Design Specifications Of An Online Collaborative Workspace

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Abstract

This article reports on a pilot project which was developed to meet the needs of specific research groups for a collaborative workspace. Such a system was deemed necessary because of today's global network of researchers who are divided by both location and time. The need therefore exists for a system which allows researchers to work on a project without the need to be in the same physical location. Such a system is called an online collaborative workspace and allows researchers to work together on projects by providing various means of sharing information and resources. The main research question in this paper centres around the user requirements and design specifications of an online collaborative workspace developed in open source software. As the final outcome of this research project was to develop a framework that meets specific user requirements, it was decided to follow a developmental approach. The research methods that were used therefore consisted of first identifying the user requirements of today's research community. This was done by combining the findings of both an informal survey and a literature review of existing systems. The study found that the user requirements and main components of an online collaborative workspace consist of a digital library, online discussion forum, adaptive hypermedia engine and a statement database. These components were successfully integrated into a framework using a developmental approach ensuring that the aforementioned user requirements were met.

Keywords

Collaborative workspace, digital library, adaptive hypermedia, discussion forum, developmental approach

1 Introduction

This article reports on a pilot project which was developed as part of a Masters degree (Bothma 2007) to meet the needs of specific research groups for a collaborative workspace. The main components of the project include a digital library, online discussion forum, adaptive hypermedia engine and a statement database.

Such a system was deemed necessary because of today's global network of researchers who are divided by both location and time. The need therefore exists for a system which allows researchers to work on a project without the need to be in the same physical location. Such a system is called an online collaborative workspace. An online collaborative workspace allows researchers to work together on projects by providing various means of sharing information and resources.

Although many projects exist that address specific requirements of the research community, the literature survey and interviews performed during this study indicated that existing systems do not necessarily satisfy all the needs of users. Moreover, most systems are built using proprietary software, thus limiting customisation of the components to suit the unique needs of an institution or a specific research group. Another result of proprietary software is the cost of development, therefore making the final system unobtainable to most research groups.

The main reason, therefore, for the development of this framework was to create a prototype, using open source software, that satisfies the needs of specific research communities by addressing the shortcomings of the existing systems.

2 Problem Statement

These limitations exposed a gap in the solutions available to today's researchers. The main research question addressed in this study follows, as well as the sub-questions that need to be addressed in order to answer the main question:
- What are the user requirements and design specifications of an online collaborative workspace developed in open source software?
  - What are the main design principles and functionalities of such a collaborative workspace?
  - How can they be integrated in developing a modular open source framework?
  - To what extent can such a framework be customised for implementation in new or existing collaborative projects?

- What are the usability requirements of such an online collaborative work-space?

To answer these questions and address the respective issues, a prototype system was developed using Open Source Software.

3 Research Methodology

As the final outcome of this research project was to develop a framework that meets specific user requirements, it was decided to follow a developmental approach. The research methods that were used, therefore, consisted of first identifying the user requirements of today's research community. This was done by combining the findings of both an informal survey and a literature review of existing systems. The literature survey consisted of consulting both scholarly research and existing systems. An informal survey consisting of a number of interviews with researchers provided invaluable insights into the exact features required by today's research community. Lastly, the framework, meeting the user requirements, could therefore only be developed after gaining a better understanding of the research field.

4 Motivation For The Use Of Open Source Software

Open source software was used for the development of this framework because of its various advantages over proprietary software. This section will briefly list the various benefits of open source software, as compiled from Bobulous (2004), CPR (2004) and Gonzalez-Barahona (2000).

- It is free: Open source software allows institutions the opportunity to obtain sophisticated solutions without the cost incurred when opting for proprietary solutions.

- Availability of source code: The source code of open source software is available to anyone and can therefore be altered to suit the specific needs of a user or institution.

- Cross platform: The ability to modify open source software allows developers to port software to any operating system. By providing users the freedom of choice with respect to operating environments, open source software limits the need for additional supporting software to be acquired.

- Not bound to a specific company: Open source software is usually developed by a group or community of developers who act on a volunteer basis. For this reason, the life time of open source software is usually not bound to a specific company or individual.

Additional choice: Open source allows users much more choice within a product or solution. One such reason is the ability of open source projects to "fork", creating a new project with a new set of goals and features.

The motivation for the use of open source software becomes clear from the above mentioned list of advantages. As a result, the final framework will be more accessible to researchers and users because of its cost, portability and availability. In the end, researchers and institutions will benefit from the various advantages of open source software.

5 Related Work

For this research a thorough literature survey was done of the three areas comprising an online collaborative workspace, namely digital libraries, adaptive hypermedia and collaborative workspaces. A review of current implementations of the various components (in both scholarly research as well as commercial systems) provides insightful information into the features of these components and how they can be adapted to suit the needs of an open source collaborative workspace. For a more detailed review of the literature, refer to Bothma (2007). Following is a brief review of the three components that were identified during the literature survey.

5.1 Digital Libraries

Levy (1995) identifies three core components of a library and then goes on to redefine these components in the context of a digital library. These three components comprise the following:
* Documents: A library can contain either a single fixed version of a document, or there could be multiple versions of a document that can change as time progresses.
* Technology: The underlying technologies of a digital library and its artefacts will inherently be of a digital form.
* Work: Most work done on the digital library, be it managing or research, is done by individuals working alone. For example, a student could sit in his/her room and use the digital library without any interaction with humans.

At the 1998 DLib Working Group on Digital Library Metrics (DLib 1998) the following properties for a digital library were proposed:
* Provide a collection of services.
* Provide support to users in dealing with information objects.
* Provide a collection of information objects.
* Organise and present information objects.
* Be available directly or indirectly.
* Be available via electronic/digital means.

If implemented correctly a digital library can have certain advantages over a traditional real-world library. Consider this list of advantages obtained from Anderson (1997), Lesk (1995), Miles-Board (2004) and Thong (2004):

- support for enterprise and work group activities
- searching
- accessibility
- preservation
- tracking
- associative linking and annotations
- multimedia/rich media

From the literature surveyed, it is evident that a digital library allows researchers to publish their research findings to a centralised repository, which assists the research community to share their findings and ideas.

5.2 Adaptive Hypermedia

The second component identified during the literature survey is adaptive hypermedia systems that arose from users' diverse needs to present information when browsing large hypermedia systems. In an adaptive hypermedia system a user can be presented with customised content and navigation links based on the user profile (Brusilovsky 1998 and Kristofic and Bielikova 2005). Questions that need to be answered include:

- Which systems can be adapted?
- What can be adapted and how?
- What user features are needed for adaptation?
- What will adaptation achieve?

Adaptive hypermedia systems have been implemented in a number of different disciplines, such as educational systems (Brusilovsky 1998 and Kristofic and Bielikova 2005) and context-aware tourist guides (Cheverst, Mitchell and Davies 2002). These systems all typically contain vast amounts of information and each user's information needs are unique, thus providing the perfect opportunity for adaptive hypermedia to support users in their information gathering needs.

An important question to ask about adaptive hypermedia is what can and should be adapted. One should identify the components of the system that need to be adapted for individual users. The two components of an adaptive hypermedia system that can be adapted are the content and links (Bailey et al 2002, Boll 2003 and Brusilovsky 1998). Link level adaptation consists of direct guiding, link presentation, adaptive ordering, link hiding and adaptive annotation. Content level adaptation is applied to the visual presentation and comprises adaptive text presentation, adaptive multimedia presentation and interface adaptivity.

In addition to adaptation, adaptive hypermedia also allows for recommendations to be made to users of the system (Bao, Zou and Zhang 2005, Han and Karypis 2005, Mobasher et al 2001 and Schafer, Konstan and Riedl 2002). Recommendations can be made by analysing a user's browsing history, comparing user profiles to both documents and other users' profiles.

5.3 Collaborative Workspaces

In many of today's collaborative projects, members can be separated geographically from one another. This has lead to the emergence of online collaborative workspaces (the third component identified during the literature survey) to allow project members to communicate with one another and to share documents and resources effectively. When analysing collaborative workspaces, one finds different approaches to how systems allow interaction between project members, resource sharing, tracking and storage. Certain systems will, for example, focus on providing members with real-time collaboration whilst others will focus more on asynchronous document management and versioning.

With regard to their functionalities most collaborative tools fall into two main categories (Dourish and Belotti 1992, Geyer et al 2003 and Spellman et al 1997), namely:

• Session-centric: These are synchronous systems that allow project members to communicate in real-time with one another, for example teleconferencing.

• Document-centric: These systems focus on document management with no synchronous interaction between project members.

Spellman et al (1997) has proposed a system combining both document and session centric approaches and places the focus on creating a collaborative "place" where project members can meet and perform both synchronous and asynchronous work.

In order to develop an effective collaborative workspace, one first needs to understand the needs of a project's team members. In their research, Tang and Leifer (1998) has identified a set of characteristics which they observed from a group of people interacting with one another during typical project meetings. These characteristics included the following:
• store information
• convey ideas
• represent ideas
• engage attention
• manage events

It is important to keep all of these features in mind when developing an online collaborative workspace, as the integration of the various components will determine the

success of the framework. The framework will therefore have to integrate the various components to ensure that users can seamlessly move between each component whilst performing their tasks.

6 Findings

By reflecting on the various components that were identified in the literature survey, it became evident that the integration of these components will provide a framework that would meet all the user requirements of an online collaborative workspace. A framework comprising a digital library, collaborative workspace and discussion forum would allow users to share their thoughts and research findings in one centralised place, which will greatly improve efficiency. Effectiveness is achieved through the standardisation of information management by both the system and the users. Moreover, users will become accustomed to performing tasks in one system, using standardised steps, which will allow them to quickly become experts in the submission as well as retrieval of information.

6.1 List Of Modules

A list of modules were derived from the components and features identified during the literature survey.

Content Module

One of the features that were identified to allow users to focus on a certain area of a research project is adaptive hypermedia. The content module provides the framework with adaptive hypermedia capabilities to customise the content, presentation and navigation for each individual user.

Online Discussion Forum Module

An important aspect of an online collaborative workspace is the ability for researchers to share and convey ideas. The online collaborative workspace provides users with a threaded discussion forum where they can post, read and reply to comments and ideas.

Digital Library And Workspace Module

Most research projects have as an outcome the publication of various research findings. The digital library and workspace allows researchers to publish the documents and resources to a centralised repository where it can then be accessed by the research community. In addition to providing researchers with a centralised repository, the workspace also allows researchers to review and revise a document during its life cycle.

Statement Database Module

The statement database allows researchers to make comments regarding certain topics or ideas. It therefore provides researchers with another form of conveying ideas to the research community.

6.2 Features That Can Be Integrated

It is important to integrate the various components and their respective features identified in the literature survey in order to develop a framework that meets all the requirements of its potential users. The literature survey exposed overlapping features between the various components which may be integrated to provide an online collaborative workspace that supports researchers in their research efforts. Features that can be integrated to provide a truly online collaborative workspace follow below.

Metadata

The use of metadata is critical when describing information objects contained in both a digital library and an adaptive hypermedia system. Metadata can be used to describe the various properties of objects, ranging from title, author and abstract to more complex properties such as level of difficulty, sequencing and requirements. It is therefore important to find a unified metadata solution that can be integrated for all the information objects used throughout the framework.

Information Management

The submission and management of information objects is a common occurrence in all three of the main components. Each component, however, has a slightly different approach to storing and managing information objects. It is therefore important to find a means of managing these information objects that is best suited to all scenarios. A unified way of submitting, editing and revising these information objects would therefore greatly assist the development and modularity of a framework supporting these various components.

Information Retrieval

In addition to the management of documents, it is also necessary for users and researchers alike to be able to retrieve these information objects using various information discovery techniques. These techniques include browsing repository hierarchies, searching and direct linking. Certain techniques are more suited to other components due to the nature on the information objects. For example, research documents are described by a richer metadata schema, allowing for more complex search queries to be performed.

Convey Ideas

An important aspect of researchers working in a collaborative environment is the ability to convey ideas relating to various topics. These ideas range from simple statements to threaded discussions. Examples of such components include threaded discussion boards, synchronous chat applications and shared whiteboards.

User profiling

User profiles can be used to provide users with customised information as well as recommendations. This can be useful in projects where researchers focus on one specific area in a multi-dimensional research project. By using profiles, users are spared the time consuming task of filtering through information that is of no importance to their specific domain. The use of metadata to both describe user interests and information objects is invaluable when determining which information is best suited for each user.

7 Development Of The Framework

For reasons of brevity, this article will only focus on the development of the repository module. For a complete description of all the modules, please refer to the full dissertation of Bothma (2007).

7.1 Digital Library And Workspace

In essence the repository is a hierarchical storage of documents of any format. Documents can be retrieved by either browsing or using the search functionality. The repository module allows for the creation of a fully functional digital library supporting versioning, hierarchies, browsing, searching, etc.

Documents are submitted to the repository, accompanied by descriptive metadata, and stored in the appropriate location in the hierarchy. A relational database is used to store the metadata to allow for fast searching. Also, on submission of a document a reverse index of the content is created to allow for full text searching of documents.

The Repository Module was developed to be flexible enough to allow for implementation in two formats, namely a digital library and a workspace.

Digital Library

When implemented as a digital library, the repository limits the functionalities that can be performed on the documents contained within. In essence, a digital library is used to store documents as they appear in their final format. It is therefore suited for documents or articles that have been through a peer review process which serves to provide users with valuable reference material.

Workspace

Unlike a digital library, a workspace allows users the ability to change documents contained within the repository. Users can check-out a document to make changes and then submit a new version of the document to the repository. It can therefore be used in a collaborative environment where documents are not yet finalised and need to evolve in conjunction with the project.

7.2 Hierarchy And Document Storage

The repository is based on a hierarchical storage that represents the logical structure and ordering of the documents contained within. The hierarchy consists of a root directory with a collection of sub-directories, each containing its own set of sub-directories and documents. Documents are submitted to the appropriate directory within the repository to allow for logical browsing and searching.

Security constraints are placed on each of the directories in the hierarchy to restrict access to authorised users. This allows moderators to create, for instance, directories for each project within a corporation and only allowing access to project members. A directory's security role cascades down to all sub-directories and only higher roles can be applied to these directories.

The repository hierarchy is presented to the user as a tree structure that contains the titles of sub-directories and the collection of documents within the current directory. A user can then either choose to view a directory's sub-directories or select a document from the collection. Each document is represented by its title, date of creation and author.

Metadata describing a document, and the actual content of the document, are stored separately. The descriptive metadata is stored in a relational database, whereas the document's actual content, for example an Adobe Acrobat document, is stored on the server in the appropriate folder.

7.3 Presentation And Functionalities

An important aspect of the repository is the presentation of a document and its associated metadata. Much attention must be paid to this because of the importance of allowing a user to easily understand the information and functionalities on the page. The presentation of a document is divided into three main sections, namely the metadata, actual document content and a collection of available functionalities.

Metadata

The metadata describing the document is divided into three main sections.

Bibliographic details: The default collection of metadata fields describing the bibliographic information regarding a document consists of the title, author, subject, date of creation and status.

Document abstract: The document abstract is defined in the Dublin Core description field of the document's metadata.

Full metadata information: Here the full collection of metadata fields describing the document is listed. This contains the full Dublin Core metadata set as well as additional information used by the framework.

Actual Document Content

The document content is the actual content of the original document or information object and can be stored in various formats, such as Adobe Acrobat Documents, JPEG images or AVI videos. By default, the content is not displayed and the user is presented with the option to view the content in the current browser or open the document in a new browser window. The available display methods are defined in the associated XML configuration and can be limited to certain repository instances.

Available Functionalities

Various functions are available to the user depending on the repository instance and the security level of the current user. The functionalities for each instance of a repository are also determined by the type of implementation, namely digital library or workspace. There are eight available functions.

- View document metadata: This allows the user to either view or hide the bibliographic details, full document abstract or full metadata information for the current document.

- View location of document in the hierarchy: The location of the current document in the repository hierarchy is displayed, and each of the parent directories can be browsed.

- Available document versions: Displays a list of all available versions of the current document, with links to each version. This function is only available for workspaces.

- OAI representation of document's metadata: Documents contained within the repository can be represented as an XML document that is OAI compliant.

- Edit the document's metadata: Allows the user to edit any of the metadata fields describing the current document.

- Revise the current document: A user can post a revised version of the current document to the repository. This function is limited to workspaces.

- Unlock the current document: Allows a user to unlock the current document if it has been checked-out by another user for editing. This function is only available in workspaces.

- Remove the current document: The current document can be removed from the repository using this function.

Each of the aforementioned functions are limited to authorised users. The security constraints for each function are defined in the repository module's associated XML configuration document and can be customised for each repository instance.

7.4 Search

The search functionality allows users to search the collection of documents using a set of criteria. Search results presented to the user are grouped according to the document's location in the hierarchy. Each search result contains the title, author and date of creation for the document, with the title of the document being a link to the full document. To assist a user in choosing a document, its abstract is displayed in a small pop-up window when the mouse is pointed to the document's title. There are three types of search interfaces available to the user, namely simple, advanced and full text.

Simple Search

The simple search is the most basic of the three interfaces and provides for only limited accuracy. A user can search for a single word or phrase occurring within one or more of the available metadata fields. Search results thus consist of documents where at least one of the selected metadata fields contains the search word or phrase. For example, a user can search for documents containing the word 'Hypermedia' in either the title or abstract of the document.

Advanced Search

The advanced search allows for more accurate searching because of its ability to limit search words to specific fields. In other words, a user can search for documents containing the word 'Hypermedia' in its title and that were created by a person with the surname 'Jones'. The collection of available metadata fields comprises of the title, subject, location in repository, author's first and last name, and date of the document.

Full Text Search

In addition to searching the metadata describing documents, a user can also search the full content of a document using a full text search engine. A reverse index is created for each of the documents contained within the repository. The global index is updated once a new document has been submitted.

7.5 Submitting New Documents

The repository allows users to perform certain functions when submitting a new document.

Fill In Metadata Fields

The first step in submitting a new document is the supplying of all required metadata information. A user is presented with a collection of fields, which must be completed when submitting a new document. Depending on the type of information required, a user is either presented with text boxes used for free form text, or drop down lists, used in the event that specific pre-defined values need to be selected.

Select Location In Hierarchy

Once the metadata has been supplied, the user will be presented with the hierarchy of the repository and he/she must then select the appropriate directory for the document.

Upload Document Content

The last step in submitting a new document is the actual uploading of the document's content, which can be in any format, for example an Adobe Acrobat document. Once the document has been uploaded it will be stored in the appropriate folder on the server with a file name matching the identifier of the document, e.g. Library123.document.

7.6 Administrative Functions For Existing Documents

A requirement of any digital library is the ability to manage the existing collection of documents in the repository. The repository module allows for administrative functions for existing documents.

Editing The Metadata Of Existing Documents

A moderator has the ability to edit the metadata of a document after it has been submitted to the repository. Any modifications to the document's metadata is validated in the same way as when a new document is submitted to the repository.

Submitting Revised Versions Of Documents

The repository allows for various versions of the same document to exist side by side in the digital library. Once a document has been submitted, a user can check-out the document for editing and then submit a revised version of the document. Once a document has been checked-out, the document is locked until the user submits a revised version, ensuring that version control is enforced. Each version of a document inherits the metadata of the original version, whilst allowing for editing of any field's value.

Accepting New Documents

A new document that is submitted to the repository is not automatically accepted, and will thus not be visible to users. In order to ensure content quality a document must first be reviewed by a moderator who can then accept it into the repository.

Removing Existing Documents

Documents can be permanently removed from the repository. Once a document has been removed, all entries in the repository database and content files are removed from the server.

7.7 Managing Directories

A moderator has the ability to alter the hierarchy representing the repository by adding or removing directories. New directories are added by simply supplying the folder name, directory title and required security role for the new directory. Lastly, the location in the hierarchy of the new directory has to be selected from the list of existing directories. Existing directories can be removed from the hierarchy as well as all files contained within the directory.

7.8 Other Modules

As stated earlier, the framework consists of four components, namely digital library, content module, online discussion forum and statement database. All of the modules followed the same design patterns and concepts. Bothma (2007) provides a detailed description of the features and development processes of these modules.

8 Implementations

In order to test the effectiveness and usability of any system it is important to subject it to user testing and evaluation. This section reviews the various instances of the framework for each of the projects where it is used as well as the usability issues that

were encountered with each implementation. Each implementation could easily be customised to meet the client's specific needs due to the framework's vast array of features and modular design. Primarily, the framework is used for research projects where team members need to publish documents and use the internet to collaborate with one another. However, the adaptability of the framework has allowed it to also be implemented in commercial sites focussing on providing visitors a rich browsing experience by allowing its owners the ability to update its content and maintain a digital library of useful resources. At the time of writing the framework has been implemented in four projects:

- DISSAnet (http://www.dissanet.com) is a research project which aims to create a platform for the advancement of Library and Information Science research in South Africa.
- IKS (http://www.iks.co.za) or the Indigenous Knowledge Systems project provides a database of experts, projects and resources aimed at documenting and preserving indigenous knowledge held by communities throughout Southern Africa.
- IFLA-KM (http://www.ifla-km.org) is the official site of the Standing Committee for Knowledge Management of the International Federation of Library Associations and Institutions, IFLA.
- The Wellness Firm (http://www.wellnessfirm.co.za) is a company that provides wellness services and solutions to corporate clients.

Customisation of each implementation included custom designs and features, meta-data schemas used to store documents in the various repositories and the availability of required features to the users. Below follows a discussion of two of these research implementations.

8.1 Dissanet

OVERVIEW

DISSAnet is a research project which aims to create a platform for the advancement of Library and Information Science research in South Africa. For this project it was necessary to create a collection of repositories where conference proceedings for conferences organised by DISSAnet could be stored. Visitors to the site are allowed access to the publicly published conference proceedings whereas moderators have the responsibility of maintaining the collection of repositories.

Also worth noting is the fact that the framework was developed based on the needs of DISSAnet and grew from there. The DISSAnet website is therefore an example of a pure implementation of the framework.

CLIENT REQUIREMENTS

The DISSAnet project's requirements to provide an online repository for conference proceedings became the main objective for the development of this framework. An informal specification document was drawn up by the DISSAnet project leaders outlining the desired features for such an online digital library. Even though the development of an online digital library would satisfy the current needs of the project, it was decided that additional features should be developed that could greatly benefit the DISSAnet project in the future.

At the time of writing, the current implementation of the DISSAnet web site does not incorporate all the features of the framework, but there are plans to extend the features provided to its users.

FEATURES AND FUNCTIONALITIES

Following is an outline of the components and features provided by the DISSAnet website.

Static Information

Not all of the information contained within the site is generated dynamically, which therefore requires a moderator to publish static content to the site using the administrative functions provided by the framework.

Browsing

Visitors to the site can browse for conference proceedings of the past conferences that were organised by DISSAnet as well as those of other conferences. The repository contains as its root folders the collection of conferences, each containing in turn a collection of dates on which the conferences were presented. For instance, a visitor could access the conference proceedings for the 2004 ProLISSA conference by selecting the ProLISSA conference folder and then following the link to the 2004 conference.

View Conference Proceedings

After a visitor has selected the desired conference and date, he/she can then select a specific proceedings from the provided list. Each conference paper is accompanied by a full Dublin Core metadata schema describing, for instance, the title, author and date of the paper. In addition to the metadata, the visitor also has access to the full text of the paper in Adobe Acrobat format which he/she can either view in a frame below the metadata or in a new window.

Searching

Visitors can search for conference proceedings in cases where they don't have the detailed information relating to the conference or date. The search functionality provides visitors with both a simple and an advanced search option allowing them to provide as many or as few search parameters depending on the complexity of the search. Alternatively, visitors can perform a full text search by providing either a single word or sentence contained within the conference paper's full text document.

Repository Management

Moderators of the site are tasked with managing the collection of conferences and their respective proceedings. This is done using the administrative functions provided by the framework.

User Management

The implementation of the framework only allows for two groups of users, namely visitors and moderators. It is therefore the responsibility of the moderators alone to manage the repositories due to the fact that visitors to the site are limited to browsing information.

Lessons Learned

The DISSAnet project was the first project for which the framework was implemented. During the implementation of the framework various lessons were learned with respect to the user requirements, possible customisations and usability requirements of such a system.

User Requirements

The user requirements of the system continually changed during the development of the framework. An important aspect to keep in mind during future implementations is that the user requirements could change over time which requires one to be flexible enough to adapt to these changes.

Customisations

Certain aspects of the framework had to be customised after the initial prototype had been developed and tested. These included the interface of the web site, the metadata schemas and also the modules that were utilised. The ease with which these customisations were possible is a testament to the flexibility of the framework.

Usability Requirements And Testing

The initial testing of the framework for the DISSAnet project highlighted certain difficulties when performing certain tasks. By evaluating the user response that was obtained during testing and interviews, one could quickly determine which areas of the framework required improvements with respect to usability.

8.2 Indigenous Knowledge Systems (IKS)

Overview

The Indigenous Knowledge Systems (IKS) project provides a database of experts, projects and resources aimed at documenting and preserving indigenous knowledge held by communities throughout Southern Africa. Currently, the various repositories are maintained by the University of Cape Town's Centre for Information Literacy and a group of individuals. The IKS project's main areas of interest lie with documenting experts, projects and resources that were identified as being important in the understanding and preservation of indigenous knowledge. At the time of writing, there was a total of roughly 2900 records in the three repositories.

IKS's focus is more on providing an online digital library than being an online collaborative workspace. Members are able to upload records to the database and, pending a moderator's approval, the records will be made accessible to other members via either browsing or searching for resources. Similarly to the DISSAnet project, IKS also provides browsing, searching and management functionalities. However, unlike DISSAnet, IKS only allows registered members to access information through browsing and searching of the three repositories. In addition to the before mentioned functionalities, IKS also provides a discussion forum consisting of four main threads, one for each repository, as well as a general discussion board. The forum allows members to submit new questions and statements or to reply on existing posts.

Client Requirements

The IKS project proved to be a great test case for the framework's ability to allow for various repositories where each repository uses a different custom metadata schema to define their respective information objects. Most digital libraries make use of standard metadata schemas, such as Dublin Core, to describe their information objects. However, the IKS project's aim is to describe information objects that are not found in standard digital libraries. It quickly became evident that a new collection of metadata schemas had to be developed in order to accurately describe these information objects. For example, one of the repositories contains a collection of experts in their respective fields. Each expert is described using a custom metadata schema that was specifically

designed for the IKS project to ensure not only an accurate description of the information object, but also its relations to other objects in the various repositories.

Implementation And Customisation

As mentioned previously, the framework was designed in a manner that would allow customisations according to the client's specific needs. One such an example is the modification of the browsing function, which for the project's repository added a map of South Africa with its provinces lighting up when the user points to one of the sub-folders. Moreover, when the user clicks on a specific province, he/she will be directed to that specific province's projects within the repository. These features were added to enhance the browsing experience for the user by providing multiple methods of accessing the same data in the repository hierarchy.

In addition to the customisation of functionalities, the IKS project also required custom metadata schemas to be used in order to accurately describe the various repositories' resources. Each repository had its own specific requirements, in addition to the Dublin Core metadata schema, with regard to metadata due to the specialised nature of the resources being described. An example is the experts repository which is used to provide a database of experts within certain fields of indigenous knowledge. It was obvious from the start of the project that the standard metadata schema used to describe literature would not be sufficient and therefore close attention was paid when creating an additional schema to adequately describe these resources. Most of the new fields that were identified were used to describe biographical and contact information for the experts and contained simple free formed textual data. There were, however, certain fields that made use of lists to ensure data conformity when dealing with for instance research areas. These fields allowed for multiple selection of, for instance, research areas as well as cross-linking to projects contained within the projects repository.

Similarly to the experts database, the project database also required a customised metadata schema to accurately describe the entries in the database. The project's metadata schema also consisted of a range of simple text fields such as contact information as well as lists to once again ensure data conformity.

During the beginning stages of the project there weren't enough records for each repository to warrant the use of sub-folders. As a result, records were placed in the root of each of the repositories. As the number of records grew, it became apparent that sub-folders were indeed needed for each repository. An additional feature was therefore added to allow moderators the ability to move existing records from the root of the repository, or any other sub-folder, to a different sub-folder contained within the same repository. This is an example of how the framework can be adapted to suit a client's

needs and also of how such features can be incorporated into the core framework, enabling it to grow continuously.

Lessons Learned

Various lessons were learned during the initial implementation of the framework for the DISSAnet project. These insights were then incorporated in the original framework to ensure that future implementations would benefit. During the IKS project, however, certain new lessons and customisations arose and insights were gained with respect to user requirements, customisations and usability requirements.

User Requirements

The main focus of the IKS project's user requirements was to be able to have customised metadata schemas that could effectively describe the indigenous knowledge of the various repositories. During the later implementation phases certain changes had to be made to fields describing the various information objects. From this it was clear that ample time should be spent during the initial phases of the implementation to ensure that the various repositories and their respective metadata schemas are defined correctly.

Customisations

The main customisations for the IKS project were for the development of customised metadata schemas. Fortunately the framework's support for custom metadata schemas succeeded in meeting the project's complex needs. Additional customisations were, however, required later on due to the increasing number of records that were stored in the various repositories. From this, it was evident that even though the initial user requirements are laid out during the initial phases of the implementation it could still be required to perform additional customisations during the various phases of the project.

Usability Requirements And Testing

As with the DISSAnet project, the usability requirements of the project were addressed during the various phases by working closely with the various stakeholders. This close relationship, once again, proved to be very beneficial in the identification and addressing of usability requirements.

9 Recommendations

Certain policies and practices were followed during the development of this framework. This section will expand on the iterative development process, integration of functionalities, modular design and interactive development of the framework.

9.1 Iterative Development

During the development stages, the specifications were continuously revised due to ever changing user requirements. The iterative development of the project consisted of constantly revisiting past work and revising components in order to ensure that all user requirements were met. Another example where an iterative approach proved to be beneficial was with the various implementations of the framework. Each implementation required that the current version of the framework had to be revisited in order to determine which modules and components could be adapted to meet the new user requirements. The knowledge that was obtained after each implementation could then again be used to further enhance the functionalities provided by the original framework. Developers and project stakeholders should therefore follow an iterative development approach in projects where the user requirements constantly change and also in cases where a core framework is to be implemented in projects with specific needs.

9.2 Integration Of Functionalities

This research project first set out to determine which components are required in an online collaborative workspace. After obtaining a better understanding of the various components needed to provide such a system, the next step was to integrate the various components into a single framework. The motivation behind integrating the various components into a single framework was two-fold, namely to determine whether such a system would benefit researchers and institutions as well as whether development efforts could be minimised. By working closely with researchers and performing usability testing during the development phases it was determined that the integration of components proved to benefit users in their research efforts. Moreover, with respect to development, the benefits of integration became evident due to the successful integration of the various components' classes, reducing development time and increasing interoperability. One should therefore aim to integrate functionalities in a framework where the opportunity exists that each component could benefit from features that are provided by the rest of the system.

9.3 Modularity

The framework was intended to be implemented in various research projects, each with their own requirements. It was therefore decided from the start that a modular approach was to be followed with respect to the development of the framework. The framework comprises of both functional and supporting core modules. Before development began, the various modules for each group were identified and also how each module could be integrated to form a complete framework. By making use of a modular framework, it was easy to add, modify and remove modules to suit each implementing project's

individual needs. Another benefit of using a modular approach was that certain functionalities provided by the various modules' classes could be shared. By sharing these common functionalities, the development time could be reduced whilst code reuse was improved. For these reasons, any project which aims at providing customisable features to its users should therefore aim at separating its components into various modules to allow for the addition and modification of modules if the need arises.

9.4 Interactive Development

The development specifications of the project were constantly revised in order to suit the ever changing user requirements. Close interaction with project stakeholders is crucial in such an ever evolving project in order to ensure that the user requirements were always understood and implemented. In addition to meeting user requirements, another benefit of interactive development is that the usability of the framework can also be continuously assessed ensuring the efficiency, effectiveness and user satisfaction. One should therefore aim to work closely with the various stakeholders in order to ensure that user and usability requirements are met in a timely manner.

10 Future Work

The current core framework was developed based on the requirements of the original projects as well as the specific customisations that were required by the various implementations. From the literature survey, however, it can be seen that there are still features that could be implemented to further enhance the usability of the framework, for example, future work on the framework could focus on four areas discussed below.

10.1 Synchronous Communication

Currently the framework only supports asynchronous communication through, for instance, shared workspaces and discussion forums. This was sufficient for the projects for which the framework was developed. However, it would be of great benefit to future projects to also implement a collection of synchronous communication channels.

10.2 Installation Module

The complexity of the framework's installation scripts makes it very difficult for ordinary users to easily implement a new instance. In order to make the framework more accessible to ordinary users, a simple to use graphical installation application could be developed to simplify the installation process. Ideally, this installation application would provide users with a list of modules which could be implemented, wizards to edit the configuration files and also a means to integrate customised modules into the framework.

10.3 Editor For Adaptive Content

The content for the adaptive hypermedia is stored in various XML documents using a structure that defines the metadata, sections and links of each page. These XML documents are complex to create and maintain manually. An editor for the various pages within the framework would therefore greatly assist moderators in creating content that could be adapted to meet each user's personal profile.

10.4 Plug And Play Metadata Schemas

The framework's repositories support the use of both standard metadata schemas, such as Dublin Core, and also custom schemas developed specifically for the repository's subject matter. These metadata schemas are created manually for each repository and stored in XML documents. A plug and play metadata editor or wizard could be developed in order to assist users in the creation of these metadata schemas.

11 Conclusion

In conclusion, many collaborative workspaces exist that are currently used by research institutions and individuals. From the literature survey it became evident that there is indeed a lack of systems that meet all the user requirements of a truly online collaborative workspace. This research study's purpose was therefore three-fold. Firstly, the user requirements of an online collaborative workspace were identified by performing both a literature survey as well as informal interviews with research experts. After establishing all the user requirements, the next step was to develop and implement a framework that would meet the requirements and also allow for future enhancements. The final framework included modules supporting both static and adaptive content, a digital library, online discussion forum, statement database and user management. In addition to developing such a framework, another requirement was to do so using open source software, making the framework accessible to research institutions with limited resources.

The flexibility, scalability and conformance to user requirements of the framework were proven by successfully implementing it in various research projects as well as commercial web sites.

References

Anderson, WL. 1997. Digital libraries: A brief introduction. *SIGGROUP* 18(2):5-6.

Bailey, C, Hall, W, Millard, DE & Weal, MJ. 2002. Towards open adaptive hypermedia. *Proceedings of the Second International Conference on Adaptive Hypermedia and Adaptive Web Based Systems.* Lecture notes in Computer Science 2347. Berlin: Springer, 36-46.

Bao, Y, Zou, H & Zhang, J. 2005. Using PACT in an e-commerce recommendation system. *Proceedings of the 7th International Conference on Electronic Commerce*. New York: ACM Press, 466-470.

Gonzalez-Barahona, JM. 2000. *Advantages of open source software.* [Online] Available at http://eu.conecta.it/paper/Advantages_open_source_soft.html.

Bobulous. 2004. *Why you should use open source software.* [Online] Available at http://www.bobulous.org.uk/misc/openVclosed.html.

Boll, S. 2003. MM4U - A framework for creating personalised multimedia content. [Online] Available at http://mmit.informatik.uni-oldenburg.de/pubs/boll_DMS2003.pdf.

Bothma, P. 2007. *Design implications of an online collaborative workspace developed using open source software*. Unpublished MIS dissertation, University of Pretoria.

Brusilovsky, P. 1998. Methods and techniques of adaptive hypermedia, in *Adaptive Hypertext and Hypermedia*, eds. P. Brusilovsky, A. Kobsa, and J. Vassileva. Dordrecht: Kluwer.

Cheverst, K, Mitchell, K & Davies, N. 2002. The role of adaptive hypermedia in a context-aware tourist GUIDE. *Communications of the ACM* 45(5):47-51.

CPR. 2004. *California Performance Review, Explore Open Source Alternatives*. [Online] Available at http://cpr.ca.gov/report/cprrpt/issrec/stops/it/so10.htm.

Dourish, P, & Belotti, V. 1992. Awareness and coordination in shared workspaces. *Proceedings of the 1992 ACM Conference on Computer-supported Cooperative Work*. New York: ACM Press, 107-114.

DLib. 1998. *DLib Working Group on Digital Library Metrics*. [Online] Available at http://www.dlib.org/metrics/public/papers/dig-lib-scope.html.

Geyer, W, Vogel, J, Cheng, L-T & Muller, M. 2003. Supporting activity-centric collaboration through peer-to-peer shared objects. *Proceedings of the 2003 international ACM SIGGROUP conference on supporting group work*. New York: ACM Press, 115-124.

Han, EHS & Karypis, G. 2005. Feature-based recommendation system. *Proceedings of the 14th ACM International Conference on Information and Knowledge Management*. New York: ACM Press, 446-452.

Kristofic, A & Bielikova, M. 2005. Improving adaptation in web-based educational hypermedia by means of knowledge discovery. *Proceedings of the sixteenth ACM Conference on Hypertext and hypermedia.* New York: ACM Press, 184-192.

Lesk, M. 1995. *Why Digital Libraries?* [Online] Available at http://www.ukoln.ac.uk/services/papers/follett/lesk/paper.html.

Levy, DM. 1995. Going digital: A look at assumptions underlying Digital Libraries. *Communications of the ACM* 38(4):77-85.

Miles-Board, T. 2004. *Everything integrated: A framework for associative writing in the web*. [Online] Available at http://eprints.ecs.soton.ac.uk/8852/.

Mobasher, B, Dai, H, Luo, T & Nakagawa, M. 2001. Effective personalisation based on association rule discovery from web usage data. *Proceedings of the 3rd international workshop on web information and data management*. New York: ACM Press, 9-15.

Schafer J, Konstan, J & Riedl, J. 2002. Meta-recommendation systems: user-controlled integration of diverse recommendations. *Proceedings of the eleventh International Conference on Information and Knowledge Management*. New York: ACM Press, 43-51.

Spellman, PJ, Mosier, JN, Deus, LM & Carlson, JA. 1997. Collaborative virtual workspace. *Proceedings of the International ACM SIGGROUP Conference on Supporting Group Work: the Integration Challenge*. New York: ACM Press, 197-203.

Tang, JC & Leifer, JL. 1988. A framework for understanding the workspace activity of design teams. *Proceedings of the 1988 ACM Conference on Computer-supported Cooperative Work*. New York: ACM Press, 244-249.

Thong, JYL, Hong, W & Tam, KY. 2004. What leads to acceptance of digital libraries? *Communications of the ACM* 47 (11):78–83.