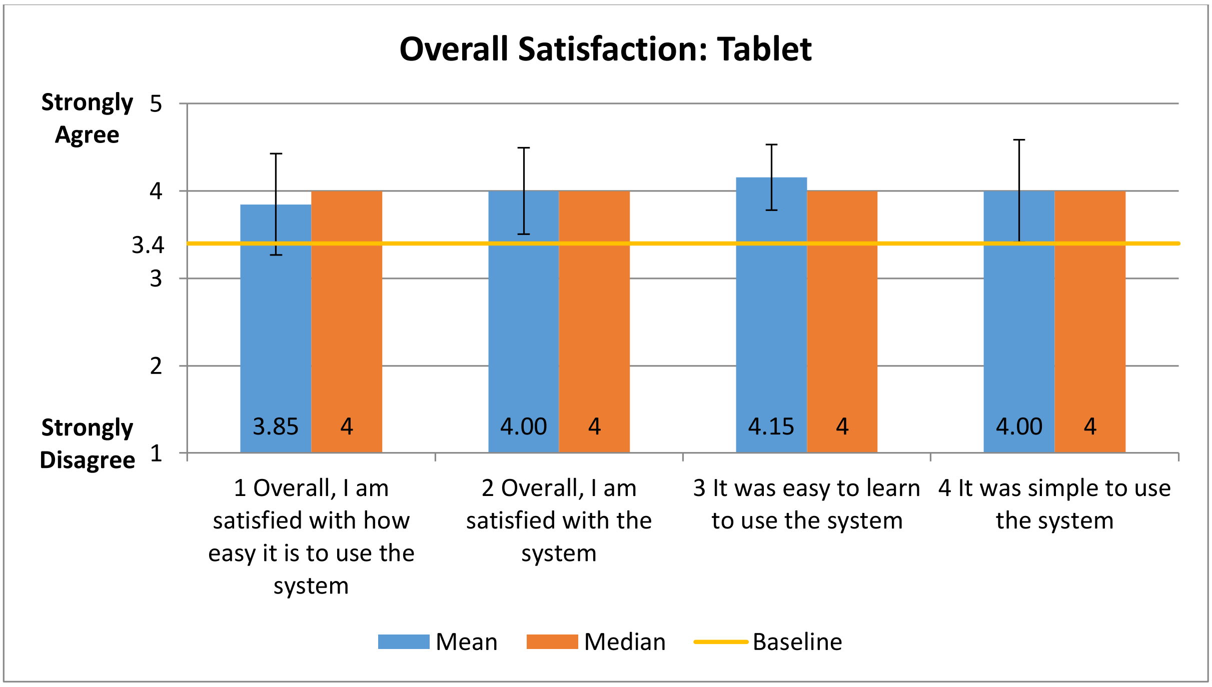
(b)

Figure 8-6 Mean Ratings for Cognitive Load using a 5-point Likert Scale (n=13)

The overall satisfaction ratings for both versions of the MyPSI prototype received positive ratings (Figure 8-7). Participants found the desktop version (Figure 8-7a) of the MyPSI prototype easier to use and learn compared to the tablet version (Figure 8-7b). This was an expected result due to the familiarity issue discussed above. Participants found that the tablet version (Figure 8-7b) of the MyPSI prototype was simple and provided slightly higher ratings for the simplicity aspect of the tablet version than for the desktop version (Figure 8-7a).



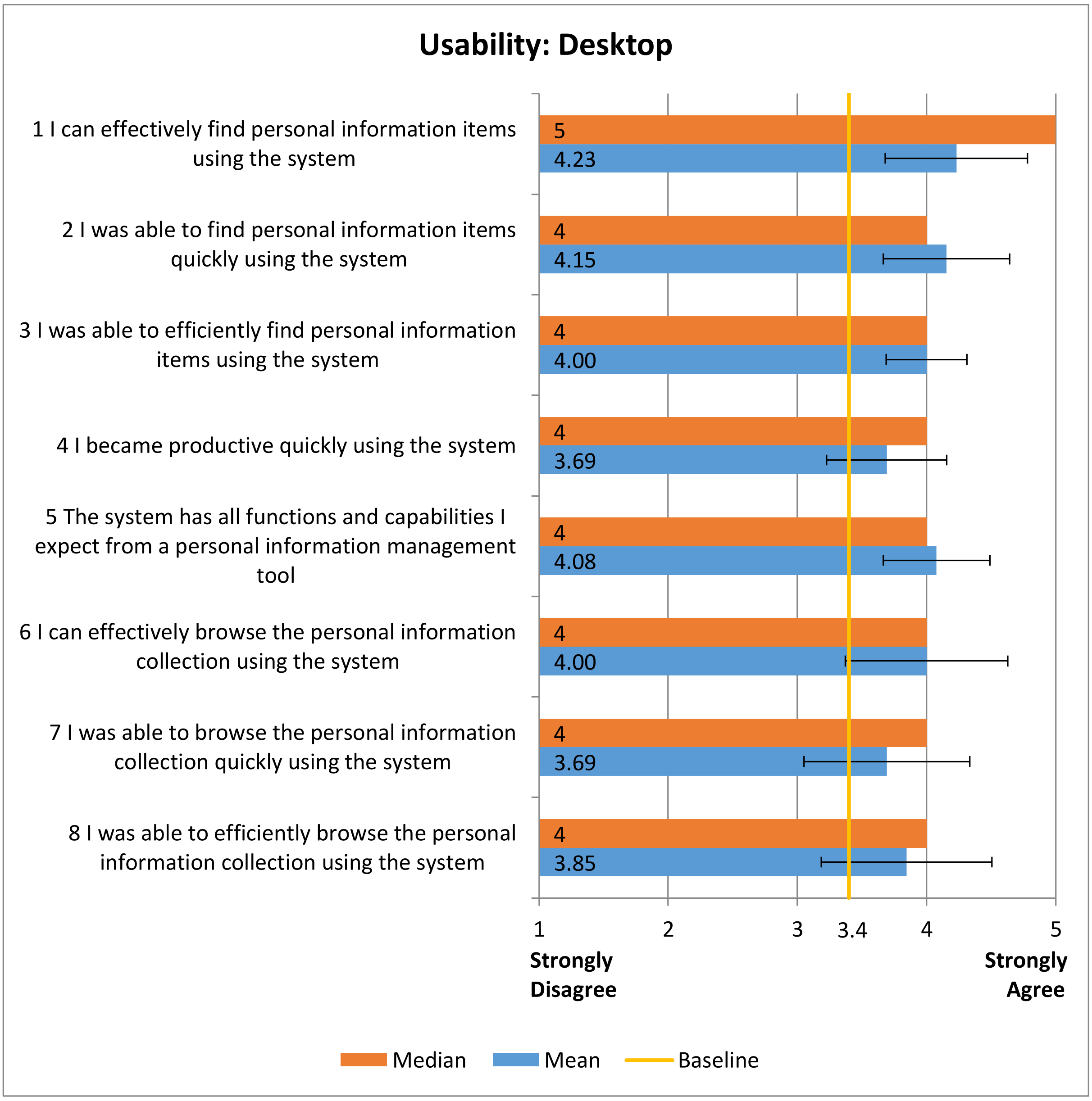
(a)



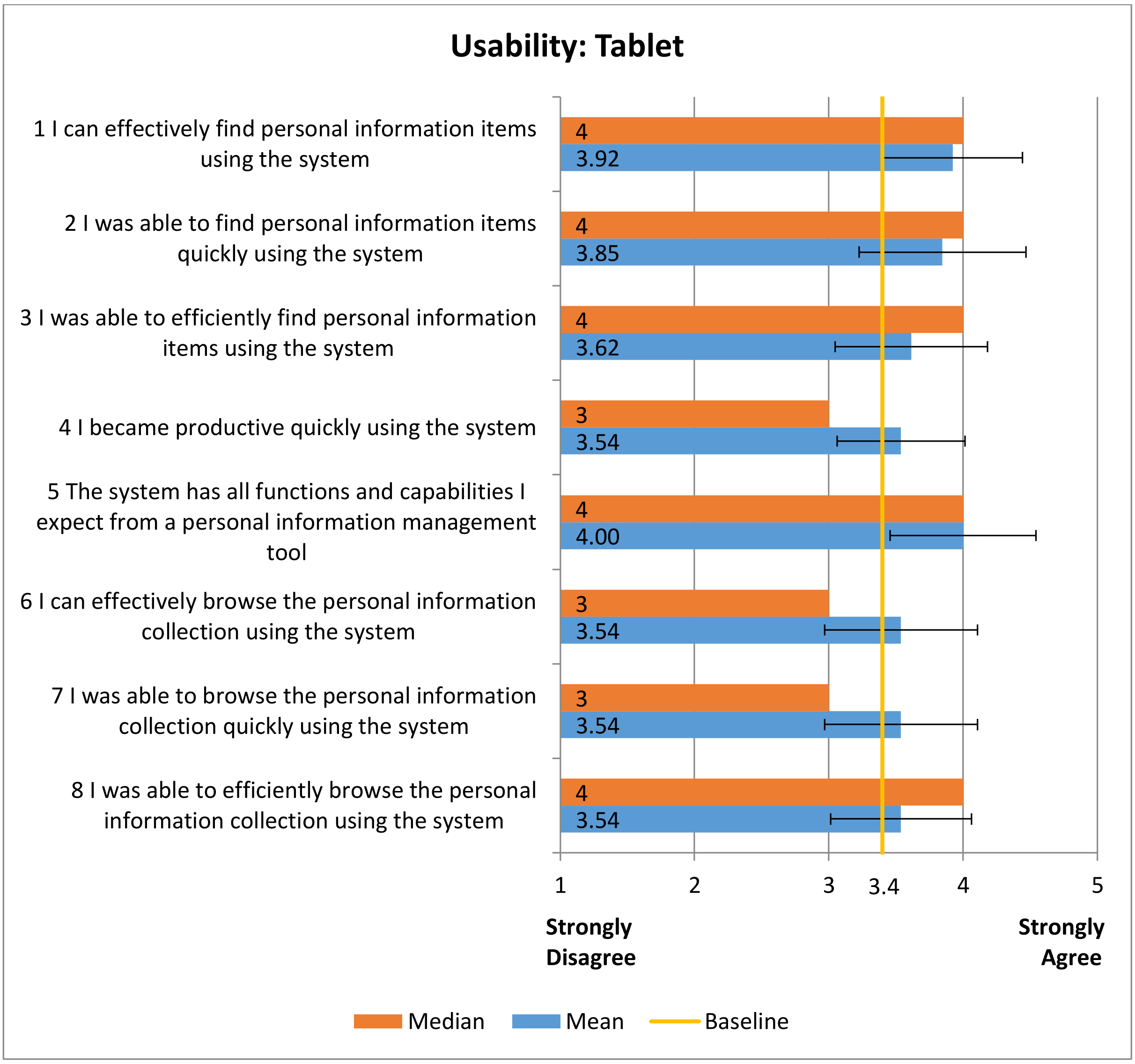
(b)

Figure 8-7 Mean Ratings for Overall Satisfaction using a 5-point Likert Scale (n=13)

The usability ratings for both versions of the MyPSI prototype are displayed in Figure 8-8. The usability ratings for both versions received positive scores. Comparing Figure 8-8a) and b), it can be seen that the desktop version of the MyPSI prototype received higher ratings for all usability questions than the tablet version of the prototype. This could be attributed to the poor responsiveness of the application on some of the tablet devices.



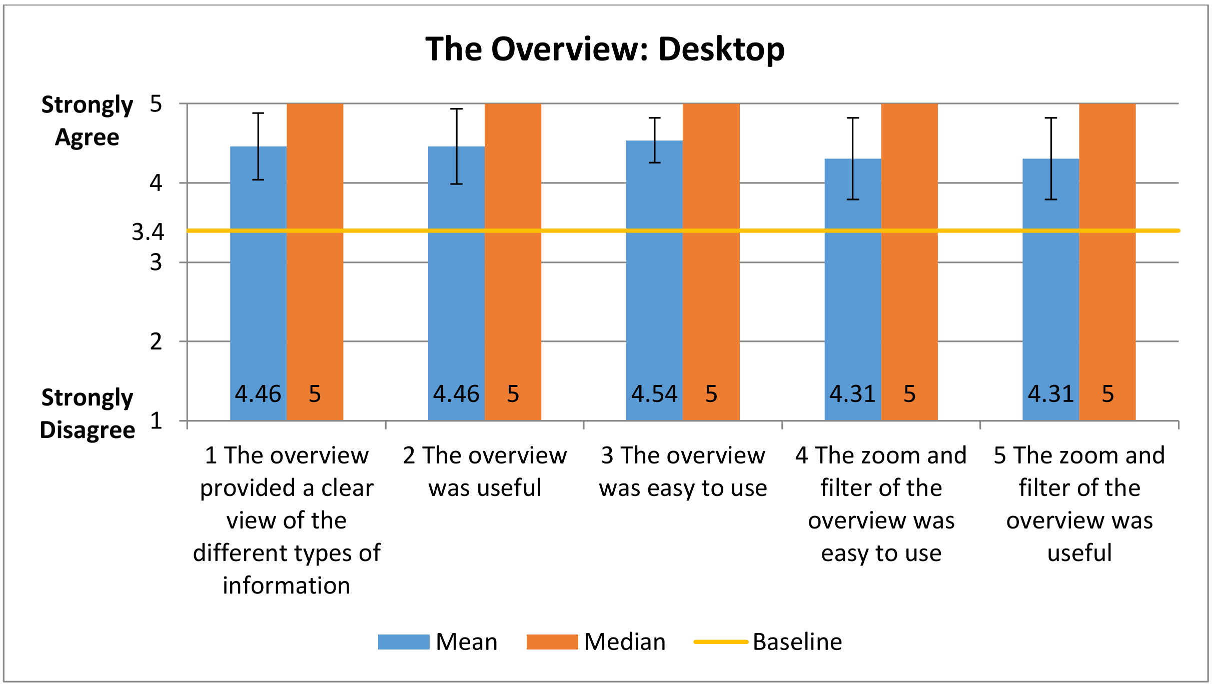
(a)



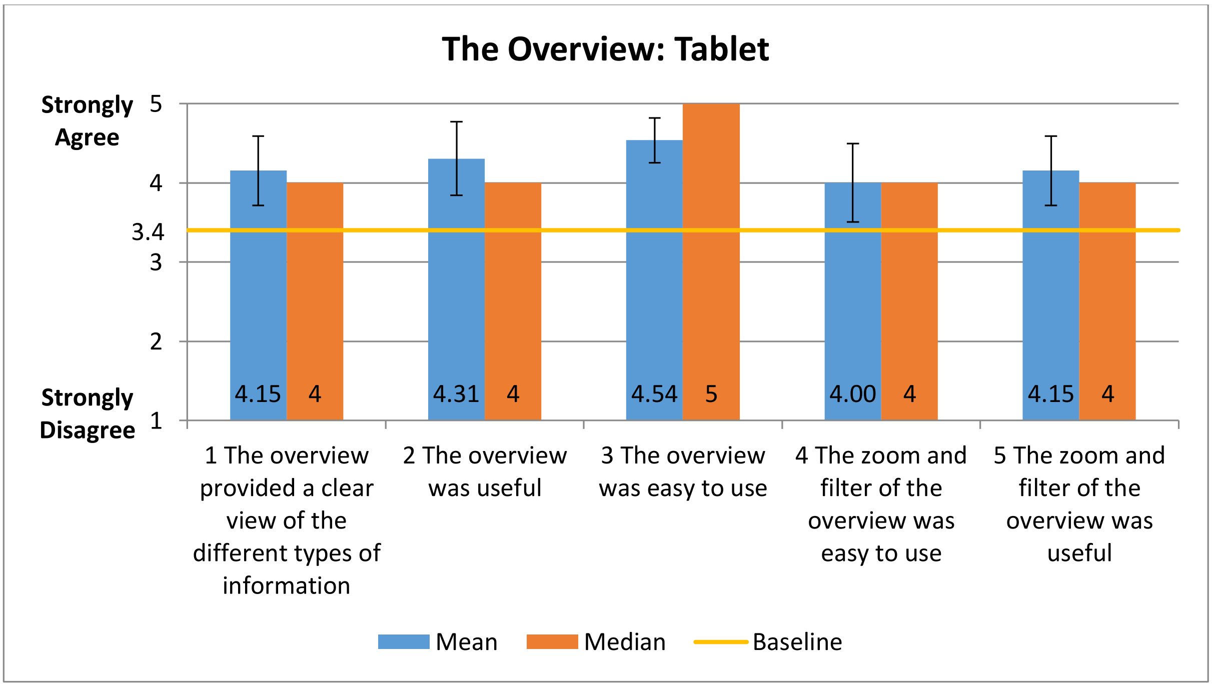
(b)

Figure 8-8 Mean Ratings for Usability using a 5-point Likert Scale (n=13)

The mean ratings for the *Overview* on both devices are shown in Figure 8-9. Both versions of the MyPSI prototype received highly positive ratings for the *Overview* IV technique incorporated in MyPSI. While the *Overview* in the desktop received slightly higher ratings (Figure 8-9a), participants found the *Overview* useful and easy to use in both versions.



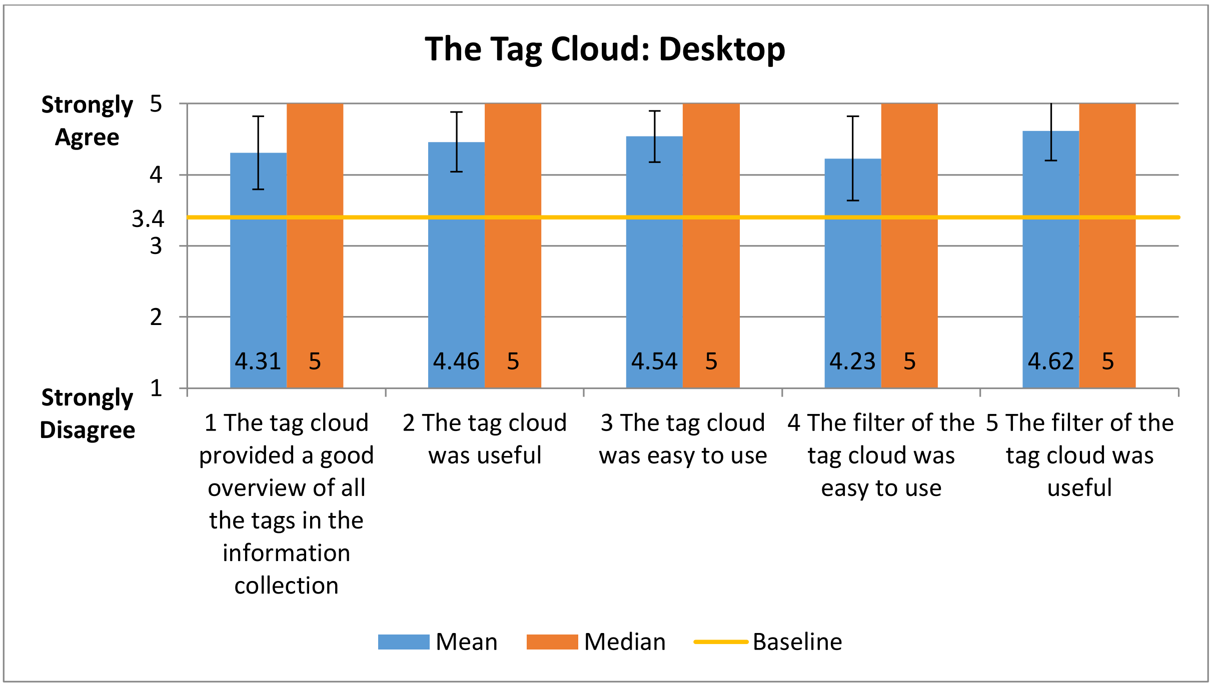
(a)



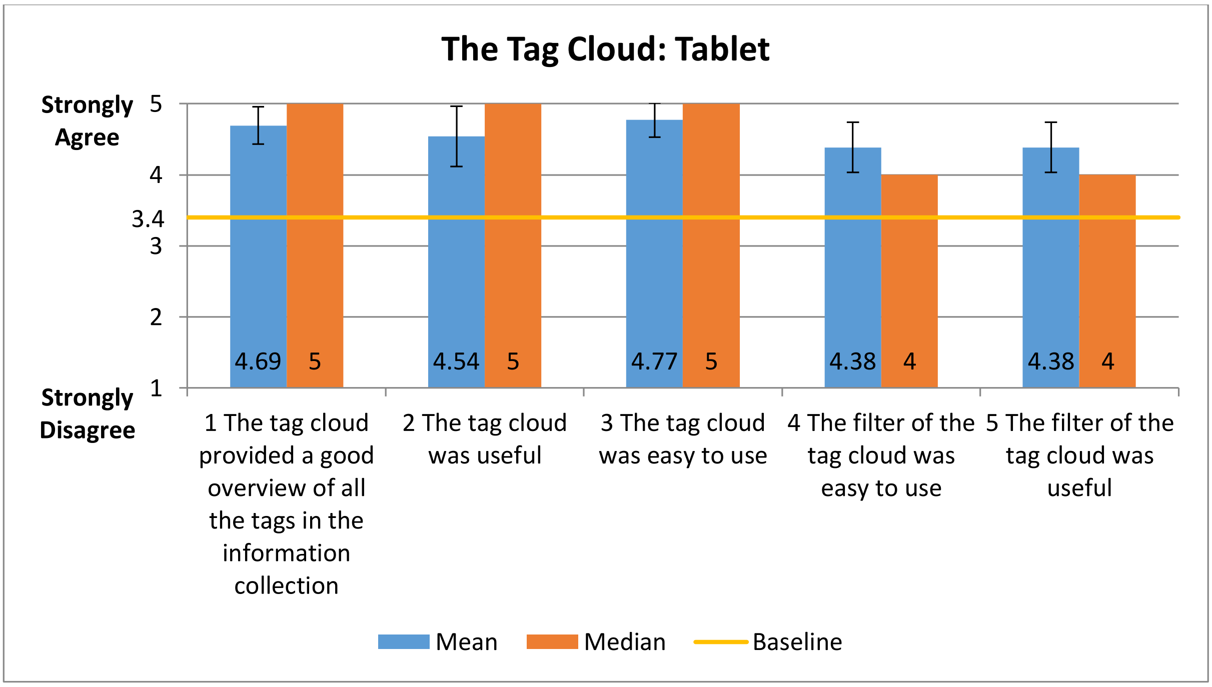
(b)

Figure 8-9 Mean Ratings for the Overview using a 5-point Likert Scale (n=13)

The mean ratings for both the desktop and tablet versions of the MyPSI prototype for the *Tag Cloud* are shown in Figure 8-10. The ratings for the *Tag Cloud* were strongly positive for both versions of the prototype. The *Tag Cloud* on the tablet (Figure 8-10b) received ratings almost as high as the *Tag Cloud* on the desktop version (Figure 8-10a) of the MyPSI prototype.



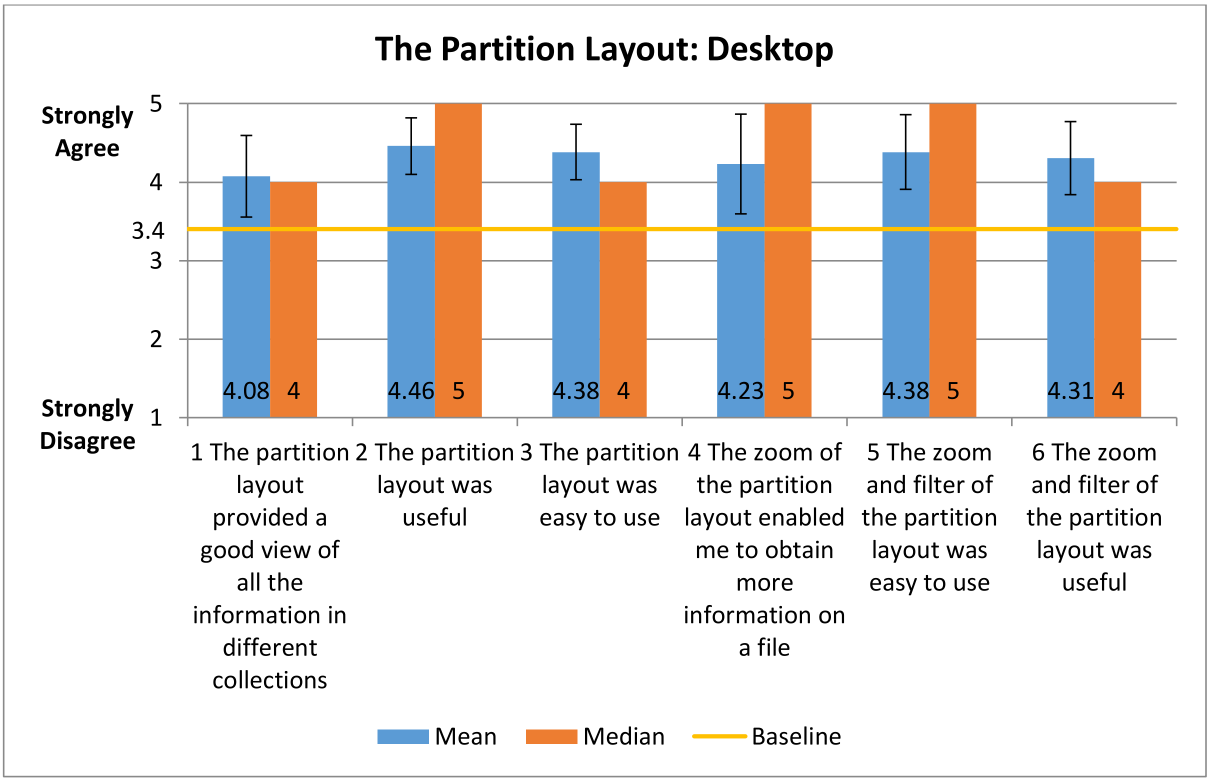
(a)



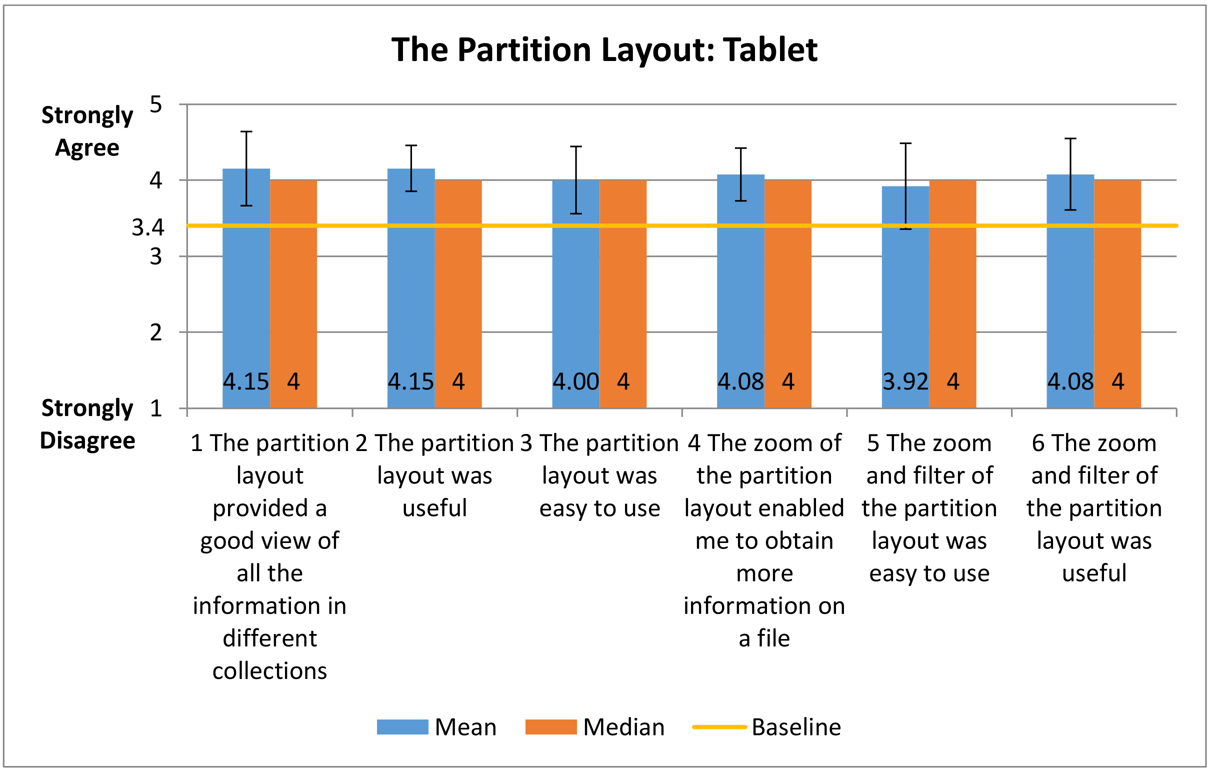
(b)

Figure 8-10 Mean Ratings for the Tag Cloud using a 5-point Likert Scale (n=13)

The mean ratings for the *Partition Layout* for both the desktop and tablet versions of the MyPSI prototype are displayed in Figure 8-11. The *Partition Layout* received positive ratings for both versions of the MyPSI prototype. In general, the desktop version (Figure 8-11a) was rated slightly higher in terms of ease of use.



(a)



(b)

Figure 8-11 Mean Ratings for the Partition Layout using a 5-point Likert Scale (n=13)

A final question was added to each of the post-test questionnaires relating to perceived future use of each version of the MyPSI prototype. As shown in Figure 8-12, participants indicated that they would like to use both versions of the MyPSI prototype in future, which is a positive result for this research. This also supports the conclusion that the IV techniques, incorporated in MyPSI, were found to be useful.

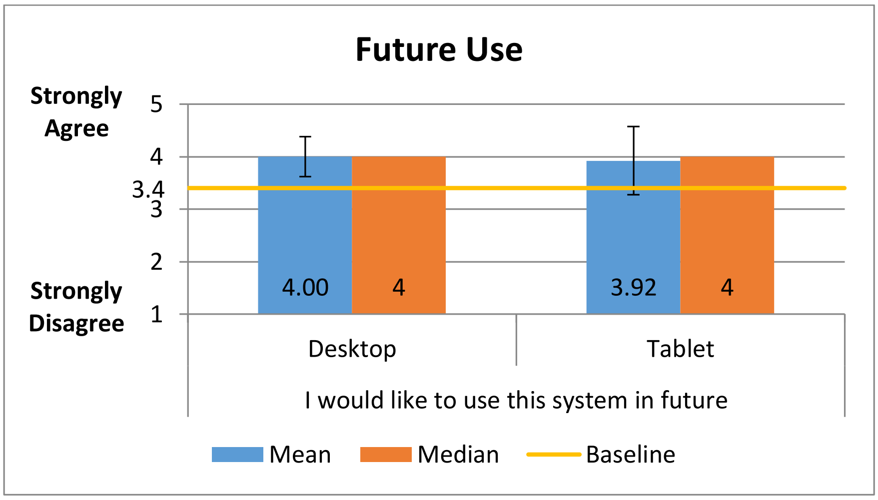


Figure 8-12 Mean Ratings for Future Use using a 5-point Likert Scale (n=13)

8.3.3. Qualitative Results

Qualitative comments were captured using the log book diaries for each day of the field study as well as the post-test questionnaires administered for both the desktop and tablet versions of the MyPSI prototype. The comments displayed in this section are those that consist of a frequency greater than one, i.e. a comment that was mentioned or identified by at least two participants.

General comments relating to the first day of each week involving data manipulation and semantic zooming tasks for both the desktop and tablet versions are displayed in Tables 8-5 and 8-6 respectively. From Table 8-5, it can be seen that participants identified that zooming (3) and data manipulation (2) was useful and simple on the desktop version. Participants also liked the way that the PI was presented in the MyPSI prototype (2).

Table 8-5 General Comments for the Desktop Version for Data Manipulation and Semantic Zooming (n=13)

	Description	Freq.	Pos or Neg Comment?
1.	Zooming allows me to get further information about any file and see the content of that file just by scrolling the mouse wheel.	3	+
2.	This application presents my information in an easy and simple way.	2	+
3.	Creating, copying and moving files were quite simple.	2	+

From Table 8-6, it can be noted that the participants liked the same UI on different devices (2) and found the UI usable and easy to learn (3) on the tablet version of MyPSI. Participants found difficulty in selecting files using touch interaction (4) and selecting small items on the screen (2) (Table 8-6). Participants also identified that the popup keyboard for text input covered most of the screen when entering text (2).

Table 8-6 General Comments for the Tablet Version for Data Manipulation and Semantic Zooming (n=13)

	Description	Freq.	Pos or Neg Comment
1.	Difficulty in file selection with touch interaction can occur.	4	-
2.	It is good to have the same interface on a different device.	3	+
3.	Difficult to tap and zoom small items.	2	-
4.	The keyboard covers the confirming popup windows.	2	-
5.	Very usable interface and easy to learn.	2	+

The general comments regarding browsing and sorting for each device are listed in Tables 8-7 and 8-8. Participants found that data manipulation was easy using the desktop (3), but experienced problems with the multi-select functionality (4) and creating a folder (2). Participants also identified that no confirmation was provided for the delete operation (2) and that the sort functionality was not working properly (2).

Table 8-7 General Comments for the Desktop Version for Browsing and Sorting (n=13)

	Description	Freq.	Pos or Neg Comment?
1.	I struggled with the selection of multiple folders.	4	-
2.	It is very easy to manipulate my files and folders, and copying/moving from one device to the next.	3	+
3.	I experienced problems when creating a folder.	2	-
4.	The system did not ask for confirmation before deleting the folder.	2	-
5.	Sort seemed not initiated after selecting sort options.	2	-

Participants identified that the browsing and sorting tasks were easy and fast to complete using the tablet (2) (Table 8-8). Participants found that some files and folders were not displaying correctly (4) and that there were problems with response from the tablet (3).

Table 8-8 General Comments for the Tablet Version for Browsing and Sorting (n=13)

	Description	Freq.	Pos or Neg Comment?
1.	Some of my folders and files were not displayed properly.	4	-
2.	MyPSI takes some time to respond when accessed from a tablet compared to when I was using a computer.	3	-
3.	Very easy and quick to complete.	2	+

The general comments for searching and filtering using the desktop and tablet versions of the MyPSI prototype are outlined in Tables 8-9 and 8-10 respectively.

Table 8-9 General Comments for the Desktop Version for Searching and Filtering (n=13)

	Description	Freq.	Pos or Neg Comment?
1.	Overall browsing and sorting was done fairly easily.	4	+
2.	Filtering Issues.	3	-
3.	I like searching information in this application.	2	+

Participants found browsing and sorting (4), as well as searching (2), easy with the desktop version (Table 8-9). Three participants experienced different issues with filtering, mentioning that the filter slider for size was too sensitive and that the filter menu did not hide after selecting to filter items.

From Table 8-10, it can be seen that participants found all the searching and filtering tasks easy to perform using the tablet (4). Participants also liked searching (2) and using the *Overview* to filter (2) on the tablet. Two participants identified that using the filter or sort functionality was difficult.

Table 8-10 General Comments for the Tablet Version for Searching and Filtering (n=13)

	Description	**Freq.**	**Pos or Neg Comment?**
1.	All tasks were easy to perform.	4	+
2.	Searching was helpful and easy.	2	+
3.	Selecting one device from overview was faster to show me what I am looking for.	2	+
4.	Struggled to filter / sort.	2	-

General comments for tagging and linking for each device are listed in Tables 8-11 and 8-12. Participants identified that tagging was useful (4), that the functionality was intuitive (2) and that linking worked well (2) on the desktop. Some participants found difficulty in linking (2) and experienced issues with tagging (2), including disappearing tags and tags having white text thus being difficult to view.

Table 8-11 General Comments for the Desktop Version for Tagging and Linking (n=13)

	Description	**Freq.**	**Pos or Neg Comment?**
1.	Tagging was useful to categorise similar documents across multiple folders.	4	+
2.	Everything is quite intuitive.	3	+
3.	Tagging issues.	2	-
4.	I was unable to get the file linking right.	2	-
5.	Linking worked perfectly.	2	+

Participants stated that tagging worked well on the tablet and assisted in filtering information (3). Some participants identified that they experienced difficulty in linking on the tablet (4) as shown in Table 8-12.

Table 8-12 General Comments for the Tablet Version for Tagging and Linking (n=13)

	Description	Freq.	Pos or Neg Comment?
1.	Had troubles with the linking.	4	-
2.	The tagging works very well and is still my favourite method of viewing and filtering data.	3	+

In the post-test questionnaires, participants were asked to identify the most positive and negative aspect(s) of the desktop and tablet versions of the MyPSI prototype. Participants were also provided with a section to identify any general comments regarding the prototype. Similarly to the log book results, aspect(s) that were mentioned by more than one participant are discussed in this section.

The most positive aspects identified by the participants for the desktop version of the MyPSI prototype included the ability of the MyPSI prototype to display PI across multiple devices in a single UI (7) as shown in Table 8-13. Participants also identified that the various data manipulation functions were useful (5). Participants found the desktop version of the prototype easy to use (3), the tagging (3) and the filtering (2) useful and the search easy to use (2).

Table 8-13 Most Positive Aspect(s) for the Desktop Version of the MyPSI Prototype (n=13)

	Description	Freq.
1.	I liked the way I was able to view all my information across different devices all in one place.	7
2.	Moving, copying and deleting files across multiple devices was useful.	5
3.	It is easy to use.	3
4.	Tagging was useful as multiple files with different formats can be linked or tagged together.	3
5.	The filtering worked well.	2
6.	Able to search and find information easily.	2

From Table 8-14, participants identified that the information windows were difficult to manipulate when there were multiple information windows open simultaneously (4). Participants also found linking difficult (3), experienced various display issues (3) and found the reloading of the page, which was necessary for system logging, to be frustrating (2).

Table 8-14 Most Negative Aspect(s) for the Desktop Version of the MyPSI Prototype (n=13)

	Description	Freq.
1.	Message boxes sometimes freeze.	4
2.	The linking was a bit difficult.	3
3.	General Display Issues.	3
4.	Reloading the page after each task.	2

Overall comments in the section for general comments on the desktop version of the MyPSI prototype identified that the participants found the prototype to be a good system in general (7), as shown in Table 8-15.

Table 8-15 General Comments for the Desktop Version of the MyPSI Prototype (n=13)

	Description	Freq.
1.	Good system.	7

The most positive aspect of the tablet version of the MyPSI prototype (Table 8-16) was that participants liked being able to use a tablet device to browse and manipulate their PI (8). Participants also found the searching, filtering and tagging useful on the tablet version of the prototype (4). Participants stated that they liked using the same UI for both devices (3) and that the tablet version of the prototype was easy to learn and easy to use (2).

Table 8-16 Most Positive Aspect(s) for the Tablet Version of the MyPSI Prototype (n=13)

	Description	Freq.
1.	Being able to browse and manipulate my personal information across multiple devices using an Android tablet.	8
2.	I could find my files very easily by searching, filtering or tagging.	4
3.	Same interface for several devices.	3
4.	The system was very easy to learn and to use.	2

The most negative aspect of the tablet version of the MyPSI prototype was the small folders (4), as shown in Table 8-17. Participants found difficulty with the zooming functionality on the tablet (3) and that the response was generally slow (3).

Table 8-17 Most Negative Aspect(s) for the Tablet Version of the MyPSI Prototype (n=13)

	Description	Freq.
1.	Folders are too small to view.	4
2.	The zooming functionality on the tablet gave me some trouble.	3
3.	Slow on tablet.	3

Similarly to the desktop version of the MyPSI prototype, participants stated that they found the system to be a good system, which they would like to use in future (6) (Table 8-18). Participants also noted that the response of the prototype on the tablet version needs to be improved (2).

Table 8-18 General Comments for the Tablet Version of the MyPSI Prototype (n=13)

	Description	Freq.
1.	I am impressed with the system and I would love to use it in the future.	6
2.	If response time was faster/responsive it would be more enjoyable to work on a tablet.	2

8.4. Discussion

Although there were problems with the system logging, the log book diaries provided valuable results to measure the effectiveness of the MyPSI prototype for both versions of the prototype evaluated. The log book diaries followed the ASQ with a section to enter general comments. All the ratings were positive for the log book diaries (Section 8.3.1). The ratings for the log books showed that the participants generally preferred the desktop version of the MyPSI prototype compared to the tablet version. The satisfaction questionnaires provided similar results. Both the desktop and tablet versions received positive results for cognitive load, overall satisfaction and usability, as well as the additional sections for each IV technique incorporated in MyPSI. Nonetheless, the desktop version was preferred slightly more than the tablet version of the MyPSI prototype. This could be due to the fact that the desktop with mouse-based interaction is more familiar to participants. Some of the participants of the field study had not used a tablet device prior to the field study, which could have introduced a learning curve with the tablet version. The tablet version had a learning curve for general use and touch interaction as well as the time and steps needed to learn to use the MyPSI prototype.

The web application, which was evaluated in the first week of the field study, was developed using Hypertext Mark-up Language (HTML), Cascading Style Sheets (CSS), JavaScript and the D_3 (Data-driven documents) visualisation library. The mobile application, which was evaluated in the second week of the field study, was developed using PhoneGap and the D_3 visualisation library. These implementations resulted in different limitations. PhoneGap, although providing a useful means for transferring a web application into an Android tablet version, has been widely criticised for its slow response time and delay within its implemented applications. As the application on the tablet was required to use D_3, the application on the tablet could not be implemented using the more direct Android-based development for a pure native application, but rather using the indirect method of PhoneGap. Thus, the limitation of PhoneGap's slow response was unavoidable. Additionally, some participants identified in the log books that the day's tasks went well, where other participants identified that they struggled to complete the tasks. This could be due to Internet availability.

Most participants liked the same UI design for both devices. This result identified that the design could be transferred from a large screen, i.e. the desktop / laptop, to a smaller screen, i.e. the tablet. This result, however, may not be applicable for even smaller screens, i.e. a mobile phone, as different screen constraints will need to be considered. Some problems that were identified with the tablet included small folder and file icons, as well as the difficulty in zooming due to these small icons, the pop-up keyboard covering the screen for text input and difficulty with the multi-select tasks. These issues will need to be addressed due to the limited screen size of the tablet. The folder and file icons and the multi-select checkboxes will need to be scaled appropriately, but the pop-up keyboard, which covers half of the screen on a search, is unavoidable and an unfortunate side-effect of the tablet functionality.

Some participants also identified problems with the information windows that were displayed when a folder or file was selected. When multiple windows were open at one time, any window behind the front information window was not accessible. This is due to the z-index that is assigned to each information window on focus and is a problem with the Bootstrap library used for the layout of the screen UI. Thus, if the home button was selected it would hide all active information windows, to assist the user, but some participants did not use this escape functionality and became frustrated. The Bootstrap information window seemed to be the best option available for a toggle window at the time of implementation. Therefore, it may be useful to replace this information window with a different information window to address these problems.

Lastly, similar to the problems experienced with system logging, some problems were experienced with the Dropbox library used to support PI storage. Dropbox provided a powerful means to simulate accessing PI across multiple devices for the field study, but participants experienced various issues, which could be attributed to the Dropbox JavaScript library used within the MyPSI prototype. The ideal solution would be to not require a user to upload PI to a cloud-based storage system, but this was a necessary requirement of the field study in order to evaluate the IV techniques with real personal spaces of information (PSIs). The same issue experienced with the system logging, was experienced with editing or appending the tagging and linking text files used to store the existing tags and links. As a result, once a participant refreshed their web page or application, the existing tags and/or links disappeared. Some problems were experienced in polling for all PI that a participant had uploaded to Dropbox and some of the information was not displayed by MyPSI.

Participants identified that they had difficulty in creating a folder. The success of this task was difficult to determine by participants as D_3 calculates the size of a folder in relation to the size of its children, i.e. the files contained within that folder. Due to the folder being empty, the resulting size was zero and so the folder was too small to display due to its size property – the folder was visible in Dropbox itself. Additionally, it was identified that the *Sort* feature was not working correctly. The *Sort* was restricted in that, the files and folder always needed to be sorted by type, otherwise the layout would not display correctly. This restricted the sort in that, each sort would be added to the layout over and above the current sort by type of file. Thus, it seemed that the sort was not changing the layout in some instances. One last issue directly related to D_3, was that existing tags that were already displayed in the *Tag Cloud* could not be assigned to PI items as the tag would disappear in the *Tag Cloud* due to its count being incremented. This has been identified as an issue of the *Tag Cloud* implementation provided by the D_3 visualisation library, which has not yet been addressed.

Other minor issues included the need to provide confirmation of deleting items as in other data manipulation tasks and adding the tag list to each PI item's tooltip, which were omitted from the implementation and need to be addressed. An additional limitation of the field study was that the MyPSI prototype was evaluated within a two-week period, whereas it would be better to conduct such an evaluation over a longer period.

8.5. Conclusion

A two-week field study was conducted to determine the effectiveness of the IV techniques designed and incorporated in the MyPSI prototype. A desktop version, which makes use of a web application using mouse-based interaction, as well as a tablet version, which makes use of a PhoneGap application with touch-based interaction, were implemented. Both the desktop and tablet versions of the MyPSI prototype were evaluated in the field study. The desktop version was evaluated in the first week of the field study and the tablet version was evaluated in the second week of the field study. Similar tasks were completed for each version of the MyPSI prototype.

The field study was conducted using the MILC approach, specifically designed to evaluate IV techniques and tools. The field study was conducted over a two-week period with 13 participants from the Department of Computing Sciences and the School of ICT from NMMU. Following the MILC approach, logging, log book diaries and questionnaires were used to measure effectiveness and satisfaction. Qualitative comments were also captured using the log book diaries and the questionnaires.

The tasks were grouped together for each week of the field study, where the groupings included: data manipulation and semantic zooming, browsing and sorting, searching and filtering, and tagging and linking.

The results of the field study were highly positive. The results from the log book diaries identified that participants could easily and quickly complete all the tasks using both versions of the MyPSI prototype. The results were slightly higher for the desktop version of the prototype than the tablet version, which could be attributed to familiarity in using a desktop with mouse-based interaction over a tablet with touch-based interaction. The satisfaction results also identified that the IV techniques were easy to use and useful. These results were also slightly higher for the desktop version of the MyPSI prototype, although both versions received positive ratings.

Detailed results were provided using the log book diaries' section for general comments as well as the comments' sections provided with the post-test questionnaires. Participants identified that both versions of the MyPSI prototype were well-designed, simple and easy to use and easy to learn. The participants also preferred to have the same UI design for both versions, although some participants experienced issues with the scaling of the icons from the desktop version to the tablet version. Some participants identified that the response was slow, which is attributed to the PhoneGap implementation, as confirmed through various forums and websites discussing PhoneGap support. Some problems, such as associating existing tags, are attributed to limitations with D_3, the problems experienced with the information windows are attributed to the Bootstrap support, and the Dropbox library also caused a few unreliable display results.

The next chapter will provide an overview of the contribution to the existing knowledge bases of the research, i.e. personal information management (PIM) and IV. The chapter will describe some design recommendations for future IV tools to support PIM across multiple devices.

Chapter 9: Design Recommendations

9.1. Introduction

Chapter 8 discussed the field study used to determine the effectiveness of the information visualisation (IV) techniques incorporated in both the desktop and tablet versions of the MyPSI prototype. At the end of Chapter 4, requirements were identified for an IV tool to support accessing personal information (PI) across multiple devices. These requirements were compared with the results of the field study to identify design recommendations for an IV tool for personal information management (PIM) across multiple devices. This chapter addresses the eighth and final research question of this research (RQ 8), namely *"What are the design recommendations resulting from this research?"* This research question assisted in adding knowledge to the existing knowledge bases, including PIM and IV, which is part of the Rigor Cycle of the design science research Methodology.

The next sections will compare the extent to which the MyPSI prototype supported the requirements identified in Chapters 2, 3 and 4. The requirements will then be compared with the results of the field study to determine the final design recommendations for an IV tool to support access to PI across multiple devices. The chapter will conclude with a discussion section.

9.2. Requirements Supported

At the end of Chapter 2, PI organisation requirements were identified from the shortcomings of current PI organisation methods (Section 2.5). Table 9-1 describes the extent to which these requirements were supported by the MyPSI prototype. The required functionality was identified from the requirements derived from the results of the field study in combination with the defined high-level and lower-level PIM tasks and the visual information seeking mantra. The acquiring PIM task was considered as a pre-task to using MyPSI, but organisation, retrieval and processing tasks were fully supported. All lower level PIM tasks were supported except for distributing and transforming. Participants of the field study identified that the MyPSI prototype contained all the functionality required by such a tool (Figure 8-8).

Table 9-1 Extent of Support for PI Organisation Requirements

Requirement	Supported?	Extent of Support
1. Organisation-dependent Visualisation	Yes	The hierarchy was preserved for each *Library* and device. The *Partition Layout* made effective use of screen space to visualise these hierarchies and their respective levels (sub-folders).
2. Context Awareness	Yes	An intention of the MyPSI prototype was to display which device is connected. All devices available to a user are available on the same user interface (UI) and the prototype is available on both desktop and tablet devices, so a user can access the prototype anywhere and at any time.
3. Support for Multiple Hierarchies	Yes	The MyPSI prototype preserves the hierarchy in which the PI of a user is stored and organised, but multiple hierarchies are used to visualise the PI collection (PIC) for each device as well as the sub-hierarchies for each *Library* folder on these devices. The data type, i.e. the hierarchical folder structure, and the requirement for multiple hierarchy visualisation was used to select appropriate IV techniques.
4. Association of PI Items	Yes	Linking is one of the main functions supported by MyPSI to allow related items to be associated. This requirement is also supported by tagging and filtering using tags.
5. File Sharing	No	Requirement removed from scope in Chapter 4.
6. User-centred Approach	Yes	An interview study was conducted to determine how participants manage PI across different devices to identify requirements and inform the design of MyPSI. A preliminary user study as well as an in-depth field study was used to identify usability problems with the prototype, and to determine the suitability and effectiveness of the IV techniques used within the prototype.
7. Access to PI across Multiple Devices	Yes	MyPSI was designed for access on both desktop/laptop devices and tablet devices supporting access to PI across multiple devices. Synchronisation was provided by the Dropbox API.

From Chapter 3, requirements were identified for PI visualisation, which were derived from the shortcomings of existing PI visualisation techniques and tools (Section 3.7). The extent to which these requirements were supported by the MyPSI prototype is described in Table 9-2.

Table 9-2 Extent of Support for PI Visualisation Requirements

Requirement	Supported?	Extent of Support
1. Browsing Support	Yes	Browsing is encouraged by MyPSI with the use of the *Overview* and *Partition Layout*. Sorting functionality also complements browsing. Search is not compulsory, but advanced searching is supported, using filtering, searching and tagging.
2. Provide a Temporal View	Yes	The hierarchy of each PIC was preserved, and so a temporal IV technique was not used directly, but the PICs were organised and sorted according to the date accessed property.
3. Allow a User to view an Overview, Set of Topics and Entire PSI	Yes	Documents and media PI types were similarly organised, and organised according to the current organisation. Multiple IV techniques were incorporated in the MyPSI prototype, namely the *Overview*, the *Partition Layout* and the *Tag Cloud*.
4. Visually Represent PI Items	Yes	All folders were represented as parent rectangles with the sub-folders directly beneath the parent folders, thus the relationship between folders and files were clear.
5. Interactivity Support	Yes	The interaction focussed on using MyPSI on multiple devices, i.e. desktop and tablet devices, and supported both mouse- and touch-based interaction.

From the results of the interview study discussed in Chapter 4, requirements were derived for a tool to support PIM across multiple devices. These requirements were discussed in detail in Section 4.5 and are summarised in Table 9-3 in terms of organisation, visualisation and interaction.

The requirements for PI organisation and visualisation were mapped to the requirements resulting from the interview study. Tables 9-4 and 9-5 show that all the requirements for PI organisation and visualisation could be mapped to the requirements derived from the interview study results.

Table 9-3 Requirements for PIM across Multiple Devices

Category	Requirement
1. Organisation	1.1. Provide a virtual storage solution which aggregates PI in a single location
	1.2. Provide support for association of linked PI items
	1.3. Provide tagging to assist in information retrieval
2. Visualisation	2.1. Use a single UI to visualise PI across multiple devices
	2.2. Visualise the PI using suitable IV techniques
	2.3. Provide different views of the PSI
	2.4. Consider each device's physical constraints
3. Interaction	3.1. Provide intelligent searching across devices
	3.2. Provide functionality associated with PI items
	3.3. Support immediate access to PI items

The *user-centred approach* requirement identified for PI organisation supports the overall process used to implement the MyPSI prototype. The requirement for *interactivity support* for PI visualisation supports the overall *Interaction* category as shown in Tables 9-4 and 9-5.

Table 9-4 Mapping of Requirements

Requirements	Organisation Requirements Supported	Visualisation Requirements Supported
1. Organisation		
1.1. Provide a virtual storage solution which aggregates PI in a single location	Organisation-dependent Visualisation Context Awareness Support for Multiple Hierarchies	Allow a User to View an Overview, Set of Topics and Entire PSI (Overview & Partition Layout)
1.2. Provide support for association of linked PI items	Association of PI Items	
1.3. Provide tagging to assist in information retrieval	Association of PI Items	Allow a User to View an Overview, Set of Topics and Entire PSI (Tag Cloud)

Table 9-5 Mapping of Requirements (Continued)

Requirements	**Organisation Requirements Supported**	**Visualisation Requirements Supported**
2. Visualisation		
2.1. Use a single UI to visualise PI across multiple devices	Support for Multiple Hierarchies Context Awareness	Browsing Support
2.2. Visualise the PI using suitable IV techniques	Support for Multiple Hierarchies	Organisation-dependent Visualisation Allow a User to View an Overview, Set of Topics and Entire PSI Visually Represent PI Items
2.3. Provide different views of the PSI		Provide a Temporal View
2.4. Consider each device's physical constraints	Context Awareness Access to PI across Multiple Devices	
3. Interaction		Interactivity Support
3.1. Provide intelligent searching across devices		Browsing Support
3.2. Provide functionality associated with PI items		Support for Information Retrieval Tasks
3.3. Support immediate access to PI items	Context Awareness Access to PI across Multiple Devices	

9.3. Design Recommendations

All of the requirements identified in Chapter 4 and summarised in Table 9-3 were confirmed by the results of the field study. These requirements were then transformed into design recommendations to inform future IV tools designed to support PIM across multiple devices. These design recommendations are listed and discussed in this section.

9.3.1. Organisation

9.3.1.1. Provide a Virtual Storage Solution which Aggregates PI in a Single Location

This recommendation is necessary as a back-end system to an IV tool such as MyPSI. The MyPSI prototype needed to be evaluated within a user's real environment with his/her own personal space of information (PSI). Dropbox was used successfully as a cloud storage system to allow a user to upload his/her PSI which was visualised by MyPSI. The ideal back-end system would be a storage solution where the PICs reside on the users' devices and only the metadata is stored in a cloud, eliminating the need for Dropbox as the primary storage system and requiring a user to upload any information beforehand.

9.3.1.2. Provide Support for Association of Linked PI items

The log books for both versions of the MyPSI prototype identified that participants found linking easy and were satisfied with the time taken to complete the linking tasks (Figures 8-3 and 8-4). Only a few participants experienced some difficulty in performing the linking (Tables 8-12 and 8-14), and none of the participants stated that linking was unnecessary.

9.3.1.3. Provide Tagging to Assist in Information Retrieval

Participants of the field study were also satisfied with the ease and time taken to complete the tasks related to tagging, which was identified from the log books (Figures 8-3 and 8-4). Participants also rated the *Tag Cloud* positively (Figure 8-10). Participants identified that the *Tag Cloud* provided a good overview of all the tags in the information collection, that the *Tag Cloud* was easy to use, and that the *Tag Cloud* and the *Tag Cloud* filter was useful. The participants also commented positively regarding the tagging functionality on both versions of the MyPSI prototype (Tables 8-11 and 8-12).

9.3.2. Visualisation

9.3.2.1. Use a single UI to visualise PI across multiple devices

The overall satisfaction section was rated positively for all questions for both the desktop and tablet versions of the MyPSI prototype (Figure 8-7). Participants were satisfied with the MyPSI prototype and found MyPSI easy and simple to use. Cognitive load ratings were also low (Figure 8-6). All questions relating to the IV techniques received positive ratings as well. Participants also agreed that they would use the MyPSI prototype in future (Figure 8-12; Table 8-18). A number of participants found MyPSI presented their PI in an easy and simple manner and agreed that it was good to have the same UI for different devices (Tables 8-5, 8-6 and 8-16). The most positive aspect identified from the desktop version of the MyPSI prototype was that participants liked viewing their PSI across different devices in a single location (Table 8-13).

9.3.2.2. Visualise the PI using Suitable IV Techniques

No major issues were identified with any of the versions of the MyPSI prototype in the log books. Thus, it was determined that the IV techniques incorporated in MyPSI were effective in supporting PIM across multiple devices. All questions relating to the IV techniques were rated positively (Figures 8-9, 8-10 and 8-11). Participants found that the *Overview* provided a clear view of the different types of information, the *Partition Layout* provided a good view of all the information in different collections and the *Tag Cloud* provided a good overview of all the tags in the information collection.

9.3.2.3. Provide Different Views of the PSI

Although no temporal visualisation or alternative viewing techniques were incorporated in MyPSI, sorting and filtering allowed the participants to view their PI in different ways. Participants rated sorting and filtering positively in the log books (Figure 8-3). Participants also rated the filtering of each IV technique highly and found this functionality to be easy to use and useful (Figures 8-9, 8-10 and 8-11). Filtering was also identified as one of the most positive aspects of the desktop and tablet versions of MyPSI (Tables 8-13 and 8-16).

9.3.2.4. Consider Each Device's Physical Constraints

The MyPSI prototype was implemented on both a desktop and tablet device. The design of the MyPSI prototype was successfully transferred from the desktop to the mobile device. MyPSI supported both mouse-and touch-based interaction for the respective devices.

9.3.3. Interaction

9.3.3.1. Provide Intelligent Searching Across Devices

The log books show very positive ratings for the searching and filtering tasks for both versions of the MyPSI prototype (Figure 8-3 and 8-4). Participants found the searching tasks easy to complete and were satisfied with the time taken to complete the tasks. Very high ratings were received for the finding-related questions for usability for the desktop version, while high ratings were received for the tablet version (Figure 8-8).

9.3.3.2. Provide Functionality Associated with PI items

Functionality to be supported by MyPSI was identified from the requirements identified from the interview study in Chapter 4 (Sections 4.5 and 5.2.3). The data manipulation functionality specified all the tasks that can be completed with a PI item. The data manipulation tasks received very high ratings in the log books in terms of the ease and time taken to complete the tasks for the desktop version of MyPSI and positive ratings for the tablet version (Figures 8-3 and 8-4). Participants identified that creating, copying and moving files was simple (Tables 8-5 and 8-7). Participants also identified the data manipulation functionality as one of the most positive aspects of the desktop version of the MyPSI prototype (Table 8-13).

9.3.3.3. Support Immediate Access to PI items

The log book ratings were all positive in terms of time taken to complete each task (Figure 8-4). The cognitive load ratings for performance were also low for both versions of the prototype (Figure 8-6). Although there were some concerns with the tasks for the tablet version (Tables 8-17 and 8-18), participants could access PI items and their related metadata with no major problems.

9.4. Conclusion

Chapters 2 and 3 identified requirements for PI organisation and PI visualisation from the shortcomings of current PI organisation methods and systems as well as PI visualisation techniques and systems. Requirements were also identified from the results of the interview study to determine how users currently manage their PI across different devices and problems experienced. These requirements were used to derive the functionality for an IV tool to support PIM across multiple devices. A field study was conducted to evaluate the MyPSI prototype implemented to support this functionality.

The extent of support for the PI organisation and PI visualisation requirements was described in Tables 9-1 and 9-2. All requirements were either partially or fully supported except for the PI organisation requirement involving file sharing, as this was removed from the interview study requirements following the cognitive walkthrough. The resulting requirements identified from the interview study following the cognitive walkthrough were listed in Table 9-3. Two requirements were removed, namely the requirements to include additional facilities other than general PI types and to provide support for file sharing and collaboration. The PI organisation and visualisation requirements were then mapped to the requirements from the interview study. All requirements were supported in the MyPSI prototype.

The resultant requirements were then converted into design recommendations to inform the design of future IV tools to support PIM across multiple devices. Each design recommendation was supported by results from the field study. The next chapter provides a conclusion to this research, where the contribution of the research will be discussed and possible future work will be identified.

Chapter 10: Conclusions

10.1. Introduction

The main aim and focus of the research was to determine the effectiveness of enhanced information visualisation (IV) techniques in supporting access to personal information (PI) across multiple devices. This research followed the design science research (DSR) methodology and each step of this approach was followed in the previous chapters (Chapters 2 – 9). Problems were identified with existing PI organisation methods and visualisation techniques and tools (Chapters 2 and 3). An interview study was conducted to determine the existing problems in managing PI across multiple devices (Chapter 4). The requirements identified for PI organisation and PI visualisation from the literature study were combined with the results of the interview study. Functionality was derived from these requirements to be incorporated in an IV tool to support accessing PI across multiple devices. This functionality informed the design of the MyPSI prototype on a desktop device incorporating several enhanced IV techniques (Chapter 5). The MyPSI prototype formed the resulting artefact required by the DSR methodology. The MyPSI prototype was evaluated using a preliminary user study to identify any usability problems (Chapter 6). No major issues were identified and the MyPSI prototype was then transferred to a mobile device, specifically a tablet device (Chapter 7). Both versions of MyPSI were evaluated using a field study (Chapter 8). Design recommendations were derived to inform future designs of IV tools to support accessing PI across multiple devices (Chapter 9). These design recommendations represent the theoretical contribution to the knowledge base as required by the DSR methodology.

This chapter concludes the research by summarising the findings and contribution of the work. Limitations, problems encountered and future work to be completed are also discussed.

10.2. Summary of Findings

This section provides a review of the research questions for this research, which were originally identified in Chapter 1. The achievements of this research are then identified. The section concludes with a discussion, which summarises the findings of this research.

10.2.1. Review of Research Questions

The aim of this research as identified in Chapter 1 was the following:

To design enhanced information visualisation (IV) techniques to support access to personal information (PI) across multiple devices.

The main research question that was addressed by this research included the following:

How should PI be visualised to support access to PI across multiple devices?

The above research question was answered by addressing the following sub-questions identified in Chapter 1 to address aim of the research using the DSR methodology:

RQ 1. What are the existing problems with current PI organisation methods? (Chapter 2)

RQ 2. What are the existing problems with current PI visualisation techniques? (Chapter 3)

RQ 3. What are the requirements for an IV tool to support access to PI across multiple devices? (Chapter 4)

RQ 4. How can enhanced IV techniques be designed to support access to PI across multiple devices on a desktop device? (Chapter 5)

RQ 5. How effective are these IV techniques in supporting access to PI across multiple devices on a desktop device? (Chapter 6)

RQ 6. How can enhanced IV techniques be designed to support access to PI across multiple devices on a mobile device? (Chapter 7)

RQ 7. How effective are these IV techniques in supporting access to PI across multiple devices in a real environment using a desktop and a mobile device? (Chapter 8)

RQ 8. What are the design recommendations resulting from this research? (Chapter 9)

10.2.2. Research Achievements

This research has shown that existing IV techniques can be enhanced to effectively support accessing PI across multiple devices. The aim of this research was addressed using the research questions by following the DSR methodology described in detail in Section 1.3.4. A summary of the process of the DSR methodology that was applied to this research is depicted in Figure 1-4, displaying each DSR activity with the respective outcomes that were achieved after conducting these activities.

The first research question (RQ 1) was addressed in Chapter 2 by conducting the *Explicate Problem* and *Outline Artefact and Define Requirements* DSR activities. The concept of PI was defined and personal information management (PIM) was discussed in general to provide an understanding of the problem domain. The need for accessing PI across multiple devices was also emphasised. PI organisation was identified as one of the key aspects of PIM. Current PI organisation strategies, i.e. the way in which users organise PI, were identified, including filing and piling. The current method to organise PI was identified as the hierarchical file/folder structure most typically used by Windows Explorer, due to its familiarity among users. Shortcomings of this organisation method were identified, which were mainly due to its inflexible and inconsistent nature. PI organisation systems found in literature, including systems such as LifeStreams and the File Concept Browser, were also discussed in terms of supported functionality. Strengths and weaknesses were identified for each PI organisation method. Most systems provided contextual information, supported annotation and association, indexing, tagging and provided a temporal organisation. Various shortcomings were identified with existing PI organisation systems. These shortcomings were due to the systems mainly focussing on improving PI organisation on a single device or replacing the hierarchy, while several systems were also search-reliant. The analysis of the PI organisation methods and systems assisted in the identification of requirements for PI organisation across multiple devices. These requirements included providing an organisation-dependent visualisation extending the hierarchy, the provision of context-aware organisation, support for multiple hierarchies, the provision of association between multiple PI items, support for file sharing and collaboration, focussing on the user rather than the tool and providing access to PI collections (PICs) across multiple devices.

Chapter 3 addressed the second research question (RQ 2) of this research. RQ 2 was also addressed using the *Explicate Problem* and *Outline Artefact and Define Requirements* DSR activities. Current PI visualisation techniques were reviewed, including the indented-list used to visualise the hierarchical folder structure incorporated in Windows Explorer. The main shortcomings of the visualisation of the hierarchical folder structure included the lack of an overview, ineffective use of screen space, lack of visibility of folders/files and the fact that the technique is limited as it does not support all the required functionality. Several PI visualisation systems were reviewed, such as the Personal Information Dashboard and InfoMaps. These systems had various strengths and weaknesses. The shortcomings of each PI visualisation system differed, but most of these shortcomings were due to the IV systems supporting either multiple IV techniques or extending the hierarchy, but not both. These visualisation systems were also limited to visualising single hierarchies on one device. There was also limited consistency between visualisation systems. From the review of the PI visualisation systems, several visualisation requirements were identified to support PIM across multiple devices. These requirements included providing browsing support, incorporating a temporal view, allowing a user to view an overview, set of topics and his/her entire PSI, supporting visual representations of PI items and supporting interaction in addition to visualisation.

The third research question (RQ 3) was addressed in Chapter 4 using a combination of the *Explicate Problem* and *Outline Artefact and Define Requirements* DSR activities. Chapter 4 described the method and results of an interview study to determine how users currently manage PI across multiple devices. The interview study was also used to identify problems with this process. The interview was conducted with participants from the Department of Computing Sciences at the Nelson Mandela Metropolitan University (NMMU). Most participants used at least three devices to manage PI. Multiple device combinations were used by each participant of the interview study, including a work/university desktop computer, a mobile phone, a home desktop computer and a laptop. Most participants owned devices which use different platforms. Half of the participants considered their university/work desktop computer as their main device for PIM and most of the remaining participants considered a combination of devices as their main devices. Different methods were used to manage their PI. The main methods included email, flash drives for storage, Windows Explorer and Dropbox. The main problems in managing PI across multiple devices included problems with the folder structure, problems experienced with Dropbox, being required to know beforehand what PI to upload, and having separate structures and applications to manage different types of PI. Almost all of the participants were positive regarding the proposal of a tool which would provide a single user interface (UI) to visualise PI across multiple devices.

From the literature review and the results of the interview study, requirements were identified for an IV tool to support accessing PI across multiple devices, which addressed the *Outline Artefact and Define Requirements* DSR activity. These requirements were categorised according to organisation, visualisation and interaction. The organisation requirements comprised providing a virtual storage solution which aggregates PI in a single location, support for association of linked PI items, tagging to assist in information retrieval and including additional facilities other than general PI types. The visualisation requirements consisted of making use of a single UI to visualise PI across multiple devices, visualising the PI using suitable IV techniques, providing different views of the personal space of information (PSI) and considering each device's physical constraints. The interaction requirements included providing intelligent searching across devices, support for file sharing and collaboration, functionality associated with PI items and supporting immediate access to PI items.

Chapter 5 addressed the fourth research question (RQ 4), which used the first iteration of the *Design and Develop Artefact, Demonstrate Artefact* and *Evaluate Artefact* DSR activities. Chapter 5 described the design and implementation of the prototype, called MyPSI, on a desktop device. A sample PSI was used for evaluation purposes. The sample PSI was captured using the Windows API Code Pack where a number of file properties were collected for each PI item, including the file name, path, whether the item was a file or folder, file type, size, thumbnail, date created, date accessed, tags and whether the folder had descendants. Initially the design of the MyPSI prototype was focussed on a desktop/laptop device. The development process followed a two-step procedure: Step One included the design and implementation of the MyPSI prototype on a desktop device with mouse-based interaction using a sample PSI, and Step Two involved the design and implementation of the MyPSI prototype on a tablet device using touch-based interaction visualising a user's own PSI.

Several IV techniques were selected to be incorporated in the MyPSI prototype. These techniques included an *Overview*, using a nested circles layout, a *Tag Cloud*, visualising the tags in the PSI, and a *Partition Layout*, which used the set-based IV technique to visualise the folder libraries within each PIC (Graham *et al.*, 2000). Each IV technique incorporated in the MyPSI prototype needed to be enhanced to support the required functionality. The requirements identified from the results of the interview study as well as the proposed design of MyPSI were provided to several participants of the interview study using a conceptual walkthrough. All requirements were confirmed except for including additional facilities other than general PI types and support for file sharing and collaboration, which were subsequently removed from the list of requirements. Several visualisation libraries and toolkits were reviewed to determine the most suitable IV tool to implement the design of MyPSI. The D_3 (Data-driven Documents) visualisation library was selected as the most appropriate implementation tool as the library provides various example layouts with powerful customisation capabilities, which are scalable for large datasets. The design of the MyPSI prototype was implemented using the D_3 visualisation library, Hypertext Mark-up Language (HTML), Cascading Style Sheets (CSS), Bootstrap, jQuery and jQueryUI. The data for the sample PSI was stored in JavaScript Object Notation (JSON) files for retrieval by the D_3 library. The design of MyPSI was successfully implemented as a web application for a desktop device.

The fifth research question (RQ 5) was addressed in Chapter 6, which addressed the *Evaluate Artefact* DSR activity in the first iteration shown in Figure 1-4. Chapter 6 discussed a preliminary user study that was used to determine the suitability of the IV techniques incorporated in the MyPSI prototype. The preliminary user study was also used to identify any usability problems with MyPSI. The participants of the user study included students and staff from the Department of Computing Sciences at NMMU. Effectiveness, in terms of task success, and user satisfaction, measured using post-test questionnaires, were captured as metrics for the user study. The functionality provided by the MyPSI prototype was compared with the visual information seeking mantra identified by (Shneiderman, 1996). It was concluded that the MyPSI functionality extensively supported Shneiderman's mantra.

User tasks were identified from the required functionality that was identified in Chapter 5. These tasks included *Overview*, *data manipulation*, *Tag Cloud*, *search*, *filter*, *semantic zooming* and *browsing* tasks. The participants of the usability evaluation rated the MyPSI prototype highly in all aspects. Participants could easily interact with the IV techniques as shown by the positive effectiveness ratings. Participants also rated cognitive load, overall satisfaction and usability positively. Participants found the system simple to use, easy to use, easy to learn and generally useful. All IV techniques received positive ratings from the participants who agreed that the MyPSI prototype provided a good view of PI across multiple devices. Minor usability problems were identified with MyPSI, including the need for better scaling of file icons, differentiating search results, improving the *Tag Cloud* layout, and better control of transitions.

Chapter 7 addressed the sixth research question (RQ 6), which involved the second iteration of the *Design and Develop Artefact, Demonstrate Artefact* and *Evaluate Artefact* DSR activities. From the results received from the preliminary user study discussed in Chapter 6, the design of the MyPSI prototype was transferred to a mobile device. An actual PSI needed to be provided for each user of the MyPSI prototype to allow for testing in a real environment with his/her own PI. A cloud storage system was selected as the most appropriate back-end system to enable a user to upload his/her own PSI to be visualised by the MyPSI prototype. A tablet device was chosen as the most suitable mobile device on which to implement MyPSI as it has a larger screen size and superior storage space and power in comparison with a mobile phone. Tablet devices are also gaining popularity among business as well as general users. The Android platform was selected as it is less restrictive in terms of development possibilities and has become the top platform for tablet devices.

The same functionality, IV techniques and design used for the desktop version of the MyPSI prototype were incorporated in the tablet version. The tablet version of the MyPSI prototype was implemented using PhoneGap. The available implementation tools to implement the tablet version were limited due to the requirement of supporting D_3 and HTML. Thus, PhoneGap was selected as the most appropriate implementation tool as it provides a simpler means of transferring a design implemented with HTML to a tablet application. A number of cloud storage application programming interfaces (APIs), including Dropbox, Google Drive and OneDrive, were compared using several criteria. Dropbox was identified as the most appropriate cloud storage API, as it provided more capabilities and fully supported the PhoneGap implementation of the prototype. The design of the tablet version of the MyPSI prototype was implemented similarly to the desktop version of the prototype, with the addition of a sign in screen, which allowed the user to log in. Required improvements identified in the preliminary user study were implemented in both versions of MyPSI. The design was successfully mapped from the desktop version of MyPSI to the tablet version, with the same look and feel.

The seventh research question (RQ 7) was addressed in Chapter 8 involving the second iteration of the DSR activities shown in Figure 1-4. Several evaluation approaches were reviewed specifically for evaluating IV techniques and tools. These approaches included grounded theory/evaluation, focus groups, crowdsourcing and the Multi-dimensional In-depth Long-term Case Study (MILC) approach (Shneiderman and Plaisant, 2006). The MILC approach makes use of system logging, log books, questionnaires and/or interviews to provide in-depth results of the evaluation of IV techniques and tools, which takes place over an extended time period. The MILC approach was selected as the most suitable evaluation approach as it was closest to evaluating “in the wild” and it has been well-documented. The participants of the field study included staff and students from the Department of Computing Sciences and the School of Information Communication and Technology (ICT) at NMMU. The evaluation metrics that were measured for the field study included effectiveness, captured using electronic log book diaries and system logging, user satisfaction, captured using post-test questionnaires, and qualitative comments, captured using the log book diaries and the questionnaires.

The field study took place over a two-week period, where participants completed a set of tasks on both versions of the MyPSI prototype for each day of the field study. Participants were provided with the set of tasks and were also encouraged to make further use of the prototype. The main functionality was grouped for the different days of the evaluation, i.e. day 1 included data manipulation and semantic zooming tasks, day 2 included browsing and sorting tasks, day

3 involved searching and filtering, and day 4 included tasks relating to tagging and linking. In the first week of the field study, participants evaluated the desktop version of the MyPSI prototype using a web page with mouse-based interaction, and in the second week, participants evaluated the tablet version of the prototype using a PhoneGap application on an Android tablet device using touch-based interaction.

The results of the field study were discussed in terms of effectiveness, user satisfaction and qualitative comments. All the results were positive and above the baseline value of 3.4, or below 2.6 for the cognitive load ratings, measured using a 5-point Likert scale. Although problems were experienced with the system logging, the log book diaries provided useful results. Each task grouping received positive ratings in terms of ease of use and time taken to complete the tasks, where the desktop version received slightly higher ratings for most of the tasks. Participants found the desktop version of MyPSI easier to use for data manipulation and zooming, searching and filtering, and tagging and linking tasks, but browsing and sorting was found to be easier on the tablet version. Participants found the desktop version of the prototype faster for all tasks excluding tagging and linking. No major issues were experienced by participants of the field study other than the delayed response from some of the older Samsung Galaxy Tab 2 tablet devices.

Similar to the preliminary user study, sub-sections were added to the questionnaires in the field study for each IV technique. The ratings for cognitive load were low for both versions of the MyPSI prototype, while the tablet version received slightly higher ratings for the tablet in terms of frustration, which could be attributed to the familiarity aspect of the desktop with mouse interaction and the response problems of PhoneGap. The ratings for satisfaction were positive for both versions of the prototype. Participants found the desktop version easier to use and easier to learn, while they found the tablet version simpler to use. The ratings for usability were positive for both versions. Participants rated the desktop version higher for all the usability questions, which could be due to the problems experienced with the slow response of the tablet version.

The *Overview* received highly positive ratings for both versions of MyPSI and participants generally found the *Overview* useful and easy to use. The *Tag Cloud* also received highly positive ratings for both versions, but the *Tag Cloud* on the desktop version was rated slightly higher. Participants also rated the *Partition Layout* positively and the desktop version received slightly higher ratings for ease of use. Participants agreed that they would use the MyPSI prototype in future, and that the IV techniques as well as the prototype were considered useful.

Qualitative comments were captured for the tasks completed for each day of the field study using the log book diaries. The comments were mixed, but positive comments were made for most of the tasks and no major issues were identified. Participants were also asked to identify the most positive and most negative aspect(s) of each version of MyPSI in the post-test questionnaires. Participants appreciated that all their PICs could be visualised in a single UI on the desktop version, the functionality provided and that the prototype was easy to use. Participants found problems with the information windows and linking on the desktop version of the prototype. Participants identified that the desktop version of the MyPSI prototype was generally a good system. Participants liked using the tablet version to visualise their PI. Participants also found that they could easily find their files using the tablet version and also liked having the same UI for both the desktop and tablet versions. The most negative aspects identified with the tablet version included the small folder size, difficulties in zooming and the slow response of the tablet. Participants were satisfied with the tablet version of the MyPSI prototype and confirmed that they would use it in future.

Chapter 9 addressed the eighth and final research question (RQ 8) of the research, which assisted in adding knowledge to the existing knowledge bases, including PIM and IV. The requirements identified for PI organisation and visualisation in Chapters 2 and 3 were compared with the MyPSI prototype to determine the extent of support provided for these requirements. All the requirements were supported by MyPSI except for the *File Sharing* requirement for PI organisation. Requirements were also identified from the results of the interview study discussed in Chapter 4. Following the conceptual walkthrough, two requirements were removed, namely *include additional facilities other than general PI types* and *provide support for file sharing and collaboration*. The updated list of requirements was then reviewed in Chapter 9. The requirements for PI organisation and visualisation were mapped to the requirements identified from the results of the interview study. These requirements were then transformed into design recommendations to inform the design of future IV tools to support accessing PI across multiple devices. These design recommendations were also supported by the results of the field study as shown in Section 9.3.

10.2.3. Summary

The DSR methodology was followed successfully for this research. This research resulted in an artefact, which included the IV techniques incorporated in the MyPSI prototype to support accessing PI across multiple devices. Knowledge was identified in the form of design recommendations for PIM and IV. The iterative process, encouraged by the DSR methodology, was successfully used in the requirements identification as well as the design and evaluation phases within this research. The guidelines for the DSR methodology identified by (Hevner and Chatterjee, 2010) were described in Table 1-2. The extent to which these guidelines were supported by this research is summarised in Tables 10-1 below.

Table 10-1 Support for the Guidelines of the DSR Methodology

	Guideline	**Support**
1.	Design as an Artefact	The MyPSI prototype was designed to support PIM across multiple devices using suitable, enhanced IV techniques on both desktop and tablet devices.
2.	Problem Relevance	The problem to be addressed by this research involved the lack of support for accessing PI across multiple devices that a user uses for PIM. The MyPSI prototype supported functionality derived from the requirements identified from the literature review and the interview study.
3.	Design Evaluation	A preliminary user study was used to determine the suitability of the proposed IV techniques in the MyPSI prototype on a desktop device. An in-depth field study was used to determine the effectiveness of the IV techniques in supporting PI across multiple devices on both the desktop and tablet versions of the prototype.
4.	Research Contributions	Design recommendations were identified to inform future design of IV tools to support access to PI across multiple devices. This contribution represents the knowledge added to the existing knowledge bases in PIM and IV.
5.	Research Rigor	Suitable IV techniques were selected to visualise PI across multiple devices supporting the required functionality. A preliminary user study was used to determine the suitability of these selected IV techniques on a desktop device. The identified problems were addressed in the second iteration of the design, where the IV techniques were incorporated on a tablet version of the prototype. An in-depth field study determined that these IV techniques and the prototype were suitable and useful.
6.	Design as a Search Process	A literature study was used to determine the shortcomings of existing PI organisation methods and IV techniques and tools. An interview study was used to determine how PI is currently being managed across different devices and to identify problems experienced with this process. Requirements were then identified to inform the design of an IV tool to support PIM across multiple devices. Functionality was derived from these requirements to be supported by the prototype. The conceptual walkthrough and preliminary user study were used to confirm the design of the IV techniques and prototype.
7.	Communication of Research	Several peer-reviewed research papers were published on this work and this thesis serves to describe the research in detail.

This research addressed the research questions identified in Chapter 1 and summarised in Section 10.2.1. Participants of the preliminary user study and the field study agreed that the MyPSI prototype effectively supported accessing PI across multiple devices using enhanced IV techniques. Participants also rated each IV technique highly. The aim of this research was therefore supported in that the enhanced IV techniques were shown to effectively support accessing PI across multiple devices. The research achievements are summarised below:

- Identification of requirements for PI organisation methods;
- Identification of requirements for PI visualisation techniques and tools;
- Identification of requirements for accessing PI across multiple devices;
- Mapping of requirements for accessing PI across multiple devices to functionality for an IV tool;
- Design of appropriate IV techniques to visualise PICs across multiple devices;
- Implementation of a prototype for accessing PI across multiple devices on a desktop device;
- Evaluation of the prototype using a preliminary user study to determine the effectiveness of the proposed IV techniques;
- Design and implementation of the prototype for accessing PI across multiple devices on a tablet device;
- Evaluation of the usefulness of the enhanced IV techniques to support PIM across multiple devices on both the desktop and tablet device;
- Design recommendations to inform the design of an IV tool to support accessing PI across multiple devices.

10.3. Contributions

The contributions of this research are discussed in this section. The contribution of this work is described in terms of the theoretical and practical contributions. The theoretical contribution includes the enhanced IV techniques incorporated in the MyPSI prototype and the design recommendations identified in Chapter 9. The MyPSI prototype represents the practical contribution of this research.

10.3.1. Theoretical Contributions

The first theoretical contribution includes the enhanced IV techniques incorporated in the MyPSI prototype. Chapter 3 concluded that it was necessary to include IV in tools supporting PIM.

Several IV techniques were identified as suitable for supporting PIM across multiple devices. These IV techniques included an *Overview*, a *Tag Cloud* and a *Partition Layout*. These IV techniques were enhanced to support the required functionality. Participants of both the preliminary user study and field study liked the IV techniques incorporated in the MyPSI prototype and rated these techniques highly.

Table 10-2 A Summary of the Design Recommendations

Category	Design Recommendation
1. Organisation	1.1. Provide a virtual storage solution which aggregates PI in a single location
	1.2. Provide support for association of linked PI items
	1.3. Provide tagging to assist in information retrieval
2. Visualisation	2.1. Use a single UI to visualise PI across multiple devices
	2.2. Visualise the PI using suitable IV techniques
	2.3. Provide different views of the PSI
	2.4. Consider each device's physical constraints
3. Interaction	3.1. Provide intelligent searching across devices
	3.2. Provide functionality associated with PI items
	3.3. Support immediate access to PI items

The second theoretical contribution relates to the design recommendations for the design of an IV tool to support accessing PI across multiple devices. Initial requirements were identified in Chapters 2 and 3 for PI organisation and visualisation. Additional requirements were identified from the interview study discussed in Chapter 4. The requirements were compared with the results of the field study to identify the design recommendations proposed in Chapter 9. A summary of these design recommendations is provided in Table 10-2. Both the enhanced IV techniques and the design recommendations form part of the knowledge that is added to the existing knowledge bases in PIM and IV.

10.3.2. Practical Contributions

The practical contribution relates to the MyPSI prototype that was designed to support accessing PI across multiple devices. The prototype supported the functionality derived from the requirements, which were identified from the results of the literature review and the interview study. The MyPSI prototype was initially implemented on a desktop device supporting a web-based application with mouse-based interaction. The design of the MyPSI prototype was then successfully transferred to a mobile device, specifically a tablet device, with touch-based interaction. Participants of the field study identified that the MyPSI prototype was a good system and that they liked that the UI design on both the desktop device and the tablet device was the same. Participants also agreed that they would like to use MyPSI in future for accessing PI across multiple devices.

Results from both the preliminary user study and field study can assist future designers with regards to the application of IV to PIM. The preliminary user study did not identify any major usability problems with the MyPSI prototype. The field study involved an in-depth evaluation of both versions of the MyPSI prototype as it involved testing "in the wild" with each participant interacting with their own PSI. The MyPSI prototype was designed as a tool that incorporated enhanced IV techniques to support accessing PI across multiple devices. The MyPSI prototype could be extended to support alternative IV techniques and the design could be adapted to meet the constraints of other mobile devices for further flexibility.

10.4. Limitations and Problems Encountered

The MyPSI prototype was initially implemented as a web application designed for a desktop device. The web-based implementation was due to the selection of D_3 as the most powerful visualisation library or toolkit to design and implement customised IV techniques. This fact also limited the implementation tool selection on the mobile device, which was implemented as an application installed using PhoneGap. Thus, a truly native application could not be developed for the mobile version of the prototype, as D_3 is limited to JavaScript. The design and implementation of the MyPSI prototype was also limited to a desktop and a tablet device.

Other limitations included the slow response of the PhoneGap application in combination with the available devices, which were used for the field study. An additional limitation included the Dropbox cloud storage system used as the storage system for the MyPSI prototype. Ideally, the virtual storage system should allow the PI to remain on each user device while providing access to this information through the MyPSI prototype. Lastly, limitations regarding the evaluations included the small sample size of each evaluation and that the participant sample was taken from the Department of Computing Sciences and the School of ICT from NMMU, who were mainly expert users.

Problems encountered included problems with the implementation tools. While D_3 provided layouts for each IV technique, these layouts were simple and the IV techniques needed to be extensively customised to support the design as well as the required functionality. Initial filtering, to make effective use of screen space, and providing Details-on-Demand (DoD) was difficult within the *Partition Layout*. Simple tasks such as label overlap and thumbnail viewing needed to be implemented from first principles. The *Tag Cloud* layout provided by D_3 included a bug that has not yet been corrected. The main problem encountered with PhoneGap included the poor response of the application on the older tablet devices. Problems experienced with Dropbox included issues with pulling changes within a PSI, problems with the system logging using text files and the lack of support for tagging and linking functionality. Lastly, the information window implemented using Bootstrap to support DoD, provided problems for the participants.

10.5. Recommendations for Future Work

From this research, a number of recommendations are proposed for future work. The MyPSI prototype was limited to two implementations, namely a web-based application supporting a desktop device and an installed application supporting a tablet device. This implementation was limited by the visualisation library selected to implement the MyPSI prototype. Thus, it may be useful to re-design the UI of the MyPSI prototype for a mobile phone to support more devices. Due to the screen size availability, the design of the IV techniques will need to be reconsidered.

The MyPSI prototype was also limited to using PhoneGap to implement the tablet version. Thus, the application was not a truly native mobile application, as the application was designed using web implementation tools, and not designed according to Android guidelines. It may also be useful to determine to what extent it may be possible to implement a native mobile application on mobile devices following standard Android guidelines (Google Inc., 2014).

The MyPSI prototype supported any platform, which had access to a browser on a desktop device, but only the Android platform for the tablet. It was also difficult to support the Windows platform using PhoneGap. In the future, the MyPSI prototype could be extended to support other platforms.

The MyPSI prototype initially used a sample PSI to evaluate the prototype in the preliminary user study. A cloud storage system was required in order to evaluate the prototype in a user's own environment with his/her own PSI. This introduced the necessity of the user to upload his/her PSI as a pre-step to the field study. It would be ideal to support the MyPSI prototype with a virtual storage solution where the PICs remain on the original devices and only metadata is stored about this information, which can then be visualised using MyPSI. The PI items could be retrieved once a user requests to view or edit an item.

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Appendix A: Visualisation Techniques Used

#	System	Year	Type of Visualisation
1.	MyLifeBits	2002	Multiple Visualisations: timeline, cluster, detail, thumbnail views (Search UI)
2.	TeamViewer	2005	Indented list visualisation
3.	ProjectFolders	2006	Indented list visualisation (hierarchy with tabs)
4.	Email Archive	2007	Multiple visualisations: treemap (thematic visualisation), social network graph with spring layout (social), temporal
5.	Dropbox	2007	Indented list visualisation
6.	Facet Folders	2008	Nested folders (treemap-like diagram) (adaptable hierarchy)
7.	ZOIL	2008	Landscape with portals and user-selected visualisations
8.	Planz	2010	Indented list (hierarchical document overlay to support current hierarchy)
9.	File Concept Browser	2012	Indented list (hierarchy with multiple categorisations)
10.	PI Dashboard	2012	Dashboard with plug-ins using various visualisations for a graphical overview of user's life patterns
11.	InfoMaps	2012	Landscape with landmarks and various layouts

Appendix B: Ethics Approval

Nelson Mandela Metropolitan University

for tomorrow

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• Port Elizabeth • 6031 • South Africa • www.nmmu.ac.za

Chairperson: Research Ethics Committee (Human)
Tel: +27 (0)41 504-2235

Ref: [H12-SCI-CS-023/Approval]

RECH Secretariat: Mrs U Spies

9 October 2013

Prof J Wesson
Faculty of Science
School of Computing Science
09-02-13
South Campus

Dear Prof Wesson

ENHANCED VISUALISATION TECHNIQUES TO SUPPORT UBIQUITOUS ACCESS TO PERSONAL INFORMATION

PRP: Prof J Wesson
PI: Ms S Beets

Your above-entitled application for ethics approval served at the Research Ethics Committee (Human).

We take pleasure in informing you that the application was approved by the Committee.

The ethics clearance reference number is **H12-SCI-CS-023**, and is valid for three years. Please inform the REC-H, via your faculty representative, if any changes (particularly in the methodology) occur during this time. An annual affirmation to the effect that the protocols in use are still those for which approval was granted, will be required from you. You will be reminded timeously of this responsibility, and will receive the necessary documentation well in advance of any deadline.

We wish you well with the project. Please inform your co-investigators of the outcome, and convey our best wishes.

Yours sincerely

CB Cilliers

Prof CB Cilliers
Chairperson: Research Ethics Committee (Human)

cc: Department of Research Capacity Development
Faculty Officer: Science

Appendix C: Informed Consent Form (Preliminary User Study)

NELSON MANDELA METROPOLITAN UNIVERSITY: INFORMATION AND INFORMED CONSENT FORM

RESEARCHER'S DETAILS	
Title of the research project	**Enhanced Visualisation Techniques to Support Access to Personal Information across Multiple Devices**
Reference number	
Principal investigator	**Simone Beets**
Contact telephone number (private numbers not advisable)	**041 504 2094**

A. DECLARATION BY OR ON BEHALF OF THE PARTICIPANT		**Initial**
I, the participant and the undersigned	(full names)	

A.1. HEREBY CONFIRM AS FOLLOW		**Initial**
I, the participant was invited to participate in the above-mentioned research project		
that is being undertaken by	Simone Beets	
from	Department of Computing Sciences	
Of the nelson Mandela Metropolitan University		

A.2 THE FOLLOWING ASPECTS HAVE BEEN EXPLAINED TO ME, THE PARTICIPANT			**Initial**
	Aim	The investigators are studying how enhanced information visualisation techniques can be designed to support access to personal information across multiple devices The information will be used for research purposes	

	Procedures	I understand that I will be evaluating the IV techniques used in the MyPSI prototype I understand that I will complete a questionnaire following the evaluation			
	Risks	I understand that there are no risks involved in participating in this process			
	Confidentiality	My identity will not be revealed in any discussion, description or scientific publications by the investigators			
	Voluntary participation / refusal / discontinuation	My participation is voluntary	YES	NO	
		My decision whether or not to participate will in no way affect my present or future career/employment/lifestyle	TRUE	FALSE	

	No pressure was exerted on me to consent to participate and I understand that I may withdraw at any stage without penalisation	

	Participation in this study will not result in any additional cost to myself	

I HEREBY VOLUNTARILY CONSENT TO PARTICIPATE IN THE ABOVE-MENTIONED PROJECT:	
Signed/confirmed at on 20	
Signature	Signature of the witness:
	Full name of witness:

Appendix D: Biographical Questionnaire

My World @ NMMU Web Survey

Nelson Mandela Metropolitan University
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Biographical Questionnaire: Personal Information Management across Multiple Devices

Page: 1

1. Biographical Questions

1.1 *	Gender	○ Male ○ Female
1.2 *	Age	○ 18-20 ○ 21-29 ○ 30-39 ○ 40-49 ○ 50+
1.3 *	Occupation	○ Post-graduate Student ○ Computing Sciences Staff
1.4 *	Computer Experience (In Years)	○ 3-5 ○ 6-9 ○ 10+
1.5 *	Computer Expertise	○ Novice ○ Intermediate ○ Expert
1.6 *	Frequency in Managing Personal Information Using a Digital Device	○ Daily ○ Weekly ○ Monthly ○ Infrequently
1.7 *	Number of Devices used to Manage Personal Information	(please select)
1.8	Please list the devices that you use to manage your personal information and what platforms are supported by each device e.g. Desktop (Windows 8)	
1.9	From the devices listed in 1.8 above, please identify which is your main device for managing personal information	

Submit Questionnaire

Appendix E: Task List (Preliminary User Study)

Personal Information Management across Multiple Devices: Preliminary user study

Task List

Task 1: The Overview

1.1. Find the *Music* circle in the Overview.
1.2. Click on the *Laptop* circle within the *Music* circle. The partitions will expand / collapse appropriately.
1.3. Mouse-over (hover) on the *Laptop* circle to view the tooltip.
1.4. What is the size of the *Music* information collection on the *Laptop*?

Answer: ______________________________

1.5. Click the *Reset* button of the Overview.
1.6. Find the *Videos* circle in the Overview.
1.7. Click on the *PC* circle within the *Videos* circle. The partitions will expand / collapse appropriately.
1.8. What other devices contain *Videos*?

Answer: ______________________________

1.9. Click the *Reset* button of the Overview.

Task 2: Manipulation

Task 2.1: Renaming a File

2.1.1. Find the *Documents* folder library on the *PC*.
2.1.2. Click on the <u>label</u> of the "*philips - 10-12-2013"* sub-folder.
2.1.3. In the popup window, enter "*Flash Backup*".
2.1.4. Click Ok.
2.1.5. How many *Music* files are contained in the *Flash Backup* folder (excluding sub-folders)?

Answer: ______________________________

2.1.6. Find the *Videos* folder library on the *Laptop*.

2.1.7. Click on the <u>label</u> of the "*Videos2"* sub-folder.
2.1.8. In the popup window, enter "*Additional Videos*".
2.1.9. Click Ok.
2.1.10. How many *Video* files are contained in the *Additional Videos* folder?

Answer: ______________________________

Task 2.2: Adding a File

2.2.1. Click on the *Music* folder on the *Tablet.*
2.2.2. In the popover window, click on the  button to add a file to this folder.
2.2.3. Mouse-over (hover) on the new document to view the tooltip.
2.2.4. What is the name of the file?

Answer: ______________________________

2.2.5. Click on the *Documents* folder on the *Phone.*
2.2.6. In the popover window, click on the  button to add a file to this folder.
2.2.7. How many *documents* does this folder contain?

Answer: ______________________________

Task 2.3: Deleting a File

2.3.1. Find the *Documents* folder library on the *Tablet.*
2.3.2. Click on the last file in this folder to view the popover.
2.3.3. In the popover window, click on the  button to delete this file.
2.3.4. How many files are contained in this folder?

Answer: ______________________________

2.3.5. Click on the *Documents* folder library on the *Phone.*
2.3.6. Click on the last file in this folder to view the popover.
2.3.7. In the popover window, click on the  button to delete this file.
2.3.8. How many files are contained in this folder?

Answer: ______________________________

Task 3: The Tag Cloud

3.1. Click on the *"Pilates"* tag in the Tag Cloud.
3.2. Click on the *Edit Tag* button.
3.3. Edit the tag in the textbox and change it to "*Blogilates"*.
3.4. Click Ok.
3.5. Click on the "*Blogilates"* tag in the Tag Cloud.
3.6. How many files have the *Blogilates* tag?

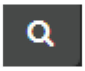
Answer: ________________________________

3.7. Click on the *"week10"* tag in the Tag Cloud.
3.8. Mouse-over (hover) the single document in the partition layout that contains this tag.
3.9. How many tags does this file have?

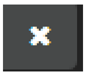
Answer: ________________________________

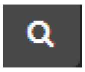
3.10. Click the *Reset* button of the Tag Cloud.

Task 4: Search

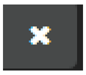
4.1. Enter the keyword *"diss"* in the search box to find documents relating to a dissertation.
4.2. In the *Search In* dropdown, *d*eselect the *All* option and select the *Title* option.
4.3. Click on the  button to refine the search.
4.4. How many files match this search?

Answer: ________________________________

4.5. Click on the  button next to the Search In dropdown to cancel the search.

4.6. Enter the keyword *"general"* in the search box to find documents relating to the general prospectus.
4.7. In the *Search In* dropdown, *d*eselect the *All* option and select the *Title* option.
4.8. Click on the  button to refine the search.
4.9. On what device is the general prospectus document found?

Answer: ________________________________

4.10. Click on the  button next to the Search In dropdown to cancel the search.

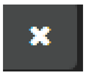
Task 5: Filter

5.1. In the *Filter* dropdown, select *Documents* under the *Type* filter and *PC* under the *device* filter.

5.2. Click on the *Filter* button.

5.3. How many documents are found on the PC?

Answer: ________________________________

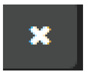
5.4. Click on the  button next to the Filter dropdown to cancel the filter.

5.5. In the *Filter* dropdown, select *Documents* under the *Type* filter and *Phone* under the device filter.

5.6. Click on the *Filter* button.

5.7. How many documents are found on the Phone?

Answer: ________________________________

5.8. Click on the  button next to the Filter dropdown to cancel the filter.

Task 6: Semantic Zooming on a File

6.1. Find the *Music* folder library on the *Tablet.*

6.2. Mouse-over (hover) the second music file.

6.3. Zoom into the file using the mouse-wheel until the name and type of the file is shown

6.4. What type of file is this?

Answer: ________________________________

6.5. Zoom further into the file using the mouse-wheel until the blue alert is shown at the top of the screen.

6.6. What information is contained in this alert?

Answer: ________________________________

6.7. Zoom out fully using the mouse-wheel to view the entire *Music* folder library on the *Tablet*.

Task 7: Browsing

7.1. Find the *Videos* folder library on the *PC.*

7.2. Click the  button on the "*Blogilates-BEGINNERS CALENDAR" folder* to display the next sub-folder.

7.3. What is the name of the next sub-folder shown?

Answer: ________________________________

7.4. Find the *Pictures* folder library on the *Tablet.*

7.5. Click the  button on the "*Pictures*" folder to display the next sub-folder.

7.6. What is the name of the next sub-folder shown?

Answer: ________________________________

Appendix F: Post-Test Questionnaire (Preliminary User Study)

My World @ NMMU Web Survey — Nelson Mandela Metropolitan University

Post-Test Questionnaire: Personal Information Management across Multiple Devices

Page: **1** 2 3 4 5 6 7

1. Cognitive Load		
1.1 *	Mental Demand: The tasks were mentally demanding	Strongly disagree ○1 ○2 ○3 ○4 ○5 ○6 ○7 Strongly agree
1.2 *	Physical Demand: The tasks were physically demanding	Strongly disagree ○1 ○2 ○3 ○4 ○5 ○6 ○7 Strongly agree
1.3 *	Temporal Demand: The pace of the tasks were hurried or rushed	Strongly disagree ○1 ○2 ○3 ○4 ○5 ○6 ○7 Strongly agree
1.4 *	Performance: I was unsuccessful in accomplishing what I was asked to do	Strongly disagree ○1 ○2 ○3 ○4 ○5 ○6 ○7 Strongly agree
1.5 *	Effort: I had to work hard to accomplish my level of performance	Strongly disagree ○1 ○2 ○3 ○4 ○5 ○6 ○7 Strongly agree
1.6 *	Frustration: I felt insecure, discouraged, irritated, stressed, and annoyed	Strongly disagree ○1 ○2 ○3 ○4 ○5 ○6 ○7 Strongly agree

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Page: 1 **2** 3 4 5 6 7

2. Overall Satisfaction		
2.1 *	Overall, I am satisfied with how easy it is to use the system	Strongly disagree ○1 ○2 ○3 ○4 ○5 ○6 ○7 Strongly agree
2.2 *	Overall, I am satisfied with the system	Strongly disagree ○1 ○2 ○3 ○4 ○5 ○6 ○7 Strongly agree
2.3 *	It was easy to learn to use the system	Strongly disagree ○1 ○2 ○3 ○4 ○5 ○6 ○7 Strongly agree
2.4 *	It was simple to use the system	Strongly disagree ○1 ○2 ○3 ○4 ○5 ○6 ○7 Strongly agree

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Page: 1 2 **3** 4 5 6 7

3. Usability		
3.1 *	I can effectively find personal information items using the system	Strongly disagree ○1 ○2 ○3 ○4 ○5 ○6 ○7 Strongly agree
3.2 *	I was able to find personal information items quickly using the system	Strongly disagree ○1 ○2 ○3 ○4 ○5 ○6 ○7 Strongly agree
3.3 *	I was able to efficiently find personal information items using the system	Strongly disagree ○1 ○2 ○3 ○4 ○5 ○6 ○7 Strongly agree
3.4 *	I became productive quickly using the system	Strongly disagree ○1 ○2 ○3 ○4 ○5 ○6 ○7 Strongly agree
3.5 *	The system has all functions and capabilities I expect from a personal information management tool	Strongly disagree ○1 ○2 ○3 ○4 ○5 ○6 ○7 Strongly agree
3.6 *	I can effectively browse the personal information collection using the system	Strongly disagree ○1 ○2 ○3 ○4 ○5 ○6 ○7 Strongly agree
3.7 *	I was able to browse the personal information collection quickly using the system	Strongly disagree ○1 ○2 ○3 ○4 ○5 ○6 ○7 Strongly agree
3.8 *	I was able to efficiently browse the personal information collection using the system	Strongly disagree ○1 ○2 ○3 ○4 ○5 ○6 ○7 Strongly agree

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Page: 1 2 3 **4** 5 6 7

4. The Overview

4.1 *	The Overview provided a clear view of the different types of information	Strongly disagree ○1 ○2 ○3 ○4 ○5 ○6 ○7 Strongly agree
4.2 *	The overview was useful	Strongly disagree ○1 ○2 ○3 ○4 ○5 ○6 ○7 Strongly agree
4.3 *	The overview was easy to use	Strongly disagree ○1 ○2 ○3 ○4 ○5 ○6 ○7 Strongly agree
4.4 *	The zoom and filter of the overview was easy to use	Strongly disagree ○1 ○2 ○3 ○4 ○5 ○6 ○7 Strongly agree
4.5 *	The zoom and filter of the overview was useful	Strongly disagree ○1 ○2 ○3 ○4 ○5 ○6 ○7 Strongly agree

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Page: 1 2 3 4 **5** 6 7

5. The Tag Cloud

5.1 *	The tag cloud provided a good overview of all the tags in the information collection	Strongly disagree ○1 ○2 ○3 ○4 ○5 ○6 ○7 Strongly agree
5.2 *	The tag cloud was useful	Strongly disagree ○1 ○2 ○3 ○4 ○5 ○6 ○7 Strongly agree
5.3 *	The tag cloud was easy to use	Strongly disagree ○1 ○2 ○3 ○4 ○5 ○6 ○7 Strongly agree
5.4 *	The filter of the tag cloud was easy to use	Strongly disagree ○1 ○2 ○3 ○4 ○5 ○6 ○7 Strongly agree
5.5 *	The filter of the tag cloud was useful	Strongly disagree ○1 ○2 ○3 ○4 ○5 ○6 ○7 Strongly agree

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Page: 1 2 3 4 5 **6** 7

6. The Partition Layout

6.1 *	The partition layout provided a good view of all the information in different collections	Strongly disagree ○1 ○2 ○3 ○4 ○5 ○6 ○7 Strongly agree
6.2 *	The partition layout was useful	Strongly disagree ○1 ○2 ○3 ○4 ○5 ○6 ○7 Strongly agree
6.3 *	The partition layout was easy to use	Strongly disagree ○1 ○2 ○3 ○4 ○5 ○6 ○7 Strongly agree
6.4 *	The zoom of the partition layout enabled me to obtain more information on a file	Strongly disagree ○1 ○2 ○3 ○4 ○5 ○6 ○7 Strongly agree
6.5 *	The zoom and filter of the partition layout was easy to use	Strongly disagree ○1 ○2 ○3 ○4 ○5 ○6 ○7 Strongly agree
6.6 *	The zoom and filter of the partition layout was useful	Strongly disagree ○1 ○2 ○3 ○4 ○5 ○6 ○7 Strongly agree

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Page: 1 2 3 4 5 6 **7**

7. General

7.1 *	Identify the most positive aspect(s) of the system	
7.2 *	Identify the most negative aspect(s) of the system	
7.3	Please provide any general comments or suggestions for improvement	

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Appendix G: Informed Consent Form (Field Study)

My World @ NMMU Web Survey

Nelson Mandela Metropolitan University

for tomorrow

Field Study of Prototype Visualisation Tool: Informed Consent Form

Research Project: Enhanced Visualisation Techniques to Support Ubiquitous Access to Personal Information (H12-SCI-CS-023); Principal Investigator: Simone Beets (Simone.Beets2@nmmu.ac.za)

1. Declaration By or On Behalf of the Participant

1.1 *	I, the participant (full name)	
1.2 *	With participant number	

2. Hereby confirm as follows

2.1 *	I, the participant, was invited to participate in the above-mentioned research project that is being undertaken by Simone Beets from the Department of Computing Sciences of the Nelson Mandela Metropolitan University	Disagree Agree

3. The following aspects have been explained to me

3.1 *	Aim: The investigators are studying how enhanced information visualisation techniques can be designed to support ubiquitous access to personal information. The information will be used for research purposes.	Disagree Agree
3.2 *	Procedures: I understand that I will be evaluating the information visualisation techniques used in the MyPSI prototype on a desktop/laptop and a tablet device. I understand that I will complete a log book on each day of the evaluation and a questionnaire following the evaluation on each device.	Disagree Agree
3.3 *	Risks: I understand that there are no risks involved in participating in this process.	Disagree Agree
3.4 *	Confidentiality: My identity will not be revealed in any discussion, description or scientific publications by the investigators. The MyPSI prototype will make use of a login to ensure that only I am able to access my personal information. The confidentiality of my personal information will be maintained.	Disagree Agree
3.5 *	Voluntary participation / refusal / discontinuation: My participation is voluntary.	Disagree Agree
3.6 *	Voluntary participation / refusal / discontinuation: My decision whether or not to participate will in no way affect my present or future career/employment/lifestyle.	False True
3.7 *	No pressure was exerted on me to consent to participate and I understand that I may withdraw at any stage without penalisation.	Disagree Agree
3.8 *	Participation in this study will not result in any additional cost to myself.	Disagree Agree

4. Consent

4.1 *	I hereby voluntarily consent to participate in the above-mentioned project.	Disagree Agree

Submit Questionnaire

Appendix H: Task List (Field Study)

The following task list was similar for both the desktop and tablet versions of MyPSI:

Day 1: Data Manipulation and Semantic Zooming

Task 1: Sign In:

1.1. Sign in to MyPSI using your assigned participant details.

Task 2: Data Manipulation (Files):

2.1. Hover over a file to view its properties.

2.2. Click on a file to view its properties and the available actions.

2.3. Rename a file.

2.4. Add a new file.

2.5. Delete a file.

2.6. Copy a file to another device.

2.7. Move a file to another device.

2.8. Open a file.

Task 3: Zooming:

3.1. Zoom in to any file to view the type of file.

3.2. Zoom in to an image to view the thumbnail of your file.

3.3. Zoom in to one of your text files to view the content of your file.

3.4. Double-click / double-tap on a folder to open that folder and display its contents.

Day 2: Browsing and Sorting

Task 1: Data Manipulation (Folders):

1.1. Rename a folder.

1.2. Add a new folder.

1.3. Delete a folder.

1.4. Copy multiple folders to another device.

1.5. Move multiple folders to another device.

1.6. Open a folder.

Task 2: Zooming:

2.1. Zoom in to any file to view the type of file.

2.2. Zoom in to an image to view the thumbnail of your file.

2.3. Zoom in to one of your text files to view the content of your file.

2.4. Double-click / double-tap on a folder to open that folder and display its contents.

Task 3: Browsing:

3.1. Browse your information to find a file.

3.2. Browse your information to find a folder (if a folder is hidden, use the arrows to browse between folders). *Please remember to upload more than three sub-folders in a destination folder to complete this task.*

Task 4: Sorting:

4.1. Sort the information in one of your Libraries by *type* and then by *file name*. Do not clear the sort, move directly to task 4.2.

4.2. Sort the information in the same Library by *type* and then by *date*.

<u>Day 3: Searching and Filtering</u>

Task 1: Browsing:

1.1. Browse your information to find a file.

1.2. Browse your information to find a folder (if a folder is hidden, use the arrows to browse between folders). *Please remember to upload more than three sub-folders in a destination folder to complete this task.*

Task 2: Sorting:

2.1. Sort the information in one of your Libraries by *date* and then by *file name*. Do not clear the sort, move directly to task 4.2.

2.2. Sort the information in the same Library by *type* and then by *date*.

Task 3: Searching:

3.1. Use the search box to search for files and/or folders.

3.2. Use the search box together with the *Search In* dropdown menu to search for a file.

3.3. Use the search box together with the *Search In* dropdown menu to search for a folder.

Task 4: Filtering:

4.1. Use the *Overview* to filter on one device e.g. device 1 or device 2.

4.2. Use the *Filter* dropdown menu to filter on a specific type of file e.g. filter to show only documents.

4.3. Use the *Filter* dropdown menu to filter on a specific type of file on a specific device e.g. filter to show only documents on device 1.

4.4. Use the *Filter* dropdown menu to filter on a specific type of file on a specific device within a specific date range e.g. filter to show only documents on device 1 within a date range.

Day 4: Tagging and Linking

Task 1: Tagging (Only Files):

1.1. Add a *new* tag to a file.

1.2. Add *new* tag to another file.

1.3. Click on a tag to view file(s) associated with this tag.

1.4. Rename a tag in the tag cloud.

1.5. Delete a tag in the tag cloud.

Task 2: Linking (Only Files):

2.1. Add a link between two files.

2.2. Add a link between two other files.

Task 3: Browsing:

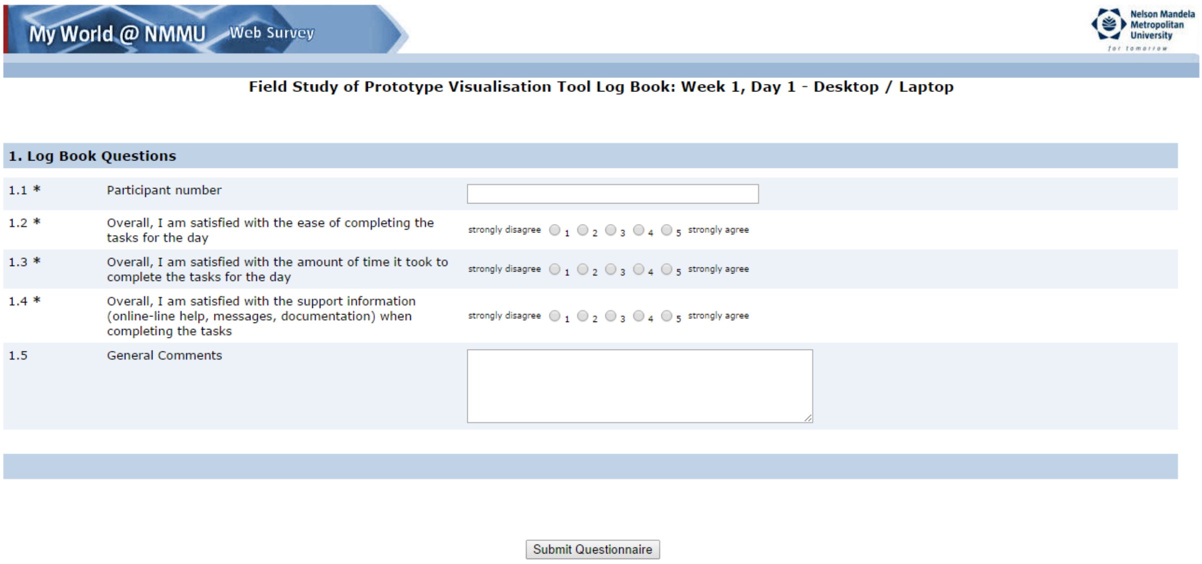
3.1. Click on one of the files that have a tag or that was linked. (Click the Home button to reset the selection.)

Task 4: Searching:

4.1. Use the search box together with the *Search In* dropdown menu to search for a file that has one of your added tags.

Appendix I: Log Books (Field Study)

Log Book for the Desktop (Week 1, Day 1)



My World @ NMMU Web Survey

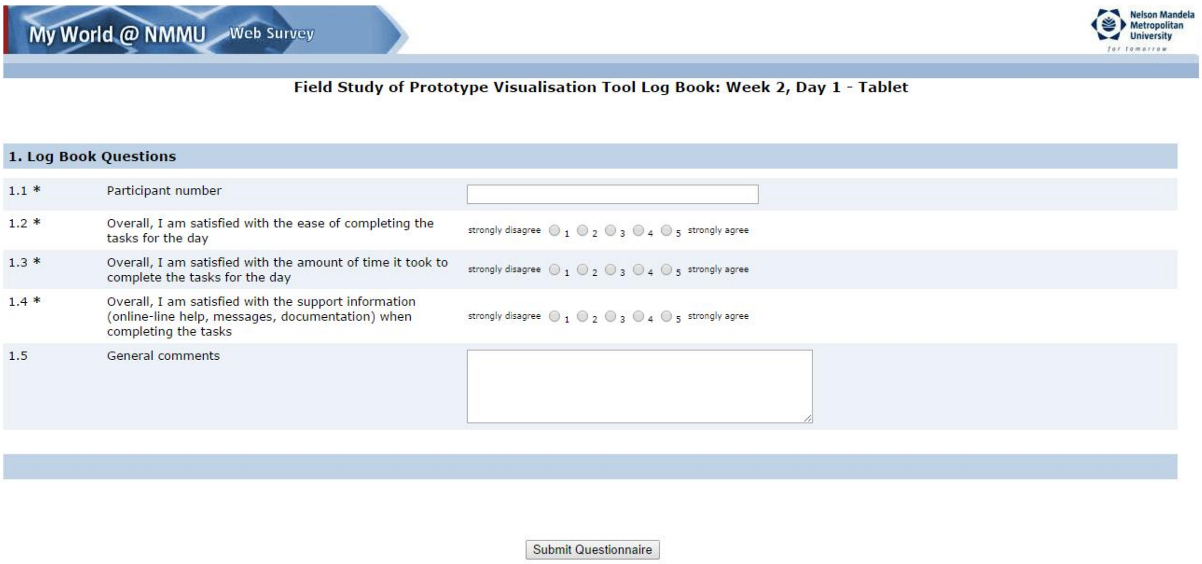
Nelson Mandela Metropolitan University

Field Study of Prototype Visualisation Tool Log Book: Week 1, Day 1 - Desktop / Laptop

1. Log Book Questions		
1.1 *	Participant number	
1.2 *	Overall, I am satisfied with the ease of completing the tasks for the day	strongly disagree 1 2 3 4 5 strongly agree
1.3 *	Overall, I am satisfied with the amount of time it took to complete the tasks for the day	strongly disagree 1 2 3 4 5 strongly agree
1.4 *	Overall, I am satisfied with the support information (online-line help, messages, documentation) when completing the tasks	strongly disagree 1 2 3 4 5 strongly agree
1.5	General Comments	

Submit Questionnaire

Log Book for the Tablet (Week 2, Day 1)



My World @ NMMU Web Survey

Nelson Mandela Metropolitan University

Field Study of Prototype Visualisation Tool Log Book: Week 2, Day 1 - Tablet

1. Log Book Questions		
1.1 *	Participant number	
1.2 *	Overall, I am satisfied with the ease of completing the tasks for the day	strongly disagree 1 2 3 4 5 strongly agree
1.3 *	Overall, I am satisfied with the amount of time it took to complete the tasks for the day	strongly disagree 1 2 3 4 5 strongly agree
1.4 *	Overall, I am satisfied with the support information (online-line help, messages, documentation) when completing the tasks	strongly disagree 1 2 3 4 5 strongly agree
1.5	General comments	

Submit Questionnaire

Appendix J: Post-Test Questionnaire – Desktop (Field Study)

My World @ NMMU Web Survey

Nelson Mandela Metropolitan University

Post-Test Questionnaire: Field Study of Prototype Visualisation Tool - Week 1: Desktop / Laptop

Page: 1 2 3 4 5 6 7

1. Participant Information		
1.1 *	Participant number	

2. Cognitive Load		
2.1 *	Mental Demand: The tasks were mentally demanding	strongly disagree ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 strongly agree
2.2 *	Physical Demand: The tasks were physically demanding	strongly disagree ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 strongly agree
2.3 *	Temporal Demand: The pace of the tasks were hurried or rushed	strongly disagree ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 strongly agree
2.4 *	Performance: I was unsuccessful in accomplishing what I was asked to do	strongly disagree ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 strongly agree
2.5 *	Effort: I had to work hard to accomplish my level of performance	strongly disagree ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 strongly agree
2.6 *	Frustration: I felt insecure, discouraged, irritated, stressed, and annoyed	strongly disagree ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 strongly agree

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My World @ NMMU Web Survey

Nelson Mandela Metropolitan University

Post-Test Questionnaire: Field Study of Prototype Visualisation Tool - Week 1: Desktop / Laptop

Page: 1 2 3 4 5 6 7

3. Overall Satisfaction		
3.1 *	Overall, I am satisfied with how easy it is to use the system	strongly disagree ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 strongly agree
3.2 *	Overall, I am satisfied with the system	strongly disagree ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 strongly agree
3.3 *	It was easy to learn to use the system	strongly disagree ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 strongly agree
3.4 *	It was simple to use the system	strongly disagree ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 strongly agree

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My World @ NMMU Web Survey

Nelson Mandela Metropolitan University

Post-Test Questionnaire: Field Study of Prototype Visualisation Tool - Week 1: Desktop / Laptop

Page: 1 2 **3** 4 5 6 7

4. Usability		
4.1 *	I can effectively find personal information items using the system	strongly disagree ○1 ○2 ○3 ○4 ○5 strongly agree
4.2 *	I was able to find personal information items quickly using the system	strongly disagree ○1 ○2 ○3 ○4 ○5 strongly agree
4.3 *	I was able to efficiently find personal information items using the system	strongly disagree ○1 ○2 ○3 ○4 ○5 strongly agree
4.4 *	I became productive quickly using the system	strongly disagree ○1 ○2 ○3 ○4 ○5 strongly agree
4.5 *	The system has all functions and capabilities I expect from a personal information management tool	strongly disagree ○1 ○2 ○3 ○4 ○5 strongly agree
4.6 *	I can effectively browse the personal information collection using the system	strongly disagree ○1 ○2 ○3 ○4 ○5 strongly agree
4.7 *	I was able to browse the personal information collection quickly using the system	strongly disagree ○1 ○2 ○3 ○4 ○5 strongly agree
4.8 *	I was able to efficiently browse the personal information collection using the system	strongly disagree ○1 ○2 ○3 ○4 ○5 strongly agree

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My World @ NMMU Web Survey

Nelson Mandela Metropolitan University

Post-Test Questionnaire: Field Study of Prototype Visualisation Tool - Week 1: Desktop / Laptop

Page: 1 2 3 **4** 5 6 7

5. The Overview		
5.1 *	The Overview provided a clear view of the different types of information	strongly disagree ○1 ○2 ○3 ○4 ○5 strongly agree
5.2 *	The overview was useful	strongly disagree ○1 ○2 ○3 ○4 ○5 strongly agree
5.3 *	The overview was easy to use	strongly disagree ○1 ○2 ○3 ○4 ○5 strongly agree
5.4 *	The zoom and filter of the overview was easy to use	strongly disagree ○1 ○2 ○3 ○4 ○5 strongly agree
5.5 *	The zoom and filter of the overview was useful	strongly disagree ○1 ○2 ○3 ○4 ○5 strongly agree

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My World @ NMMU Web Survey

Nelson Mandela Metropolitan University

Post-Test Questionnaire: Field Study of Prototype Visualisation Tool - Week 1: Desktop / Laptop

Page: 1 2 3 4 **5** 6 7

6. The Tag Cloud		
6.1 *	The tag cloud provided a good overview of all the tags in the information collection	strongly disagree ○1 ○2 ○3 ○4 ○5 strongly agree
6.2 *	The tag cloud was useful	strongly disagree ○1 ○2 ○3 ○4 ○5 strongly agree
6.3 *	The tag cloud was easy to use	strongly disagree ○1 ○2 ○3 ○4 ○5 strongly agree
6.4 *	The filter of the tag cloud was easy to use	strongly disagree ○1 ○2 ○3 ○4 ○5 strongly agree
6.5 *	The filter of the tag cloud was useful	strongly disagree ○1 ○2 ○3 ○4 ○5 strongly agree

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My World @ NMMU Web Survey

Nelson Mandela Metropolitan University

Post-Test Questionnaire: Field Study of Prototype Visualisation Tool - Week 1: Desktop / Laptop

Page: 1 2 3 4 5 6 7

7. The Partition Layout		
7.1 *	The partition layout provided a good view of all the information in different collections	strongly disagree ○1 ○2 ○3 ○4 ○5 strongly agree
7.2 *	The partition layout was useful	strongly disagree ○1 ○2 ○3 ○4 ○5 strongly agree
7.3 *	The partition layout was easy to use	strongly disagree ○1 ○2 ○3 ○4 ○5 strongly agree
7.4 *	The zoom of the partition layout enabled me to obtain more information on a file	strongly disagree ○1 ○2 ○3 ○4 ○5 strongly agree
7.5 *	The zoom and filter of the partition layout was easy to use	strongly disagree ○1 ○2 ○3 ○4 ○5 strongly agree
7.6 *	The zoom and filter of the partition layout was useful	strongly disagree ○1 ○2 ○3 ○4 ○5 strongly agree

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My World @ NMMU Web Survey

Nelson Mandela Metropolitan University

Post-Test Questionnaire: Field Study of Prototype Visualisation Tool - Week 1: Desktop / Laptop

Page: 1 2 3 4 5 6 7

8. General		
8.1 *	I would like to use this system in future	strongly disagree ○1 ○2 ○3 ○4 ○5 strongly agree
8.2 *	Identify the most positive aspect(s) of the system	
8.3 *	Identify the most negative aspect(s) of the system	
8.4	Please provide any general comments or suggestions for improvement	

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Appendix K: Post-Test Questionnaire – Tablet (Field Study)

My World @ NMMU Web Survey

Nelson Mandela Metropolitan University

Post-Test Questionnaire: Field Study of Prototype Visualisation Tool - Week 2: Tablet

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1. Participant Information		
1.1 *	Participant number	

2. Cognitive Load		
2.1 *	Mental Demand: The tasks were mentally demanding	strongly disagree ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 strongly agree
2.2 *	Physical Demand: The tasks were physically demanding	strongly disagree ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 strongly agree
2.3 *	Temporal Demand: The pace of the tasks were hurried or rushed	strongly disagree ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 strongly agree
2.4 *	Performance: I was unsuccessful in accomplishing what I was asked to do	strongly disagree ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 strongly agree
2.5 *	Effort: I had to work hard to accomplish my level of performance	strongly disagree ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 strongly agree
2.6 *	Frustration: I felt insecure, discouraged, irritated, stressed, and annoyed	strongly disagree ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 strongly agree

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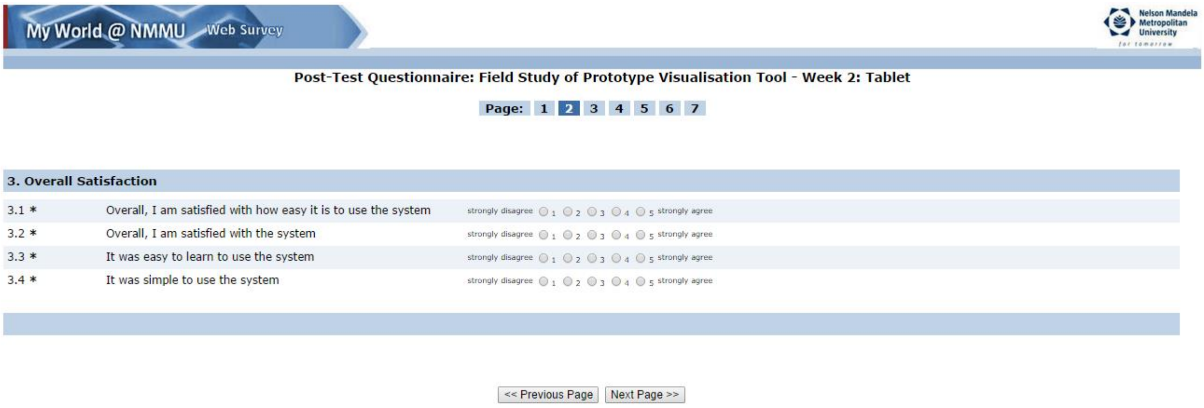

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3. Overall Satisfaction		
3.1 *	Overall, I am satisfied with how easy it is to use the system	strongly disagree ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 strongly agree
3.2 *	Overall, I am satisfied with the system	strongly disagree ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 strongly agree
3.3 *	It was easy to learn to use the system	strongly disagree ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 strongly agree
3.4 *	It was simple to use the system	strongly disagree ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 strongly agree

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4. Usability		
4.1 *	I can effectively find personal information items using the system	strongly disagree ○1 ○2 ○3 ○4 ○5 strongly agree
4.2 *	I was able to find personal information items quickly using the system	strongly disagree ○1 ○2 ○3 ○4 ○5 strongly agree
4.3 *	I was able to efficiently find personal information items using the system	strongly disagree ○1 ○2 ○3 ○4 ○5 strongly agree
4.4 *	I became productive quickly using the system	strongly disagree ○1 ○2 ○3 ○4 ○5 strongly agree
4.5 *	The system has all functions and capabilities I expect from a personal information management tool	strongly disagree ○1 ○2 ○3 ○4 ○5 strongly agree
4.6 *	I can effectively browse the personal information collection using the system	strongly disagree ○1 ○2 ○3 ○4 ○5 strongly agree
4.7 *	I was able to browse the personal information collection quickly using the system	strongly disagree ○1 ○2 ○3 ○4 ○5 strongly agree
4.8 *	I was able to efficiently browse the personal information collection using the system	strongly disagree ○1 ○2 ○3 ○4 ○5 strongly agree

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5. The Overview		
5.1 *	The overview provided a clear view of the different types of information	strongly disagree ○1 ○2 ○3 ○4 ○5 strongly agree
5.2 *	The overview was useful	strongly disagree ○1 ○2 ○3 ○4 ○5 strongly agree
5.3 *	The overview was easy to use	strongly disagree ○1 ○2 ○3 ○4 ○5 strongly agree
5.4 *	The zoom and filter of the overview was easy to use	strongly disagree ○1 ○2 ○3 ○4 ○5 strongly agree
5.5 *	The zoom and filter of the overview was useful	strongly disagree ○1 ○2 ○3 ○4 ○5 strongly agree

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6. The Tag Cloud		
6.1 *	The tag cloud provided a good overview of all the tags in the information collection	strongly disagree ○1 ○2 ○3 ○4 ○5 strongly agree
6.2 *	The tag cloud was useful	strongly disagree ○1 ○2 ○3 ○4 ○5 strongly agree
6.3 *	The tag cloud was easy to use	strongly disagree ○1 ○2 ○3 ○4 ○5 strongly agree
6.4 *	The filter of the tag cloud was easy to use	strongly disagree ○1 ○2 ○3 ○4 ○5 strongly agree
6.5 *	The filter of the tag cloud was useful	strongly disagree ○1 ○2 ○3 ○4 ○5 strongly agree

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7. The Partition Layout

7.1 *	The partition layout provided a good view of all the information in different collections	strongly disagree ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 strongly agree
7.2 *	The partition layout was useful	strongly disagree ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 strongly agree
7.3 *	The partition layout was easy to use	strongly disagree ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 strongly agree
7.4 *	The zoom of the partition layout enabled me to obtain more information on a file	strongly disagree ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 strongly agree
7.5 *	The zoom and filter of the partition layout was easy to use	strongly disagree ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 strongly agree
7.6 *	The zoom and filter of the partition layout was useful	strongly disagree ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 strongly agree

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8. General

8.1 *	I would like to use this system in future	strongly disagree ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 strongly agree
8.2 *	Identify the most positive aspect(s) of the system	
8.3 *	Identify the most negative aspect(s) of the system	
8.4 *	Please provide any general comments or suggestions for improvement	

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Appendix L: Cross Platform Mobile Development Model