AN EFFICIENT MANAGEMENT SYSTEM FOR LARGE DIGITAL OBJECT COLLECTIONS

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DECLARATION

I know the meaning of plagiarism and declare that all of the work in this document, save that which is properly acknowledged, is my own.

_____ **Date:** 31 January 2011

Ms Kathryn Michele van Niekerk

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Finally, I would like to thank the test subjects who gave of their time to perform user evaluations and to provide carefully thought out and constructive feedback. It is important when building any application that the opinions of the users are considered. Ultimately, they are the ones who will be using the product of this thesis, and not the programmers.

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ABSTRACT

The modern approach to Cultural Heritage Preservation (CHP) acknowledges the importance of preserving not only existing cultural history, but also the current and future states of a society or a group of people. Cultures evolve continuously, and it is therefore vital to track and record these changes, and most importantly of all, manage the resulting huge mass of data such as images, video clips, audio recordings and documents.

This thesis examines the design of a Web-based solution, hereafter referred to as the Information Management System (IMS), to handle the efficient, accurate and secure management of a large number of objects. The primary goal of IMS is to make reviewing, organising and manipulating objects (images, audio recordings, video recordings and documents of many types) scalable from small to large collections.

Essential elements of the IMS are the efficiency, usability and simplicity of the Graphical User Interface (GUI) itself, the ability to handle large numbers of different, but related, objects simultaneously in a non-specific manner with good data security. Other important aspects are ease of software maintenance with customisable object formats and metadata types.

Much research and system development has taken place on the storing, viewing, sharing and managing of digital objects. IMS shares many of the features of these systems, but its primary focus is to enhance the metadata management process to include fast and efficient simultaneous management of multiple digital objects, while not neglecting other features of a digital object management system.

The IMS application development path used evolutionary prototyping to refine a series of evolving prototypes until the final version was acceptable to the final group of evaluating users.

User perceptions were measured by encouraging evaluators to express their opinions on aspects such as menu navigation, complexity, intuitive actions, effectiveness and response times of the GUI.

User and system performance was measured by comparing the time taken to complete tasks that manipulated multiple objects simultaneously versus achieving the same action on one object at a time.

The results of the final user evaluations of IMS performance show that it is possible to design a Web-based solution that offers a significant time saving when performing goals specific to the simultaneous management of large numbers of objects coded in diverse digital formats.

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List of Acronyms

AJAX	Asynchronous JavaScript and XML
CD	Compact Disc
CHP	Cultural Heritage Preservation
CPU	Central Processing Unit
DBMS	Database Management System
DHTML	Dynamic HTML
DVD	Digital Video Disc, later usage Digital Versatile Disc with improving technology
EB	Exabyte
GPS	Graphical Positioning system
GUI	Graphical User Interface
HCI	Human Computer Interaction
HDD	Hard Disk Drive
HTML	Hyper Text Mark-up Language
IMS	Information Management System
IP	Intellectual Property
MB	Megabyte
MIMIC	Microclimate Indoor Monitoring in Cultural Heritage Preservation Project
MP3	MPEG-1 Audio Layer 3, a compression format for audio
MPG-4	(Moving Picture Experts Group) coding method for Audio/Visual recording
PB	Petabyte
PC	Personal Computer
RDBMS	Relational Database Management System
RFID	Radio-frequency Identification
RFS	Requirements Functional Specification
SDLC	Software Development Lifecycle
SQL	Structured Query Language
TB	Terabyte
UCT	University of Cape Town
URL	Uniform Resource Locator
WWW	World Wide Web
XML	Extensible Markup Language

Chapter 1

Introduction

1.1 The Need for Cultural Heritage Preservation

Mankind has a vast collection of historical events, languages with many thousands of dialects, arts and crafts, paintings and diverse cultural practices inherited from its ancestors. This collection of items from the past is referred to as Cultural Heritage, affecting present attitudes, government and social structures and the development of society [21].

The society of today consists of many nations and cultural groupings that often place a high value on technology, industry, the military and science. However, other important aspects of society include social values, traditions, customs, artistic activities, theatre, language, arts and crafts, religion and other human activities.

The artefacts that make up a cultural heritage are often fragile, unique and irreplaceable. This places the responsibility for preservation on the current generation [68]. Society is realising that the past affects the present and the future, as is illustrated by the following quotes: “We need to preserve our sense of place, our sense of community spirit”; “The value of history is how it benefits people who are here today”; “Anything authentic - we need to keep it” [10].

The United Nations Educational, Scientific and Cultural Organization (UNESCO) declared in July 2010, that 911 sites in 158 countries were classified on the World Heritage List, in line with the November 1972 resolution at the Convention Concerning the Protection of World Culture and Natural Heritage [48].

The opinions of society, existing laws and proposed legislation highlight the importance of Cultural Heritage Preservation (CHP) to the societies of today and tomorrow.

1.1.1 The Modern Approach to CHP

CHP has in the past been dominated mainly by the collection and conservation of tangible objects relating to the cultural history of a community. By contrast, the modern approach to CHP is to broaden the scope so as to acknowledge not only the importance of preserving existing cultural history, but also the current culture and its continual development. This will preserve the collective memory of the community, the language, the oral traditions and everyday experiences (Section 1.1).

Democratisation of information has also become important, i.e. the need to share information and to spread knowledge so that ideas, opinions, cultural diversity, knowledge and education will be accessible anywhere, any time to everybody [71]. In the primary and secondary education systems, field-trips to museums, art galleries and cultural collections are now a standard part of the curricula.

1.1.2 CHP Artefacts – Tangible and Intangible

CHP tasks involve the collection, conservation, cataloguing and secure storage of two main classes of artefacts – tangible and intangible [57].

1. Tangible
   - movable (paintings, sculptures, coins, manuscripts, etc.)
   - immovable (buildings, monuments, archaeological sites, historic places etc.)
   - natural (landscapes, physical, geological formations, flowers and animals etc.)
2. Intangible
   - languages, dialects, traditions, performing arts, rituals and events [57].

Tangible objects are collected, manually sorted, catalogued and then stored correctly by experts. The type of object affects the storage environment. For instance, old celluloid films must be stored at the correct temperature and humidity to prevent image deterioration. Ancient documents and paintings need the correct humidity and protection from ultra-violet (UV) radiation to prevent loss of colour and fading. These storage environments are fixed, may be bulky and expensive, and cannot easily be shared with other parties. They need constant monitoring - to quote from the Microclimate Indoor Monitoring in CHP Project (MIMIC) Project, *"Assessment of damage to indoor cultural heritage, in particular by pollutants, is a major and growing concern for curators and conservators"* [29].

The exponential increase in computing power and communications bandwidth over the past two decades has contributed to a huge increase in collected objects and material being converted into objects for distribution, access and maintenance. Paper documents, maps, photos, books, old films, classic vinyl records and historic audio recordings on magnetic wire or magnetic tape are all being converted and can be shared over the Internet. This promotes the democratisation of information (Section 1.1.1). Therefore, the need for preserving this information is growing daily, and the tools for sorting and securely storing and manipulating the results of the CHP research must be simple, cost-effective and readily available.

1.1.3 Digital Objects and Their Storage

Figure 1.1 below highlights the exponential nature of the compounded annual growth of the total size of objects created (60 percent from 2006 to 2011) e.g. satellite images, video conferencing, security systems, email [12].

The quantity predicted for 2011 is ten times that produced in 2006, and will grow to 1 700 Exabytes (EB)[2] in 2011.

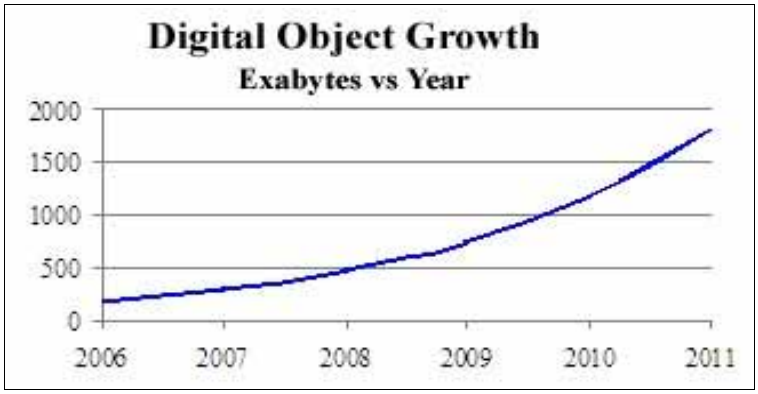


Figure 1.1: Digital Object Growth

Considerable time, effort and money go into producing objects that must be correctly managed and archived. Archiving has become a complex process – the stored data must be compatible with the hardware and software of the future, and hence loss of objects is increasing daily. This increases the risk that this huge heritage will not be available to present and future generations. "Most people haven't recognized that digital stuff is encoded in some format that requires software to render it in a form that humans can perceive" [45].

The main problems encountered in correlating and storing this huge mass of digital data are centred around preserving the quality and integrity of the objects over a long period of time. The process of stable preservation of objects rests heavily upon the computer operating systems, the storage media and the hardware and software of the management application. If any of the components in the preservation chain malfunctions, then the object could become unstable and, as a consequence, maybe lost to future generations.

The computer hardware industry has kept pace with these needs, especially over the past decade. The power of the Central Processing Units (CPU) and the storage capacity of Hard Disk Drives (HDD) have grown exponentially, while costs have dropped linearly. This has placed huge storage capacity, fast operating systems and therefore allowing reasonably-priced storage and management tools to be developed for smaller CHP centres.

2 1 EB = 1 000 000 000 000 000 000 bytes = 10^{18} bytes = 1 billion gigabytes = 1 million terabytes

For example, the jump in HDD storage capacity, Figure 1.2 below shows a slow increase in HDD capacity from 5 Megabytes (MB) in 1980 (A), to 340 MB in 1999 (B), a sharp increase to 500 000 MB in 2005 (C) and an exponential increase in storage capacity (with a linear decrease in price) that took place from the 500 000 MB in 2005 (C) to 3 000 000 MB in 2010 [67].

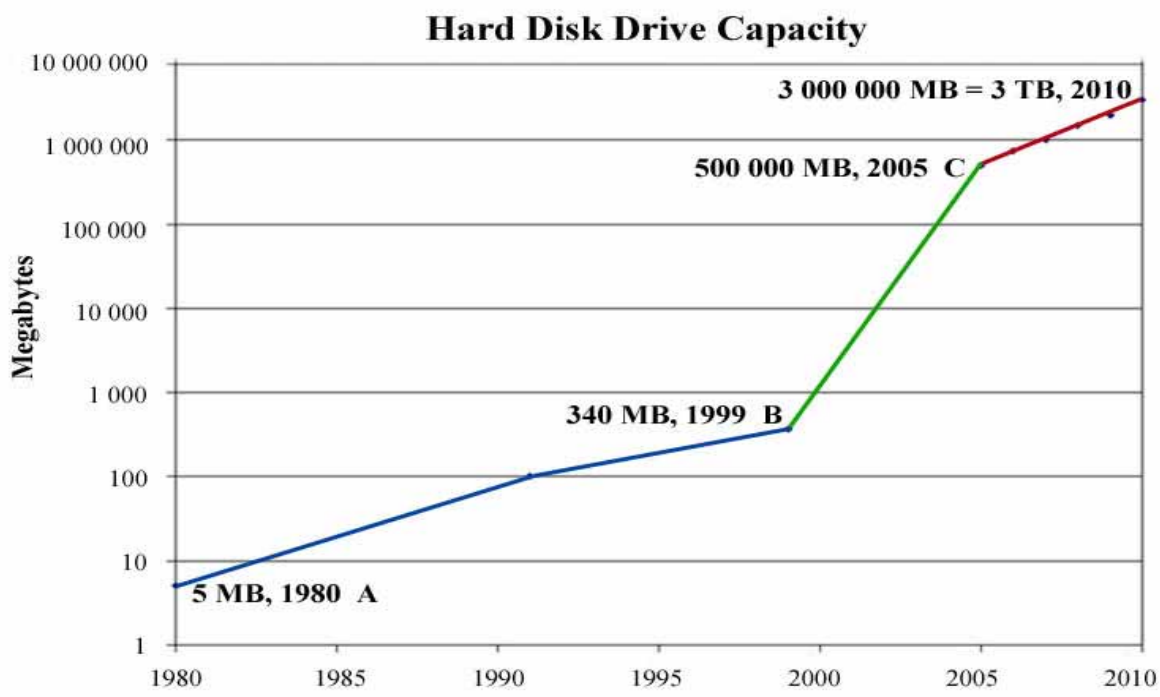


Figure 1.2: HDD Capacity versus Year

Table 1.1 below illustrates the large amount data that can be stored on a 3 Terabyte[1] (TB) HDD, using typical figures for various types of objects.

Digital Object	**Number**	**Units**
MPEG-1 Audio Layer 3 (MP3) Quality Stereo Audio	50 000	Hours
Compact Disc (CD) Quality Audio	4 960	Hours
Moving Picture Experts Group (MPG-4) Video	6 200	Hours
Digital Video Disc (DVD) Quality Video	2 100	Hours
High Quality Images	600 000	Images

Table 1.1: Object Storage Capacity of a 3 TB HDD

As a comparison, the US Library of Congress data storage by 2005 contained 29 million books, 2.7 million recordings, 12 million photographs, 4.8 million maps and 58 million manuscripts occupying an estimated 10 Petabytes[2] (PB) [23]. Therefore, the 2005 Library of Congress could be stored on roughly 3 500 HDDs of 3 TB each.

1 3 TB = 3 000 000 000 000 bytes = $3x10^{12}$ bytes = 3 million MB

2 1 PB = 1 000 000 000 000 000 bytes = $3x10^{15}$ bytes = 1 000 TB

Most computer dealers (at the time of writing) sell a 2 TB (2 000 000 MB) HDD for about R1 100 and a 3 TB (3 000 000 MB) HDD for R1 700, putting this technology within the reach of a CHP centre with budget problems.

1.2 Thesis Motivation

Two distinct CHP aspects have developed as a result of the growth of technology:

1. **Collection and recording** of data and material, performed by experts in the field. Physical materials, whilst being stored in the conventional manner (Section 1.1.2), also need to be converted into a suitable digital format by scanning, photographing or recording (audio, visual and other intangible typed of artefacts).
2. **Loading, manipulation, storage and long-term secure archiving** of dissimilar, but related, objects in a simple, consistent and non-specific manner into collections such as animals, people, buildings, flowers, historic events, sub-cultures etc.

The latter task is often inefficient, time-consuming or not possible when using existing software applications, for the following reasons (the Abstract summarises the points below):

- They are purely editing programmes for a particular type of object, e.g. graphic images, documents, audio objects or video objects – the application is object format dependant.
- They are sorting and correlating programmes for a particular type of object (as above).
- Most can do only one object at a time, whereas, the results of surveys conducted with 20 interviewees show that batches of objects may range from 10 to 1 000, and that batch processing should be independent of the batch size.
- They can correlate objects, but searching for a particular item is not easy, as the search has a single criterion and not multiple simultaneous criteria.
- Referential Integrity is non-existent, or data security is minimal.

The disadvantages, particularly of the metadata management abilities of popular existing object management tools, are summarised in:

1. Facebook in Section 2.4.1.
2. Picasa in Section 2.4.2.
3. Aperture in section 2.4.3.

A summary of other general tasks performed in these tools is given in Section 2.4.

Dissimilar objects may be placed in the same collection, being stored with their ancillary information, e.g. title, author, location, date of creation and maybe a short description. This extra information, known as metadata, can be loosely defined as *"data describing data"*.

The adding and editing of metadata types, the organising, the storing and the searching for objects usually occurs in batches containing large numbers of individual objects.

This thesis concentrates on managing this mass of data in a simple, non-specific, secure and cost-effective manner. It focuses on investigating and developing a solution to overcome the limitations of existing software (as listed above).

The new software application, to be named the Information Management System and hereinafter referred to as (IMS), must conform to at least the following specifications:

- Scalable from small to large collections with no change in software set up.
- Transparent as to the type of digital object.
- Simple, consistent and intuitive to enhance the user perception of its ease of use.
- Secure for long-term storage.
- Customisable for object and metadata type and collection names directly in the Graphical User Interface (GUI).
- Batch tasks must be transparent for all object types and batch size.

The fundamental question that this research must therefore investigate is "Is it possible to build a GUI that facilitates the efficient, accurate management of a large quantity of dissimilar, but related, digital objects?".

Steps to be followed in finding the answer to the main research question include:

1. User surveys to define the features needed (rather than merely wanted).
2. The design criteria for the features, based on (1) above.
3. Choice of a suitable development Software Development Life Cycle (SDLC).
4. A survey of software technology that will achieve the end goal.
5. Field testing to judge the success of the solution against the fundamental research question criteria.
6. A critical evaluation of the result and recommendations for possible improvements.

1.3 Objectives

The main objectives of the thesis are:

1. To gather information about the useful, not so useful and additional features needed for effective object management.
2. To design a usable Web-based computer application that facilitates the efficient, accurate and secure management and storage of large numbers of objects and their associated metadata. The objects are organised into collections, and, as mentioned above, must be stored so as to preserve the quality and integrity over a long period of time.
3. As part of the design process, both low-fidelity and high-fidelity prototypes, user and performance evaluations will be used to test the usability of the IMS.

1.4 Scope and Limitations

Objects can be stored in a variety of file formats. For example:

- Documents – PDF, DOC, ODT
- Images - JPEG, TIF, TIFF, GIF, BMP, PNG, RAW
- Audio - MP3, WAV
- Video - MPG-4, AVI, VOB

This thesis focuses on the preservation of objects limited to the file formats listed in Table C.5 in Appendix C.

The IMS GUI was tested using 1 000 objects with an average size of 2 MB each, sorted into Animal, Nature, People and Waterfall collections The objects were mostly photographs plus a few MP3 audio recordings, 2 MPG-4 video clips and documents in the Microsoft Office Word DOC and PDF formats. These were relatively easy to assemble from personal collections, friends' collections and the Internet.

1.5 Overview of Thesis

This Thesis is organised into the following chapters.

1.5.1 Chapter 2: Background

This chapter gives an overview of heritage digital libraries, the work pertinent to the management of large collections of objects, the functionality of popular object management systems and Web technologies relevant to the rest of this thesis. All subsequent chapters are built on these background concepts.

1.5.2 Chapter 3: Methodology

This chapter describes the SDLC and the evolutionary prototyping path used during the development of IMS. A brief outline of the implementation details of each phase is given and are then discussed in greater detail in subsequent chapters.

1.5.3 Chapter 4: Understanding Users

This chapter describes the processes followed to gain insight into the current situation in the University of Cape Town (UCT) Fine Arts Department and to gather user requirements. The results of the questionnaire and interview that were used to design the initial prototype are discussed, as are the evaluations of the low-fidelity prototype.

1.5.4 Chapter 5: Design and Implementation

This chapter explores the design and implementation of the final system resulting from the initial requirements gathering phase and the low-fidelity prototype evaluations.

1.5.5 Chapter 6: User Evaluation

This chapter reviews the results of the high-fidelity prototype user and performance evaluations.

1.5.6 Chapter 7: Conclusion

This chapter discusses how well the objectives of this thesis were achieved. It takes into account features implemented versus the initial specification and the modifications as a result of user feedback from the low-fidelity prototype.

Recommendations for future work are given.

Chapter 2
Background

2.1 Introduction

This chapter gives an overview of heritage digital libraries and the work related to management of large collections of objects. The features of popular object management systems are compared, i.e. Facebook, Picasa and Aperture, focusing on performing tasks such as uploading, managing metadata, moving, deleting and selecting multiple objects at a time. Web 2.0 technologies that enhance the user experience are also discussed.

2.2 Heritage Digital Libraries

A digital library is a collection of objects in digital format, stored locally or accessed remotely via computer networks and the Internet. The DELOS Digital Library Reference Model defines a digital library as "*An organisation, which might be virtual, that comprehensively collects, manages and preserves for the long term rich digital content, and offers to its user communities specialised functionality on that content, of measurable quality and according to codified policies*" [66]. A search tool is used to find and summarise the information about digital objects from these various digital libraries, archives, collections etc.

In the past, CHP concentrated mainly on collecting and preserving physical artefacts that are often housed in individual centres of expertise, e.g. Museums, Art Galleries, National Archives and Libraries.

The Digital Age, stimulated by the inflow of Personal Computers (PCs) and software (starting from about the early 1990s) into every walk of life, has provided a huge computing pool with a storage capacity unequalled in history.

Modern digitisation and recording techniques provide convenient tools to conserve information about artefacts in the form of digital objects. It is therefore relatively simple to widen the scope of CHP to preserve photographs of physical objects such as sculptures, art works, animals and people, sound recordings of languages, video recordings of important events and traditional techniques and documents in many formats.

The following sections provide an overview of the Bleek and Lloyd Collection [58], Europeana and Dspace which are typical projects initiated for CHP.

2.2.1 The Digital Bleek and Lloyd Collection

The Bleek and Lloyd collection is a set of artefacts that preserve the culture, language and history of the Bushman people of Southern Africa. The collection derives its name from Lucy Lloyd and Wilhelm Bleek. During the 1870s, they preserved the culture of the Bushman in

handwritten notebooks, typical of Figure 2.1 below, and drawings [70]. The UCT Centre for the archive digitised these handwritten notebooks and drawings using special tools to create a portable digital library system. It can be hosted locally or distributed via the Internet or CDROM [53]. The collection consists of 157 notebooks containing 14 128 pages and 752 drawings. It represents the coming together of an archive dispersed across the National Library, Iziko South African Museum, Unisa and UCT [58].

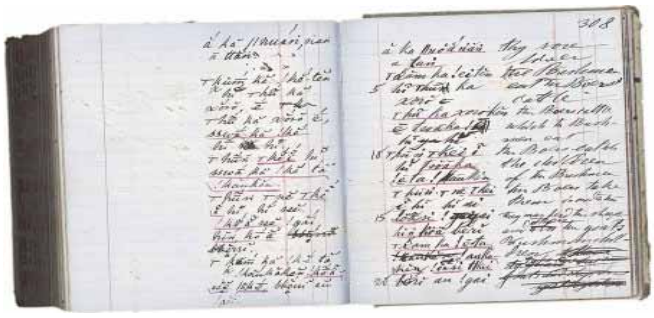


Figure 2.1: A Notebook Page from the Bleek and Lloyd Collection

The Bleek and Lloyd collection contains a handwritten dictionary of over 14 000 entries of English words and their corresponding Bushman language translations. This allows for the manual translation to English of the Bushman words that appear in the notebooks. However, manual translation is not practical due to the size of the dictionary. A content-based image retrieval system was developed to return the matching English word automatically for a selected Bushman word [70].

2.2.2 Europeana

Europeana is a platform that enables users to search through over 15 million objects from the digital libraries of Europe's museums, libraries, archives and audio-visual collections. The items consists of images (paintings, drawings, maps etc.), texts (books, newspapers, letters etc.), sounds (music, tapes, discs etc.) and videos (films, newsreels, television broadcasts etc.). The Laws of Motion by Isaac Newton , drawings of Leonardo da Vinci and objects about the Berlin Wall are a few of the world-famous topics available [11].

This collection represents the contributions of around 1 500 institutions including the British Library in London, the Rijksmuseum in Amsterdam and the Louvre in Paris [11].

A large portion of the objects in the Europeana collection have insufficient metadata associated with them. This is often due to the lack of capacity of institutions to enter the metadata manually. A system currently being developed uses annotations to allow users to augment the digital objects with information. A user enters in an annotation and then the system provides a ranked list of potential resources. The proposed resource is then marked as relevant or non- relevant before the annotation is saved [19].

2.2.3 DSpace

DSpace is an open source system developed by Hewlett-Packard and the Massachusetts Institute of Technology to provide tools for the management of digital objects. A wide variety of data including books, theses, 3D digital scans etc. are supported. It was first released in 2002, and is now in production at over 800 institutions, ranging from large universities to small research centres, around the world [65].

2.3 Related Work

Work related to this thesis can be divided into the following sections:

1. Storage and searching of objects.
2. Managing objects.
3. Viewing objects.
4. Sharing objects.

This research investigates if it is possible to build a GUI that facilitates the efficient and accurate management of a large quantity of objects, and therefore focuses on Point 2 above. Object management can be defined as the tasks users perform *after* uploading objects to a server to store in a database (Section 2.3.1), prior to sharing them with other users (Section 2.3.3). It relies on being able to locate the objects for management through efficient and effective searching and viewing techniques (Section 2.3.1 and 2.3.2).

2.3.1 Storage and Searching Digital Objects

A relational database management system (RDBMS) has been used to develop IMS. By comparison, the semi-structured approach of Extensible Markup Language (XML) makes the process of data storage and searching a challenging task requiring complex algorithms.

2.3.1.1 Extensible Markup Language

XML is a flexible and powerful tool used widely for defining structured information in a text format. It was originally designed to meet the challenges of large scale electronic publishing [60]. XML allows for the sharing of information among devices and organisations, as XML documents can be extended to include domain specific tags (labels) and thereby encode information with meaningful structure and semantics.

Tree-based Approach and Relational Approach

XML is playing an increasingly important role in storing, exchanging and transporting data. A scalable technology is therefore needed to store and search a huge volume and variety of data effectively. Two common approaches to XML retrieval (storing and searching) are [4]:

1. **A Tree-based Approach** - The tree-based approach has been designed to deal with elements, attributes and text nodes, representing the XML object as a tree. This method relies on tree-traversals to find specific elements within the XML tree. Indexes and path-join algorithms are used to speed up the searching process.
2. **A Relational Approach -** The relational approach flattens the hierarchy of an XML document and stores it in a relational database. XML queries are then mapped to Structured Query Language (SQL) to retrieve the results from the database. This method takes advantage of the efficient access methods relational databases have developed. The returned results are then reconstructed into an XML document.

Tree-based and relational approaches have extremely complex searching algorithms. The relational approach provides maturity, stability, portability and scalability, plus it offers a significant time saving performance over the tree-based approach [31].

Extensible Markup Language Systems

XML technologies were used in the following examples, providing a flexible solution since data interchange between systems was needed:

1. A system that manages a digital library of historical artefacts. The major goal of the system was to create an architecture in which artefacts could be reused across various digital library systems [17].
2. A system used in a presentation of an approach to the problem of organising and managing archaeological data. A user can use a handheld PC when visiting an archaeological site to retrieve a personalised plan for their visit [59].

2.3.1.2 Relational Databases

A database management system (DBMS) is the interface to the physical storage, file system and operating system technologies. A relational database reduces redundancy and maintains consistency between data. These are essential components supporting the growing complexities of data storage. Additional features such as indices can be used to accelerate access [47].

Relational Database Systems

DBMS technologies are used in the following examples of cases where data is accessed through a single system:

1. A system that manages the data during an archaeological excavation. A Web interface was used so that at any given moment it could present updated information about the excavation. MySQL was chosen as the DBMS. MySQL does not require a

licence and can be freely installed. A RDBMS was used as the archaeologists were familiar with the technology, and the data needed to be accessible via a SQL request. A flexible structure was also needed to support structural modifications that improved the software model over time [7].

2. A system for managing the collection of cultural assets, assisting collection curators in defining, populating, and searching collections in a flexible way. A DBMS was used as it is a more mature technology offering essential components for managing data [52].

Encrypted Data and Intellectual Property Protection in Relational Databases

Access control and firewalls no longer provide enough security against hackers, and therefore encrypting the database is an effective last line of defence [3]. SQL Server 2005 and SQL Server 2008 have built-in encryption features to assist customers with security concerns [37].

The revolution in information technology has resulted in increasing amounts of collected data and material being produced, distributed, accessed and maintained as objects. Technologies that provide a data access framework, i.e. computers connected by networks and the World Wide Web (WWW), are raising issues with the proper preservation of sensitive cultural heritage data and Intellectual Property (IP) rights. The following are mechanisms used to protect IP [56]:

1. Metadata that manages the object description and copyright.
2. Global standards for unique identification of objects.
3. Watermarking techniques to mark, detect and prove the existence of the copyright of the object.

2.3.2 Viewing Digital Objects

There are many techniques for organising object collections. Many use the metadata associated with the object, e.g. author, title, description etc. Searches are done on selected metadata criteria, allowing viewing of the returned results. Advances in computer technology and modelling capabilities have resulted in new techniques being developed.

2.3.2.1 Geographic Location

A technique that has gained popularity is the use of the geographical location of the object to facilitate browsing. The following are examples of systems using this technique:

1. PhotoCompas uses the time and location of digital images to organise them into collections [40].
2. World Wide Media eXchange uses the time and location to arrange the digital images onto a 2D map [54].
3. Realityflythrough uses a networked mobile video camera to create the illusion of live coverage in a physical environment [36].

2.3.2.2 3D Digital Images

Advances in computer modelling capabilities have allowed unstructured collections of 2D digital images to be reconstructed into 3D digital visualisations. Photo Tourism is an example of a system handling large collections of unstructured digital images, taken with different cameras under different conditions, and reconstructing 3D visualisations of the scenes (each point below correlates to the red number illustrated in Figure 2.2 below [50]):

1. A collection of unstructured digital images from online searches.
2. Reconstructed 3D points and view points.
3. A 3D visualisation of the scene as created to assist in the browsing of large collections of digital images.

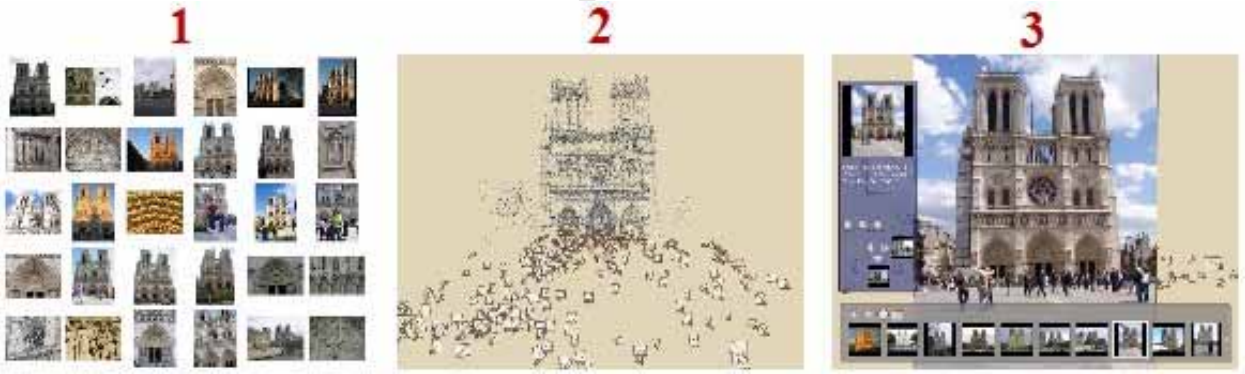


Figure 2.2: Photo Tourism

Photo Tourism uses the camera pose (location, orientation and field of view) and sparse 3D scene information to create a 3D visualisation of the scene, the latter serving as an interface backdrop for browsing digital images. Morphing techniques are used to create smooth transitions between the digital images. Viewers can then select a digital image from the visualisation and view information such as title, author, creation date, and have the ability to search for other digital images with similar geometric relations [50].

Another example of a 3D reconstruction and visualisation is the cultural heritage data set of Graz in Austria, illustrated in Figure 2.3 below [33]. The Old Town of Graz was awarded World Cultural Heritage by UNESCO in 1999 as one of the best preserved towns in Europe.

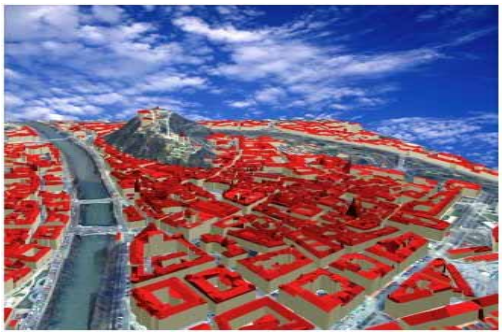


Figure 2.3: The Virtual World Cultural Heritage of Graz

2.3.3 Sharing Digital Objects

Objects are easily shared outside a home or organisation, but sharing within a home or organisation is harder - objects are typically stored on PCs and users have difficulty in recalling the location of them. A mechanism that can be used to overcome this is to identify memorabilia that can serve as memory triggers for certain events. These physical memorabilia are then used to associate events with particular object collections. A small Radio Frequency IDentification (RFID) tag is glued onto the bottom of physical memorabilia and placed on a platform enclosing an RFID reader. The RFID tag is read and associated with an object collection. The object collection can easily be recalled without knowing its physical location, simply by placing the physical object on the platform [43].

Real prints of photographs have regained popularity over the last few years. Once a photograph is printed, there is no link to its object. A mechanism that overcomes this problem is to send an image of the photograph to a server, where image analysis techniques are used to retrieve the corresponding object information [20].

The ideas discussed in this section can be extended to the sharing of cultural heritage data. A museum can associate a physical artefact with an object collection using RFID tags to enrich stories associated with the artefact. Photos could also be taken of selected artefacts and sent to a server for image analysis. This process can be enhanced so as to return the metadata associated with the artefact instead of the object.

2.3.4 Managing Digital Objects

Object management can be divided into the following main tasks:

1. Uploading
2. Organising

3. Browsing
4. Searching
5. Editing

Determining how users manage their digital image collections has been the focus of various researchers. One such research studied how users organise and browse their digital image collections. The results showed that some users organised their digital images into folders grouped according to events, whereas others used a single folder. Users generally felt more organised when their digital images were in one place, grouped in folders corresponding to events and organised in chronological order [46]. The results of a further studied showed that grouping digital images into folders according to events was a natural part of the uploading process [32].

The frequency with which users look at their digital images decreases over time. When users search for digital images they have the following requirements [46]:

1. A group of digital images from a particular event.
2. An individually remembered digital image.
3. A group of digital images over different events and containing a specific person.

The following sections provide an overview of digital image management systems researches have implemented.

2.3.4.1 Shoebox Photo Application

Shoebox is a Windows GUI with a DBMS to store the data and metadata. It provides a suite of tools that simplify the organising, browsing and searching of large digital image collections. The digital images are stored in a workspace known as a shoebox and are organised into albums of varying size. Text or audio annotations can be attached to individual or groups of digital images. Basic tools are provided for editing i.e. colour correction or rotation.

Browsing was identified as the most basic and important feature of any digital image management system. Shoebox provides the following methods for browsing:

1. Tooltips display information about albums and digital images when hovered over.
2. A timeline enables easy selection of digital images within a specified date range.
3. A topic view lists the nouns extracted from the text and audio annotations and returns the digital images with the selected noun.

Shoebox provides the following methods for searching:

1. The audio annotations are converted to text using speech recognition and are used in combination with the album and digital image text as keywords for searching.
2. A search based on the digital images visual content.

Shoebox showed that retrieving digital images based on audio annotations proved to be successful despite degradation and inaccuracies introduced by speech cognition. Shoebox focused on the browsing and searching while neglecting the organising and metadata management of multiple digital images [38].

2.3.4.2 FXPAL Photo Application

FXPAL Photo Application is an example of a system that simplifies the management of large digital image collections. Digital images are displayed in a grid on the GUI and optimised for scrolling by caching and pre-fetching thumbnails. Multiple digital images can be uploaded at a time into the system, and then organised into categories such as type, date, event, people, places and labels. Users can select, rotate, attach captions, or assign categories to multiple digital images at a time [16].

FXPAL Photo Application neglects the searching and metadata management aspects of collection management. Users are unable to search for digital images with specific criteria across all categories, and then select only those to move, delete or manage metadata. There is no concept of metadata apart from a caption and the assigned category associated with the digital image. FXPAL Photo Application is limited to the management of digital images only.

2.4 Digital Image Management Tools

This section extends the discussion on managing digital objects by comparing management tasks performed with other popular digital object management tools. Much research and system development has taken place on the storing, viewing, sharing and managing of digital objects.

IMS shares many of the features of these systems, but its primary focus is to enhance the metadata management process to include fast and efficient simultaneous management of multiple digital objects, while not neglecting other features of a digital object management system.

This section gives an overview of digital image management in Facebook, Picasa and Aperture, focusing on popular tasks and on exploring metadata management in more detail.

In Section 4.2.1.1 Facebook and Picasa are identified as the most popular digital image management systems. The prime features identified as desirable in Section 4.2.3 were the

ability to perform tasks such as uploading, managing metadata, moving, deleting and selection of multiple digital images in a batch mode. These prime features are compared in Table 2.1 below.

Image Tasks	Facebook	Picasa
Upload	Adobe Flash Player is required for multiple image upload.	Uses standard Windows folders.
Manage Metadata	Limited to tagging one image in one album at a time.	Limited to tagging multiple images in one folder at time.
Move	Limited to moving one image within an album at a time.	Limited to moving multiple images from one folder to another at a time.
Delete	Limited to deleting one image in one album at a time.	Limited to deleting multiple images from one folder at a time.
Select	Limited to selecting one image in one album at a time.	Limited to selecting multiple images from one folder at a time.

Table 2.1: Popular Tasks Performed with Multiple Digital Images

2.4.1 Facebook

Facebook is a social networking service and website launched in February 2004. It has been privately owned by Facebook, Inc. since September 2006. Users can share personal details about themselves, e.g. school, university, religious views and favourite music. A popular feature is the ability to organise uploaded *images* from a cellphone, camera or HDD into albums, and to then share them with family and friends. Users can search for other friends, join hobby or interest groups and add applications ranging from “top friends” to places visited.

The following actions are available for tag management (each point below correlates to the red number illustrated in Figure 2.4 below):

1. An image tag can be added by entering text into a text box and clicking the button.
2. A tag can be added from an existing tag by selecting it from the closest matches provided in the list.
3. A tag can be removed by clicking the remove tag button.
4. A caption can be added to the image.

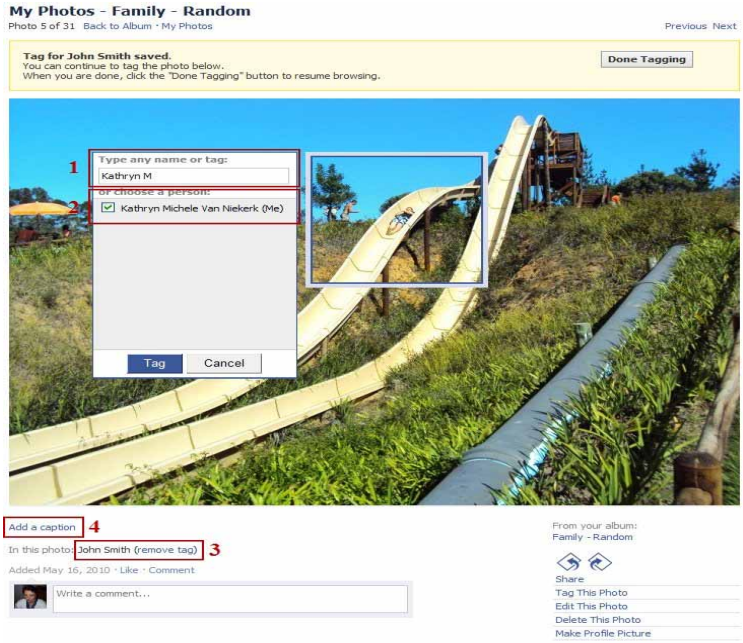


Figure 2.4: Facebook Tag Management

Facebook tag management has the following disadvantages:

1. Only one tag and a caption can be added to a single image at a time. The user must enter a tag into the text box and click the tag button for each added tag and then navigate to each image to add a caption. A more efficient method is to add tags provided by Facebook as illustrated in Figure 2.5 below. A user can select a tag and click on each photo to apply the tag. This method will still tag only one image at a time.
2. Tags cannot be edited, but only removed and then added again.
3. Only tags of one type can be added to an image. The tag is specifically designed to tag other friends or family. There are no tags for author, description or category etc.
4. There is no option to search for images with a specific tag.

Figure 2.5: Faster Facebook Tag Management

2.4.2 Picasa

Picasa is a free software application offered by Google, since 2004, for organising and editing digital *images*. Online albums to share with family and friends can be created with Picasa Web Albums. The latest features include [44]:

1. Editing images in Picnik (an easy to use and powerful image editor).
2. Using Face Movie to create a slide show featuring someone special. It comes complete with transitions, music and captions.
3. Uploading batches of images in an entire collection to Picasa Web Albums.

The following features are available for tag management (each point below correlates to the red number illustrated in Figure 2.6 below):

1. Simultaneous tagging of multiple images in one folder or album.
2. Tags for selected images can be added by entering text into text box and clicking the add button.
3. A tag can be added from an existing tag by selecting it from “Quick Tags”.
4. Tags can be removed from selected images by clicking the remove button.
5. A list of tags and tag counts of selected images can be viewed.
6. Ability to search for images with a specific tag.

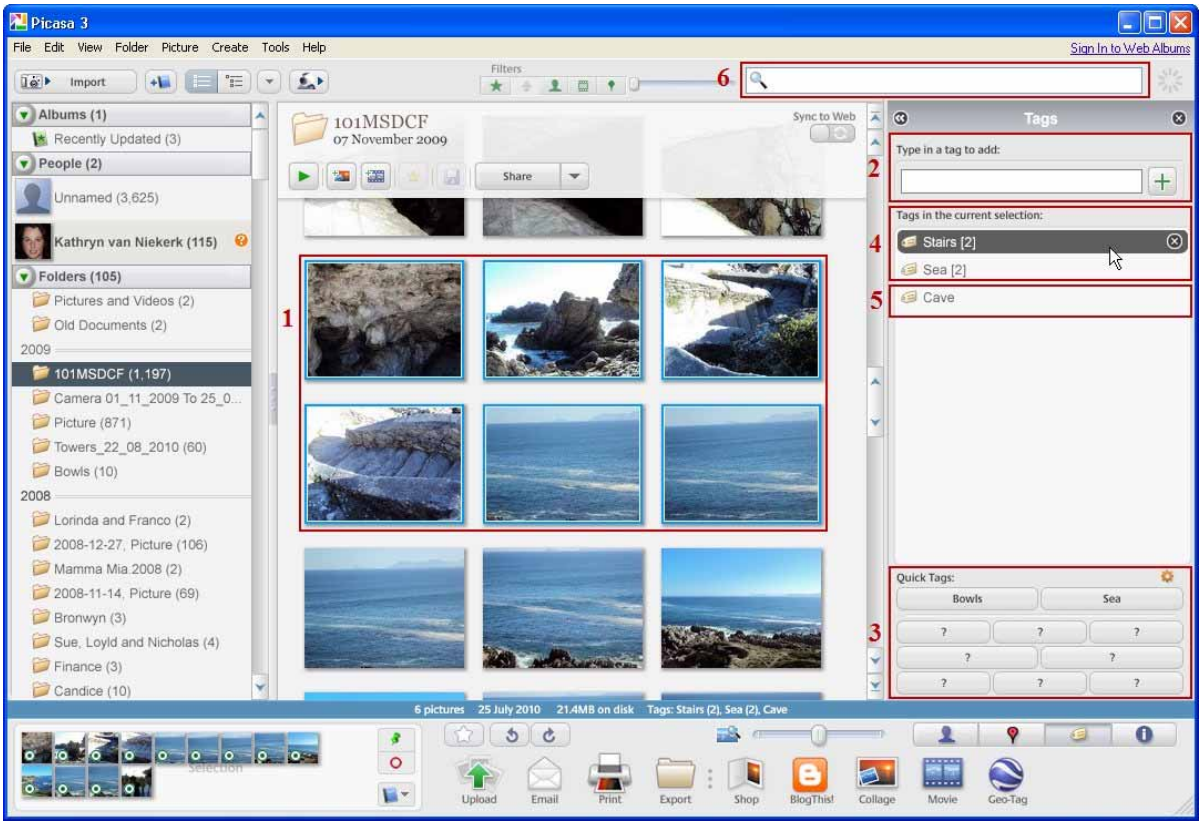


Figure 2.6: Picasa Tag Management

Picasa tag management has the following disadvantages:

1. Only multiple images in one folder or album can be tagged at a time.
2. Tags can not be edited, only removed and added again.
3. Only one tag can be added to selected images at a time. The user must enter a tag into the text box and click the add button for each tag added.
4. Only tags of one type can be added to selected images. There is no way of knowing which tag is the title, author or description. When searching for images with a specified tag, the search cannot be narrowed, for example, search for all images with "sea" in their title.
5. All tags that are common or non-common to selected images can be removed. This is dangerous as a user may unintentionally remove a tag from an image. It is difficult to know which tags belong to which images without selecting each image individually, but with the disadvantage that the selection of images is lost.
6. There is no convenient method to view tags, e.g. by hovering over an image. The image needs to be selected in order to view tags.

2.4.3 Aperture

Aperture was developed by Apple for the Mac OS X operating system. It is a digital ***image*** editing and management application, performing tasks associated with image management e.g. importing, organising, applying corrective adjustments, displaying slide shows and printing images. Latest features include [64]:

1. Selecting images *"by faces"* using face detection and recognition algorithms, or *"by places"* using Graphical Positioning system (GPS) metadata.
2. Applying corrective brushing effects such as skin smoothing and polarization.
3. Facilitates uploading images to popular social networking websites e.g. Facebook, Flicker, SmugMu and Apple's MobileMe service.

Windows, Linux or the Mac OS X are three popular operating system choices for a PC. Windows computers have enjoyed greater popularity and have dominated the PC industry by having a wider selection of software applications. Windows computers have also traditionally cost a lot less than the Mac units. The majority of users (should they choose to use Aperture) would have to consider changing their PCs from a Windows-based unit to a Mac with a considerable additional capital outlay [30].

Aperture needs 10GB of RAM to prevent slow operation when working with very large collections. However, in spite having this large RAM capacity available, it is still slow (at random times) when initially opening Aperture or when moving between other applications.

Aperture stores all files and data in one huge database located on a single PC. To prevent slow operation, the versions and previews should be stored on a fast HDD separate to the master image HDD. This requires careful management to ensure that the integrity of the link between the master image and its versions and previews are preserved over time.

Aperture provides the following tools to manage metadata:

1. Batch Change – Changes the metadata, i.e. time zone, version naming format and values for fields within user defined metadata sets on multiple images at a time.
2. Lift and Stamp – Metadata from one image can be copied to multiple images at a time.

While Aperture is good at handling metadata, its behaviour when handling batch changes can be confusing as extra menus must be called via a sequence of keyboard shortcuts to handle multiple metadata operations. Batch changes to user defined metadata can only be applied once a predetermined set of metadata changes have been saved. The images are then selected and the appropriate metadata change set is applied. This becomes cumbersome as the user must manage these predetermined sets of metadata changes, i.e. remembering what changes

each set contains and deleting the sets once the metadata changes have been applied. The dynamic management of metadata in IMS is discussed in more detail in Section 5.3.2.5.

Aperture is a single, computer-centric application and cannot take advantage of the benefits offered by web-based applications, including access by many users anywhere on the Internet, of storing of data on remote servers, of cross-platform compatibility and better protection from viruses. The benefits of Web-based applications are discussed in detail in Chapter 5.

2.5 The World Wide Web

This section describes Web 2.0 technologies and how they can be used to develop IMS to enhance the user experience.

2.5.1 Web 1.0

Web 1.0 was released to the public in 1993 and was used mainly as a source of information to gain knowledge on a particular topic. Users would enter a Uniform Resource Locator (URL) to locate information and then use hyperlinks to navigate between the web pages. Web 1.0 was considered to be impersonal and viewed merely as a collection of documents.

2.5.2 Web 2.0

Web 2.0 is still evolving, and therefore does not yet have a concise definition. The informal definition is its really a second round of new technology development and adoption after Web 1.0 [35].

Web 2.0 is characteristic of an era of social networking. Users express themselves and interact with information on the Internet. In the late 1990s, Lycos offered users Community Pages similar to the web pages of today, but were not successful - people were writing their own personal web sites. The concept of a social web did not yet exist.

Access to the Internet was limited by slow dial-up connectivity. Broadband and associated technologies were expensive or did not exist. In addition, they were in reality limited to government agencies up to the early 1990s. The concepts of Web 2.0 only took off when the Internet became easier to access and when Generation Y started to use the Internet to express themselves. People were in general much more conservative and private before the period starting 5 to10 years ago [8].

In 2004, it was considered as the idea of having a “Web as a platform”, meaning that instead of the web being a place to view data, it really allowed people to get things done. Few people really understood what this actually meant. Later on, Web 2.0 began to refer to the programming tools (Asynchronous JavaScript and XML (AJAX), JavaScript, Dynamic Hyper Text Mark-up Language (DHTML), XML and SOAP). These programming tools were used to create web pages that behaved more like desktop applications.

Web 2.0 is now referred to as a *combination of technologies that allow users to interact with information*. Examples of Web 2.0 are social networking sites (Facebook [13] and Myspace [39]), blogs, wikis and video sharing. The combination of powerful JavaScript tools (AJAX and DHTML) is what really defines Web 2.0 [34].

The earlier Web 1.0 signified major strides in technology, but the changes in Web 2.0 technology were more subtle. Two technologies associated with Web 2.0 are AJAX and the "Web as a platform" model (referred to as "mashups").

Table 2.2 below illustrates examples of the changes in intent from Web 1.0 to Web 2.0 [1].

Web 1.0	Web 2.0
Reading	Writing
Companies	Communities
Client-Server	Peer to Peer
HTML	XML
Home Pages	Blogs
Lectures	Conversation
Advertising	Word of Mouth

Table 2.2: Development from Web 1.0 to Web 2.0

2.5.3 Web 2.0 Technologies

IMS uses Web 2.0 technologies to enhance user experience as to the usability of the features. The web page appears to be dynamic and reactive as portions of it are updated as needed without reloading the entire web page, thereby saving time.

2.5.3.1 Asynchronous JavaScript and XML

AJAX as promoted by Google from 2005, is not a new programming language. It is merely a new technique created from a combination of existing Web technologies including JavaScript, DHTML and XMLHttp [2].

This new technique creates faster, more usable web pages. Information is sent and received via JavaScript to the web server without having to reload the entire current web page. The key word is asynchronous, which means small pieces of information are requested on user events, i.e. onclick(), onblur() or onMouseOver(). The information can be in formats such as XML, Hyper Text Mark-up Language (HTML) and text files [61]. Figure 2.7 below [24] shows the exchange of information between the browser and the server.

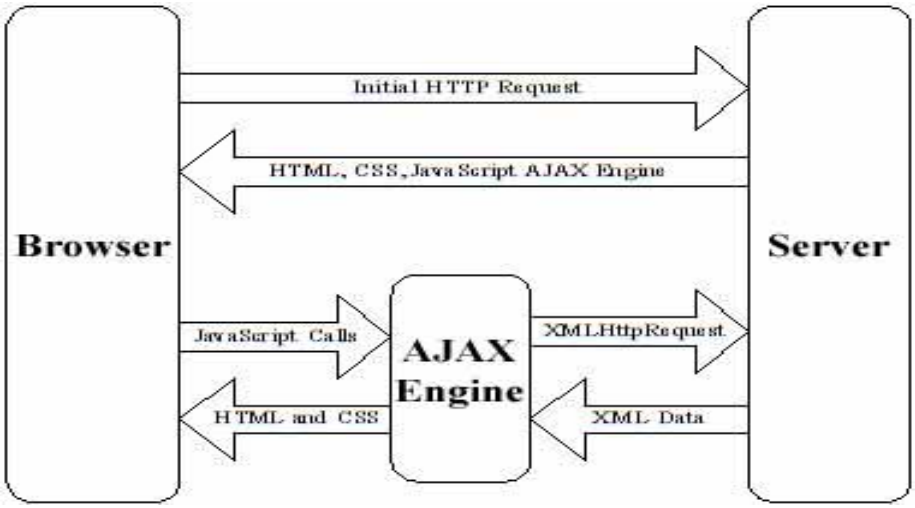


Figure 2.7: AJAX

Auto-complete is a well known feature of desktop applications such as Excel. Text boxes will suggest a list of words depending on the letters entered by the users. AJAX can produce this same functionality on a web page. As the user types, an XMLHttpRequest is sent to the web server to find a list of possible words from the database. Figure 2.8 below is an example of this auto-complete functionality as used by Google[1] [2].

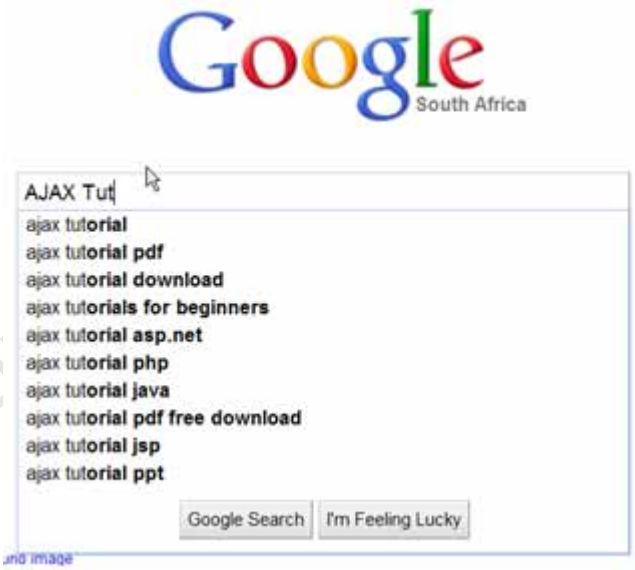


Figure 2.8: Google Search

1 http://www.google.co.za

2.5.3.2 AJAX Uploader

IMS uses the AJAX Uploader[1]. This enables multiple files of different formats and sizes to be uploaded to the server without refreshing the web page. It is easy to use, has low memory consumption and is customisable to blend in with the look and feel of IMS.

The following summarises the top features of the AJAX Uploader [6]:

1. Multiple files can be uploaded to the server at once.
2. The client side can validate the file format and the size to reduce the consumption of network and server resources.
3. High performance is achieved by streaming uploads directly to the output stream instead of loading them to memory.
4. Users can view the upload progress of every file via a real time progress bar. Upload of an individual file can be cancelled while continuing to upload the remaining files.
5. Multiple files can be uploaded without refreshing the web page.
6. File uploading is asynchronous, which gives the benefit that users can continue to use the web page whilst files are uploaded.

The AJAX Uploader implementation in IMS is described in more detail in Section 5.3.2.7.

2.5.3.3 Dynamic HTML

DHTML can be described as a combination of Document Object Model (DOM), Scripts, Cascading Style Sheets (CSS) and XHTML that enable a web page to appear to be dynamic. By contrast, a standard HTML page loaded from a server will not change until another page load request is sent to the server. DHTML can control the HTML elements on a web page and change them without returning to the server for a total page refresh.

The DOM allows access to any object on the web page by using consistent naming conventions. Scripts can be written in JavaScript or ActiveX and are used to control the objects that are accessed by the DOM. CSS is used to control the look and feel of the web page by altering the background colours or the placement of the objects accessed by the DOM. XHTML is used initially to create the web page

Two useful features of DHTML are highlighted below:

1. Changing the tags and properties – events outside the browser such as mouse clicks are used to change the qualities of an HTML tag.
2. Real-time positioning – to animate portions of a screen or to play interactive games.

1 http://ajaxuploader.com/download.htm

2.5.3.4 Comparison of Existing Technologies

Table 2.3 below gives a summary comparison of the technologies AJAX, JavaScript, DHTML and XML (each point in the table below correlates to the explanation below). A Likert-scale[1] ranging from 1 ("very poor") to 5 ("very good") is used to rate items 6 to 8.

	Comparison	AJAX	JavaScript	DHTML	XML
1	Combination of Technologies	Yes	No	Yes	No
2	Browser Dependency	Yes	No	Yes	No
	Scripting Language	No	Yes	No	No
	Mark up Language	No	No	No	Yes
3	Prone to Errors	Yes	No	Yes	No
4	GUI Experience	4	N/A	4	N/A
5	Bandwidth Usage	4	3	3	2
6	Developer Friendliness	3	3	3	3

Table 2.3: Comparison of AJAX, JavaScript, DHTML and XML

The following is an explanation of the comparison of technologies in Table 2.3 above:

1. AJAX is a combination of the following technologies: XHTML and CSS (for styling and marking up), XMLHttpRequest objects (to exchange data with the web server) and XML (the format used in transferring information). DHTML is a combination of the following technologies: CSS (for styling and markup), HTML (structure of document), DOM (a standard way to manipulate and access HTML objects) and JavaScript (code to control HTML elements).
2. AJAX uses the XMLHttpRequest object which is created differently in browsers. JavaScript requires a run time environment, and is therefore web browser independent. DHTML is supported differently by different web browsers and can therefore be fine tuned on only a limited number of browser and screen size combinations. XML is platform independent and is relatively unaffected by technology changes.
3. AJAX relies very heavily on JavaScript which is implemented differently by different web browsers. Users also disable JavaScript in their browsers, causing errors in a web page running AJAX. DHTML has display errors as a result of web browser dependency.

1 Likert-scale questions must make a statement e.g. The Summer holidays are too long. The respondent must give a score according to the following scale: 1 – strongly agree 2 – somewhat agree 3 – neutral/no opinion 4 – somewhat disagree 5 – strongly disagree

4. Pages using AJAX allow a faster response to a user request as the page is updated dynamically. Users no longer have to wait while the entire web page gets reloaded. This improves the user experience. DHTML allows a developer to position and display HTML elements in a browser window in a more usable way.

5. AJAX allows for the fetching of small amounts of data from the web server, thereby giving the appearance that the web page loads relatively quickly. JavaScript calls are needed to run the web page, and will therefore need to be fetched as needed. XML is used to describe the data as well as actually holding the data. Therefore, depending on the data size, vast amounts of information may have to be downloaded.

6. Very often code needs to be written many times for error handling as AJAX and DHTML are browser dependant.

2.6 Summary

This chapter has provided an overview on the work related to this thesis, such as:

- An overview of heritage digital libraries.
- Object storage, searching, viewing, sharing and management.
- Popular object management systems were compared, paying particular attention to simultaneous multiple digital image management features such as uploading, managing metadata, moving, deleting and selecting.
- An exploration of popular Web 2.0 technologies, e.g. AJAX, the AJAX Uploader and DHTML. This was done with reference as to how they could be used to develop IMS.
- This thesis examines the design of a Web-based solution to handle the efficient, accurate and secure management of a large number of objects to ensure they will be available to present and future generations.

Chapter 3

Research Methodology

3.1 Introduction

This chapter will focus on the details of the research methodology used in the design of IMS.

3.2 Human Computer Interaction

The term Human Computer Interaction (HCI) was adopted in the mid 1980s to describe the interaction between users and computers [51]. HCI is a discipline concerned with the design, evaluation and implementation of interactive computing systems for human use, and the study of major phenomena surrounding them [22].

Computers are no longer used solely by highly skilled technical people, but have rather become an important tool used everyday by many people with a broad and diverse range of knowledge and experience. There are many examples of systems that have some kind of embedded computer in them e.g. cell phones, microwaves ovens, watches and automated teller machines.

The introduction of the GUI concept helped users to interact with computers in an intuitive manner to complete a task. When a system is designed and built, analysts and developers often fail to consider the end users, and as a result the system could lack features that are considered essential or are not usable in the way that users expect them to be.

When attempting to build any system, the opinions of potential users must be taken into consideration very early in the design process, as ultimately they will be the ones to use it and determine the success of the proposed system i.e. acceptance or rejection.

3.3 Evolutionary Prototyping

Several styles of SDLC exist, including the Waterfall Model, the Spiral Model (combining elements of both the Waterfall and Rapid Prototyping models), Iterative/Incremental Development and Agile Development (the latter uses feedback, iteration and regular testing rather than very detailed pre-planning). Prototyping is an essential component of most of these styles - it is an effective technique used to gain an understanding of user requirements, to reduce the complexity of the problem and to gain user approval of the proposed product early in the design process [72].

The evolutionary prototyping model is a combination of the Waterfall Development and simple Prototype Model processes.

Waterfall Development is a methodology that completes the work items of each discipline within the proposed end object in a single step before moving on to the next discipline in

sequence. The end product is delivered all at once only at the end of the project. However, iterative changes may not always be simple to implement without considerable re-work.

By introducing carefully chosen staged Prototypes (that can be improved by iteration at each step) within the Waterfall Model, it can reduce the possibility of a major re-work and maximise the benefit of the work put in at each stage.

The main goals are to build robust prototypes in a structured manner so as to help users get an idea of what the system will look like. Instead of discarding the prototype, it is continuously developed and refined until it becomes the final system.

The communication process between the developers and the users is improved. Design decisions can be made without the user having to wait until the complete system is built (as occurs with a pure Waterfall approach). It has the advantage over a throwaway prototype approach in that it is a functional system from the start. As users work with it, they identify opportunities for improvements early in the SDLC. This reduces the overall cost of the project. Development time is also less since a major portion of the coding and the knowledge built into it is retained in the final system [49].

The Evolutionary Prototype model has been used to develop IMS, being eminently suitable for refining the GUI requirements.

The users did not clearly understand and/or define many of their needs identified during the "requirements gathering phase" (3.4.1 below). The Evolutionary Prototype focuses on the implementation of features that are clearly understood rather than the implementation of poorly understood ones. As users work with the system they detect opportunities for new features, resulting in multiple iterative requirements gathering sessions. It is analysis, redesign, prototype development and user responses that create the next set of requirements that define the next iteration [51].

The Evolutionary Prototype lifecycle consists of six development phases as illustrated in Figure 3.1 below. The first step in the evolutionary prototyping lifecycle model is to gather the initial **user requirements,** moving into an iterative cycle of **designing** the prototype, **implementing** the prototype, user **evaluation** of the prototype and **refining** the prototype. Once the user is satisfied with the prototype, the final set of user requirements is produced and the **final system** can be delivered [14].

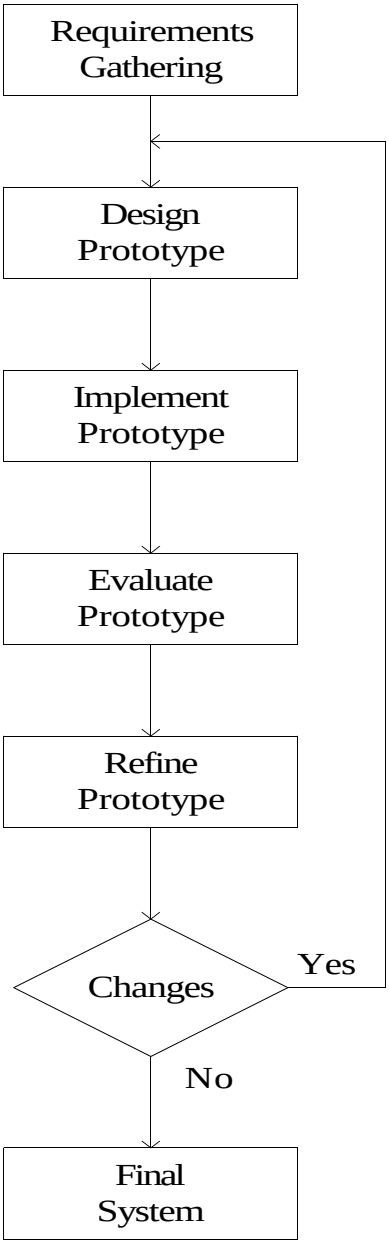


Figure 3.1: Evolutionary Prototyping

An overview of the GUI of the final system developed using the evolutionary prototyping model is given in Figure 3.2 below.

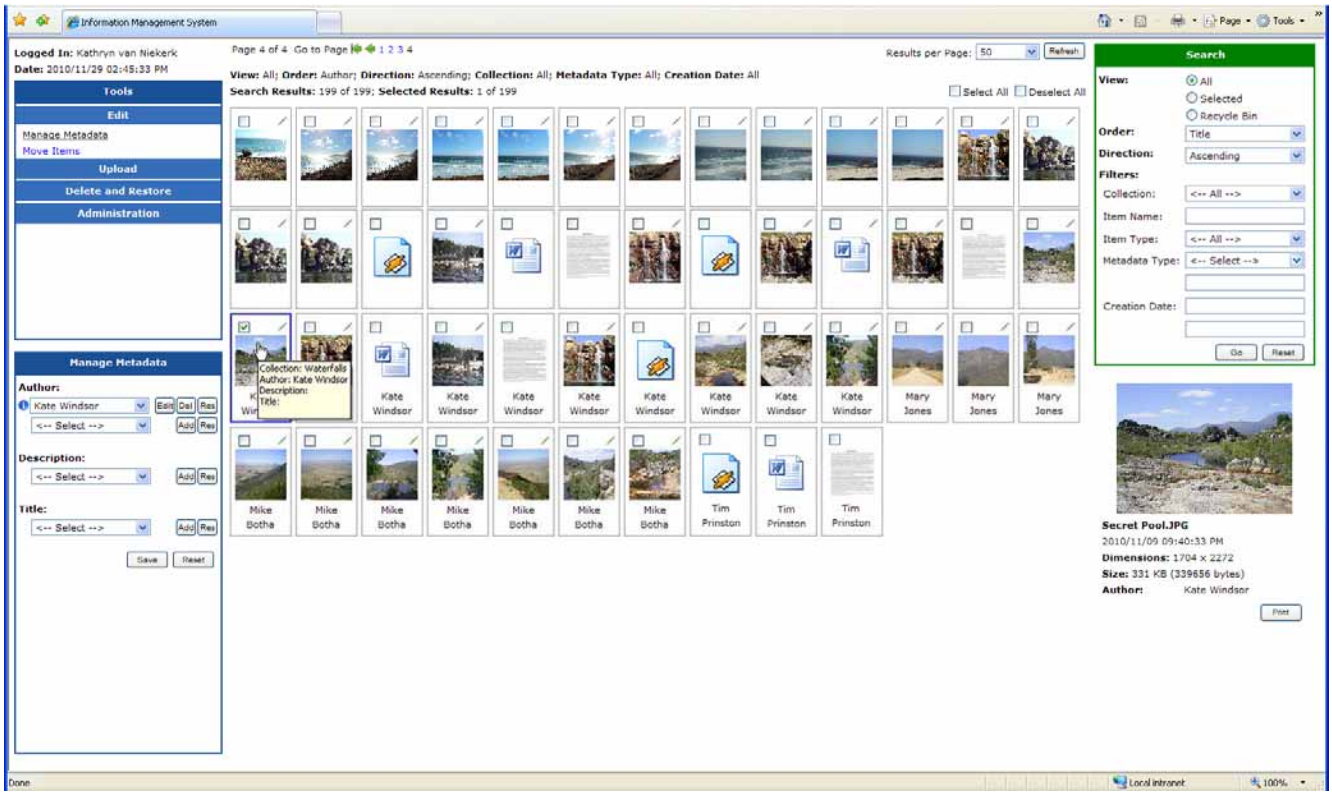


Figure 3.2: Main Graphical User Interface of Final System

3.4 Research Overview

An overview of how each phase in the Evolutionary Prototype lifecycle was implemented in IMS is given below.

3.4.1 Requirements Gathering

The requirements gathering phase provides an insight into the existing system and determines the real needs rather than the perceived wishes of the users. This is the most crucial phase, as a "*requirement*" specifies exactly what the system should do. Without a good understanding of what is wrong with the current system, there is a high probability that the new version will follow the same trends as the old one, and will consequently be no better [49].

The initial requirements are documented in a Requirements Functional Specification (RFS). The RFS is continually revised as new real needs are identified from the iterative user evaluations at each prototype release. Once the user is satisfied, the RFS is signed off. The maintenance team will then have a clear statement of the current functionality of the system so as to prevent a maintenance nightmare [49].

Two basic data collection techniques can be classified - Structured and Unstructured.

- Structured techniques (also known as Quantitative Research Technologies) have a low degree of flexibility i.e. the questions are specific, planned and closed-ended. The answers to these questions can be counted and expressed numerically.

- Unstructured techniques (also known as Qualitative Research Techniques) have a high degree of flexibility i.e. loosely structured interviews where questions are unplanned, open-ended and designed to allow users to add their own opinions. Answers to these questions provide insight into user behaviour. The most important questions come first, and should be short and to the point to avoid boredom [27].

The following combined data collection techniques were used here to gather information:

- Questionnaire
- Interview (face-to-face)

It is often difficult to design a single GUI catering for all users i.e. that can be used by both skilled professionals and by users with no previous computer experience. In this instance, it might be better to design two GUIs, each tailored to meet the individual needs of the specific target audience [49]. The target users for IMS are skilled professionals using existing tools for digital image management.

3.4.1.1 Questionnaire

This consisted of a set of structured questions designed to capture information about current systems used for digital image management. Included were written answers to short questions and answers to Likert-scale questions. The short questions allowed users to express their opinions about useful, not so useful and additional features needed during editing, uploading, selecting and organising images of current systems. The Likert-scale questions were used to rate the ease of uploading images and manipulating a subset of images.

3.4.1.2 Interview

This took the form of an individual face-to-face interview to determine current practice in the UCT Fine Arts Department. The answers to the questions were written down during the interview. The process began with a set of structured questions (designed to capture information about the current UCT system used for digital image management). Users were then invited to make suggestions as to how their current system could be improved.

3.4.2 Design Prototype

Prototyping can involve two phases producing low-fidelity and high-fidelity prototypes.

A low-fidelity prototype is built using techniques different from that of the final system. However, the importance of the low-fidelity prototype is that it is quick to build, readily providing the user with a good understanding of what the final system will look like. Once the user is satisfied, the low-fidelity prototype is discarded, while leaving the basic ideas to be developed into the high-fidelity prototype [5].

Prototyping can be further refined into horizontal and vertical prototypes. A horizontal prototype has a wide range of functions, each with very few details. The vertical prototype has a limited range of functions, but these contain much detail [5].

A horizontal, low-fidelity prototype was designed and implemented using the initial RFS from the requirements gathering phase (3.4.1 above). The idea was to build this as quickly as possible, while still ensuring that it contained the key user functionality. Slight imperfections in this prototype could be ignored as they did not seriously impair the user evaluation by giving a false impression of the final system look and behaviour.

The main goal here was to show the feasibility of the GUI interacting with the underlying object management techniques. The high-fidelity prototype could then be developed once a clear understanding of the basic requirements was gained.

The low-fidelity prototype is discussed in more detail in Chapter 4. The high-fidelity prototype is discussed in more detail in Chapter 5.

3.4.3 Evaluate Prototype

When using iterative prototyping to refine user requirements, there should always be a limit to the number of iterations or else the project will never end. Users will **always** find something wrong, or something that needs improvement, no matter how many times they are shown the prototypes. IMS went through two iterations before the final system was produced. Users were interviewed, followed by a walk-through of the GUI (performed with the help of a horizontal, low-fidelity prototype). The evaluation of the low-fidelity prototype is discussed in more detail in Chapter 4.

The most important question that this research investigates is “Is it possible to build a GUI that facilitates the efficient and accurate management of a large quantity of objects”.

In order to answer this question, user evaluations of a high-fidelity prototype were essential. These evaluations consisted of a fixed set of tasks the user needed to perform to cover the range of features. The tasks were then followed by a short questionnaire consisting of written answers and answers to Likert-scale questions. The short questions allowed the users to express their opinions on the features of IMS they liked and disliked and where improvements were needed. The Likert-scale questions were used to rate the levels of menu navigation, complexity, intuitiveness, effectiveness and response times. The evaluation of the high-fidelity prototype is discussed in more detail in Chapter 5.

3.5 Constraints and Anticipated problems

The following were considered as potential constraints and problems to hinder the process:

- **Lack of cooperation from UCT Fine Arts Department** to explain their current practices, hindering the understanding of, and impeding the building of, a better object management system.
- **Lack of availability of users** who use the current digital image management tools. The users need to be screened to ensure that they fit the "target user" profile.
- **Lack of timely feedback** could delay the design and implementation of the next prototype iteration.

3.6 Summary

This chapter discussed the research methodology used to develop the IMS.

- The Evolutionary Prototype model was used as it is a suitable methodology for fine-tuning the GUI requirements.
- The data collection techniques used to gather the initial user requirements were questionnaires and interviews (face-to-face) of existing practices and systems.
- Low-fidelity and high-fidelity prototypes were designed and implemented from the initial user requirements.

Chapter 4
Understanding Users

4.1 Introduction

To facilitate better system design, a few basic questions must be answered before starting.

1. What end goal will the users be trying to accomplish with the system?
2. What do the users need from the system in order to accomplish it?
3. How should the system supply the users with what they need?

As the system is built and refined through iterations, answers to the following are needed:

4. What in the new system is ineffective or just not working for the users?
5. How can the system be made more effective for the user?

Answers can be found using various data collection techniques. As mentioned in the previous chapter, a combination of questionnaires, interviews, and low-fidelity prototype evaluations was used to gather the information for this design. The details of the results from the various data collection techniques are discussed in this chapter.

The target market can be defined as "any unique groups or segment of users that will use the product" [9]. The GUI usability (as defined in Section 6.1) can be designed more effectively once the target users have been defined. In this case, the users are skilled professional adults, familiar with computers and that have a keen interest in digital image management. They were selected as they would most likely have used existing digital image management systems and were looking for a new system that would help improve their productivity.

4.2 Requirements Gathering

The actual questions used in both the questionnaire and the interview are given in Appendix A. The answers are sorted roughly into 3 categories using Questions 1 in Section 4.1 as the main criteria.

- Category 1 gathers basic information about the user and evaluates their level of experience managing personal digital image collections. The user is asked to provide the names and descriptions of the systems they use to manage their digital image collections.
- Category 2 gathers information about the useful, not so useful and additional features needed during editing, uploading, selecting and organising images.
- Category 3 (applicable to the interview only) comprises of unstructured questions. The topics aim to gather more information on selected answers from the questionnaire.

The users for the questionnaire and prototype evaluations were skilled professionals. They are surrogate in nature - even though they may not themselves use the system, they are useful as stand-ins [5]. It is better to use surrogate users than to talk to no one and incorrectly fabricate user requirements in an arbitrary open-loop process.

4.2.1 Questionnaire Results

Twenty-four users from different age groups ranging from 20 to 52 (mean age of 27) participated in the Questionnaire. The users were provided with a URL and were told that the duration would be approximately thirty minutes.

4.2.1.1 Basic User Information

This part of the questionnaire collected data on the digital image management systems they were currently using. The management programmes and the number of users are shown in Figure 4.1 below. The programmes are Facebook, Picasa, Hi5, Dropbox, Family Tree Maker, Picture Acquisition Wizard and Adobe Photoshop.

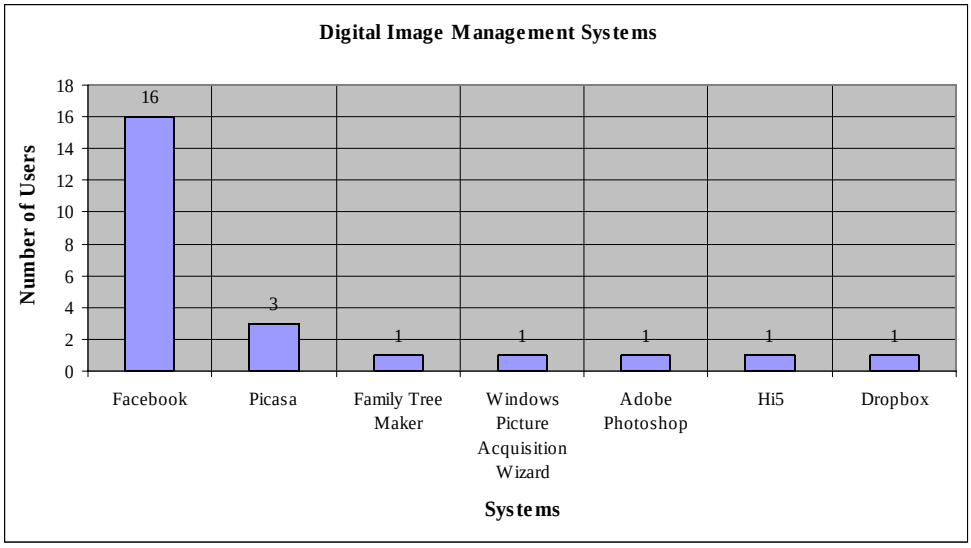


Figure 4.1: User Digital Image Management Systems

Picasa, Facebook, Hi5 and Dropbox are classified as social networking systems - users can upload images for storage in albums, perform basic editing and then share them with other users. Family Tree Maker, Picture Acquisition Wizard and Adobe Photoshop are Windows applications used to store images in albums and to perform basic editing.

4.2.1.2 Editing Images

The majority of users found it useful to be able to "tweak" images e.g. automatic colour fixing, cropping, rotation, deletion. Tagging (also referred to as metadata) is used to store additional information about the image e.g. title and description. Users can change the metadata of only one image at a time.

4.2.1.3 Uploading Images

Results of the user ratings for uploading 100 images for the digital image management systems currently used are illustrated in Figure 4.2 below.

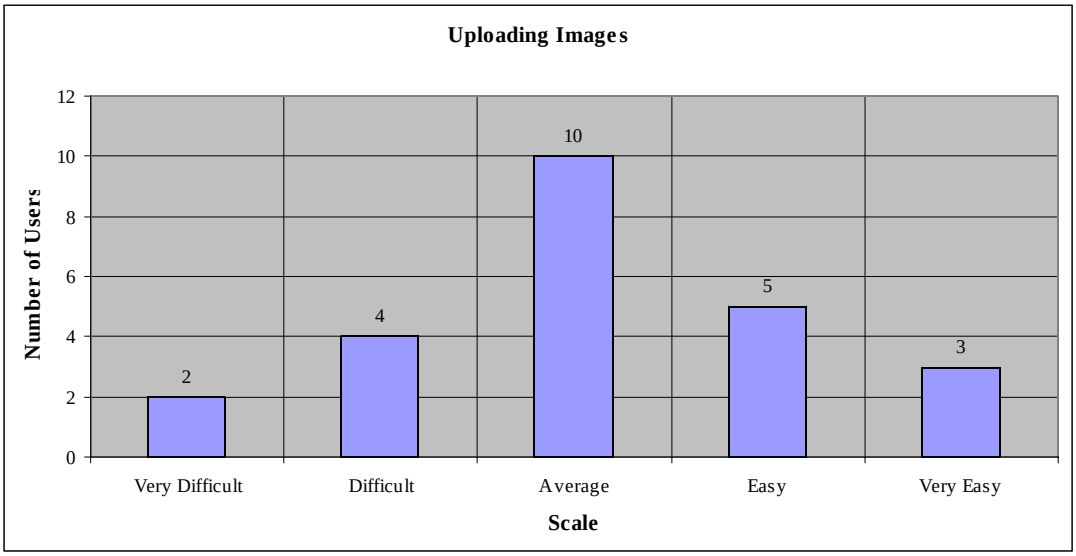


Figure 4.2: Uploading Images

The majority of users found the upload GUI of Facebook, Picasa, Dropbox and Adobe Photoshop to be user friendly. All programmes had the ability to select multiple images for upload. The three users who found it very easy to upload images (refer Figure 4.2) correspond to the users who use the Windows applications in that they currently only need to copy or move images to folders managed by their applications.

Six users did not find it useful being able to upload only a single image at a time, were unable to install a multiple image upload plug-in on their current Facebook application. This corresponds to the 6 users who found uploading images to be very difficult or difficult (refer Figure 4.2). Users also felt it was not clear what they needed to do to upload images and felt that the menu navigation was very poor. Two Facebook users had no control over the upload folder during image upload to a default folder - a subsequent step was needed to navigate to the default folder and move the images to the desired one.

4.2.1.4 Selecting Images

The majority of the users can select an image by either clicking on an image or "ticking" a check-box. The three users using the Windows applications have standard file selecting techniques to choose a single image, but not an entire group of images at the same time.

4.2.1.5 Manipulating Images

The ratings for manipulation of a subset of images for the digital image management systems currently used are shown in Figure 4.3 below.

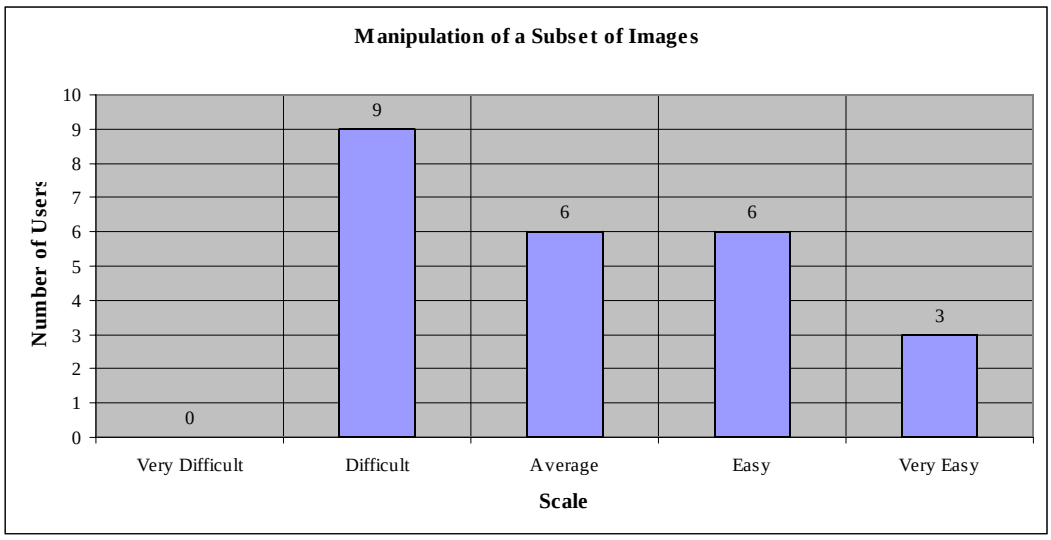


Figure 4.3: Manipulation of a Subset of Images

All the users could organise images into folders or albums. These destinations can be created and edited, allowing images to be added continuously to them. The three users who found it very easy to manipulate a subset of images in (refer Figure 4.3) corresponded to the Windows applications that allow the user to manipulate images in a manner similar to any other file or folder. Only one user was able to organise images alphabetically by image title.

Some users were able to move only a single image between the folders or albums - two users not at all. This corresponds with the 15 users who found it difficult or average to manipulate a subset of images (refer Figure 4.3).

4.2.2 Interview

An expert from the UCT Fine Arts Department participated in a 45 minute interview based on Aperture. This is currently the standard Departmental digital image management tool.

Aperture takes up a huge amount of physical drive space - scrolling, searching, exporting and moving between folders etc. becomes slower as the size of the collection increases. It is therefore only suitable for smaller collections of an estimated maximum of 50 000 images.

Video and audio files can only be stored by attaching them to existing digital images, and not as independent digital objects, each with their own associated metadata. The Aperture version used shared a common problem identified from the questionnaire results in Section 4.2.1.2 i.e. users can edit the metadata of only one image at a time.

Aperture has become such a large application that the GUI is not at all intuitive. First time users easily become lost in using the menus and shortcuts.

4.2.3 Summary

The data gained from the questionnaire and the interview was sufficient to get an answer to Question 2 and Question 3 in Section 4.1. The paragraphs below are a summary of the initial RFS for IMS.

The majority of users would like the metadata feature to be improved. Currently, users can change only the metadata of one image at a time. This is extremely time consuming when many images must be updated e.g. with the same title. When multiple users edit images, the image being edited must be locked so that no updates are lost during multiple saves.

The majority of users would also like to upload multiple images to a destination folder with a progress bar to indicate how many images have already been uploaded. Users should have a facility to view the images that have just been uploaded in case they forget which ones they did. Two users indicated that they would like the ability to upload other file formats.

The majority of users would like to move multiple images at the same time between folders or albums. Currently, users can move only one image at a time. This is time consuming when many images must be moved between folders or albums. Users would also like the ability to sort images within the folders or albums using information contained in the tags.

The majority of users would like to select a group of images at the same time to assist in the multiple editing of tags, moving between folders or albums and deleting of images. Users should be able to search for a specific image or a specific group of images. The user must be able to select them all at once and not have to check each and every selection check box.

One user indicated that there should be user permissions to control the uploading, viewing and editing of images. The majority of the users indicated that there needed to be an overall improvement of the menu navigation.

4.3 Prototype Evaluation

Twelve users from different age groups from 22 to 68 with a mean age of 37 participated in the prototype evaluations. The prototype evaluations took the form of individual interviews with the help of a horizontal low-fidelity prototype designed and implemented using the initial RFS from the requirements gathering phase.

The interviews and walk-through were conducted in my study to keep the environment constant for all users – this should produce consistent results. Sounds were kept at a low volume, and the users were placed with their backs to the other objects in the room to limit any distraction. The users were informed that the duration of the interview and walk-through would be approximately 45 minutes.

4.3.1 Prototype Evaluation Results

A walk-through of the GUI was done, discussing menu navigation, layout, the usefulness of the features and any features that might be missing.

4.3.1.1 Main Graphical User Interface

The main Prototype GUI is shown in Figure 4.4 below (each point below correlates to a red number in Figure 4.4) and contains the following functionality:

1. **Items Search** – Search for items using a pre-defined search filter.
2. **Item Listing** – A list of items meeting the search filter criteria.
    - Select Item – Select an item in preparation for editing.
    - Edit Item – Open up an item in an external editing tool.
    - View Item Detail – View the metadata and full details of an item.
3. **Tools**
    - **Editing**
        - Edit Metadata – Add, edit and delete metadata associated with selected items.
        - Move Items – Move the selected items from one collection to another collection.
        - Delete Items – Delete the selected items to the recycle bin.
        - Upload Items – Upload multiple items to a target collection.
    - **Selection**
        - Select Items - Select multiple items in preparation for editing.
    - **Administration**
        - Add Collection – Add and edit collections.
        - Add Metadata Type – Add and edit metadata types.
        - Recycle Bin – Permanently erase the recycle bin.
        - Refresh Page – Reload the home page of IMS.

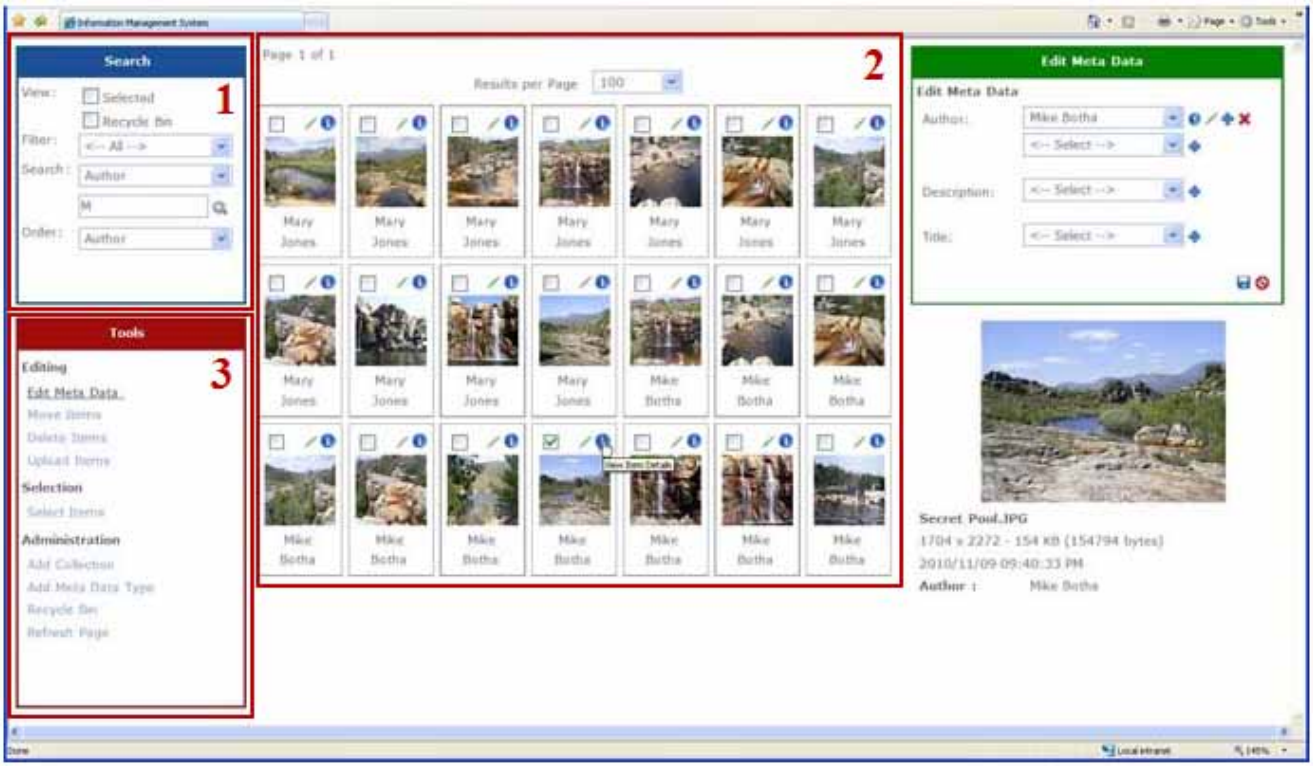


Figure 4.4: Prototype Main Graphical User Interface

There was a clear split in opinion about the exact placement of the Search, Tool and Action frames i.e. consistency in that the Tool and Actions frames should be placed together, however there was no agreement as to where the frames should be positioned on the screen. There was consensus about an optimal white space in the middle to display images.

Conclusions were that the colouring of the Tools and Action frames should be the same to indicate a relationship between them, with grey text for content, blue text for links and black text for selected links. People with colour blindness might have problems distinguishing between content and their selected links.

A collapsible menu structure was also preferred to simplify menu choices concurrently displayed. Simple, yet precise, main menu items should accurately describe the sub-menu items listed beneath them.

The action images throughout the system were confusing - it was not clear what action would be performed when clicked. Hence, action buttons should rather have descriptive text e.g. “Save” instead of an icon to represent saving. All action icons for Save and Reset should be replaced with actions buttons titled “Save” and “Reset”.

Users should be able to use their preferred input method, and should also be able to navigate through IMS using the keyboard and not merely by relying on mouse events.

4.3.1.2 Searching

The search frame is illustrated in Figure 4.5 below.

Radio buttons instead of check-boxes should be used when selecting a view as the choices are mutually exclusive and therefore the user can select only one option. A default option "All" should be included to view all images.

The "Filter" and "Search" headings should be more specific i.e. "Collection" and "Metadata Type", and grouped beneath a main heading "Filter" to allow for additional filters to be included. Additional filters to search for an item by name and type should be added.

The search text box should be improved to use the principles of AJAX, including "Auto-complete" and "Sort Order" to select an ascending or a descending sort.

Users should be able to view the search criteria of the current item listing; hence this should be displayed above the listing to give users feedback so as to avoid "search lostness". The total number of images displayed in the item listing should be displayed below the search criteria feedback.

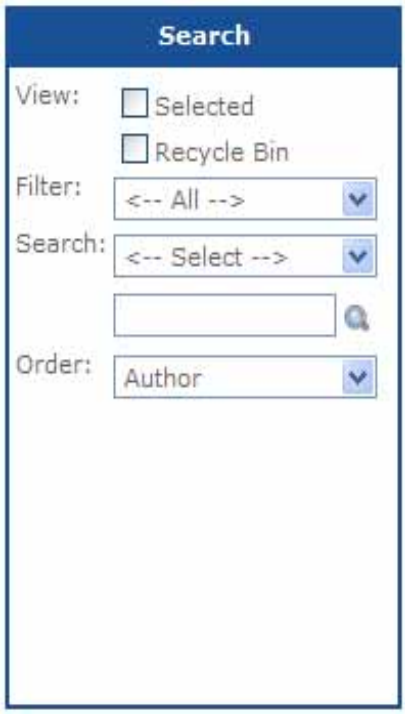


Figure 4.5: Search Frame

4.3.1.3 Collection Administration

The collection administration frame is illustrated in Figure 4.6 below.

Users should have the ability to delete collections using a "Delete" action button. A collection cannot be deleted if any items are associated with it. The menu title and action frame heading should change to "Manage Collections" to include deleting collections.

It was not obvious to the users that they needed to select "Add Collection" from the drop-down list to add a new collection. An action button titled "Add" will be positioned to the right of the drop-down list.

Figure 4.6: Collection Administration Frame

4.3.1.4 Metadata Type Administration

The metadata type administration frame is illustrated in Figure 4.7 below.

Users should be able to delete metadata types using an action button titled “Delete”. The menu title and action frame heading should change to “Manage Metadata Types” to include deletion of metadata types.

It was not obvious to users that they needed to select “Add Metadata Type” from the drop down list in order to add a new metadata type. An action button titled “Add” must be positioned to the right of the drop down list.

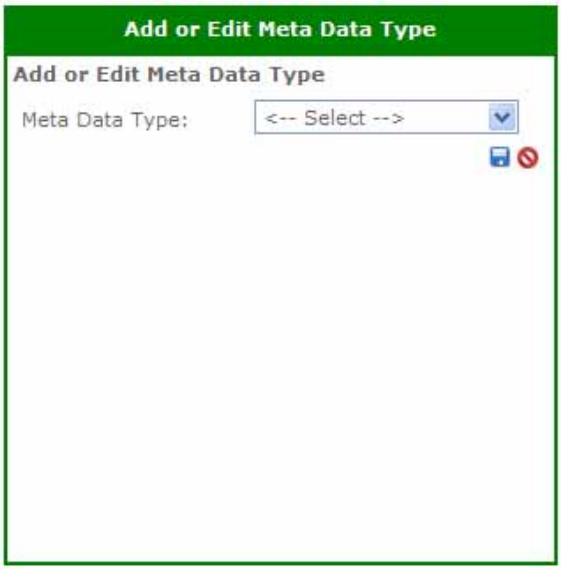


Figure 4.7: Metadata Type Administration Frame

4.3.1.5 Edit Metadata

The edit metadata frame is illustrated in Figure 4.8 below.

The menu title and action frame heading should change to “Manage Metadata” to be consistent with the changes in Sections 4.3.1.3 and 4.3.1.4.

The action image of the pencil, plus sign and cross must be replaced with text action buttons titled “Add”, “Edit” and “Del” respectively.

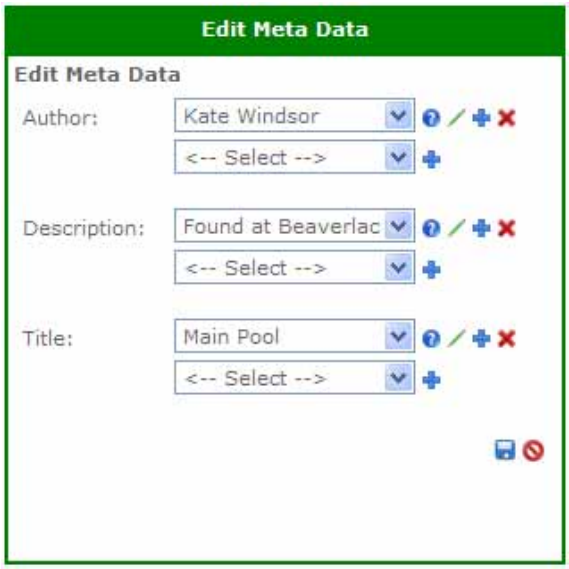


Figure 4.8: Edit Metadata Frame

Users should have the ability to add multiple new metadata at the same time. It will be time consuming if the user needs to click Add, Save, Add then Save again to add two authors for example. The user should be able to click Add then Save once to add multiple new metadata.

4.3.1.6 Move Items

The move items frame is illustrated in Figure 4.9 below.

The heading "Move Items" should be changed to "Target Collection" to avoid ambiguities as to what this collection is used for.

Figure 4.9: Move Items Frame

4.3.1.7 Upload Items

The upload items frame is illustrated in Figure 4.10 below.

The sub-menu item "Upload Items" should move from the main menu item "Edit" to a new menu item "Upload" - uploading items has no relationship to editing items.

The heading "Collection" should be changed to "Target Collection" to avoid ambiguities as to what the collection is to be used for. The user should also be warned when the target collection is changed to avoid accidental uploading to the wrong target collection.

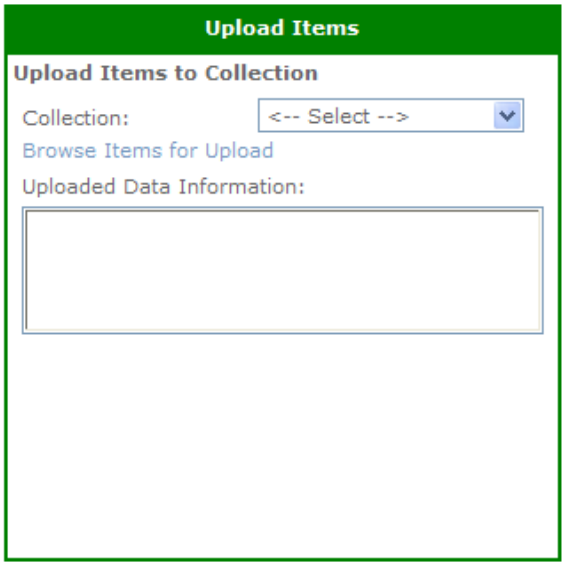


Figure 4.10: Upload Items Frame

The heading "Browse Items for Upload" should be changed to "Browse and Upload Items" to indicate that the browsing for items to be uploaded and the actual uploading of these items takes place in one action. In addition, the number and details of successfully uploaded items and duplicate items not uploaded should be displayed once the upload has completed.

4.3.1.8 Select Items

The select items frame is illustrated in Figure 4.11 below.

The "Select Items" frame should be removed. It is time consuming to click on a menu item and choose "Select All" or "Deselect All" items. It is also confusing for the user to find the "Select By Date Picture Taken" search under the select items menu item.

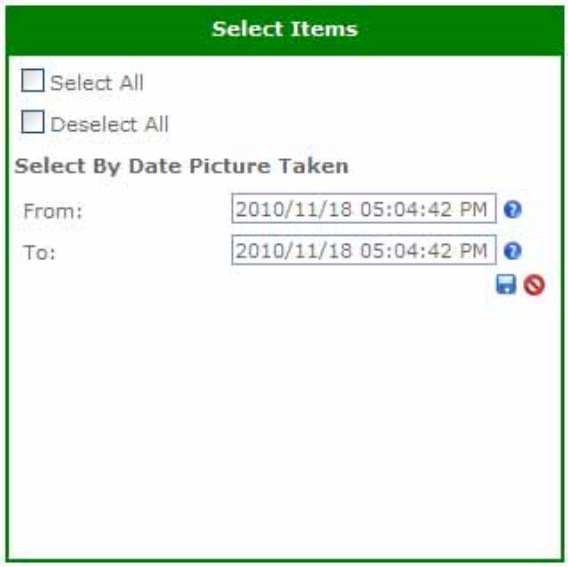


Figure 4.11: Select Items Frame

The "Select All" and "Deselect All" check boxes should be positioned at the top and to the right of the item listing for easy access. All items in the current item listing should be selected or deselected and not just the items on the current page. There should be an indication as to the number of items selected as indicated beneath the "Search Criteria" feedback. For consistency, the "Select By Date Picture Taken" choice should be moved to be beneath the heading "Filter" on the search frame.

4.3.1.9 Delete Items

The sub-menu item "Delete Items" and "Recycle Bin" (associated with main menu items "Edit" and "Administration" respectively) should both be moved to a new menu item "Delete and Restore" as Delete and Restore have no tangible relationship to editing and administration.

4.3.1.10 Restore Items

The restoring of an item is illustrated in Figure 4.12 below.

Currently, users can only restore a single item at a time by clicking the restore action image in Figure 4.12. This is time consuming if multiple items need to be restored. The selecting of items to be restored should be consistent with the mechanism used for selecting items for editing.

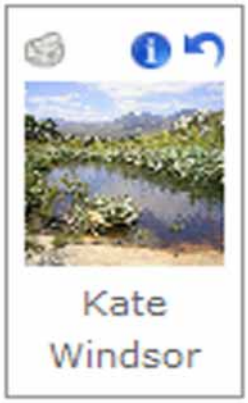


Figure 4.12: Restoring an Item

4.3.1.11 Viewing Image Details

The viewing of item details is illustrated in Figure 4.13 below and Figure 4.14 below.

The action image of the information symbol in Figure 4.13 should be removed as the item should be highlighted and item details displayed when the mouse hovers over the item. When the item is clicked, the item details should freeze until the item is clicked again or another item is selected.

The headings "Dimensions" and "Size" should be added to the item details in Figure 4.14 to make it clear to the user what the information below the title is about.

Figure 4.13: Viewing Item Metadata Details

Figure 4.14: Viewing Item Details

4.3.2 Summary

The data collected from the prototype evaluations was sufficient to answer Questions 4 and 5 in Section 4.1. After the interviews were completed, the GUI was modified to produce the candidate system discussed in Chapter 5.

Chapter 5

Design and Implementation

5.1 Introduction

The work presented so far has covered the research methodology appropriate to this field of study, including various techniques used to define user requirements. The results of the initial user requirements gathering phase and of the low-fidelity prototype evaluations have been presented and used to redefine the user requirements. The candidate system can now be implemented and presented for final evaluation.

This chapter will focus on the details of the proposed Web application solution, named IMS, which will facilitate the efficient and accurate management of a large number of digital items.

5.1.1 Web Application

A Web application is a programme that stores data to be delivered to users on a Web server, much like the Internet. Web applications are increasing in popularity, mainly due to the growing use of Web browsers as clients interacting with secure, backed-up servers on the Intranet, or even on the Internet [25].

However, the main reason for choosing to implement IMS as a Web application is that, unlike desktop applications, Web based applications can be accessed from any computer or location that has Internet access. This is ideal for any user telecommuting i.e. working from home or travelling. They can continue to work and keep up to date with the latest changes. Users can manage items without having to email or transfer them from user to user via a flash drive, etc. This reduces the possibility that the quality and integrity of the items will be compromised over time. Users are supplied with user names and passwords that control access to the server, making it easier to monitor every user action and produce an audit trail [18].

Figure 5.1 below illustrates the network diagram of a Web application deployment and the various groups of users who require access to it. WEB01 and WEB02 are servers where the Web application is deployed and SQL01 is the database server. WEB01 and WEB02 are considered to be mission critical and have therefore been mirrored in the event that if one server goes down the other server will continue to operate. Daily backups of these servers can be scheduled and copied to BACKP01 to prevent downtime and, most importantly, any data loss. All upgrades made to the basic software on the servers are automatically available to all users, reducing upgrade time and cost.

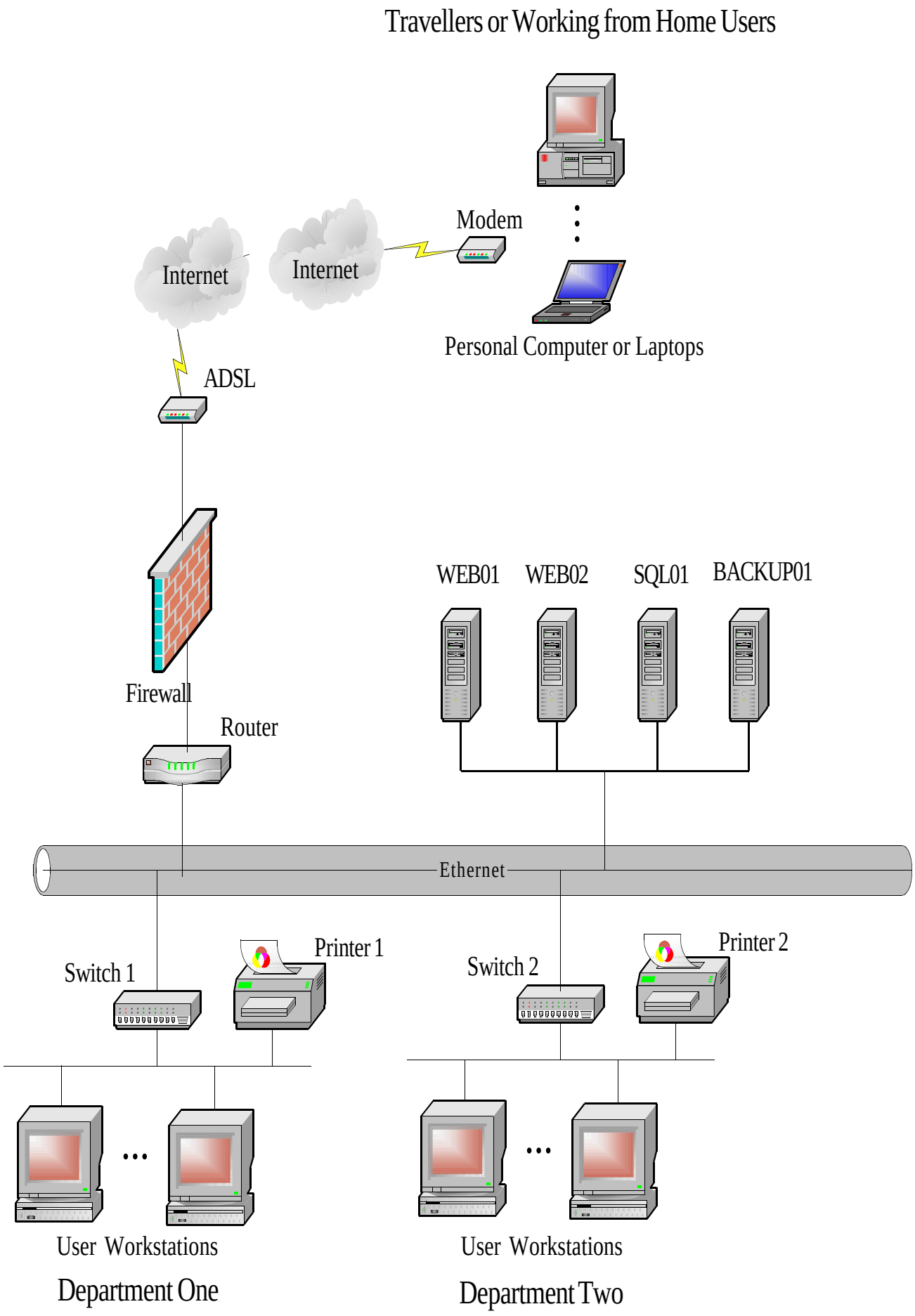


Figure 5.1: Network Diagram

5.2 Application Architecture

This section is a high-level overview to provide a contextual background for IMS.

5.2.1 Application Context

Figure 5.2 below is a simplified view of the relationship between the user access, their privileges, the IMS application and the IMS database. As illustrated in Figure 5.1 above the IMS application and database can reside on the same or on separate servers.

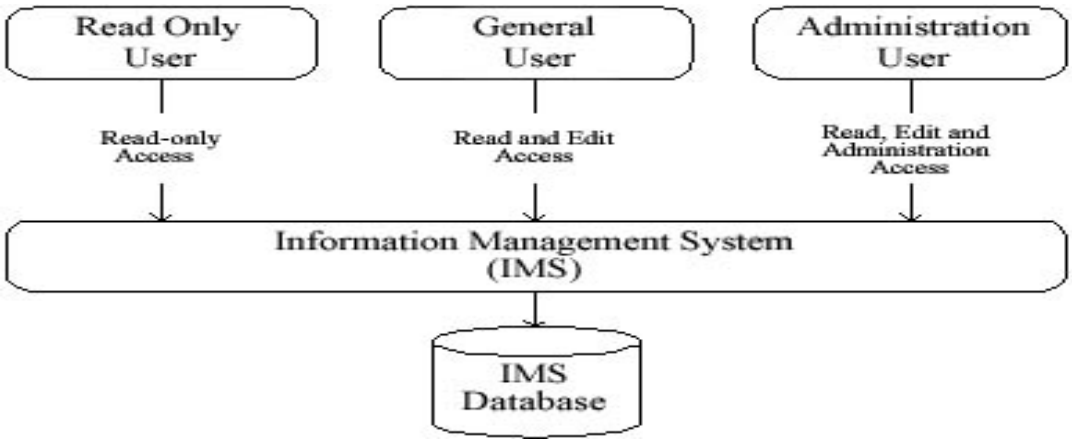


Figure 5.2: Application Context

5.2.2 Application Site Map

Figure 5.3 below is a map showing the IMS functionality at a high level. It forms the basis of the menu navigation. Users can view only the menu items for which they have privileges.

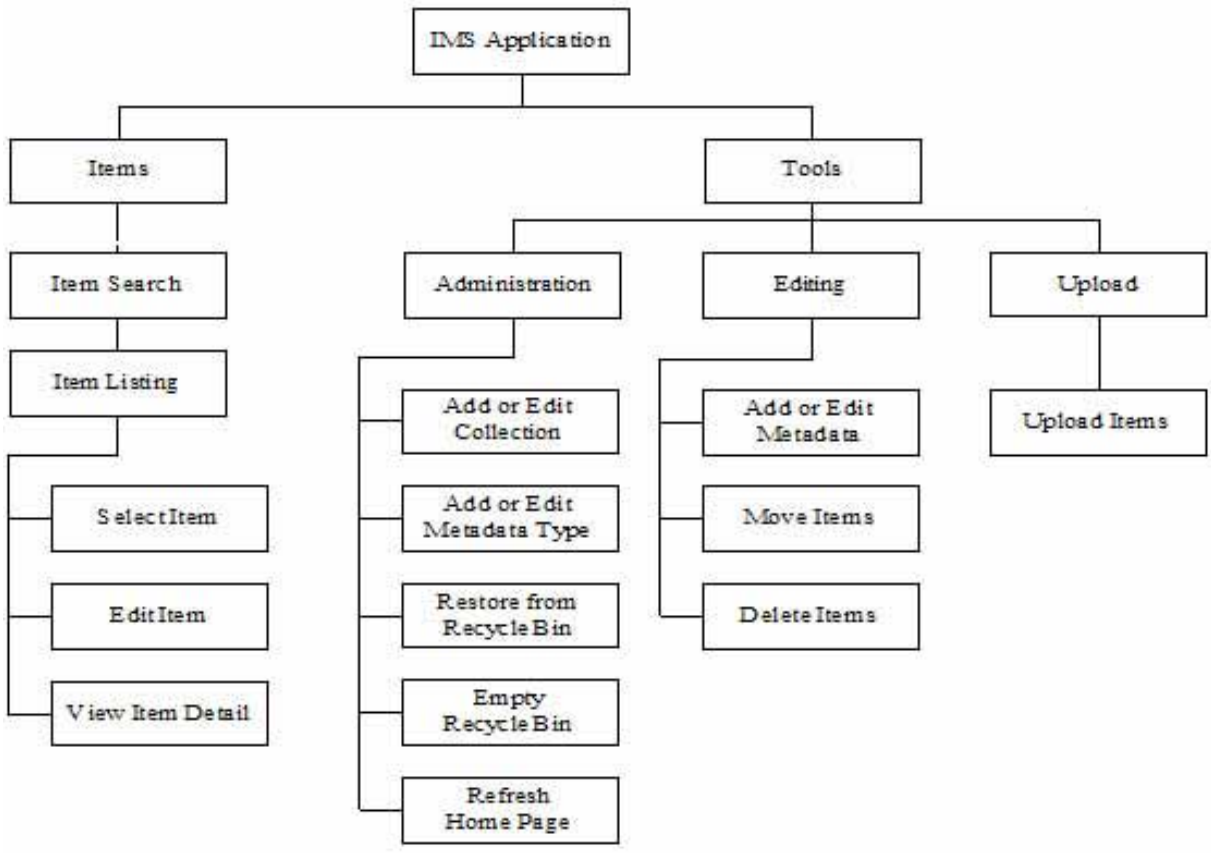


Figure 5.3: Site Map

IMS has the following functions - access privileges are given shown below for each function:

1. **Items** - Read only, general and administration users will have access to the following:
    - **Item Search** – Search for items using a pre-defined search filter.
    - **Item Listing** – A list of items meeting the search filter criteria.
        - Select Item – Select multiple items in preparation for editing.
        - Edit Item – Open up an item in an external editing tool.
        - View Item Detail – View the metadata and full details of an item.
2. **Tools**
    - **Edit** – General and administration users can access the following menu items.
        - Manage Metadata – Add, edit and delete metadata for selected items.
        - Move Items – Move selected items from one collection to another.
    - **Upload** – General and administration users can access the following:
        - Upload Items – Upload multiple items to a target collection.
    - **Delete and Restore Items** - General and administration users will have access to the following:
        - Delete Items – Delete the selected items to the recycle bin.
        - Restore from Recycle Bin – Restore selected items from the recycle bin.
        - Empty Recycle Bin – Permanently erase the recycle bin.
    - **Administration –** Administration users will have access to:
        - Manage Collection – Add, edit and delete collections.
        - Manage Metadata Type – Add, edit and delete metadata types.
        - Refresh Home Page – Reload the home page of IMS.

5.3 Application Functionality

The programme features were finalised after the initial user requirements gathering phase and the low-fidelity prototype evaluations were conducted, now including many of the suggestions and enhancements recommended by the potential users.

The GUI is written in the C# programming language and is implemented using Microsoft Visual Web Developer 2008 Express Edition.

5.3.1 Design Goals

The GUI is designed using the following principles from Constantine and Lockwood, the main aim being that of improving quality[5]:

- **The structure principle** – This is concerned with the overall architecture of the GUI. It should be organised in a meaningful and purposeful way with related things grouped together and unrelated things separated. Similar things should resemble each other while dissimilar things should be differentiated.
- **The simplicity principle** – The GUI design should make simple and common tasks easy to perform by communicating them to the users in simple, clear language. Meaningful shortcuts should be provided for longer tasks.
- **The visibility principle** – To prevent the user from being distracted and overwhelmed, the GUI should limit unnecessary or redundant information and the number of alternatives. Only options and materials for the given task should be visible.
- **The feedback principle** – Clear, concise and unambiguous language should be used to keep users informed of relevant and interesting errors or exceptions, changes in state or condition and actions or interpretations.
- **The tolerance principl**e – The cost of mistakes should be reduced by allowing the undoing and redoing of actions. Errors should be prevented wherever possible.
- **The reuse principle** – Internal and external components and behaviours should be reused to maintain consistency and to reduce the user need to rethink and remember.

5.3.2 Design Overview

An overview of the GUI is given in Figure 5.4 below - there are six main frames (each point below correlates to a red number in Figure 5.4):

1. **The tools and tools action frame on the left-hand side of the screen.** The tools frame is always visible, and depending on the selected menu item, will determine the tool action visible in the tool action frame.
2. **The information header and item listing frame in the centre of the screen.** These are always visible, but the information displayed in them will be determined by the search criteria selected by the user in the search frame.
3. **The search and item details frame on the right-hand side of the screen.** The search frame is always visible. The item details frame will only be visible when an item is hovered over or clicked on by the user in the item listing frame.

The tool tip displayed for all “Add”, “Save”, “Delete” and “Reset” action buttons when hovered over, can be found in Appendix B Section B.1.

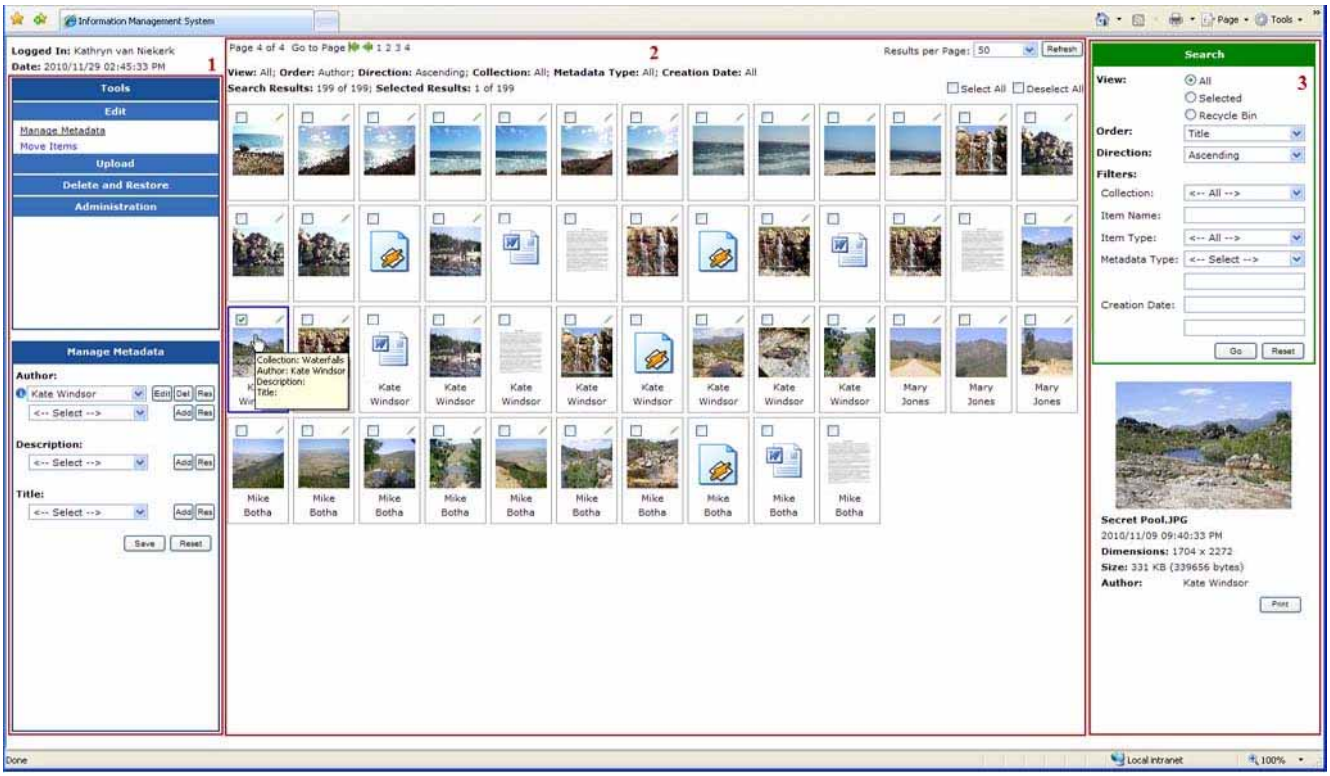


Figure 5.4: Main Graphical User Interface

Details of the functionality are discussed below.

5.3.2.1 Item Search

Users will have the ability to search for and display item information using the following search criteria (each point below correlates to the red number in Figure 5.5 below):

1. Users can select the view displayed in the item listing by using the radio buttons. The radio button options will display the following items:
   - "All" - All items.
   - "Selected" - Only selected items.
   - "Recycle Bin" - All items in the Recycle Bin.
2. Items can be ordered by metadata type. The caption displayed beneath the item in Figure 5.7 below is determined by the metadata type chosen for the ordering.
3. The ordered items can be displayed in an ascending or descending manner.
4. The search can be refined further by using the filters. Items can be filtered by collection, by item name, by item type, by metadata type and by item creation date. The item name and metadata type filters are auto-complete and will return all items that partially match the search criteria.

The search criteria can be reset by clicking the "Reset" action button.

The tool tip and information messages displayed to the user when searching for items can be found in Appendix B Section B.2.

Figure 5.5: Item Search

5.3.2.2 Item Listing

The item listing is illustrated in Figure 5.7 below. Users will view a list of items on the item listing page based on the search results returned from the search criteria. The thumbnails are 60 pixels x 60 pixels with file sizes between 8KB and 12KB. Thumbnail dimensions are customisable and are stored in the database table SystemSetting.

The following information is displayed in the information header frame and item listing frame (each point below correlates to the number in Figure 5.7):

1. Page navigation is hyperlinked to allow direct navigation to the item listing pages. Users can use the navigation action buttons to skip directly to the first or last page and to the next or previous page. The current item listing page out of the total number of pages is displayed.
2. The search criteria feedback displays the search criteria used to generate the results for the current item listing.
3. The “Search Results” displays the number of items returned from the search criteria out of the total items stored in the database.
4. The “Selected Results” displays the number of items selected out of the total items stored in the database.
5. The “Results per Page” drop down list controls the number of items displayed per page in the item listing.

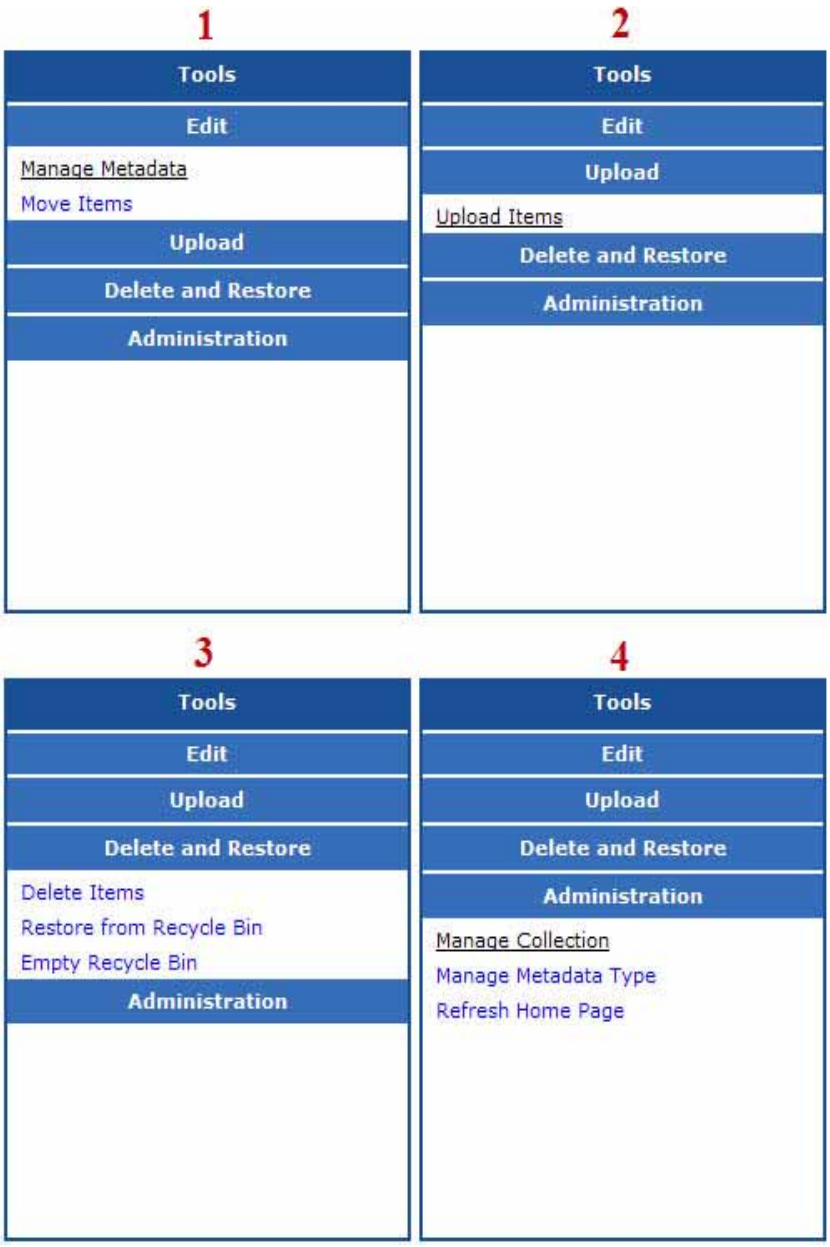


Figure 5.6: Main Menu Items

6. All items in the current item listing can be selected or deselected by clicking the check boxes.
7. An individual item can be selected or deselected by clicking the check box.
8. An item can be "tweaked" by opening it for edit in the current editor (Microsoft Paint). The changes will reflect in the item listing once the listing has been refreshed using the "Refresh" action button.

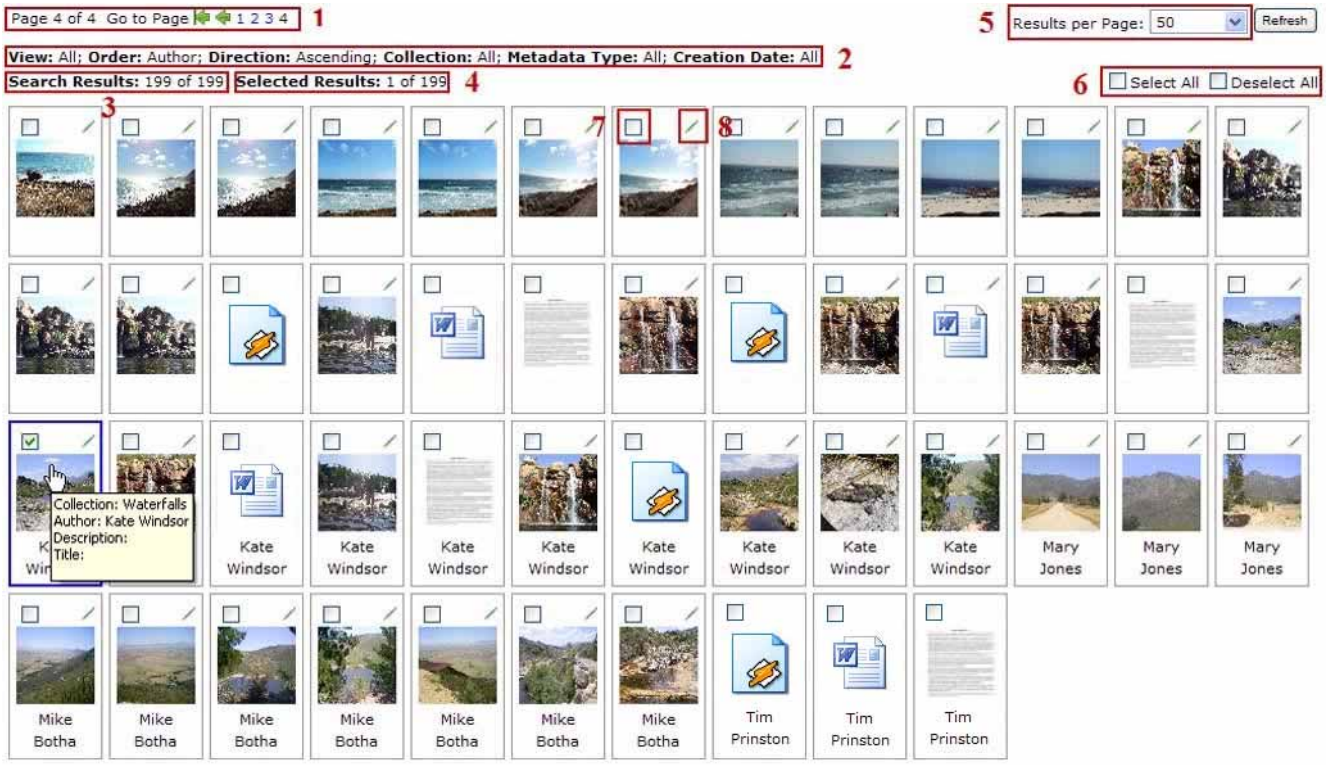


Figure 5.7: Item Listing

Specific thumbnails are generated for each file format (points below correspond to red numbers in Figure 5.8 below):

1. BMP, Exif, GIF, JPEG, JPG, PNG, RAW and TIFF
2. PDF
3. DOC
4. MP3

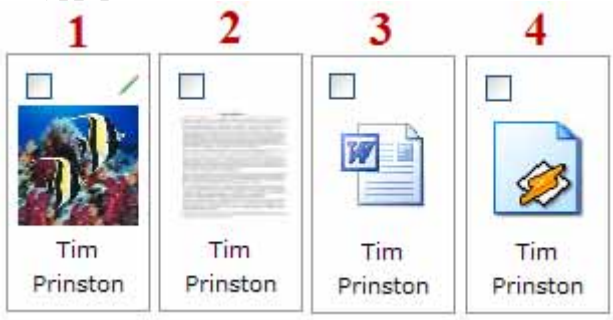


Figure 5.8: Item Thumbnails

5.3.2.3 View Item Detail

The following item details can be viewed (each point below correlates to the red number illustrated in Figure 5.9 below):

1. Metadata details can be viewed by hovering over an item with the mouse pointer. The metadata details will be displayed in a pop-up text box.

2. General details can be viewed by hovering over an item with the mouse pointer. The item border will be highlighted in blue, and the details will be displayed in the item details frame. The details frame can be frozen by clicking on the item. It will remain frozen and highlighted in blue until it is clicked again or another item is selected.

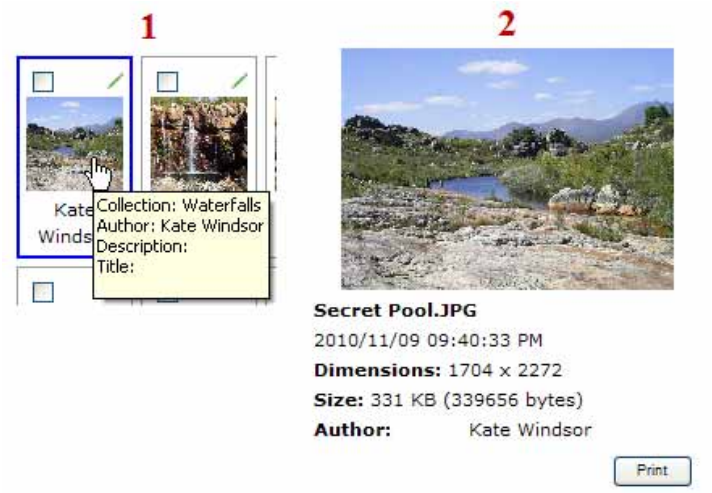


Figure 5.9: View Item Details

5.3.2.4 Main Menu Items

The main menu items are divided into the following categories (each point correlates to the red number illustrated in Figure 5.6 above):

1. Edit Menu (default “Manage Metadata”)
2. Upload Menu (default “Upload Items”)
3. Delete and Restore Menu
4. Administration Menu (default “Manage Collection”)

The main menu items have a collapsible menu structure to simplify the choices concurrently displayed to the user. The sub menu item hyperlinks are displayed in a blue font. When selected, the font becomes black and underlined as illustrated.

5.3.2.5 Manage Metadata

The following actions are available for metadata management (each point below correlates to the red number illustrated in Figure 5.10 below):

1. Selected items' metadata can be edited by clicking the “Edit” action button. A text box will be displayed, populated with the metadata of the selected item. This is the edit area where changes can be made. The metadata can be changed to that of an existing metadata by selecting it from the drop down list. To save edited metadata click the “Save” action button. Only metadata that is common to all selected items may be edited.

2. Selected items' metadata can be added by clicking the “Add” action button. An empty text box will be displayed where new metadata can be added. The metadata can be added from an existing metadata by selecting it from the drop down list. To save added metadata click the “Save” action button.

3. Selected items' metadata can be deleted by clicking the “Del” action button. The metadata will become greyed out indicating that it has been marked for delete. To save deleted metadata, click the “Save” action button.

The “Reset” action button will reset the current changes to the changes made when the last “Save” action button was clicked.

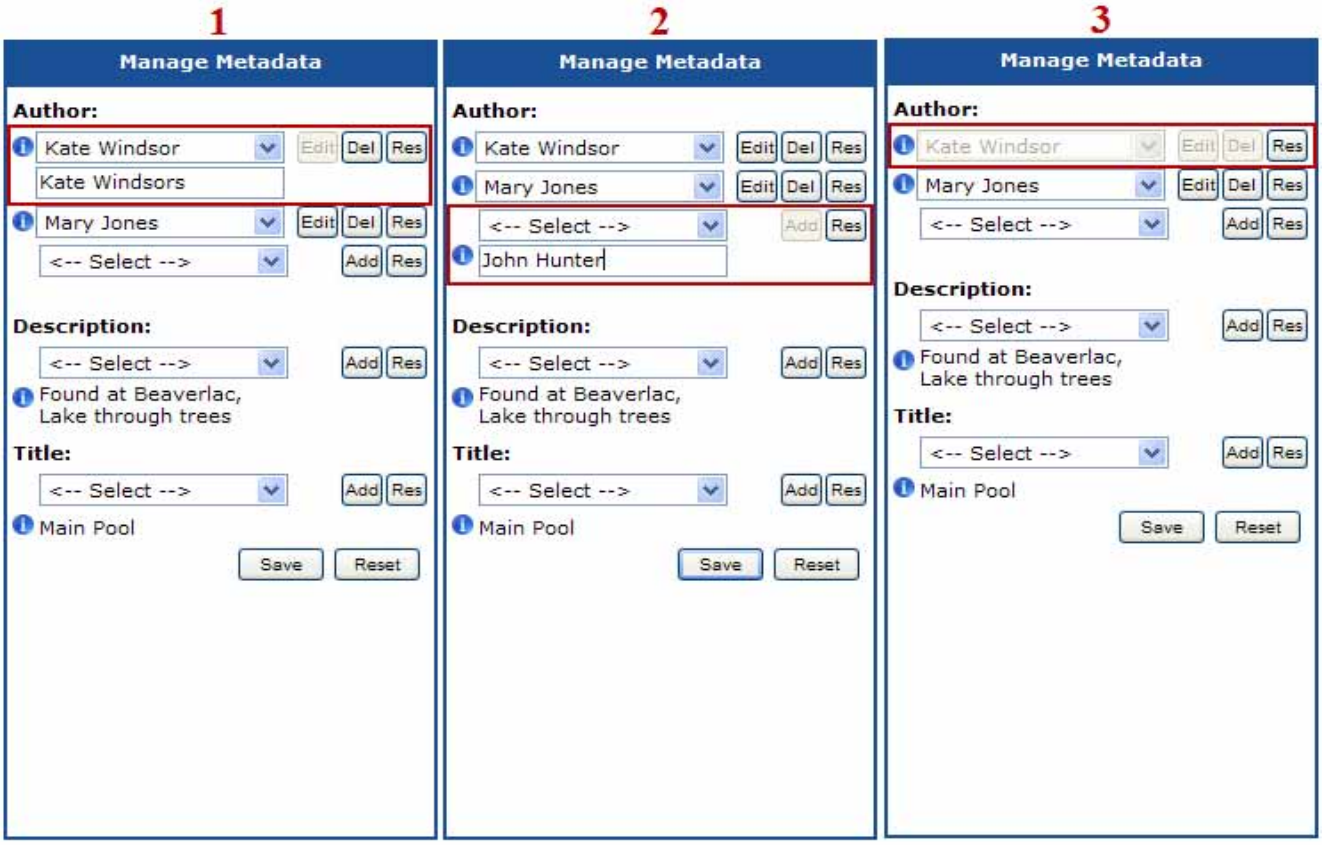


Figure 5.10: Manage Metadata

The tool tips and information messages displayed to the user when managing metadata can be found in Appendix B Section B.3.

5.3.2.6 Move Items

Selected items can be moved from their current collection to another collection by selecting a target collection from the drop down list, illustrated in Figure 5.11 below. To save an item move click the "Save" action button. The "Reset" action button will reset the target collection.

The information messages displayed to the user when moving items can be found in Appendix B.4.

Figure 5.11: Item Move

5.3.2.7 Upload Items

The following actions are available for item upload (each point below correlates to the number illustrated in Figure 5.12 below):

1. Items will be uploaded to the selected target collection. The target collection will default to "Unsorted".
2. When the "Browse and Upload Item" hyperlink is clicked, a file explorer is displayed.
3. Files can be selected using the traditional Windows shortcuts - "Ctrl A" - to select all items. When "Open" is clicked the items are uploaded. Users can select multiple files of different formats limited to the file formats specified in the "File of type" drop down list. The file formats are listed in Table C.4 in Appendix C.

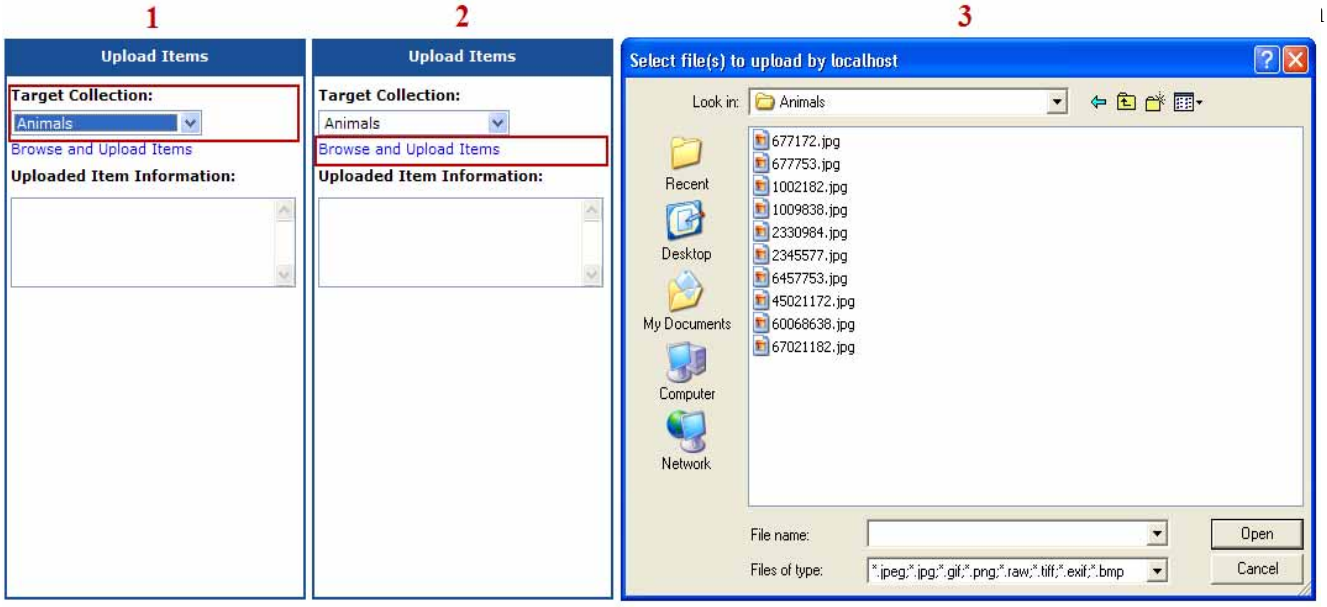


Figure 5.12: Upload Items

1. The number of items and file names successfully uploaded are displayed in the text box.
2. The number of items not uploaded due to their existence in the database is displayed, along with the file names, in the text box.
3. A message box warns the user that the target collection is to be changed. "OK" will change the target collection and "Cancel" will return the target collection to "Unsorted".

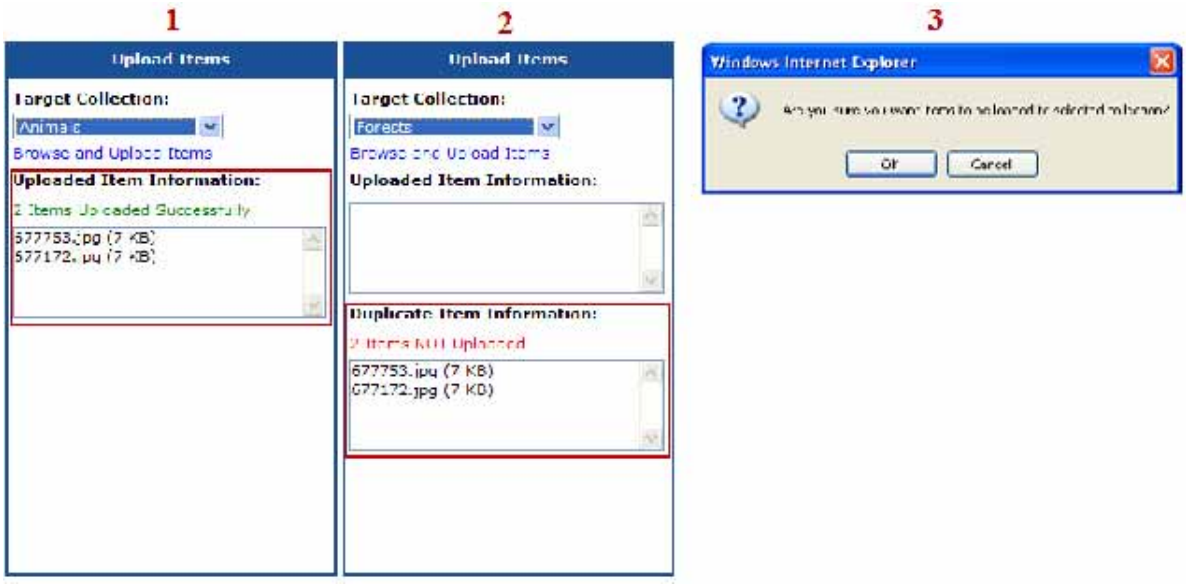


Figure 5.13: Upload Items Information Messages

5.3.2.8 Delete Items

The following information messages are displayed to the user when deleting items (points below correlate to the red numbers in Figure 5.14 below):

1. If the "Delete Items" hyperlink is clicked, the user is asked if the selected items must go to the recycle bin. "OK" deletes the items and "Cancel" reverts to the tool frame.
2. When the selected items have been deleted, an information message is displayed indicating the total number of items sent to the recycle bin.

Figure 5.14: Delete Items Information Messages

5.3.2.9 Restore from Recycle Bin

Users will get an information message as in Figure 5.15 below if the "Restore from Recycle Bin" hyperlink is clicked, and are asked if they would like to restore selected items from the recycle bin. "OK" will restore items and "Cancel" reverts to the tools frame.

Figure 5.15: Restore from Recycle Bin Information Message

5.3.2.10 Empty Recycle Bin

The following information messages are displayed to the user when emptying the recycle bin (each point correlates to the red numbers in Figure 5.16 below):

1. When the "Empty Recycle Bin" hyperlink is clicked, users are asked if they would like to empty the recycle bin. "OK" will empty the recycle bin and "Cancel" will return the user to the tools frame.
2. When the recycle bin has been emptied an information message is displayed indicating the total number of items deleted from the recycle bin.

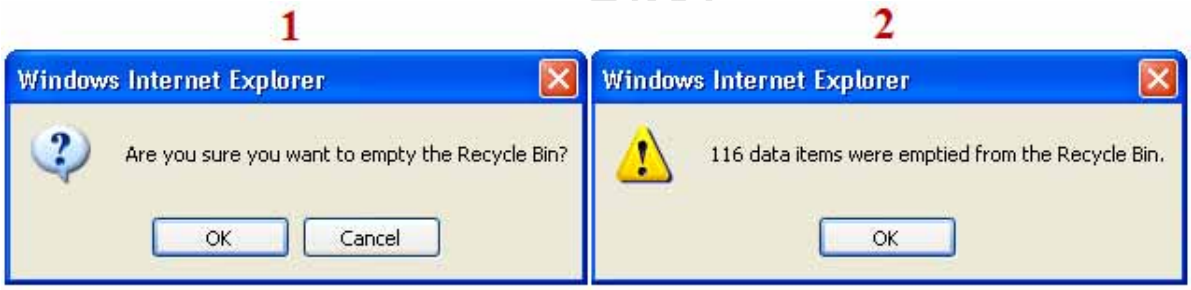


Figure 5.16: Empty Recycle Bin Information Messages

5.3.2.11 Manage Collection

The following actions are available for collection management (each point below correlates to the red number illustrated in Figure 5.17 below):

1. A collection can be edited by selecting it from the drop down list. A text box will be displayed populated with the selected collection where changes can be made. To save an edited collection click the "Save" action button.
2. A collection can be added by clicking the "Add" action button. An empty text box will be displayed where a new collection can be added. To save an added collection click the "Save" action button.

3. A collection can be deleted by selecting it from the drop down list. A text box will be displayed and populated with the selected collection. To delete a collection click the "Delete" action button.

The "Reset" action button will reset the current changes to the changes made when the last "Save" or "Delete" action button was clicked.

Figure 5.17: Add, Edit and Delete Collections

The information messages displayed to the user for collection management can be found in Appendix B Section B.5.

5.3.2.12 Manage Metadata Type

The following actions are available for metadata type management (each point below correlates to the red number illustrated in Figure 5.18 below):

1. A metadata type can be edited by selecting it from the drop down list. A text box will be displayed populated with the selected metadata type where changes can be made. To save an edited metadata type click the "Save" action button.
2. A metadata type can be added by clicking the "Add" action button. An empty text box will be displayed where a new metadata type can be added. To save an added metadata type, click the "Save" action button.
3. A metadata type can be deleted by selecting it from the drop down list. A text box will be displayed and populated with the selected metadata type. To delete a metadata type, click the "Delete" action button.

The "Reset" action button will reset the current changes to the changes made when the last "Save" or "Delete" action button was clicked.

The information messages displayed to the user for metadata type management, can be found in Appendix B Section B.6.

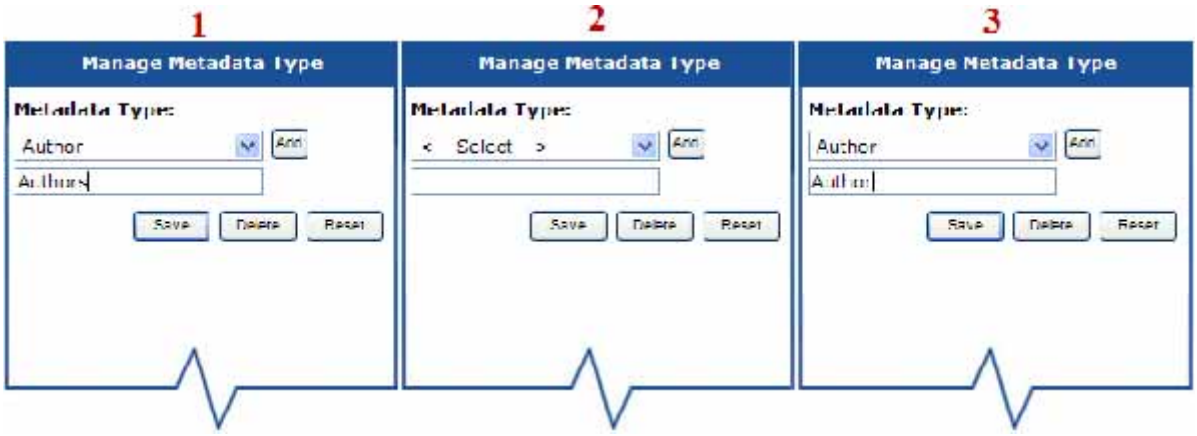


Figure 5.18: Add, Edit and Delete Metadata Types

5.4 Database Design

A relational database was used to store the items for the following reasons:

1. Normalisation eliminates redundant data in tables. Storing the same data in more than one table is bad practice and must be eliminated. It makes sure that the data dependencies make sense i.e. the data stored in a table should be related.
2. Clustered and non-clustered indexes increase performance when searching for data as tables grow to millions of rows.
3. Referential integrity ensures the relationship between tables remain consistent.

The database is written in the SQL programming language and implemented using Microsoft SQL Server 2005.

5.4.1 Entities and Attributes

Step one in database design is to identify real-world objects to be associated with object management. These real-world objects are then mapped to entities with a number of properties or attributes. This section describes the entities and attributes needed for object management.

The entity attributes and the lists of pre-populated data values, if applicable, can be found in the tables in Appendix C. ItemType, Collection, Location, MetaDataType, Title and Privilege are separate entities, this removing any problems associated with duplicate data.

The following entities have been defined:

- Item - This table is at the highest level in the database, storing the list of objects that are managed via the GUI. Items may belong to only one collection, may be of one item type and are stored in one location. The Item table “scales” easily to allow uploading of items in large batches.

- ItemType - This table contains the list of file formats used to organise and store items. Many items will share the same item type. ItemType will be pre-populated with a list of predefined item formats.
- Collection - This table contains the list of collections that store similar objects. The collections have the names of the Windows folders currently used. This is a convenient bridging mechanism (between existing data and the IMS) used to organise and store digital items. Many items will share the same collection. Collections are easily added, edited and deleted via the GUI.
- Location - This table contains a list of file locations for items to be uploaded and stored on the server. Many items will share the same location. Currently, there is only one pre-defined location where items are uploaded from and stored. Location will scale easily to allow for different file locations.
- MetaData - This table contains the list of extra information associated and stored with an item. The MetaData table scales easily to allow for multiple metadata of the same metadata type to be associated with a single item. Metadata is easily added, edited and deleted via the GUI.
- MetaDateType - This table contains the list of extra information types. Many metadata will share the same metadata type. Metadata types are easily added, edited and deleted via the GUI.
- Users - This table stores basic user information i.e. user name and password required for authentication and the associated system access privileges.
- Title - This table stores a list of titles associated with a user. Many users share the same title.
- Privilege - This table stores a list of user access privileges. Many users will share the same privileges.
- ItemSearch - This table stores the items that are displayed in the current item listing. The algorithm to calculate this item list is complex as it uses the search criteria. This set of items is often used in other queries. This list reduces the query time since the item list will not need to be recalculated for each search instance.
- SystemSetting - This table stores the system settings used by the application e.g. item thumbnail size.

5.4.2 Entity-Relationship Diagram

An entity-relationship diagram shows the relationships existing among entities. Entities can be classified as independent or dependent:

- An independent entity does not rely on another entity for identification.
- A dependent entity does depend on other entities.

Relationships are associations between the entities and can be classified as [62]:

- One-to-one - One instance of entity A is associated with one instance of entity B.
- One-to-many - One instance of entity A is associated with zero, one or many instances of entity B. One instance of entity B is associated with one instance for entity A.
- Many-to-many - One instance of entity A is associated with zero, one or many instances of entity B. One instance of entity B is associated with zero, one or many instances for entity A.

Figure 5.19 below illustrates the entity-relationship diagram of IMS [26]. The relationship between Users and SystemSetting is shared by all existing tables and Users. This relationship has not been shown in order to simplify the entity-relationship diagram.

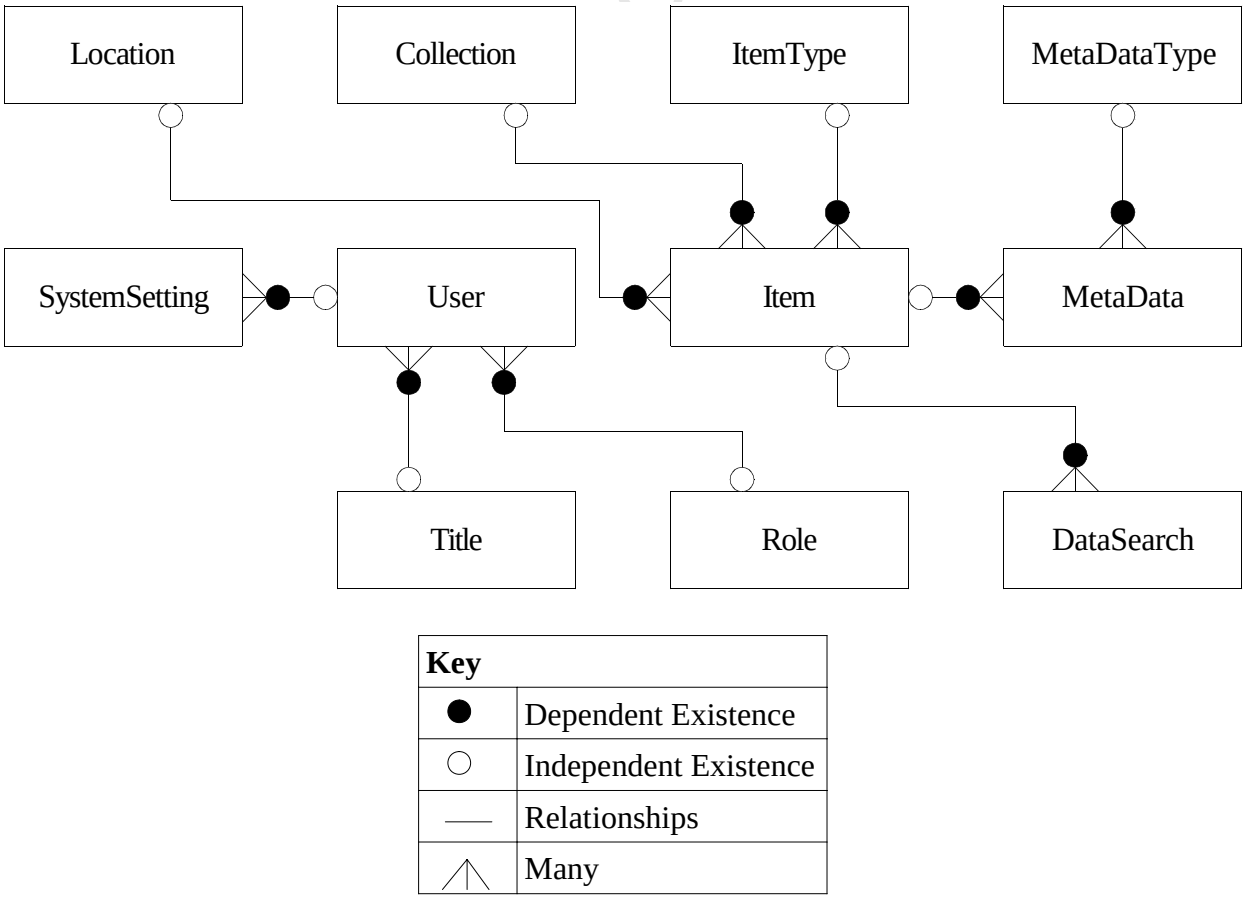
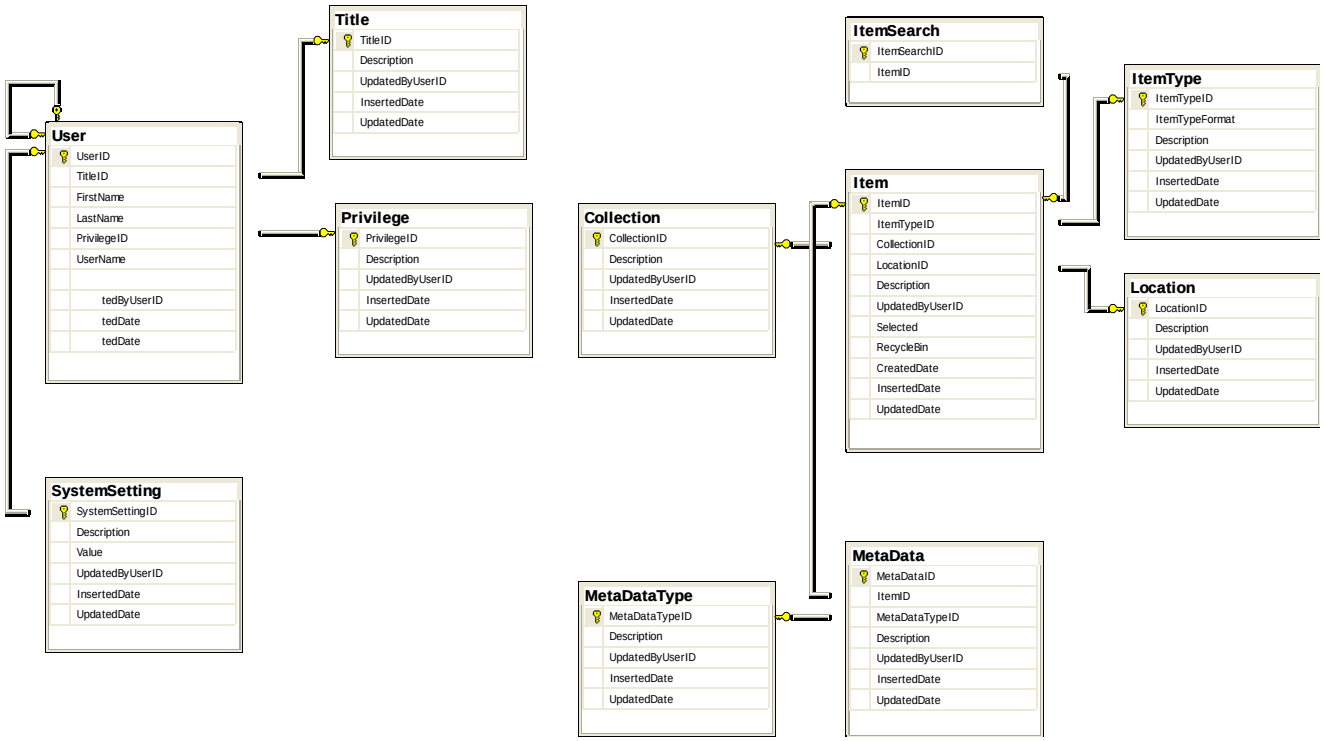


Figure 5.19: Entity-Relationship Diagram of IMS

5.4.3 Relational Database Schema



Key	
	Primary Key of Entity
	Many-to-one Foreign Key Relationship Between Entities

Figure 5.20: Relational Database Schema of IMS

Figure 5.20 above illustrates the relational database schema of IMS Database Normalisation

IMS will handle a large volume of items, and has therefore only been normalised to the Third Normal Form. This will prevent any creation, update and deletion anomalies that could occur on a non-normalised database, while ensuring that performance is not dramatically decreased.

5.5 Security

The list of user access privileges are detailed below (each point below correlates to the red number illustrated in Figure 5.21 below):

1. Read Only User – A read only user has access to the application excluding the menu items under the tools menu.
2. General User - A general user has access to the application excluding the administration menu under the tools menu.
3. Administrator – The administrator has access to the full application.

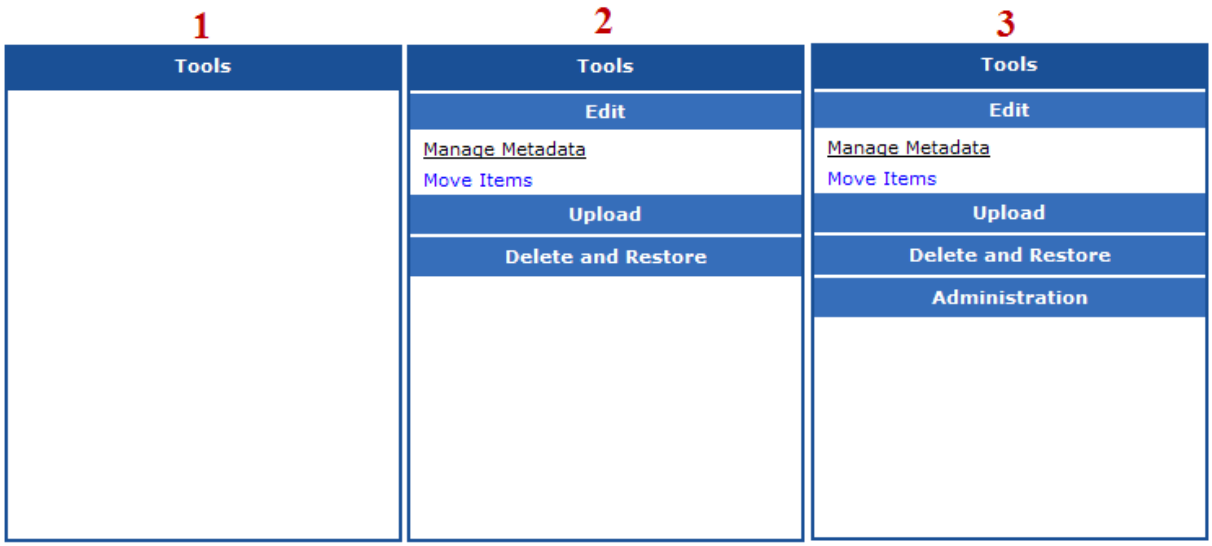


Figure 5.21: Menu Items Displayed for User Privileges

5.6 Summary

A detailed overview of the functionality offered by the web-application IMS as well as the supporting database design was discussed in this chapter.

Finally it is possible to perform the last round of user evaluations on this high-fidelity prototype.

Chapter 6

User Evaluation

6.1 Introduction

Usability is defined in ISO 9241-11 (1998) as the "*effectiveness, efficiency and satisfaction with which specified users achieve specified goals in particular environments*".

- *Effectiveness* is the accuracy and completeness with which users can achieve specified goals.
- *Efficiency* is the relationship between the accuracy and the completeness with which users can achieve specified goals.
- *Satisfaction* is the comfort and acceptability of a system to its users.

The three aspects of usability depend on whether the users are highly trained or novices, on what they are trying to achieve with the system and where and how the system is to be used. It is important not to confuse usability and functionality. The latter refers to the system functions, but doesn't take into account whether they are practical or usable. More functionality does not necessarily translate into a system being more usable - it can possibly even have the opposite effect [15].

Usability is an important condition for survival of a system - if it is too difficult to use and users get lost in the navigation, they simply switch to another system. It is no good if the system offers them just what they want, but the GUI to achieve these goals is too difficult to use [42].

This chapter presents the user evaluation of the GUI implemented for IMS both from a user and a performance perspective.

6.2 Pre-Pilot Study

Before performing the main user evaluation, it is essential to pilot the questionnaire in order to identify any ambiguities. This is not a formal procedure, but should rather be seen as an information gathering session. A pre-pilot study is usually conducted by sitting down with colleagues and friends and working through the questions together, identifying potential problems. After each session, the questionnaire should be amended before commencing with the next one [69].

The pre-pilot sessions took place in my study with one friend and two family members.

6.3 Pilot Study

The pilot study was conducted under the user evaluation environment specified in 6.4.2 below. The only problem encountered was that users preferred that the introduction and

overview (Appendix D Sections D.1 and D.2) be explained to them rather than reading it themselves. Three users taking part in the pilot study also formed part of the main user evaluation since no major problems were discovered.

6.4 User Evaluations

This research posed the question *"Is it possible to develop a Web application solution that facilitates the efficient and accurate management of a large quantity of objects?"* A final round of user evaluations was also done to verify the usability of the GUI implemented for IMS.

6.4.1 User Demographics

Twenty users from different age groups from 18 to 68 with a mean age of 36.5 participated in the evaluations. There were 12 females and 8 males. According to Jakob Nielsen and Tom Landauer, the number of usability problems found can be represented by the equation in Figure 6.1 below [41].

N is the total number of usability problems in a system, *L* is the proportion of usability problems found by a single user and *n* the number of users.

$$N\left(1-\left(1-L\right)^{n}\right)$$

Figure 6.1: Usability Problems Found Equation

Figure 6.2 below is a plot of the equation using a typical value of 31% for *L*. The curve is, for all practical purposes, asymptotic to 100% with only 15 individual user evaluations. The actual number of evaluations (20) is therefore well above the recommended minimum [41].

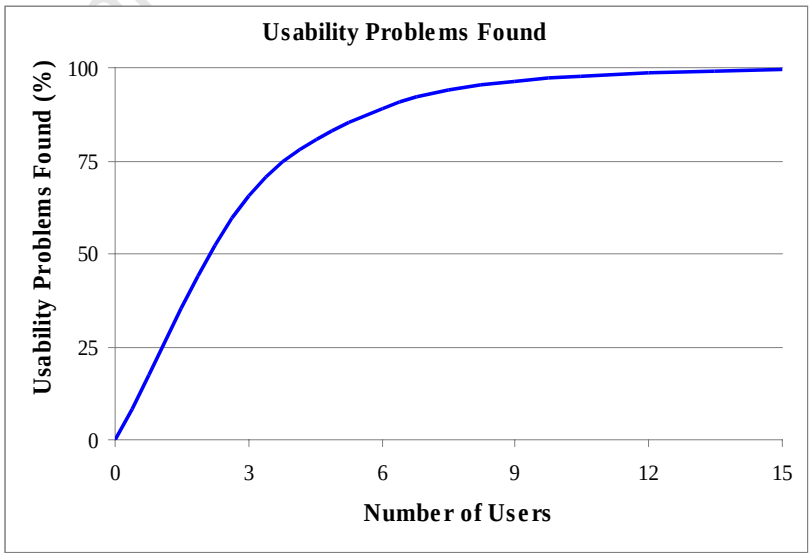


Figure 6.2: Usability Problems Found vs No. of Users

Users evaluating the IMS GUI were skilled professionals (but surrogate in nature). Table 6.1 below gives a summary of their daily occupations. All users reported that they used a PC program to manage their digital image collections. The programmes are Facebook, Picasa, Blender, Flash, Windows Explorer, Photoshop, Darkroom, Lightroom and Bridge (Adobe).

User Professions	Number of Users
Assistant Manager	2
Bookkeeper	2
Customer Services Representative	1
Financial Advisor	1
Journalist	1
Lecturer	3
Manager	3
Medical Representative	1
Software Engineer	4
Scholar	1
Test Analyst	1

Table 6.1: Summary of User Occupations

Table E.1 in Appendix E lists the users' demographic information.

6.4.2 User Evaluation Environment

User evaluation sessions were held in my study to keep the facility constant for all users to ensure consistent results. Sound levels were kept at a minimum and the users were placed with their back to the other objects in the room in order to limit any distractions. The users were informed that the duration of the evaluation would be approximately one hour. Figure 6.3 below is a view of the evaluation environment.

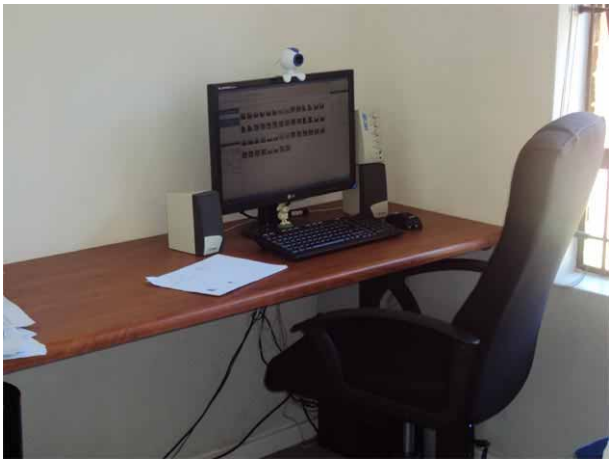


Figure 6.3: User Evaluation Environment

6.4.3 User Evaluation Design

The evaluation consisted of five sections:

- *Basic information gathering* about the user i.e. name, age, gender and occupation. Questions on computer usage and personal digital image management tools used evaluated their level of experience in managing personal digital image collections.
- *An overview of digital image management* to set the scene and bring everybody up to the same mindset for the evaluation.
- *A demonstration of the basic functionality of IMS* to provide the necessary background information for the individual user evaluation tasks ahead.
- *An opportunity to ask questions* before continuing with the evaluation.
- *The actual evaluation tasks* – manipulating and editing the collections, the metadata and, in general, exercising the features of IMS.
- *The post-test questionnaire* - each task focused on specific IMS functional areas, followed by a short questionnaire.
- *The post-intervention questionnaire* - finally, the users were given the opportunity to provide feedback on the general aesthetics of the GUI, the features they did and did not like and any other additional comments on improving general usability.

As mentioned in Section 3.4.3, the short questionnaire consisted of written answers for qualitative data and answers to Likert-scale questions for quantitative data. A facilitator observed the process, recording any extra information such as critical errors experienced and any associated recovery procedures. The actual tasks and questions used in the evaluations are given in Appendix D.

Data gleaned from the exercise can be sorted into two main classes i.e. Demographic Information and, more importantly, Usability Information.

- **Demographic Information**
    1. Data about the user plus an estimate of their level of expertise in managing personal digital image collections, including the names and descriptions of the systems they currently use to manage their digital image collections.
    2. User perceptions about their overall usability experience.
- **Usability Information** – Comprehensively tested seven main areas.
    3. Managing collections and metadata types i.e. adding, editing and deleting.
    4. Uploading items.

5. Managing metadata i.e. adding, editing, deleting.
6. Moving items between collections.
7. Viewing item details.
8. Deleting and restoring items.
9. Searching for and selecting items.

6.4.4 User Evaluation Results

The results are analysed below using descriptive statistics. Descriptive statistics is described in more detail in Appendix E.1.

6.4.4.1 Tasks Completed

The number of tasks completed is measured by the percentage of given tasks that the users were able to complete. All users completed 100% of the tasks.

6.4.4.2 Effectiveness

For the purpose of the evaluation, the definition of effectiveness was defined as *"How close does the GUI come to the ideal way of performing any task?"*.

Additional questions about menu navigation and complexity were further used to rate the effectiveness of the GUI.

The users were asked to rate the effectiveness on a scale ranging from 1 ("least effective") to 10 ("most effective") for each task. Figure 6.4 below and Table 6.2 below give the frequency distribution and the descriptive statistics for the effectiveness of all tasks.

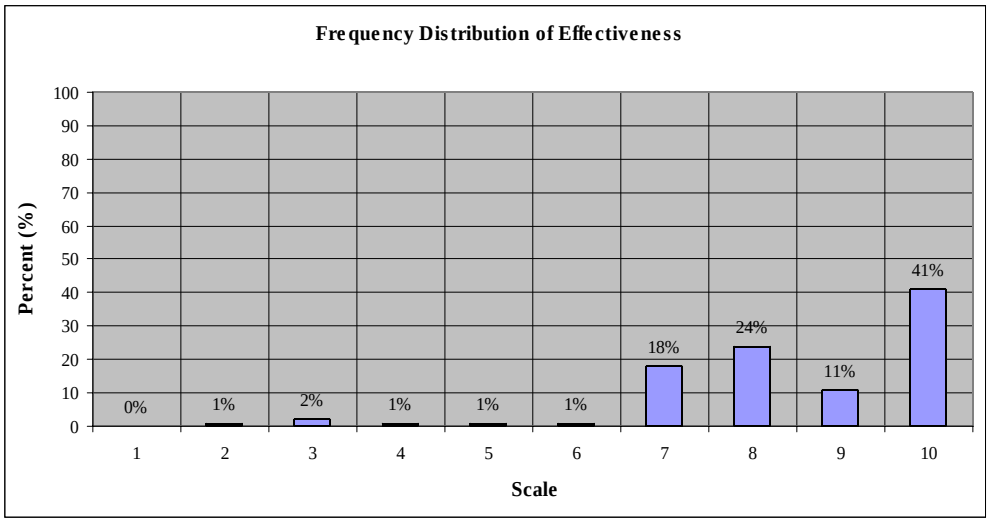


Figure 6.4: Frequency Distribution Summary of Effectiveness

Taking an average over all the tasks, 94% of the users rated the effectiveness of the GUI between 7 and 10, with a mean of 8.50 and a standard deviation of 1.66. Most values fall within one standard deviation of the mean i.e. the majority of users found the GUI implementation to be close to their ideal way of performing tasks to achieve a specific goal.

Min	Max	Mean	Median	Mode	Std Dev
3.76	10	8.50	8.50	9.88	1.66

Table 6.2: Summary of Descriptive Statistics for Effectiveness

Table E.2 and Table E.3 in Appendix E give the frequency distribution and descriptive statistics for the effectiveness of individual tasks.

Menu Navigation

The users were asked to rate the menu navigation on a scale ranging from 1 ("very difficult") to 5 ("very easy"). Figure 6.5 below and Table 6.3 below give the frequency distribution and descriptive statistics for the menu navigation for all tasks.

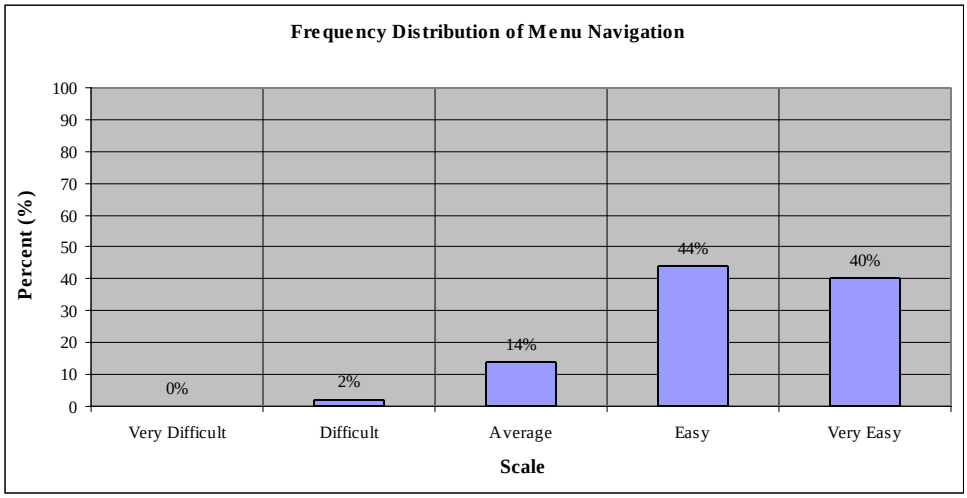


Figure 6.5: Frequency Distribution Summary of Menu Navigation

Taking an average over all the tasks, 84% of the users rated the menu navigation of the GUI as "easy" and "very easy", with a mean of 4.21 and a standard deviation of 0.74. Most values fall within one standard deviation of the mean. The majority of users found the menu navigation of the GUI easy to use. This correlates with the user comments about the menu structure being simple, not multi-level, with menu items being well characterised.

Min	Max	Mean	Median	Mode	Std Dev
2.58	5	4.21	4.05	4.35	0.74

Table 6.3: Descriptive Statistics Summary of Menu Navigation

Table E.4 and Table E.5 in Appendix E give the frequency distribution and descriptive statistics respectively for the menu navigation of individual tasks.

Complexity

For the purpose of the evaluation, the definition of complexity was defined as *"How many separate sequential steps are needed to achieve a goal?"*.

Users were asked to rate the complexity of the GUI on a scale ranging from 1 ("very difficult") to 5 ("very easy"). Figure 6.6 below and Table 6.4 below give the frequency distribution and descriptive statistics for the complexity of all tasks.

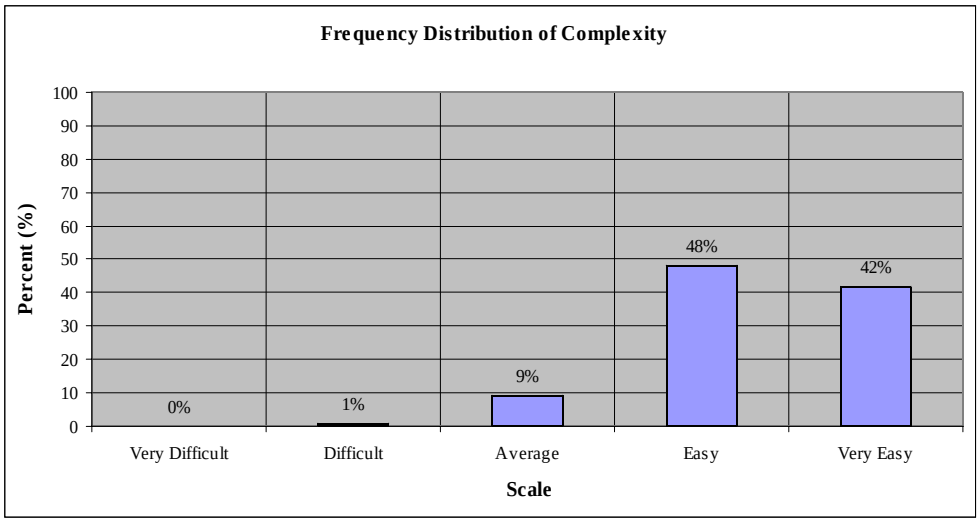


Figure 6.6: Frequency Distribution Summary of Complexity

Taking an average over all the tasks, 90% of the users rated the complexity of the GUI as "easy" and "very easy", with a mean of 4.29 and a standard deviation of 0.69. The majority of the values fall within one standard deviation of the mean. The results show that the majority of the users found that tasks needed to perform and achieve specific goals were easy.

Min	Max	Mean	Median	Mode	Std Dev
2.76	5	4.29	4.08	4.53	0.69

Table 6.4: Frequency Distribution Summary of Complexity

Table E.6 and Table E.7 in Appendix E give the frequency distribution and descriptive statistics for the complexity of individual tasks.

6.4.4.3 Satisfaction

For the purpose of the evaluation, satisfaction was defined as *"The comfort and acceptability of a system to users"*.

Questions about intuitive ease, ease of learning, responsiveness and general aesthetics were used to rate the level of user satisfaction with the GUI.

Intuitive Ease

Intuitive Ease was deemed to be *"The ease with which a user automatically knows the next step in a sequence"*. Users were asked to rate the intuitive ease on a scale ranging from 1 ("very difficult") to 5 ("very easy").

Figure 6.7 below and Table 6.5 below give the frequency distribution and descriptive statistics for the intuitive ease of all tasks.

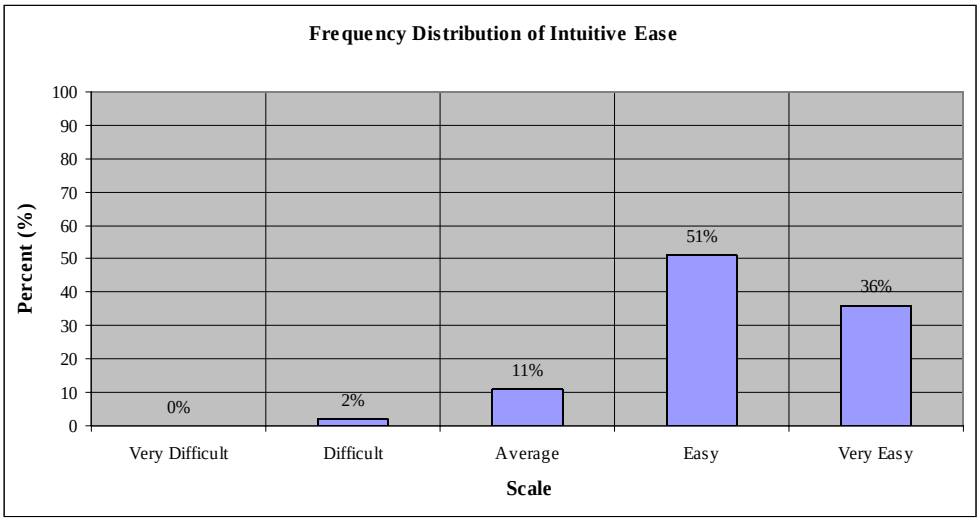


Figure 6.7: Frequency Distribution Summary of Intuitive Ease

Taking an average over all the tasks, 97% of the users rated the intuitive ease of the GUI as "easy" and "very easy", with a mean of 4.22 and a standard deviation of 0.72. The majority of the values fall within one standard deviation of the mean. The results show that users found that the manner in which tasks were performed was obvious in that they knew instinctively what action needed to done next to complete their goal.

Min	Max	Mean	Median	Mode	Std Dev
2.7	5	4.22	4.06	4.06	0.72

Table 6.5: Descriptive Statistics Summary for Intuitive Ease

Table E.8 and Table E.9 in Appendix E give the frequency distribution and descriptive statistics respectively for the intuitive ease of individual tasks.

Ease of Learning

Ease of Learning can be considered to be *"The effort required to become familiar with the IMS GUI"*.

Users were asked to rate the ease of learning on a scale ranging from 1 ("very difficult") to 5 ("very easy"). Figure 6.8 below and Table 6.6 below give the frequency distribution and descriptive statistics for the ease of learning.

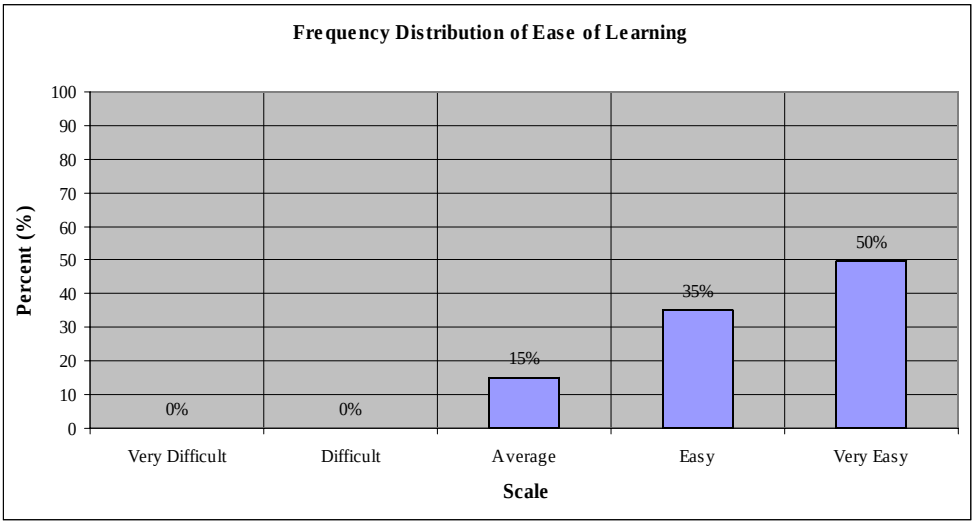


Figure 6.8: Frequency Distribution of Ease of Learning

Taking an average over all the tasks, 85% of the users rated the ease of learning the GUI "easy" and "very easy", with a mean of 4.35 and a standard deviation of 0.75. The majority of the values fall within one standard deviation of the mean. The results indicated that the GUI was easy to learn and it can therefore be considered usable. The majority of the users indicated that once they had become familiar with the GUI, it became very easy to use.

Min	Max	Mean	Median	Mode	Std Dev
3	5	4.35	4.50	5.00	0.75

Table 6.6: Descriptive Statistics for the Ease of Learning

Responsiveness

Responsiveness can be considered to be "*The user perception of how quickly the IMS responds after executing a command in a sequence of steps*".

The users were asked to rate the responsiveness on a scale ranging from 1 ("least effective") to 10 ("most effective"). Figure 6.9 below and Table 6.7 below give the frequency distribution and descriptive statistics for the responsiveness respectively for all tasks.

Taking an average over all the tasks, 100% of the users rated the responsiveness of the GUI between seven and ten, with a mean of 9.10 and a standard deviation of 1.20. The results indicated that the GUI responded reasonably quickly to user actions. Users did not perceive that they had to wait for the GUI to respond while it processed their input commands.

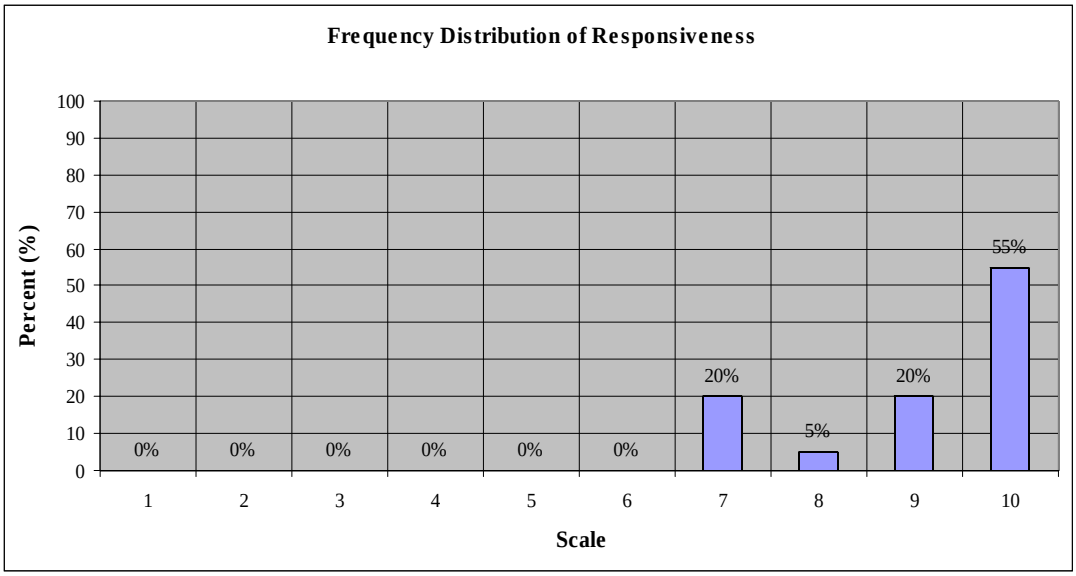


Figure 6.9: Frequency Distribution of Responsiveness

Min	Max	Mean	Median	Mode	Std Dev
7	10	9.10	10.00	10.00	1.20

Table 6.7: Descriptive Statistic for Responsiveness

6.4.4.4 General Feedback

The users were asked direct questions about the general aesthetics of the user interface, the features they did and did not like, as well as any additional comments about improving usability.

General Aesthetics

The general consensus was that the look and feel of the GUI is clear, precise, usable and easy to understand. The GUI is very easy to learn, and as the user gains some familiarity with the concepts, it is extremely simple to use.

The following are quotes and opinions from users, being typical of those from the body of evaluators:

- "It is user-friendly and idiot proof".
- "If you can read, then you can do".
- The GUI layout is simple - everything is one screen.
- The need for navigation movements via pop-up windows is minimised.
- The menu structure is simple (not multi-level) thereby avoiding menu "lostness".
- The main menu is also intuitive with clearly categorised items.

The following quote is a summary "*When can I get a copy of this program?*"

User Likes

- Users felt that they were already familiar with the GUI as it followed the same principles and behaviours of other Windows programmes i.e. the “delete” and “restore” behaviour.
- They also felt confident that they wouldn't make mistakes due to the confirmation messages that are displayed when an action button is clicked.
- The thumbnail dimensions optimise the number of items displayed on the screen, but are not too small to compromise the viewing detail.
- The functionality that IMS offers, e.g. managing and editing a group of items instead of merely one at a time, saves considerable time and effort.

User Dislikes

- Users disliked the case sensitivity of search criteria i.e. words differ in meaning based upon the use of uppercase and lowercase letters.
- A collection or metadata type can be edited by selecting it from a drop-down list. A change text box is then displayed, populated with the selected collection or metadata type. Initially, the “drop-down list” edit method confused users. However, the confusion was cleared after the first editing session.

User Suggested Improvements

The GUI was generally well received by the users. However, there were a few suggestions for possible improvements.

- There should be additional information messages confirming the result of the action that has just been performed e.g. “The new collection People has been saved”.
- “Ctrl A” or dragging the mouse over an area should select all items.
- Dragging an item onto the GUI from an Explorer Window should initiate the uploading of that item.
- A separate “Notes” text box should be added to each item to record any additional comments or information.

6.5 Performance Evaluation Hardware and Software

The performance evaluation was done on a DELL Latitude E6510 2.4 GHz Intel Core Laptop with 4GB of RAM. The SQL Server was installed on the Laptop to eliminate any random latency between it and a Network Server. In addition, this made the system portable to accommodate evaluators who were restricted to weekends or evenings.

6.5.1 Efficiency

The efficiency is "*the relationship between the accuracy and the completeness with which users can achieve specified goals"* (as defined in Section 6.1), and can be measured by comparing the time taken "*to complete a task to achieve a certain goal on multiple items versus achieving the same goal, one item at a time"*.

Performance evaluation tasks are the steps a user needs to achieve a specific goal.

1. Upload Items
   - Select "Target Collection"
   - Click on "Browse and Upload Items"
   - Select items for upload
   - Click "Open"
2. Add Item Metadata
   - Click "Add"
   - Type "This is a new item" in the text box
   - Click "Save"
3. Edit Item Metadata
   - Click "Edit"
   - Type "This is an edited item" in the text box
   - Click Save
4. Delete Item Edit
   - Click "Del"
   - Click "Save"
5. Move Items
   - Select "Target Collection"
   - Click "Save"
6. Select All Items
   - Click "Select All"

Table 6.8 below gives a summary of the performance evaluation results in seconds for each task.

	Number of items				
Task	**1**	**10**	**100**	**500**	**1000**
Upload Items	12	16	76	513	[1]
Add Item Metadata	12	11	12	13	12
Edit Item Metadata	12	12	14	13	13
Delete Item Metadata	5	5	5	6	6
Move Items	6	6	6	7	7
Select All Items	1	2	3	3	3

Table 6.8: Performance Evaluation Summary (in seconds)

Table 6.8 shows that for the tasks of:

- Managing metadata, moving and selecting items had no significant time variations when performing the task on 1, 10, 100, 500 or 1000 items.
- Upload items tasks showed a significant, but expected, time variation when uploading 1, 10, 100 or 500[1] items, mainly due to the increase in total file size with each item range.

The practical performance evaluation results correlated with the user perception evaluation results for the following questions in that all users agreed with the following statements:

1. It was as easy uploading 10 images as it was for 100 images.
2. It was as easy (1) selecting all images and (2) adding metadata for 10 images as it was for 100 images.
3. It was as easy adding multiple metadata as adding one metadata to a metadata type i.e. adding two or one new authors in the task above.
4. It was as easy (1) selecting a subset of images and (2) editing metadata for 10 images as it was for 100 images.
5. It was as easy moving 10 images as it was for 100 images.

1 The AJAX up-loader cannot handle more than 500 items at once

Table E.10 to Table E.14 in Appendix E show performance results of individual tasks.

In Section 4.2.3 the majority of users indicated they would like to manage the metadata of multiple items when moving and selecting. Currently, users can perform these tasks with only one item at a time in most systems, this being extremely time consuming. Table 6.9 below gives the time taken to complete a task with multiple items in seconds versus completing the same task but with one item at a time. IMS offers a significant time saving when managing the metadata when moving and selecting multiple items. The time taken to move one item at a time multiple times has been calculated by multiplying the time taken for one item and the number of items i.e. 1, 10, 100, 500.or 1000. This is merely a linear estimate and is expected to be higher due to user fatigue over a long operating period.

	Multiple Items at a Time					**One Item at a Time**				
Task	**1**	**10**	**100**	**500**	**1000**	**1**	**10**	**100**	**500**	**1000**
Add Item Metadata	12	11	12	13	12	12	120	1200	6 000	12 000
Edit Item Metadata	12	12	14	13	13	12	120	1400	6 000	12 000
Delete Item Metadata	5	5	5	6	6	5	50	500	2 500	5 000
Move Items	6	6	6	7	7	6	60	600	3 000	6 000
Select All Items	1	2	3	3	3	1	10	100	5 000	1 000

Table 6.9: Multiple Items at a Time versus One Item at a Time (in seconds)

6.6 Summary

This chapter presented two experimental studies and their results.

- An investigation of user experience by measuring the effectiveness and user satisfaction of the GUI.
- An investigation of performance by comparing the time taken to complete a task to achieve a goal simultaneously on multiple items time versus achieving the same goal, but doing it on one item at a time.

6.7 Conclusion

The IMS GUI was well received by all users as the performance evaluation results showed that IMS offered a substantial time saving over other systems.

Chapter 7

Conclusion and Future Work

7.1 Introduction

This thesis targeted the design of a usable, Web-based computer application. It had to be capable of managing a large number of objects with associated metadata. The objects should be organised into collections and stored to preserve the data quality and integrity over a long period of time.

The target system, named IMS, was designed using evolutionary prototyping. Instead of discarding a series of rapidly changing low-fidelity prototypes, they were continuously developed and refined until they become the final system high-fidelity prototype.

The GUI was designed for a target audience of skilled professionals using existing tools for digital image management. Once the final system was reached, the last round of user and performance evaluations were conducted.

During the evaluations, 20 users were each asked to perform a set tasks consisting of a list of instructions focusing on an area of functionality in IMS. The effectiveness of the GUI was measured by analysing the data from questions about tasks completed, the effectiveness (*How close does this come to the ideal way of performing a task?*), menu navigation and complexity.

User satisfaction with the GUI was measured by analysing the data from questions about intuitive ease, ease of learning, responsiveness and general aesthetics.

The efficiency of the GUI was measured by analysing the data from performance evaluations, comparing the time taken to complete a task to achieve a goal simultaneously on multiple items versus achieving the same goal, but doing it on one item at a time.

7.2 Analysis of the User Evaluations

The conclusion is based on the results discussed in the following sections.

7.2.1 Tasks Completed

Table 7.1 below (a summary of the user requirements described in Section 4.2.3) show that these have been achieved in IMS. All users completed 100% of the tasks.

User Requirement	Achieved
Managing the metadata of multiple items	Yes
An indication on the progress of how many items have been uploaded	Yes
View the list of items that have just been uploaded	Yes
Upload different file formats	Yes
Move multiple items between collections	Yes
Sort item by metadata type	Yes
Select a group of items	Yes
Search for items	Yes
User Permissions	Yes
Improved menu navigation	Yes

Table 7.1: User Requirements Achieved in IMS

7.2.2 User Rating Summary

The majority of users rated the following aspects of IMS:

- GUI effectiveness as a 10 (scale from 1 “least effective” to 10 “most effective”).
- Menu navigation as “easy” and “very easy”.
- Complexity as “easy” and “very easy”.
- Intuitive Ease as “easy” and “very easy”.
- Ease of learning as “easy” and “very easy”.
- Responsiveness as a 10 (scale from 1 “least effective” to 10 “most effective”).

While the ease of learning of IMS was rated as “easy” and “very easy”, users requested help for the initial few tasks until they got familiar with the general look and feel of the GUI.

The performance results show a significant time saving (100 items was chosen as an example) as compared to using their existing systems. The savings are listed in Table 7.2 below.

Task	Time Saved in Minutes
Adding Metadata	20
Editing Metadata	23
Deleting Metadata	8
Moving Items	10
Select All Items	5

Table 7.2: Time Saved in Minutes Manipulating 100 Items

The prime feature identified as desirable in Section 4.2.3 was the ability to perform tasks on multiple items at a time - this was not possible on many previous systems. The performance results in Section 6.5.1 and Table 6.5 above show that this has not only been achieved, but with insignificant time variations in IMS when performing tasks on 1, 10, 100, 500 or 1000 items.

7.3 Conclusion

The end product arising from the work performed for this thesis has shown that it is indeed possible to design a usable Web-based computer application that manages a large number of objects.

7.4 Future Work

There are a number of areas in IMS that can be improved and extended on in future work.

7.4.1 Undo and Redo Functionality

One of the most useful features supported by the majority of Windows programs is the ability to edit, undo or redo. Users expect to be able to perform multiple undo and redo actions should they make mistakes.

Undo and Redo are ancillary actions useful for maintaining the state of the object. IMS should be enhanced to store the current state before saving the new state so that it can be restored should an undo or redo action be performed.

7.4.2 Audit Trail

Object management should provide a complete history over the life cycle of each object. For example, if an edit is made to the metadata, then a copy of the old metadata should be saved and recorded to show that an edit action occurred. A digital signature should be added to the object and updated with each action to ensure that the changes have been made by an authorised user via the GUI. If an unauthorised modification has been made to an object, then the signature authentication will fail, indicating that it has been tampered with. The object can then be restored to the last authorised action from the audit trail. Audit trails are essential to build confidence in the quality of the data preserved [28].

IMS currently stores the history of only the last user and the date that the record in a database table was updated. IMS should be enhanced to store a complete history over the life cycle of each object.

7.4.3 Search Criteria

IMS could be enhanced to include more search criteria e.g. file properties, multiple metadata types, audio properties or camera properties to further refine the search (often called “Advanced Search” in Web pages). This should take the form of a collapsible search criteria

structure to simplify the search choices concurrently displayed.

7.4.4 Default Program

IMS currently uses Microsoft Paint to "tweak" images e.g. automatic colour fixing, cropping, rotation, deletion etc. IMS could be enhanced to examine the file extension and open the graphics editor that the user has chosen for that file format. The shell command can be used to automatically open the file in the associated application.

7.4.5 Additional File Formats

Objects can be stored in a variety of file formats such as documents e.g. PDF, DOC and ODF, images e.g. JPEG, GIF or BMP and audio e.g. MP3 or WAV etc. IMS currently focuses on the preservation of objects limited to the file formats listed in Table C.5 in Appendix C.

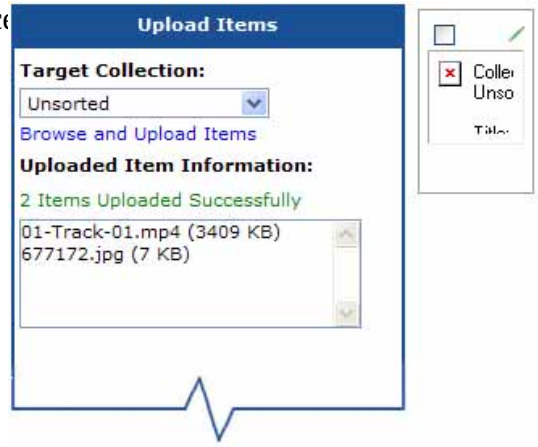
Figure 7.1 below illustrates that IMS can easily be expanded to incorporate new file formats by simply adding them to the database table ItemType.

ItemTypeID	ItemTypeFormat	Description
1	BMP	Windows Bitmap
2	Exif	Exchangeable Image File Format
3	GIF	Graphics Interchange Format
4	JPEG	Joint Photographic Experts Group
5	JPG	Joint Photographic Experts Group
6	PNG	Portable Network Graphics
7	RAW	Raw Image File Format
8	TIFF	Tagged Image File Format
9	PDF	Portable Document Format
10	DOC	Microsoft Document
11	MP3	MPEG-1 Audio Layer 3
12	MP4	MPEG-4 Part 14

Figure 7.1: Adding New File Formats to Table ItemType

Figure 7.2 below shows that the new file format is uploaded correctly; however the thumbnail is not generated correctly.

IMS could be enhanc



ing to the file format.

Figure 7.2: Uploading Items

7.5 Summary

This thesis investigated if it was possible to build a GUI that facilitates the efficient and accurate management of a large quantity of objects. The IMS satisfies the motivation for this thesis by having produced a satisfactory, working, usable and acceptable program.

The main feature identified as extremely desirable was the ability to perform tasks on multiple items at a time. The performance results show that this has been achieved, with the added advantage that there are insignificant time variations between manipulating 10 items or 1 000 items. The key aspect of IMS is scalability, enabling users to preserve and organise an ever-increasing quantity of objects i.e. IMS shows that it is possible to view, organise and manipulate large object collections.

A number of areas needing improvement and additional functionality have been identified. However, they do not detract from the ability of the system to be used by the target users, as the basic system is forward compatible by the use of correct and extensible database design right from the beginning.

Bibliography

[1] Barefoot D. (2006). Web 1.0 vs. Web 2.0. [Online]. Available: http://www.darrenbarefoot.com/archives/2006/05/web-10-vs-web-20.html [Last Accessed 14/01/2011].

[2] Beacon Computer Technology Ltd. (2011). AJAX (Asynchronous Javascript And XML). [Online]. Available: http://www.beacon-ct.co.uk/knowledge/ajax-asynchronous-javascript-and-xml [Last Accessed 14/01/2011].

[3] Canim, M. & Kantarcioglu, R. (2007). Design and Analysis of Querying Encrypted Data in Relatonal Databases. *In Proceedings of the 21st annual IFIP WG 11.3 working conference on Data and applications security.* Springer-Verlag Berlin, Heidelberg.

[4] Cathey, R.J., Beitzel, S.M., Jensen, E.C., Grossman, D. & Frieder, O. (2007). Using a Relational Database for Scalable XML Search, *The Journal of Supercomputing*. 44(2). pp. 146-178.

[5] Constantine, L. & Lockwood, L., *Software for Use: A Practical Guide to the Models and Methods of Usage-Centered Design*, New York: Addison-Wesley. 1999. pp. 51-63, 72 & 213.

[6] CuteSoft.net (2011). AJAX Uploader. [Online]. Available: http://ajaxuploader.com [Last Accessed 14/01/2011].

[7] Drap, P. & Long, L. (2001). Towards a Digital Excavation Data Management System :The "Grand Ribaud F" Estruscan Deep-water Wreck. *In Proceedings of the 2001 conference on Virtual reality, archeology, and cultural heritage*. New York, NY, USA: ACM.

[8] Eduardo C. (2007). Commercializing Web 2.0: Hype vs. Reality. [Online]. Available: http://www.chromewalker.com/cw_six/?p=293 [Last Accessed 14/01/2011].

[9] eHow (2009). How to Define Your Target Audience. [Online]. Available: http://www.ehow.com/how_5084025_define-target-audience.html [Last Accessed 09/11/2010].

[10] Emily Ford (2010). Residents Want Historic Preservation. [Online]. Available: http://www.salisburypost.com/News/120110-Historic-Preservation-Master-Plan-kicks-off-qcd [Last Accessed 19/01/2011].

[11] Europeana. Europeana: Think Culture. [Online]. Available: http://www.europeana.eu/portal/aboutus.html [Last Accessed 05/02/2011].

[12] Exlibris Preservation (2008). Digital Preservation: Why Should Institutions Care about it and what can they do Today, [Online]. Available: http://www.digitalpreservationeurope.eu/resources/exlibris1.pdf [Last Accessed 07/12/2010].

[13] Facebook (2011). [Online]. Available: http://www.facebook.com [Last Accessed 02/02/2011].

[14] Freetutes (2010). Prototyping Software Life Cycle Model. [Online]. Available: http://www.freetutes.com/systemanalysis/sa2-prototyping-model.html [Last Accessed 28/10/2010].

[15] Frokjaer, E., Hertzum, M. & Hornbaek, K. (2000). Measuring Usability: Are Effectiveness, Efficiency, and Satisfaction Really Correlated?, *In Proceedings of the SIGCHI conference on Human factors in computing systems*.

[16] Girgensohn, A., Adcock, J., Cooper, M. & Foote, J. (2003). Simplifying the Management of Large Photo Collections. *In Proceedings of INTERACT'03, IOS*.

[17] Goh, D.H.L. & Foo, S.S.B. (2002). Developing a Digital Library of Reusable Historical Artifacts. *In Proceedings of the 2nd ACM/IEEE-CS joint conference on Digital libraries*. New York, NY, USA: ACM.

[18] Golden, J. (2009). Web Applications vs Desktop Applications. [Online]. Available: http://www.studentwebstuff.com/mis/showthread.php?t=7988 [Last Accessed 09/11/2010].

[19] Haslhofer, B., Momeni, E., Gay, M. & Simon, R. (2010). Augmenting Europeana Content with Linked Data Resources. *In Proceedings of the 6th International Conference on Semantic Systems*. New York, NY, USA: ACM.

[20] Henze, N. & Boll, S. (2008). Snap and Share Your Photobooks. *In Proceeding of the 16th ACM international conference on Multimedia*. New York, NY, USA: ACM.

[21] Heritage Foundation of Newfoundland and Labrador (2008). What Is Intangible Cultural Heritage?. [Online]. Available: http://www.mun.ca/ich/what_is_ich.pdf [Last Accessed 26/01/2011].

[22] Hewett, Baecker, Card, Carey, Gasen, Mantei, Perlman, Strong & Verplank, *Human Computer Interaction*, New York: The Association for Computing Machinery. 1992. pp. 5.

[23] Hickey, Thom (2005). Entire Library of Congress. [Online]. Available: http://outgoing.typepad.com/outgoing/2005/06/entire_library_.html [Last Accessed 27/01/2011].

[24] Ho K. (2008). AJAX. [Online]. Available: http://khoaho.wordpress.com/2008/12/06/ajax-diagram/ [Last Accessed 14/01/2011].

[25] Housley, S. (2010). Webware vs Desktop Software. [Online]. Available: http://www.small-business-software.net/webware-vs-desktop.htm [Last Accessed 09/11/2010].

[26] Information Technology Services (2003). Introduction to Data Modelling. [Online]. Available: http://www.utexas.edu\its\windows\database\datamodeling\index-2.html [Last Accessed 28/10/2010].

[27] International Development Research Centre (2010). Overview of Data Collection Techniques. [Online]. Available: http://www.idrc.ca/en/ev-56606-201-1-DO_TOPIC.html [Last Accessed 03/11/2010].

[28] Jantz, R. & Giarlo, M.J, (2005). Digital Preservation: Architecture and Technology for Trusted Digital Repositories, *D-Lib Magazine [Online]*. 11(6). Available: http://www.dlib.org/dlib/june05/jantz/06jantz.html.

[29] Johanna Leissner (2002). Microclimate Indoor Monitoring in Cultural Heritage Preservation. [Online]. Available: http://iaq.dk/mimic/ingles/ppal_i.htm [Last Accessed 24/01/2011].

[30] Jon Henshaw, M.A. Buying a Home Computer (Mac vs Windows). [Online]. Available: http://www.familyresource.com/lifestyles/technology/buying-a-home-computer-mac-vs-windows [Last Accessed 09/11/2010].

[31] Khan, L. & Rao, Y. (2001). A Performance Evaluation of Storing XML Data inRelational Database Management Systems. *In Proceedings of the 3rd international workshop on Web information and data management*. NewYork, NY, USA: ACM.

[32] Kirk, D., Sellen, A., Rother, C. & Wood, K. (2206). Understanding Photowork, *In Proceedings of the SIGCHI conference on Human Factors in computing systems*. (). pp. 761 - 770. New York, NY, USA: ACM.

[33] Klaus, A., Bauer, J., Karner, K. & Grabner,M. (2001). Modeling and Visualizing the Cultural Heritage Data Set of Graz. *In Proceedings of the 2001 conference on Virtual reality, archeology, and cultural heritage*. New York, NY, USA: ACM.

[34] Kyrnin J. What is Web 2.0? Getting Beyond the Hope of Web 2.0. [Online]. Available: http://webdesign.about.com/od/web20/a/aa021306.htm [Last Accessed 14/01/2011].

[35] Marlow, E. (2009). Web 2.0 Defined. [Online]. Available: http://www.nprcenter.org/knowledgebase-mainmenu-203/web-20-for-nonprofits-mainmenu-402/web-20-defined-mainmenu-413.html [Last Accessed 04/02/2011].

[36] Mccurdy, N.J. & Griswold, W.G. (2005). A Systems Architecture for UbiquitousVideo. *In MobiSys '05: Proceedings of the 3rd international conferenceon Mobile systems, applications, and services*. New York, NY, USA: ACM.

[37] Microsoft. Microsoft SQL Server 2005 Database Encryption Step-by-Step. [Online]. Available: http://blogs.microsoft.co.il/blogs/applisec/archive/2008/06/15/microsoft-sql-server-2005-database-encryption-step-by-step.aspx [Last Accessed 24/01/2011].

[38] Mills, T,J., Pye, D., Sinclair, D. & Wood, K.R. (2000). Shoebox: A Digital Photo Management System. AT&T Laboratories Cambridge.

[39] Myspace (2011). [Online]. Available: http://www.myspace.com [Last Accessed 02/02/2011].

[40] Naaman, M., Song, Y.J. & Garcia-Molina, H. (2004). AutomaticOrganization for Digital Photographs with Geographic Coordinates. *In Proceedings of the 4th ACM/IEEE-CS joint conference on Digital libraries*. New York, NY, USA: ACM.

[41] Nielsen, J. (2000). Why You Only Need to Test with 5 Users. [Online]. Available: http://www.useit.com/alertbox/20000319.html [Last Accessed 05/12/2010].

[42] Nielsen, J. (2000). Introduction to Usability. [Online]. Available: http://www.useit.com/alertbox/20030825.html [Last Accessed 05/12/2010].

[43] Nunes, M., Greenber, S. & Neustaedter, C. (2009). Using Physical Memorabilia as Opportunities to Move into Collocated Digital Photo-sharing, *International Journal of Human-Computer Studies*. 67(12). pp. 1087 - 1111. Academic Press, Inc. Duluth, MN, USA.

[44] Picasa (2010). New Features in Picasa 3.8. [Online]. Available: http://picasa.google.com/support/bin/answer.py?answer=93773 [Last Accessed 20/01/2011].

[45] Reagan, Brad (2009). The Digital Ice Age. [Online]. Available: http://www.popularmechanics.com/technology/gadgets/news/4201645 [Last Accessed 27/01/2011].

[46] Rodden, K. & Wood, K.R. (2003). How do People Manage their Digital Photographs?, *In Proceedings of the SIGCHI conference on Human factors in computing systems*. 5(1). pp. 409 - 416. New York, NY, USA: ACM.

[47] Rodig, P., Borghoff, U.M., Scheffczyk, J. & Schmitz, L. (2003). Preservation of Digital Publications. *In Proceedings of the 2003 ACM symposium on Document engineering*. New York, NY, USA: ACM.

[48] Salmon, Lynn (2010). UNESCO World Heritage List. [Online]. Available: http://www.thesalmons.org/lynn/world.heritage.html [Last Accessed 19/01/2011].

[49] Schach, S.R., *Classical and Object-Oriented Software Engineering*, Boston: Irwin. 1996. pp. 58-60 & 198-201.

[50] Snavely, N., Seitz, S.M. & Szeliski, R (2006). Photo Tourism: Exploring Photo Collections in 3D. *In Proceeding SIGGRAPH '06 ACM SIGGRAPH 2006 Papers*. New York, NY, USA: ACM.

[51] Spiegel, D. (1998). Human Computer Interaction. [Online]. Available: http://www.zainbooks.com/books/computer-sciences/human-computer-interaction.html [Last Accessed 03/11/2010].

[52] Styliaras, G.D., Tsolis, G.K. & Papaterpos, C.M. (2007). AssetCollector: A system for Managing Collections of Cultural Assets, *International Journal on Digital Libraries*. 8(1). pp. 61 - 77. Springer-Verlag Berlin, Heidelberg.

[53] Suleman, H. (2009). Bleek and Lloyd Collection. [Online]. Available: http://www.husseinsspace.com/research/projects/bleeklloyd/ [Last Accessed 05/02/2011].

[54] Toyama, K., Logan, R. & Roseway, A. (2003). Geographic Location Tags onDigital Images. *In MULTIMEDIA '03: Proceedings of the eleventh ACM internationalconference on Multimedia*. New York, NY, USA: ACM.

[55] Trochim, W.M.K. (2006). Descriptive Statistics. [Online]. Available: http://www.socialresearchmethods.net/kb/statdesc.php [Last Accessed 09/12/2010].

[56] Tsolis, D.K., Tsolis, G.K., Karatzas, E.G. & Papatheodorou, T.S. (2001). Copyright Protection and Management and A Web Based Library for Digital Images of the Hellenic Cultural Heritage. *In Proceedings of the 2001 conference on Virtual reality, archaeology, and cultural heritage*. New York, NY, USA: ACM.

[57] UNESCO (2008). Definition of Cultural Heritage. [Online]. Available: http://portal.unesco.org/culture/en/ev.php-URL_ID=34050&URL_DO=DO_PRINTPAGE&URL_SECTION=201.html [Last Accessed 19/01/2011].

[58] University of Cape Town. The Digital Bleek and Lloyd. [Online]. Available: http://lloydbleekcollection.cs.uct.ac.za/ [Last Accessed 05/02/2011].

[59] Vezzoso, A., Romagnoli, A., Bocchini, O. & Locati, S. (2001). Managing and Organizing Archaeological Data Sets with an XML Native Database. *In Proceedings of the 2001 conference on Virtual reality, archeology, and cultural heritage*. New York, NY, USA: ACM.

[60] W3C. Extensible Markup Language (XML). [Online]. Available: http://www.w3.org/XML/ [Last Accessed 23/01/2011].

[61] w3schools. AJAX Tutorial. [Online]. Available: http://www.w3schools.com/ajax/default.asp [Last Accessed 14/01/2011].

[62] Webopedia. Entity-Relationship Diagram. [Online]. Available: http://www.webopedia.com/TERM/E/entity_relationship_diagram.html [Last Accessed 12/12/2010].

[63] Wikipedia (2010). Human Computer Interaction. [Online]. Available: http://en.wikipdia.org/wiki/Human-computer [Last Accessed 15/10/2010].

[64] Wikipedia (2010). Aperture (Software). [Online]. Available: http://en.wikipedia.org/wiki/Aperture_3 [Last Accessed 06/11/2010].

[65] Wikipedia (2011). DSpace. [Online]. Available: P:\Masters\Tutorials\Thesis Tutorials\Chapter 2\Research Papers\DSpace\DSpace - Wikipedia, the free encyclopedia.htm [Last Accessed 06/02/2011].

[66] Wikipedia (2011). Digital Library. [Online]. Available: http://en.wikipedia.org/wiki/Digital_library [Last Accessed 05/02/2011].

[67] Wikipedia (2011). History of Hard Disk Drives. [Online]. Available: http://en.wikipedia.org/wiki/History_of_hard_disk_drives [Last Accessed 18/01/2011].

[68] Wikipedia (2011). Cultural Heritage. [Online]. Available: http://en.wikipedia.org/wiki/Cultural_heritage [Last Accessed 26/01/2011].

[69] Williams, A. (2003). How to Write and Analyse a Questionnaire, *Journal of Orthodontics*. 30(3). pp. 245-252. British Orthodontic Society.

[70] Williams, K. & Suleman, H. (2010). Translating handwritten Bushman Texts. *In Proceedings of the 10th annual joint conference on Digital libraries*. New York, NY, USA: ACM.

[71] Winkler, Dr Enno (2003). Democratization of Information. [Online]. Available: http://www.humanrightsaction.org/information/eng.htm [Last Accessed 15/01/2011].

[72] Zhang, K., Song, G.L. & Kong, J. (2004). Rapid Software Prototyping Using Visual Language Techniques, In Rapid System Prototyping, 2004. Proceedings. 15th IEEE International . pp. 119-126. IEEE Computer Society.

Appendix A

Understanding Users Questionnaire
for a
Digital Object Management & Storage Application

Approximate Duration:

30 minutes

Prepared by:
Kathryn van Niekerk

A.1 User Information

The aim of this section is to gather basic user information.

A.1.1 How often do you use a computer for at least an hour?

Daily	Weekly	Monthly	Yearly

A.1.2 Do you use a computer to manage your digital images/ photos/ pictures?

Yes	No

A.1.3 If YES, what is the program e.g. Facebook, Photoshop, Explorer etc.?

A.2 Editing Images

The aim of this section is to evaluate the editing of images.

A.2.1 What useful features are there to help you edit images?

A.2.2 What features do you not find useful for editing images?

A.2.3 What extra features do you think would be useful to aid in editing images?

A.3 Uploading Images

The aim of this section is to evaluate the uploading of images.

A.3.1 How easily can you upload 100 images?

Very Difficult	Difficult	Average	Easy	Very Easy

A.3.2 What useful features are there to help you upload images?

A.3.3 What features do you not find useful for uploading images?

A.3.4 What extra features do you think would be useful to aid in uploading files?

A.4 Selecting Images

The aim of this section is to evaluate the selecting of images.

A.4.1 What useful features are there to help you select images?

A.4.2 What features do you not find useful for selecting images?

A.4.3 What extra features would you want as useful to aid in selecting images?

A.5 Organising Images

The aim of this section is to evaluate the organising of images.

A.5.1 How can you organise the images? e.g. folders, albums

A.5.2 What useful features are there to help you organise images?

A.5.3 What features do you not find useful for organising images?

A.5.4 What extra features would you want as useful to aid in organising images?

A.6 Manipulation of a Subset of Images

The aim of this section is to evaluate the manipulation of a subset of images.

A.6.1 How easily can you manipulate a subset of images of a collection?

Very Difficult	Difficult	Average	Easy	Very Easy

Appendix B

Tool Tips and Information Messages

B.1 Design Overview

All “Add”, “Save”, “Delete” and “Reset” action buttons display a “tool tip” when hovered over. Examples are illustrated in Figure B.1 below.

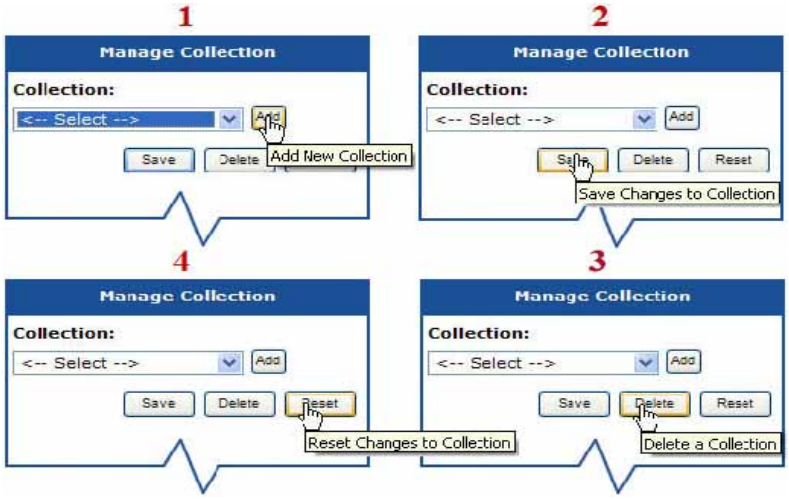


Figure B.1: Add, Save, Delete and Reset Tool Tips

B.2 Item Search

The following tool tips and information messages are displayed when searching for items (bullet points below correlate with the red numbers in Figure B.2 below):

1. A pre-defined date format tool tip is shown when hovering over the entry box.
2. An error message box is given when the “Go” action button is clicked to save a metadata entry without selecting the metadata type from the “Metadata Type” drop down list.

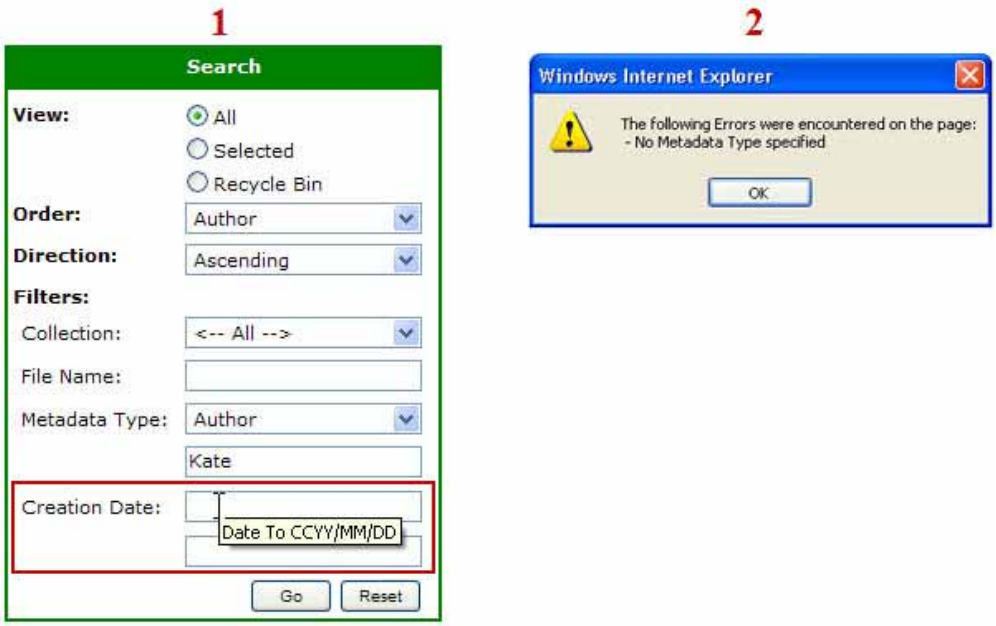


Figure B.2: Search Item Tool Tip and Information Message

B.3 Manage Metadata

The following tool tips and information messages are displayed when searching for items (each bullet point below correlates with the red numbers in Figure B.3 below):

1. The current metadata data is displayed as a tool tip. This is to help the user keep track of what the metadata was before it was edited.
2. Multiple new metadata can be added at the same time by entering them, separated by a semi colon e.g. John Smith; Andrea Copeland.
3. The metadata that are not common to selected items (and that cannot therefore be edited) are displayed as a tool tip.
4. When the "Save" action button is clicked, the users are asked if they would like to save the metadata changes.

When the "Reset" action button is clicked, users are asked if they would like to reset the metadata changes.

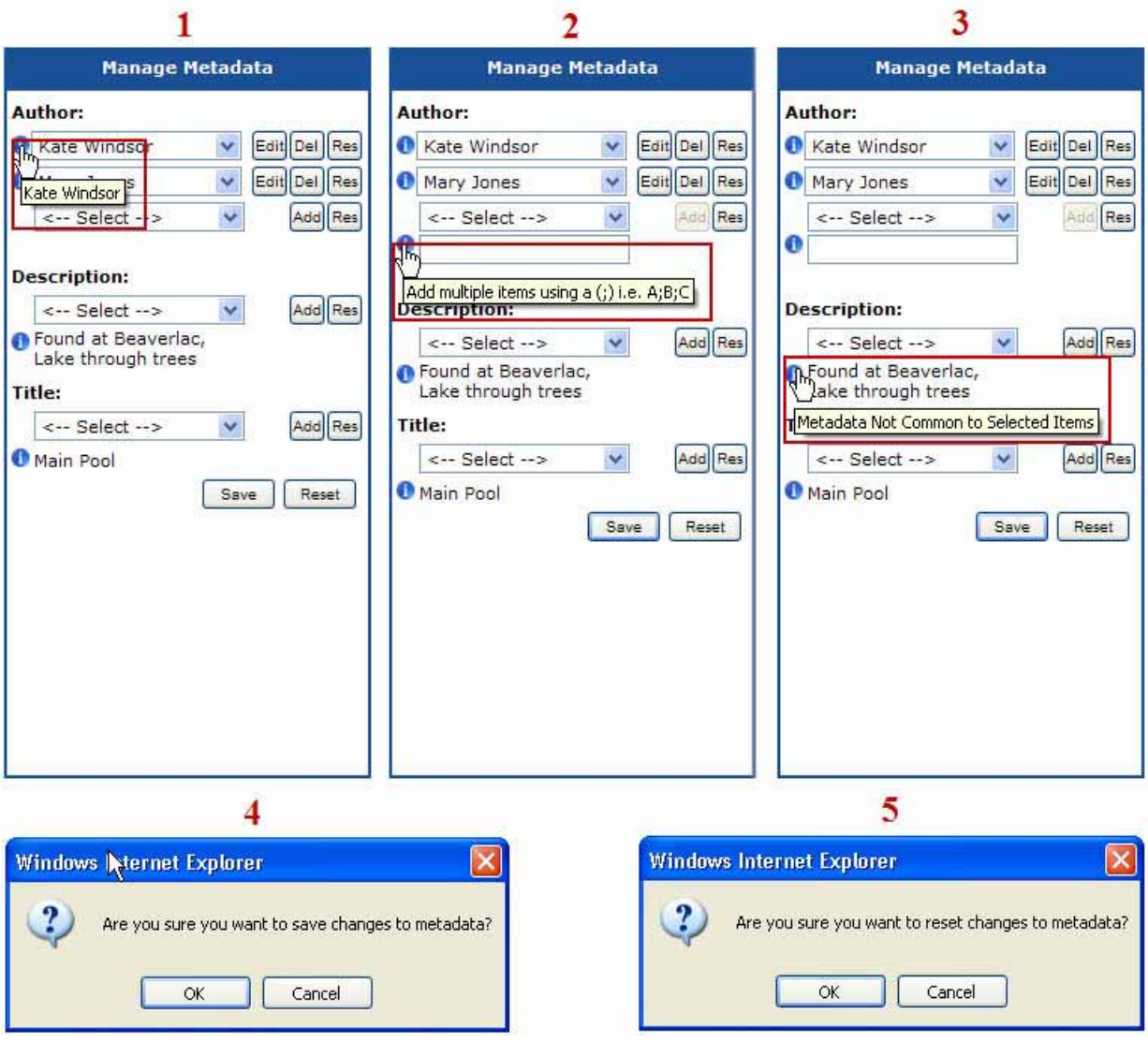


Figure B.3: Manage Metadata Information Messages

B.4 Move Items

The following information messages are displayed to the user when moving items (each point below correlates to the number illustrated in Figure B.4 below):

1. When the “Save” button is clicked the user is asked to confirm the “Item Move” save.
2. When the “Reset” button is clicked the user is asked to confirm the “Item Move” reset.

“OK” will move the items and “Cancel” will return the user to the move item frame.

Figure B.4: Move Items information Messages

B.5 Manage Collections

The following information messages are displayed to the user for collection management (bullet points below correlate with the red numbers in Figure B.5 below):

1. When the “Save” button is clicked users, are asked if they would like to save the changes made to the collection.
2. When the “Delete” button is clicked, users are asked if they would like to delete the collection.
3. Users cannot delete a collection that has items.
4. When the “Reset” button is clicked, users are asked if they would like to reset the changes to the collection.

“OK” will save the changes to the database, “Cancel” will revert to the manage collection frame.

Figure B.5: Manage Collection Information Messages

B.6 Manage Metadata Type

The following information messages are displayed to the user for metadata type management (each point below correlates to a red number illustrated in Figure B.6 below):

1. When the “Save” button is clicked, users are asked if they would like to save the changes made to the metadata type.
2. When the “Delete” button is clicked, users are asked if they would like to delete the metadata type.
3. Users cannot delete a metadata type that has items.
4. When the “Reset” button is clicked, users are asked if they would like to reset the changes to the metadata type.

“OK” will save the changes to the database and “Cancel” will return the user to the manage metadata type frame.

Figure B.6: Manage Metadata Types Information Messages

Appendix C

Database Table Structures

This appendix is a collection of table structures for the IMS database. The database is structured around SQL.

C.1 Item Table

Table C.1 below gives Item table attributes and Table C.2 below gives indexes and constraints.

Column	Type	Null	Description
ItemID	int	No	A system generated unique number identifying an item.
ItemTypeID	int	No	A unique number identifying an item type.
CollectionID	int	No	A unique number identifying a collection.
LocationID	int	No	A unique number identifying a location.
Description	varchar(255)	No	The name of the item.
Selected	bit	No	Indicates the item >selection status. Valid values are 0 -> Deselected and 1 – Selected.
RecycleBin	bit	No	Indicates the item deletion status. Valid values are 0 –> Not deleted and 1 –> Deleted.
CreatedDate	datetime	No	The date and time the item was created by a user.
UpdatedByUserID	int	No	The user that last updated the record.
InsertedDate	datetime	No	The date and time the record was inserted by a user.
UpdatedDate	datetime	No	The date and time the record was last updated by a user.

Table C.1: Item Table Attributes

Index or Constraint	Base Column	Foreign Table	Foreign Column
Primary Key Clustered	ItemID	N/A	N/A
Foreign Key	ItemTypeID	ItemType	ItemTyeID
Foreign Key	CollectonID	Collection	CollectionID
Foreign Key	LocationID	Location	LocationID
Foreign Key	UpdatedByUserID	User	UserID

Table C.2: Item Table Indexes and Constraints

C.2 Item Type Table

Table C.3 below gives ItemType table attributes, Table C.4 below gives indexes and constraints and Table C.5 below lists the pre-populated object formats [63].

Column	Type	Null	Description
ItemTypeID	int	No	System generated unique number identifying item type.
ItemTypeFormat	varchar(255)	No	The name of the item type.
Description	varchar(255)	No	The description of the item type.
UpdatedByUserID	int	No	The user that last updated the record.
InsertedDate	datetime	No	The date and time the record was inserted by a user.
UpdatedDate	datetime	No	The date and time the record was last updated by a user.

Table C.3: ItemType Table Attributes

Index or Constraint	Base Column	Foreign Table	Foreign Column
Primary Key Clustered	ItemTypeID	N/A	N/A
Foreign Key	UpdatedByUserID	User	UserID

Table C.4: ItemType Table Indexes and Constraints

ItemTypeID	ItemTypeFormat	Description
1	BMP	Windows Bitmap
2	Exif	Exchangeable Image File Format
3	GIF	Graphics Interchange Format
4	JPEG	Joint Photographic Experts Group
5	JPG	Joint Photographic Experts Group
6	PNG	Portable Network Graphics
7	RAW	Raw Image File Format
8	TIFF	Tagged Image File Format
9	PDF	Portable Document Format
10	DOC	Microsoft Document
11	MP3	MPEG-1 Audio Layer 3

Table C.5: List of Pre-populated Digital Object File Formats

C.3 Collection Table

Table C.6 below gives Collection table attributes and Table C.7 below gives indexes and constraints.

Column	Type	Null	Description
CollectonID	int	No	A system generated unique number identifying a collection.
Description	varchar(255)	No	The name of the collection.
UpdatedByUserID	int	No	The user that last updated the record.
InsertedDate	datetime	No	The date and time the record was inserted by a user.
UpdatedDate	datetime	No	The date and time the record was last updated by a user.

Table C.6: Collection Table Attributes

Index or Constraint	Base Column	Foreign Table	Foreign Column
Primary Key Clustered	CollectionID	N/A	N/A
Foreign Key	UpdatedByUserID	User	UserID

Table C.7: Collection Table Indexes and Constraints

C.4 Location Table

Table C.8 below gives Location table attributes, Table C.9 below gives indexes and constraints, Table C.10 below lists pre-populated file locations.

Column	Type	Null	Description
LocationID	int	No	A system generated unique number identifying a collection.
Description	varchar(255)	No	The name of the location.
UpdatedByUserID	int	No	The user that last updated the record.
InsertedDate	datetime	No	The date and time the record was inserted by a user.
UpdatedDate	datetime	No	The date and time the record was last updated by a user.

Table C.8: Location Table Attributes

Index or Constraint	Base Column	Foreign Table	Foreign Column
Primary Key Clustered	LocationID	N/A	N/A
Foreign Key	UpdatedByUserID	User	UserID

Table C.9: Location Table Indexes and Constraints

LocationID	Description
1	C:\IMS\Images\Items

Table C.10: List of Pre-populated Locations

C.5 MetaData Table

Table C.11 below gives the MetaData table attributes and Table C.12 below gives the indexes and constraints.

Column	Type	Null	Description
MetaDataID	int	No	A system generated unique number identifying metadata.
ItemID	int	No	A unique number identifying an item.
MetaDataTypeID	int	No	A unique number identifying a metadata type.
Description	varchar(255)	No	The name of the metadata.
UpdatedByUserID	int	No	The user that last updated the record.
InsertedDate	datetime	No	The date and time the record was inserted by a user.
UpdatedDate	datetime	No	The date and time the record was last updated by a user.

Table C.11: MetaData Table Attributes

Index or Constraint	Base Column	Foreign Table	Foreign Column
Primary Key Clustered	MetaDataID	N/A	N/A
Foreign Key	ItemID	Data	ItemID
Foreign Key	MetaDataTypeID	MetaData	MetaDataTypeID
Foreign Key	UpdatedByUserID	User	UserID

Table C.12: MetaData Table Indexes and Constraints

C.6 MetaDataType Table

Table C.13 below gives MetaDataType table attributes and Table C.14 below gives indexes and constraints.

Column	Type	Null	Description
MetaDataTypeID	int	No	System generated unique number identifying a metadata type.
Description	varchar(255)	No	The name of the metadata type.
UpdatedByUserID	int	No	The user that last updated the record.
InsertedDate	datetime	No	The date and time the record was inserted by a user.
UpdatedDate	datetime	No	The date and time the record was last updated by a user.

Table C.13: MetaDataType Table Attributes

Index or Constraint	Base Column	Foreign Table	Foreign Column
Primary Key Clustered	MetaDataTypeID	N/A	N/A
Foreign Key	UpdatedByUserID	User	UserID

Table C.14: MetaDataType Table Indexes and Constraints

C.7 User Table

Table C.15 below gives User table attributes, Table C.16 below gives indexes and constraints and Table C.17 belowlists the pre-populated users.

Column	Type	Null	Description
UserID	int	No	A system generated unique number identifying a user.
PrivilegeID	int	No	A unique number identifying a privilege.
TitleID	int	No	A unique number identifying a title.
FirstName	varchar(255)	No	The first name of the user.
LastName	varchar(255)	No	The last name of the user.
UpdatedByUserID	int	No	The user that last updated the record.
InsertedDate	datetime	No	The date and time the record was inserted by a user.
UpdatedDate	datetime	No	The date and time the record was last updated by a user.

Table C.15: User Table Attributes

Index or Constraint	Base Column	Foreign Table	Foreign Column
Primary Key Clustered	UserID	N/A	N/A
Foreign Key	PrivilegeID	Privilege	PrivilegeID
Foreign Key	TitleID	Title	TitleID
Foreign Key	UpdatedByUserID	User	UserID

Table C.16: User Table Indexes and Constraints

UserID	RoleID	TitleID	FirstName	LastName
1	3	4	Kathryn	van Niekerk

Table C.17: List of Pre-populated Users

C.8 Title Table

Table C.18 below gives Title table attributes, Table C.19 below gives indexes and constraints, Table C.20 below lists the pre-populated users.

Column	Type	Null	Description
TitleID	int	No	A system generated unique number identifying a title.
Description	varchar(255)	No	The name of the title.
UpdatedByUserID	int	No	The user that last updated the record.
InsertedDate	datetime	No	The date and time the record was inserted by a user.
UpdatedDate	datetime	No	The date and time the record was last updated by a user.

Table C.18: Title Table Attributes

Index or Constraint	Base Column	Foreign Table	Foreign Column
Primary Key Clustered	TitleID	N/A	N/A
Foreign Key	UpdatedByUserID	User	UserID

Table C.19: Title Table Indexes and Constraints

TitleID	Description
1	Mr
2	Mrs
3	Miss
4	Ms
5	Dr
6	Prof
7	Other

Table C.20: List of Pre-populated Titles

C.9 Privilege Table

Table C.21 below gives Privilege table attributes, Table C.22 below gives indexes and constraints, Table C.23 below lists the pre-populated users.

Column	Type	Null	Description
PrivilegeID	int	No	A system generated unique number identifying a privilege.
Description	varchar(255)	No	The name of the role.
UpdatedByUserID	int	No	The user that last updated the record.
InsertedDate	datetime	No	The date and time the record was inserted by a user.
UpdatedDate	datetime	No	The date and time the record was last updated by a user.

Table C.21: Privilege Table Attributes

Index or Constraint	Base Column	Foreign Table	Foreign Column
Primary Key Clustered	PrivilegeID	N/A	N/A
Foreign Key	UpdatedByUserID	User	UserID

Table C.22: Privilege Table Indexes and Constraints

PrivilegeID	Description
1	Read Only User
2	General User
3	Administrator

Table C.23: List of Pre-populated Privileges

C.10 ItemSearch Table

Table C.24 below gives ItemSearch table attributes and Table C.25 below gives the indexes and constraints.

Column	Type	Null	Description
ItemSearchID	int	No	System generated unique number identifying an item search.
ItemID	int	No	A unique number identifying an item.

Table C.24: ItemSearch Table Attributes

Index or Constraint	Base Column	Foreign Table	Foreign Column
Primary Key Clustered	ItemSearchID	N/A	N/A
Foreign Key	ItemID	Item	ItemID

Table C.25: ItemSearch Table Indexes and Constraints

C.11 SystemSetting Table

Table C.26 below gives the SystemSetting table attributes, Table C.27 below gives the indexes and constraints and Table C.28 below lists the pre-populated users.

Column	Type	Null	Description
SystemSettingID	int	No	System generated unique number identifying system setting.
Description	varchar(255)	No	The name of the system setting.
Value	varchar(255)	No	The value of the system setting.
UpdatedByUserID	int	No	The user that last updated the record.
InsertedDate	datetime	No	The date and time the record was inserted by a user.
UpdatedDate	datetime	No	The date and time the record was last updated by a user.

Table C.26: SystemSetting Table Attributes

Index or Constraint	Base Column	Foreign Table	Foreign Column
Primary Key Clustered	SystemSettingID	N/A	N/A
Foreign Key	UpdatedByUserID	User	UserID

Table C.27: SystemSetting Table Indexes and Constraints

SystemSettingID	Description	Value
1	Results per Page	50
1	Thumbnail Size	60

Table C.28: List of Pre-populated System Settings

Appendix D

User Evaluation Document

for a

Digital Object Management & Storage Application

Approximate Duration:

1 hour

Prepared by:

Kathryn van Niekerk

D.1 Introduction

This user evaluation consists of four sections. The first section will gather basic information about you and evaluate your level of experience managing personal digital image collections. This information will be used to help classify the results of this user evaluation.

Next an overview of digital image management is provided and then a demonstration of the basic functionality of the IMS will be given. This will provide the necessary background information for the user evaluation tasks ahead. You will then have the opportunity to ask questions before preceding with the user evaluation tasks.

Each task consists of a list of instructions that focuses on an area of functionality of IMS followed by a short questionnaire. The questionnaire will test the usability of IMS. ISO 9241-11 (1998) defines usability "as the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use". While you are executing the tasks you will be observed by a facilitator. The facilitator will record extra information such as critical errors you may experience and any recovery procedures you performed.

Finally you will be given the opportunity to provide feedback on the general aesthetics of the user interface, the features you liked and did not like and any other additional comments that will improve the usability.

Please note that this is not a test or an evaluation of your computer literacy skills. The results will be recorded by pen a paper and will remain confidential.

Please feel free to ask questions throughout the evaluation.

D.2 Overview of Digital Image Management

Considerable amount of time, effort and money goes into producing digital images. It is therefore important that these images are correctly stored and cared for.

When photos are taken very often you will document extra information about the image that will need to be associated and stored with it such as title, author, location, a short description etc. This extra information is known as metadata and can be defined as data providing information about one of more pieces of other data. In order to preserve the quality and integrity of the metadata over a long period of time we need to ensure that these digital images are stored correctly. One of the challenges of storing metadata is its continuous evolution with time as new metadata types are added and existing ones are edited. The format of the metadata must be efficient and scalable so that the quality and integrity of the existing metadata is not compromised and can be expanded to incorporate this new information.

Another process that is specifically associated with digital image management is the organising and storing like subject images together in collections such as animals, people, buildings, flowers etc. The structure of these collections takes the form of Windows folders.

The addition and editing of metadata types, organising, storing and searching of digital images usually occurs in batches consisting of large quantities. The IMS is an application that has been specifically designed to manage a large number of digital images, that gave been organised in collections, and their associated metadata.

When you are ready, please fill in the User Information overleaf, and then ask the facilitator to demonstrate the IMS.

D.3 User Information

Name: _____ **Age:** _____

Occupation: _____ **Gender**:

Male	Female

D.3.1 How often do you use a computer for at least an hour?

Daily	Weekly	Monthly	Yearly

D.3.2 Do you use a computer to manage your digital images/ photos/ pictures?

Yes	No

D.3.3 If YES, what is the program e.g. Facebook, Photoshop, Explorer etc.?

_____

_____

_____

_____

D.4 User Evaluation Tasks

For the purpose of this user evaluation the definition of effectiveness is: How close does this come to your ideal way of performing this task?

D.4.1 Adding Collections and Metadata Types

The aim of is to successfully add collections and metadata types in which images can be grouped by subject, and in addition extra information associated with an image can be stored.

D.4.1.1 Add the following collections:

- Animals
- People

D.4.1.2 Add the following metadata types:

- Author
- Location

D.4.1.3 Questionnaire

1. **Were you able to complete these tasks successfully?**

Yes	No

2. **If you were not able to complete these tasks successfully, please give any reasons why not.**

_____

_____

_____

_____

3. **How do you rate the menu navigation while adding collections and metadata types?**

Very Difficult	Difficult	Average	Easy	Very Easy

4. **How do you rate the complexity of adding collections and metadata types?**

Very Difficult	Difficult	Average	Easy	Very Easy

5. **How do you rate the intuitive ease of adding collection and metadata types?**

Very Difficult	Difficult	Average	Easy	Very Easy

6. **How do you rate the effectiveness of adding collection and metadata types?**

   Scale: Least Effective ➡ 1 to 10 ⬅ Most Effective

1	2	3	4	5	6	7	8	9	10

7. **Do you have any suggestions for improving the adding of collections and metadata types?**

_____

_____

_____

_____

D.4.2 Uploading Images

The aim of this task is to successfully upload images to a selected collection.

D.4.2.1 Upload all the images found in the specified folder to the following collections:

- Animals (C:\Temp\Animals – 10 images)
- People (C:\Temp\People – 100 images)

D.4.2.2 Questionnaire

1. **Were you able to complete this task successfully?**

Yes	No

2. **If you were not able to complete this task successfully then please state why.**

_____

_____

_____

_____

3. **Do you agree with the following statement? It was as easy uploading 10 images (Animal) as it was for 100 images (People).**

Yes	No

4. **How do you rate the menu navigation of uploading images?**

Very Difficult	Difficult	Average	Easy	Very Easy

5. **How do you rate the complexity of uploading images?**

Very Difficult	Difficult	Average	Easy	Very Easy

6. **How do you rate the intuitive ease of uploading images?**

Very Difficult	Difficult	Average	Easy	Very Easy

7. **How do you rate the effectiveness of uploading images?**

Scale: Least Effective ➡ 1 to 10 ⬅ Most Effective

1	2	3	4	5	6	7	8	9	10

8. **Do you have any suggestions for improving the uploading of images?**

_____

_____

_____

_____

D.4.3 Selecting and Adding Metadata

The aim of this task is to select all images in a collection successfully and to add metadata to the images.

D.4.3.1 Search for all images in the Animal collection.

D.4.3.2 Select all the searched for images.

D.4.3.3 Add the following metadata to all selected images in the Animal collection:

- Author - George Meyers
- Location - Kruger Park

D.4.3.4 Search for all selected images.

D.4.3.5 Deselect all searched for images.

D.4.3.6 Search for all images in the People collection

D.4.3.7 Select all the searched for images.

D.4.3.8 Add the following metadata to all selected images in the People collection:

- Author - Melanie Morgan and Howard Wrigley
- Location - Cape Town Waterfront

D.4.3.9 Search for all selected images.

D.4.3.10 Deselect all selected images.

D.4.3.11 Questionnaire

1. **Were you able to complete this task successfully?**

Yes	No

2. **If you were not able to complete this task successfully then please state why.**

3. **Do you agree with the following statement? It was as easy (1) selecting all images and (2) adding metadata for 10 images (People) as it was for 100 images (Animal).**

	Yes	No
(1)		
(2)		

4. **Do you agree with the following statement? It was as easy adding multiple metadata as adding one metadata to a metadata type i.e. adding two or one new authors in the task above.**

Yes	No

5. **How do you rate the menu navigation of (1) selecting all images and (2) adding metadata?**

	Very Difficult	Difficult	Average	Easy	Very Easy
(1)					
(2)					

6. **How do you rate the complexity of (1) selecting all images and (2) adding metadata?**

	Very Difficult	Difficult	Average	Easy	Very Easy
(1)					
(2)					

7. **How do you rate the intuitive ease of (1) selecting all images and (2) adding metadata?**

	Very Difficult	Difficult	Average	Easy	Very Easy
(1)					
(2)					

8. **How do you rate the effectiveness of (1) selecting all images and (2) adding metadata?**

Scale: Least Effective ➡ 1 to 10 ⬅ Most Effective

1	2	3	4	5	6	7	8	9	10

9. **Do you have any suggestions for improving selecting all images and adding of metadata?**

_____

_____

_____

_____

D.4.4 Selecting a Subset of Images and Editing Metadata

The aim of this task is to successfully select a subset of images in a collection and edit the metadata of the images.

D.4.4.1 Search for all images in the Miscellaneous collection.

D.4.4.2 Select all images with a "Date Picture Taken" of "2006/01/01 08:00:00 AM" to "2006/01/31 08:00:00 AM.

D.4.4.3 Edit the metadata of all selected images in the Miscellaneous collection:

- Title - Water
- Description - Water in various forms and uses

D.4.4.4 Search for all selected images.

D.4.4.5 Deselect all selected images.

D.4.4.6 Search for all images in the Miscellaneous collection.

D.4.4.7 Select all images with a "Date Picture Taken" of "2007/01/01 08:00:00 AM" to "2007/01/31 08:00:00 AM".

- Edit the following metadata of all selected images in the Miscellaneous collection:
- Title – Household Objects
- Description - Objects used around the house

D.4.4.8 Search for all selected images.

D.4.4.9 Deselect all selected images.

D.4.4.10 Questionnaire

1. **Were you able to complete this task successfully?**

Yes	No

2. **If you were not able to complete this task successfully then please state why.**

_____

_____

_____

_____

3. **Do you agree with the following statement? It was as easy (1) selecting a subset of images and (2) editing metadata for 10 images as it was for 100 images.**

	Yes	No
(1)		
(2)		

4. **How do you rate the menu navigation of (1) selecting a subset of images and (2) editing metadata?**

	Very Difficult	Difficult	Average	Easy	Very Easy
(1)					
(2)					

5. **How do you rate the complexity of (1) selecting a subset of images and (2) editing metadata?**

	Very Difficult	Difficult	Average	Easy	Very Easy
(1)					
(2)					

6. **How do you rate the intuitiveness of (1) selecting a subset of images and (2) editing metadata?**

	Very Difficult	Difficult	Average	Easy	Very Easy
(1)					
(2)					

7. **How do you rate the effectiveness of (1) selecting a subset of images and (2) editing metadata?**

Scale: Least Effective ➡ 1 to 10 ⬅ Most Effective

1	2	3	4	5	6	7	8	9	10

8. **Do you have any suggestions for improving selecting a subset of images and editing metadata?**

D.4.5 Moving a Subset of Images between Collections

The aim of this task is to successfully move a subset of images between collections.

D.4.5.1 Search for images with a Title of Animals in the Miscellaneous collection.

D.4.5.2 Select all searched for images.

D.4.5.3 Move all selected images to the Animal Collection.

D.4.5.4 Search for all selected images.

D.4.5.5 Deselect all selected images.

D.4.5.6 Search for images with a Title of People in the Miscellaneous collection.

D.4.5.7 Select all searched for images.

D.4.5.8 Move all selected images to the People Collection.

D.4.5.9 Search for all selected images.

D.4.5.10 Deselect all selected images.

D.4.5.11 Questionnaire

1. **Were you able to complete this task successfully?**

	Yes	No
(1)		
(2)		

2. **If you were not able to complete this task successfully then please state why.**

3. **Do you agree with the following statement? It was as easy moving 10 images (Animal) as it was for 100 images (People).**

Yes	No

4. **How do you rate the menu navigation of moving images?**

Very Difficult	Difficult	Average	Easy	Very Easy

5. **How do you rate the complexity of moving images?**

Very Difficult	Difficult	Average	Easy	Very Easy

6. **How do you rate the intuitive ease of moving images?**

Very Difficult	Difficult	Average	Easy	Very Easy

7. **How do you rate the effectiveness of moving images?**

Scale: Least Effective ➡ 1 to 10 ⬅ Most Effective

1	2	3	4	5	6	7	8	9	10

8. **Do you have any suggestions for improving the moving of images?**

_____

_____

_____

_____

D.4.6 Viewing Image Details

The aim of this task is to successfully view the details of an image.

D.4.6.1 Hover over an image and view the metadata.

D.4.6.2 Click on and view the details of the image.

D.4.6.3 Questionnaire

1. **Were you able to complete this task successfully?**

Yes	No

2. **If you were not able to complete this task successfully then please state why.**

_____

_____

_____

_____

3. **How do you rate the menu navigation of viewing image details?**

Very Difficult	Difficult	Average	Easy	Very Easy

4. **How do you rate the complexity of viewing image details?**

Very Difficult	Difficult	Average	Easy	Very Easy

5. **How do you rate the intuitive ease of viewing image details?**

Very Difficult	Difficult	Average	Easy	Very Easy

6. **How do you rate the effectiveness of viewing image details?**

Scale: Least Effective ➡ 1 to 10 ⬅ Most Effective

1	2	3	4	5	6	7	8	9	10

7. **Do you have any suggestions for improving the viewing of image details?**

_____

_____

_____

_____

D.4.7 Deleting and Recovering Images

The aim of this task is to successfully delete and recover an image.

D.4.7.1 Select an image for deletion.

D.4.7.2 Delete the image.

D.4.7.3 Search for the deleted image in the Recycle Bin.

D.4.7.4 Recover the deleted image from the Recycle Bin.

D.4.7.5 Questionnaire

1. **Were you able to complete this task successfully?**

Yes	No

2. **If you were not able to complete this task successfully then please state why.**

_____

_____

_____

_____

3. **How do you rate the menu navigation of (1) deleting and (2) recovering an image?**

	Very Difficult	Difficult	Average	Easy	Very Easy
(1)					
(2)					

4. **How do you rate the complexity of (1) deleting and (2) recovering an image?**

	Very Difficult	Difficult	Average	Easy	Very Easy
(1)					
(2)					

5. **How do you rate the intuitive ease of (1) deleting and (2) recovering an image?**

	Very Difficult	Difficult	Average	Easy	Very Easy
(1)					
(2)					

6. **How do you rate the effectiveness of (1) deleting and (2) recovering an image?**

Scale: Least Effective ➡ 1 to 10 ⬅ Most Effective

1	2	3	4	5	6	7	8	9	10

7. **Do you have any suggestions to improve deleting and recovering images?**

_____

_____

_____

_____

D.4.8 Searching for Images

Throughout this user evaluation you had to search for a pre-specified selection of images.

D.4.8.1 Questionnaire

1. **Were you able to complete this task successfully?**

Yes	No

2. **If you were not able to complete this task successfully then please state why.**

_____

_____

_____

_____

3. **How do you rate the menu navigation of searching for images?**

Very Difficult	Difficult	Average	Easy	Very Easy

4. **How do you rate the complexity of searching for images?**

Very Difficult	Difficult	Average	Easy	Very Easy

5. **How do you rate the intuitive ease of searching for images?**

Very Difficult	Difficult	Average	Easy	Very Easy

6. **How do you rate the effectiveness of searching for images?**

Scale: Least Effective ➡ 1 to 10 ⬅ Most Effective

1	2	3	4	5	6	7	8	9	10

7. **Do you have any suggestions for improving searching for images?**

D.5 General Feedback

D.5.1 Was the application easy to learn?

Very Difficult	Difficult	Average	Easy	Very Easy

D.5.2 How responsive is the application i.e. time to respond to a mouse click?

Scale: Least Responsive➡ 1 to 10 ⬅ Most Responsive

1	2	3	4	5	6	7	8	9	10

D.5.3 Please comment on the general aesthetics of the user interface?

D.5.4 Do you have any suggestions for improving the aesthetics of the user interface?

D.5.5 What features did you like about the user interface?

D.5.6 What features did you NOT like about the user interface?

D.5.7 Additional Comments?

Thank you for participating in this survey

Appendix E

Detailed Evaluation Results

This appendix gives the definition of descriptive statistic and the detailed results from the user and performance evaluations.

E.1 Descriptive Statistics

Descriptive statistics form the basis of quantitative data analysis. They provide simple summaries of a large quantity of data in a sensible way. Four major characteristics examined are:

- *Distribution* - A summary of the frequency of individual values or ranges of values.
- *Central Tendency* - Central tendency can be classified further as the mean (average), median (value in middle) and mode (most frequent value) and is an estimate of the centre of distribution of values.
- *Dispersion* - Is the measure of the spread of values around the central tendency.
- *Standard Deviation* - Shows the relationship between a set of values and the mean.

When the distribution of values is normal, then 68% of values are in one standard deviation from the mean, 95% are two standard deviations from the mean and 99% are three standard deviations from the mean [55].

E.2 Demographic Information

Table E.1 below gives the basic information of the users.

Age	Gender	Occupation	PC Usage
42	Female	Test Analyst	Daily
34	Female	Financial Advisor	Daily
30	Female	Manager	Daily
39	Female	Lecturer	Daily
40	Male	Manager	Daily
34	Female	Journalist	Daily
32	Male	Software Engineer	Daily
33	Male	Software Engineer	Daily
42	Male	Assistant Manager	Daily
18	Male	Scholar	Daily
69	Male	Software Engineer	Daily
62	Female	Bookkeeper	Daily
32	Female	Lecturer	Daily
33	Female	Software Engineer	Daily
30	Female	Assistant Manager	Daily
35	Female	Bookkeeper	Daily
30	Female	Lecturer	Daily
39	Male	Customer Service Representative	Daily
27	Female	Medical Representation	Daily
29	Male	Manager	Daily

Table E.1: Basic Information

E.3 Frequency Distribution for Effectiveness

Table E.2 below gives the frequency distribution for effectiveness of IMS per user evaluation task.

Task	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Add Collection	0% (0)	5% (1)	0% (0)	0% (0)	0% (0)	0% (0)	20% (4)	30% (6)	5% (1)	**40% (8)**
Edit Collection	0% (0)	0% (0)	5% (1)	0% (0)	0% (0)	0% (0)	20% (4)	30% (6)	5% (1)	**40% (8)**
Delete Collection	0% (0)	0% (0)	0% (0)	0% (0)	5% (1)	0% (0)	15% (3)	30% (6)	5% (1)	**40% (8)**
Add Metadata Type	0% (0)	5% (1)	0% (0)	0% (0)	0% (0)	0% (0)	20% (4)	30% (6)	5% (1)	**40% (8)**
Edit Metadata Type	0% (0)	0% (0)	5% (1)	0% (0)	0% (0)	0% (0)	20% (4)	30% (6)	5% (1)	**40% (8)**
Delete Metadata Type	0% (0)	0% (0)	5% (1)	0% (0)	5% (1)	0% (0)	15% (3)	30% (6)	5% (1)	**40% (8)**
Upload Items	0% (0)	0% (0)	5% (1)	0% (0)	0% (0)	0% (0)	10% (2)	**30% (6)**	25% (5)	**30% (6)**
Add Item Metadata	0% (0)	5% (1)	0% (0)	0% (0)	0% (0)	10% (2)	20% (4)	20% (4)	15% (3)	**30% (6)**
Edit Item Metadata	0% (0)	0% (0)	0% (0)	5% (1)	0% (0)	0% (0)	25% (5)	20% (4)	10% (2)	**40% (8)**
Delete Item Metadata	0% (0)	0% (0)	0% (0)	5% (1)	0% (0)	0% (0)	25% (5)	20% (4)	10% (2)	**40% (8)**
Move Items	0% (0)	0% (0)	0% (0)	0% (0)	5% (1)	0% (0)	15% (3)	30% (6)	15% (3)	**35% (7)**
View Item Detail	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)	20% (4)	0% (0)	10% (2)	**70% (14)**
Delete Items	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)	15% (3)	20% (4)	15% (3)	**50% (10)**
Restore Items	0% (0)	0% (0)	0% (0)	0% (0)	5% (1)	0% (0)	10% (2)	20% (4)	15% (3)	**50% (10)**
Search for Items	0% (0)	0% (0)	0% (0)	5% (1)	0% (0)	0% (0)	10% (2)	35% (7)	10% (2)	**40% (8)**
Select All Items	0% (0)	0% (0)	5% (1)	0% (0)	0% (0)	10% (2)	20% (4)	20% (4)	5% (1)	**40% (8)**
Select Subset of Items	0% (0)	0% (0)	0% (0)	5% (1)	0% (0)	0% (0)	25% (5)	20% (4)	20% (4)	**30% (6)**

Table E.2: Frequency Distribution for Effectiveness

E.4 Descriptive Statistics for Effectiveness

Table E.3 below gives the descriptive statistics for the effectiveness of IMS per user evaluation task.

Task	Min	Max	Mean	Median	Mode	Std Dev
Add Collection	2	10	8.35	8.00	10.00	1.93
Edit Collection	3	10	8.40	8.00	10.00	1.76
Delete Collection	3	10	8.30	8.00	10.00	1.89
Add Metadata Type	2	10	8.35	8.00	10.00	1.93
Edit Metadata Type	3	10	8.40	8.00	10.00	1.76
Delete Metadata Type	3	10	8.30	8.00	10.00	1.89
Upload Items	3	10	8.50	9.00	8.00	1.64
Add Item Metadata	2	10	8.05	8.00	10.00	1.99
Edit Item Metadata	4	10	8.45	8.50	10.00	1.64
Delete Item Metadata	4	10	8.45	8.50	10.00	1.64
Move Items	5	10	8.55	8.50	10.00	1.39
View Item Detail	7	10	9.30	10.00	10.00	1.22
Delete Items	7	10	9.00	9.50	10.00	1.17
Restore Items	5	10	8.90	9.50	10.00	1.41
Search for Items	4	10	8.60	8.50	10.00	1.54
Select All Items	3	10	8.20	8.00	10.00	1.91
Select Subset of Items	4	10	8.35	8.50	10.00	1.57

Table E.3: Descriptive Statistics for Effectiveness

E.5 Frequency Distribution for Menu Navigation

Table E.4 below gives the frequency distribution for the menu navigation of IMS per user evaluation task.

Task	Very Difficult	Difficult	Average	Easy	Very Easy
Add Collection	0% (0)	0% (0)	10% (2)	**45% (9)**	**45% (9)**
Edit Collection	0% (0)	0% (0)	20% (4)	35% (7)	**45% (9)**
Delete Collection	0% (0)	5% (1)	15% (3)	35% (7)	**45% (9)**
Add Metadata Type	0% (0)	5% (1)	10% (2)	40% (8)	**45% (9)**
Edit Metadata Type	0% (0)	0% (0)	20% (4)	35% (7)	**45% (9)**
Delete Metadata Type	0% (0)	5% (1)	15% (3)	35% (7)	**45% (9)**
Upload Items	0% (0)	0% (0)	15% (3)	**70% (14)**	15% (3)
Add Item Metadata	0% (0)	5% (1)	15% (3)	**55% (11)**	25% (5)
Edit Item Metadata	0% (0)	5% (1)	15% (3)	**40% (8)**	**40% (8)**
Delete Item Metadata	0% (0)	5% (1)	15% (3)	**40% (8)**	**40% (8)**
Move Items	0% (0)	0% (0)	15% (3)	**50% (10)**	35% (7)
View Item Detail	0% (0)	0% (0)	0% (0)	25% (5)	**75% (15)**
Delete Items	0% (0)	0% (0)	5% (1)	**55% (11)**	40% (8)
Restore Items	0% (0)	0% (0)	10% (2)	**50% (10)**	40% (8)
Search for Items	0% (0)	5% (1)	15% (3)	**45% (9)**	35% (7)
Select All Items	0% (0)	5% (1)	15% (3)	**55% (11)**	25% (5)
Select Subset of Items	0% (0)	0% (0)	25% (5)	**40% (8)**	35% (7)

Table E.4: Frequency Distribution for Menu Navigation

E.6 Descriptive Statistics for Menu Navigation

Table E.5 below gives the descriptive statistics for the menu navigation of IMS per user evaluation task.

Task	Min	Max	Mean	Median	Mode	Std Dev
Add Collection	3	5	4.35	4.00	4.00	0.67
Edit Collection	3	5	4.25	4.00	5.00	0.79
Delete Collection	2	5	4.20	4.00	5.00	0.89
Add Metadata Type	2	5	4.25	4.00	5.00	0.85
Edit Metadata Type	3	5	4.25	4.00	5.00	0.79
Delete Metadata Type	2	5	4.20	4.00	5.00	0.89
Upload Items	3	5	4.00	4.00	4.00	0.56
Add Item Metadata	2	5	4.00	4.00	4.00	0.79
Edit Item Metadata	2	5	4.15	4.00	4.00	0.88
Delete Item Metadata	2	5	4.15	4.00	4.00	0.88
Move Items	3	5	4.20	4.00	4.00	0.70
View Item Detail	4	5	4.75	5.00	5.00	0.44
Delete Items	3	5	4.35	4.00	4.00	0.59
Restore Items	3	5	4.30	4.00	4.00	0.66
Search for Items	2	5	4.10	4.00	4.00	0.85
Select All Items	2	5	4.00	4.00	4.00	0.79
Select Subset of Items	3	5	4.10	4.00	4.00	0.64

Table E.5: Descriptive Statistics for Menu Navigation

E.7 Frequency Distribution for Complexity

Table E.6 below gives the frequency distribution for the complexity of IMS per user evaluation task.

Task	Very Difficult	Difficult	Average	Easy	Very Easy
Add Collection	0% (0)	5% (1)	10% (2)	40% (8)	**45% (9)**
Edit Collection	0% (0)	0% (0)	15% (3)	40% (8)	**45% (9)**
Delete Collection	0% (0)	0% (0)	15% (3)	40% (8)	**45% (9)**
Add Metadata Type	0% (0)	5% (1)	10% (2)	40% (8)	**45% (9)**
Edit Metadata Type	0% (0)	0% (0)	15% (3)	40% (8)	**45% (9)**
Delete Metadata Type	0% (0)	0% (0)	15% (3)	40% (8)	**45% (9)**
Upload Items	0% (0)	0% (0)	15% (3)	**55% (11)**	30% (6)
Add Item Metadata	0% (0)	0% (0)	10% (2)	**50% (10)**	40% (8)
Edit Item Metadata	0% (0)	5% (1)	5% (1)	**60% (12)**	30% (6)
Delete Item Metadata	0% (0)	5% (1)	5% (1)	**60% (12)**	30% (6)
Move Items	0% (0)	0% (0)	15% (3)	40% (8)	**45% (9)**
View Item Detail	0% (0)	0% (0)	0% (0)	25% (5)	**75% (15)**
Delete Items	0% (0)	0% (0)	5% (1)	**65% (13)**	30% (6)
Restore Items	0% (0)	5% (1)	0% (0)	**45% (9)**	30% (6)
Search for Items	0% (0)	0% (0)	5% (1)	45% (9)	**50% (10)**
Select All Items	0% (0)	0% (0)	10% (2)	**50% (10)**	40% (8)
Select Subset of Items	0% (0)	0% (0)	10% (2)	**55% (11)**	35% (7)

Table E.6: Frequency Distribution for Complexity

E.8 Descriptive Statistics for Complexity

Table E.7 below gives the descriptive statistics for the complexity of IMS per user evaluation task.

Task	Min	Max	Mean	Median	Mode	Std Dev
Add Collection	2	5	4.25	4.00	5.00	0.85
Edit Collection	3	5	4.30	4.00	5.00	0.73
Delete Collection	3	5	4.30	4.00	5.00	0.73
Add Metadata Type	2	5	4.25	4.00	5.00	0.85
Edit Metadata Type	3	5	4.30	4.00	5.00	0.73
Delete Metadata Type	3	5	4.30	4.00	5.00	0.73
Upload Items	3	5	4.15	4.00	4.00	0.67
Add Item Metadata	3	5	4.30	4.00	4.00	0.66
Edit Item Metadata	2	5	4.15	4.00	4.00	0.75
Delete Item Metadata	2	5	4.15	4.00	4.00	0.75
Move Items	3	5	4.30	4.00	5.00	0.73
View Item Detail	4	5	4.75	5.00	5.00	0.44
Delete Items	3	5	4.25	4.00	4.00	0.55
Restore Items	2	5	4.20	4.00	4.00	0.70
Search for Items	2	5	4.45	4.50	5.00	0.60
Select All Items	3	5	4.30	4.00	4.00	0.66
Select Subset of Items	3	5	4.25	4.00	4.00	0.64

Table E.7: Descriptive Statistics for Complexity

E.9 Frequency Distribution for Intuitive Ease

Table E.8 below gives the frequency distribution for the intuitive ease of IMS per user evaluation task.

Task	Very Difficult	Difficult	Average	Easy	Very Easy
Add Collection	0% (0)	0% (0)	15% (3)	**50% (10)**	35% (7)
Edit Collection	0% (0)	0% (0)	15% (3)	**50% (10)**	35% (7)
Delete Collection	0% (0)	5% (1)	10% (3)	**50% (10)**	35% (7)
Add Metadata Type	0% (0)	0% (0)	15% (3)	**50% (10)**	35% (7)
Edit Metadata Type	0% (0)	0% (0)	15% (3)	**50% (10)**	35% (7)
Delete Metadata Type	0% (0)	5% (1)	10% (3)	**50% (10)**	35% (7)
Upload Items	0% (0)	10% (2)	5% (1)	**45% (9)**	40% (8)
Add Item Metadata	0% (0)	5% (1)	15% (3)	**55% (11)**	25% (5)
Edit Item Metadata	0% (0)	5% (1)	15% (3)	**50% (10)**	30% (6)
Delete Item Metadata	0% (0)	5% (1)	15% (3)	**50% (10)**	30% (6)
Move Items	0% (0)	0% (0)	20% (4)	**40% (8)**	**40% (8)**
View Item Detail	0% (0)	0% (0)	5% (1)	25% (5)	**70% (14)**
Delete Items	0% (0)	0% (0)	0% (0)	**70% (14)**	30% (6)
Restore Items	0% (0)	0% (0)	5% (1)	**65% (13)**	30% (6)
Search for Items	0% (0)	0% (0)	0% (0)	**60% (12)**	40% (8)
Select All Items	0% (0)	5% (1)	10% (2)	**55% (11)**	30% (6)
Select Subset of Items	0% (0)	0% (0)	20% (4)	**45% (9)**	35% (7)

Table E.8: Frequency Distribution for Intuitive Ease

E.10 Descriptive Statistics for Intuitive Ease

Table E.9 below gives the descriptive statistics for the intuitive ease of IMS per user evaluation task.

Task	Min	Max	Mean	Median	Mode	Std Dev
Add Collection	3	5	4.25	4.00	4.00	0.72
Edit Collection	3	5	4.25	4.00	4.00	0.72
Delete Collection	2	5	4.20	4.00	4.00	0.83
Add Metadata Type	3	5	4.25	4.00	4.00	0.72
Edit Metadata Type	3	5	4.25	4.00	4.00	0.72
Delete Metadata Type	2	5	4.20	4.00	4.00	0.83
Upload Items	2	5	4.15	4.00	4.00	0.93
Add Item Metadata	2	5	4.00	4.00	4.00	0.79
Edit Item Metadata	2	5	4.05	4.00	4.00	0.83
Delete Item Metadata	2	5	4.05	4.00	4.00	0.83
Move Items	3	5	4.20	4.00	4.00	0.77
View Item Detail	3	5	4.65	5.00	5.00	0.59
Delete Items	4	5	4.30	4.00	4.00	0.47
Restore Items	3	5	4.25	4.00	4.00	0.55
Search for Items	4	5	4.40	4.00	4.00	0.50
Select All Items	2	5	4.10	4.00	4.00	0.79
Select Subset of Items	3	5	4.15	4.00	4.00	0.75

Table E.9: Descriptive Statistics for Intuitive Ease

E.11 Performance Evaluation of One Item

Table E.10 below gives the performance evaluation of one item.

Task	1	2	3	4	5	6	7	8	9	10	Avg
Upload Items	12	11	11	11	11	12	13	12	11	13	**12**
Add Item Metadata	12	12	12	13	11	13	13	12	12	12	**12**
Edit Item Metadata	11	12	12	12	13	11	13	13	11	12	**12**
Delete Item Metadata	5	5	5	6	5	5	5	5	5	5	**5**
Move Items	6	6	6	5	6	6	5	6	6	5	**6**
Select All Items	1	1	1	1	1	1	1	1	2	1	**1**

Table E.10: Performance Evaluation of One Item (in seconds)

E.12 Performance Evaluation of Ten Items

Table E.11 below gives the performance evaluation of ten items.

Task	1	2	3	4	5	6	7	8	9	10	Avg
Upload Items	17	18	16	17	16	17	17	15	16	15	**16**
Add Item Metadata	11	12	11	12	11	11	11	11	11	12	**11**
Edit Item Metadata	12	11	12	12	12	12	11	11	12	12	**12**
Delete Item Metadata	5	5	5	5	5	5	5	5	5	5	**5**
Move Items	6	6	6	6	6	6	6	6	5	6	**6**
Select All Items	2	2	2	2	2	2	2	2	2	2	**2**

Table E.11: Performance Evaluation of Ten Items (in seconds)

E.13 Performance Evaluation of 100 Items

Table E.12 below gives the performance evaluation of 100 item.

Task	1	2	3	4	5	6	7	8	9	10	Avg
Upload Items	72	79	84	83	75	79	68	81	70	72	**76**
Add Item Metadata	12	11	11	13	13	13	13	12	12	12	**12**
Edit Item Metadata	12	13	13	14	13	13	13	13	21	13	**14**
Delete Item Metadata	5	5	5	6	6	5	6	6	5	5	**5**
Move Items	5	6	6	6	6	6	7	7	6	7	**6**
Select All Items	3	2	3	2	2	2	3	3	3	3	**3**

Table E.12: Performance Evaluation of 100 Items (in seconds)

E.14 Performance Evaluation of 500 Items

Table E.13 below gives the performance evaluation of 500 items.

Task	1	2	3	4	5	6	7	8	9	10	Avg
Upload Items	476	496	506	521	528	503	549	499	516	536	**513**
Add Item Metadata	13	13	14	14	14	14	12	13	14	14	**13**
Edit Item Metadata	14	13	13	13	13	13	13	13	14	13	**13**
Delete Item Metadata	6	6	6	7	6	6	6	6	7	6	**6**
Move Items	7	6	6	7	6	7	7	7	7	7	**7**
Select All Items	3	3	3	3	3	3	3	3	4	4	**3**

Table E.13: Performance Evaluation of 500 Items (in seconds)

E.15 Performance Evaluation of 1000 Items

Table E.14 below gives the performance evaluation of 1000 items.

Task	1	2	3	4	5	6	7	8	9	10	Avg
Add Item Metadata	12	11	11	13	12	12	13	13	12	12	**12**
Edit Item Metadata	12	13	13	13	12	13	13	14	14	14	**13**
Delete Item Metadata	6	6	7	6	5	6	6	6	5	5	**6**
Move Items	6	7	6	7	7	7	6	7	6	7	**7**
Select All Items	3	4	3	3	4	3	3	4	3	4	**3**

Table E.14: Performance Evaluation of 1000 Items (in seconds)