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Abstract

Concept lattices assist human understanding in three ways: firstly, by collecting formal concepts that contain maximal sets of objects with shared attributes; secondly, the relatedness of concepts is revealed by providing a hierarchy of formal concepts in the information space. Finally, the concept lattice (drawn as a line diagram) reveals inferences that can automatically derive association rules. Therefore, a major hypothesis of the application of concept lattices is that they visually assist in understanding the structure of information contained within an information space. However, there has been little in the way of empirical tests to substantiate this hypothesis. This paper describes the process and results of a usability evaluation for a program called Mail-Strainer, a Web-based variant of the Mail-Sleuth program, which in turn is based on the Conceptual Email Manager (Cem).

Keywords

Evaluation, Concept, Lattice, web, based, Mail, browser

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Evaluation of Concept Lattices in a Web-based Mail Browser

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Abstract. Concept lattices assist human understanding in three ways: firstly, by collecting formal concepts that contain maximal sets of objects with shared attributes; secondly, the relatedness of concepts is revealed by providing a hierarchy of formal concepts in the information space. Finally, the concept lattice (drawn as a line diagram) reveals inferences that can automatically derive association rules. Therefore, a major hypothesis of the application of concept lattices is that they visually assist in understanding the structure of information contained within an information space. However, there has been little in the way of empirical tests to substantiate this hypothesis. This paper describes the process and results of a usability evaluation for a program called MAIL-STRAINER, a Web-based variant of the MAIL-SLEUTH program, which in turn is based on the Conceptual Email Manager (CEM).

1 Introduction

This paper presents software with a design methodology that places Formal Concept Analysis (FCA) as the core navigation and visualisation aid to manage Web-based email. The hypothesis is that if users are able to read and understand the MAIL-STRAINER line diagram, then the program serves as an appropriate tool to manage Webmail. In so far as MAIL-STRAINER is a authentic implementation of concept lattices for information visualisation, its evaluation can be used to draw conclusions about the ability of novice FCA users to interpret line diagrams.

The paper is presented in two parts. The first looks at the development of an open source Web-mail implementation based on SquirrelMail [1]: the resulting FCA Web-mail environment is called MAIL-STRAINER. To gauge how true an implementation MAIL-STRAINER is of FCA, we need to understand its pedigree. This description of the MAIL-STRAINER is intended to convince the reader it is an authenticate FCA implementation. The second part of the paper includes the presentation of results from a usability study with 16 University students. The conclusions drawn about the information visualisation aspects of MAIL-STRAINER are used to infer conclusions about the ease of use and readability of concept lattices by an audience untrained in Formal Concept Analysis (FCA).

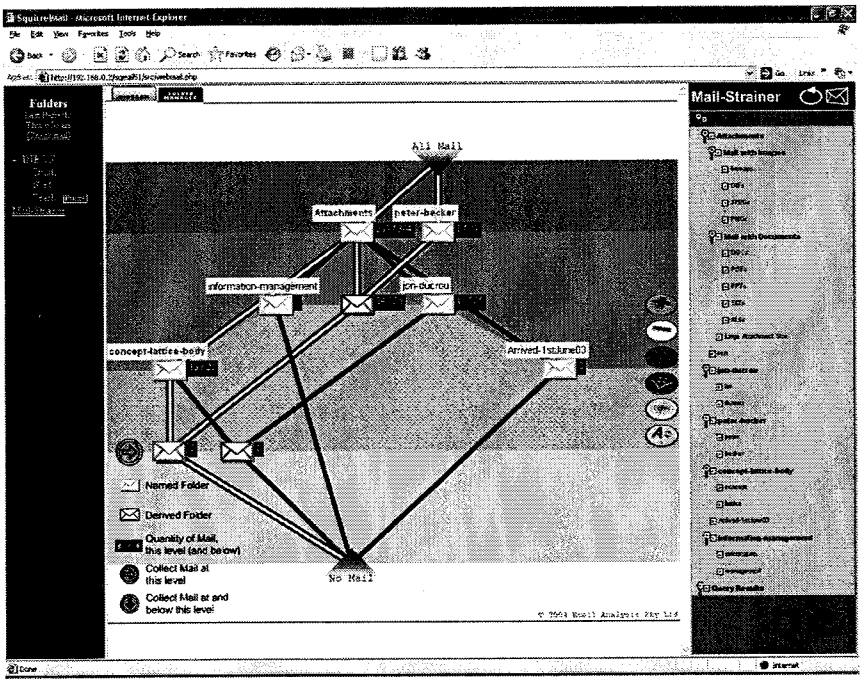

Fig. 1. A screenshot of the MAILSTRAINER program showing the re-used elements of the flash-lattice drawing program (center) and a multiple inheritance tree-widget on the right. On the left are typical Webmail controls such as those used in Mirapoint. MAILSTRAINER is built on top of the open-source SquirrelMail program and is a concept lattice-based Webmail environment.

2 Background and Survey: Email Management and FCA

Email management is a specific type of knowledge management problem. It is a sub-class of document management in that the typical methodologies for indexing, searching and modifying documents are employed. It differs from document management in that the task of processing email is based on a single identifiable process – namely, retrieving and browsing email in a single context. The research described in this paper looks at the issue of Email Management with this in mind.

Cole and Stumme [8] describe a technique for organizing email to be searched and browsed with a central visual concept lattice component. In a series of papers by Cole, Eklund and Stumme [8,9,6,7], the authors show how a concept lattice can be used to navigate text document collections. More generally, information retrieval systems based on concept lattices have been experimentally evaluated in Godin et al [11] and Carpineto and Romano [2,3] who have shown that the FCA-based technique is useful for document browsing and discovery.

2.1 MAILSTRAINER Objectives

Web-based mail (Webmail) is a popular client type for email. The hypothesis of this research is that if it is possible to build a Webmail interface using concept lattices: if users then understand how to examine concept lattices it follows that they will have a greater likelihood to search, browse and manage email in the Web-based context. One aim is to engineer an interactive environment for searching and browsing email in a Web-based context. The work therefore extends research carried out by Cole et al. [7], applying concept lattices as a lightweight visualisation package and applying a virtual file structure for managing email in an open-source, server-side environment. The functionality of a Conceptual Email Manager (CEM) [7] from a user's perspective is to:

1. *retrieve previously stored emails* – in a visual and logically clustered way;
2. *discover knowledge in the email collection* – to find collections of emails thematically linked and discover patterns of communication between different groups or to detect frequently recurring topics.

From an implementation perspective, the system functionality is to:

1. *engineer* a method for indexing mailboxes, via a protocol such as IMAP, and determine how to integrate the MAIL-STRAINER framework into an open-source Webmail package;
2. *adapt* the existing implementation of the concept lattice in the parent program – MAIL-SLEUTH – and apply it to a Web-based context, examining the index structures built in point 1.;
3. *create* the necessary navigational structures required to mimic the MAIL-SLEUTH (CEM) folder structure presented through a traditional tree widget.

2.2 FCA and Information Retrieval

In [4], Carpineto and Romano present an overview on Information Retrieval using Formal Concept Analysis (FCA). In applying FCA to the domain of email management (or document retrieval systems in general), we consider documents to be the objects, and a set of index-terms or keywords to be the attributes that describe a particular email or document. A concept within the domain of such a system would consist of a subset of the documents and a subset of the index-terms. Cole and Eklund [5] report that previous applications that have made use of FCA for Information Retrieval can be divided into two categories: (i) those that generate a large concept lattice, the number of concepts is roughly the square of the number of documents; (ii) those that use conceptual scaling and/or object zooming to reduce computational and display complexity.

Carpineto and Romano [4] explain that automatic generation of index terms can be done in several ways. While "full-text retrieval is easily handled by most statistical information retrieval systems, it is not practical for concept lattice-based applications, for which we need to generate a restricted set of terms". To overcome this problem they suggest that a five step approach involving *text*

segmentation, word stemming, stop wording, word weighting (based on term frequency) and *word selection*, i.e. using some heuristic threshhold with which to select the index terms (attributes) with the highest weighting.

Cole and Stumme [8] describe the process of creating a *Hierarchy of Classifiers* for an email knowledge base. This Hierarchy of Classifiers is based on partial order theory, and allows a series of catchwords to be associated with an email. Further, the Hierarchy of Classifiers allows a specific ordering of these catchwords implied by the user's search query. The Hierarchy of Classifiers play an important role in internally mapping email concepts based on the email knowledge base.

2.3 Conceptual Email Manager (CEM)

There are several detailed papers that outline arguments for using a concept lattice within a Conceptual Email Manager (CEM). Cole and Stumme [8] tie the archetypical Conceptual Email Manager with Formal Concept Analysis, and hence, with concept lattices. They describe a Conceptual Email Manager as three high-level structures:

> (i) a formal context which assigns to each email a set of catchwords;
> (ii) a hierarchy on the set of catchwords in order to define an information ordering over the catchwords; and
> (iii) a mechanism for creating conceptual scales which are used within a graphical interface for the retrieval of emails.

An important realisation about filing email is that it is usually multi-attributed. When we classify email under one attribute it detracts from the meaning of the email because we loose the ability to recall the email by its other attributes. This is a general problem with the traditional hierarchical filing methods. Creating folders for files for an email means it must fit into one directory or file otherwise copies need to be made. Meaning is lost as a result of decreasing the number of attributes an object is associated with. In a CEM, "the formal concepts replace the folders. In particular, this means that emails can appear in different concepts" [8]. A concept lattice is a proven visual tool for navigational aid and moreover, a good conceptual organiser.

2.4 Mail-Sleuth

In MAIL-SLEUTH, conceptual scales are determined by the user, and the realised scales are derived from them when a diagram is requested by the user. MAIL-SLEUTH is capable of restoring scales defined in previous sessions, via the storage of scales against unique names. There were four requirements in the design of MAIL-SLEUTH, namely:

1. to assist the user in editing and browsing a classifier hierarchy (the underlying folder structure): the classifier hierarchy is a partially ordered set $(M, \leq)$ where each element of M is a classifier. The structure of $(M, \leq)$ must be evident, and modifiable.

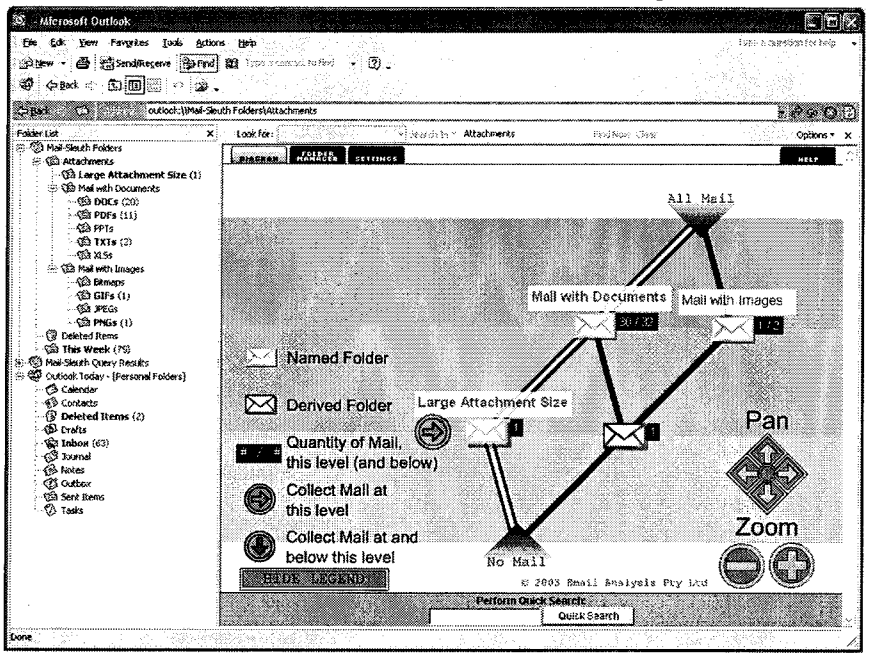

Fig. 2. The final "look" of MAIL-SLEUTH. The line diagram is highly stylized and interactive. Folders "lift" from the view surface and visual clues (red and blue arrows) suggest the queries that can be performed on vertices. Layer colors and other visual features are configurable. Unrealized vertices are not drawn and "Derived" Virtual Folders are differentiated from Named Virtual Folders. A high level of integration with the Folder List to the left and the Folder Manager (see tab) is intended to promote a single-user Conceptual Information System task flow using small diagrams [13].

2. to help the client visualise and modify conceptual scales.
3. to allow the client to manage the assignment of classifiers to emails (query to structure attribution): MAIL-SLEUTH should (a) automatically associate emails with classifiers based on email content, and (b) view and modify email classifiers
4. to assist the client in searching the conceptual space of emails for both individual and conceptual groupings of emails: navigation through concept lattices derived from conceptual scales.

Eklund et al. [13] describe an independent test and survey that was carried out on MAIL-SLEUTH. In a discussion about the incorporation of the concept lattice in MAIL-SLEUTH they state that "participants were able to read the lattice diagrams without prompting" [13]. This gives partial evidence for the incorporation of line diagrams within an email management context but needs to be independently verified in the context of this study.

This research will therefore make use of concept lattices for two reasons. The first is that it is a authentic implementation of concept lattices for information

visualization. The second is that, usability testing for MAIL-SLEUTH suggested user acceptance and understanding of concept lattices. This prompts speculation that if the interface of MAIL-STRAINER closely resembles that of MAIL-SLEUTH, then a similar usability rating would result.

3 Usability Evaluation

3.1 Test Methodology

This research adopts a quasi-naturalistic approach to HCI research methodology [12] where the experimenter attempts to set up an trial as close as possible to a real-life situation, while still maintaining some level of control over the experiment. In the case of MAIL-STRAINER, Webmail will look as similar as possible to the University of Wollongong's Mirapoint Webmail: a system the subjects are familiar with.

One of the driving forces behind this research is the opportunity to endorse awareness about Formal Concept Analysis and its use by way of developing a prototype that makes use of concept lattices. MAIL-STRAINER has two main user contexts. The first monitors the effect that visualisation – through the use of concept lattices – has on a user in a Web-based environment. This involves a usability analysis and exploration as to whether or not MAIL-STRAINER meets the requirements of a user configured email management tool. The second context examines how MAIL-STRAINER works within the environment in which it is embedded.

3.2 Test Subjects

The study seeks to create an understanding of users across a range of disciplines and computer usage capabilities and capacities. One of the necessary requirements in the design of MAIL-STRAINER is that it targets a wide range of users of diverse ability, culture and age. This study is aimed at sixteen test subjects sought to complete a usability test of MAIL-STRAINER based on a pre-conceived usability script. Twenty is a good sample for a study of this magnitude, and while there should have been 20 undertaking the usability sessions, 4 were unable to attend due to last minute difficulties. A commercial study might look at a sample of up to 300–400 people in a much broader demographic. Sixteen participants attended testing sessions for around 1 to 1.5 hours each. Attendance times differed substantially because users took different amounts of time to complete the script and answer the survey/feedback questions.

A reduced and specific target audience is chosen for pragmatic reasons and to eliminate several unnecessary variables. In an attempt to understand how MAIL-STRAINER affects its target audience, a sample of University students from a range of disciplines were chosen (see Fig. 5). These students were asked to use MAIL-STRAINER within a restricted test-bed. Within testing sessions, participants provide evaluative feedback in response to a series of survey questions

	Description
1	Mail-Strainer makes it easier to locate emails - especially when the inbox is full and also makes it easier to locate specific attachments
2	The Concept Lattice is good because it shows links between folders and emails
3	A comprehensive and functional tool and fairly simple to operate, a powerful search facility with customisable queries for most useful email qualities
4	Appealing to visual senses
5	Great for searching for specific emails, when you are too lazy or have too much mail in your mailboxes
6	Easy to navigate - even for a computer dummy
7	Mail-Strainer would be an extremely useful tool, especially for someone who received > 200 emails per day (or just lots of email in general) - many people mentioned this
8	Extremely useful tool for email sorting and categorisation
9	Once over the initial learning curve, it is quite simple to use, it would be useful to someone who took the time to figure it out
10	Virtual Folders make viewing of a particular subset of emails much easier, and you don't have to remember where you put an email (like with traditional filing)
11	Allows the user to personalise their mailboxes to suit their requirements
12	Mail-Strainer is a much better way of organising email than simply placing separate emails into folders that have no connection/interaction, and provides a permanent way of searching and categorising mail without having to repeat the search query
13	Good idea to have the Mail-Strainer tree in conjunction with the lattice
14	Folder Manager is easy to use

Table 1. Mail-Strainer Positives as identified by Testing Participants

(shown in Table 3), and in most cases, one-on-one interview questions as well as providing feedback through a test script (summarized in Tables 1 and 2). The test-bed includes an instance of MAIL-STRAINER embedded within SquirrelMail and an adequate set of test email. The test data is a single IMAP email account with an mailbox containing approximately 300 mail items. This mailbox is the same as that used in Access Testing's evaluation of the Mail-Sleuth product reported in [13].

To summarise previous ideas mentioned in this section, the second phase of this research focuses on hypothesis testing through qualitative cross-sectional study and assessment: encouraging users to evaluate MAIL-STRAINER as an email management tool through participation and observation. It observes group statistics that point out the participants abilities to complete the tasks in the test script. The second phase is a conversion of the results from this study into an argument in favour or against the use of Web-based email management using MAIL-STRAINER.

	Description
1	There is a large learning curve related to understanding the Line Diagram, and Mail-Strainer in general
2	The concept lattice is invaluable but needs more assistance and explanation
3	Should be able to delete emails though Mail-Strainer folders and deleting folders with a tick-box would also be a benefit
4	Creating substructures within the folder structure was an issue (programmer's fault)
5	One person said that "Mail-Strainer was annoying to navigate"
6	The "monster lattice" is a problem that occurs when there are too many structures within the folder structure. This is both a problem computationally and also in terms of readability. There should be a reduced Line Diagram (functionality wasn't turned on at testing time)
7	Would be less frustrating when the bugs are ironed out, e.g., Mail-Strainer became very slow when adding 2 extra 'queries' (structures)
8	There should be more limitations so that the items that are in trash are not indexed (this is available in Mail-Sleuth)
9	Labels on the lattice were hard to read (this was typically a user navigational issue - not understanding the components in the panel properly), but was a statement made on a number of other occasions also
10	Users couldn't understand what the bottom two buttons in the navigational component did
11	Some people didn't like the generate structure by keywords (especially having to supply 2 or more keywords)
12	Mail-Strainer may not be useful for a home user (who uses Client-Side Email Management Software)
13	Although the system is intended for people with many emails in their mail-boxes, it might not be useful for this target audience since it gets slower as there are more emails

Table 2. Mail-Strainer negatives as identified by testing participants

3.3 Data Collection

This empirical study seeks to gather information in relation to the following questions. Firstly, from the test script (described in Section 3.4): 1. Can users define what each of the main components in Mail-Strainer actually does? 2. Are users able to perform email management using Formal Concept Analysis? 3. What are the positives and negatives about this tool?

Secondly, via self-assessed psychometric surveys (described in Table 3): (i) What are user's main goals in relation to using Webmail? (ii) Do Webmail users have a pre-established reliance on existing email solutions? (iii) What type of email manager are they (see Section 2.3.2)? (iv) Does Mail-Strainer actually perform the task it says it does? (v) What features presented by this tool assist in managing email? (vi) What features presented by this tool make it more difficult to manage email? (vii) Could Mail-Strainer or a related tool be used to improve Webmail in the future?

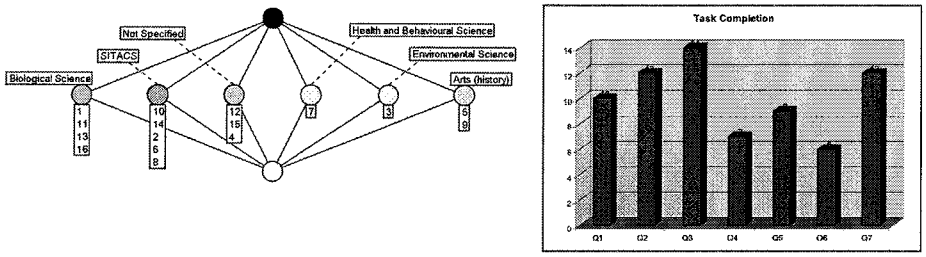

Fig. 3. (left) The concept lattice shows the distribution by discipline of the students involved in the study and (right) A bar graph displays the distribution of task completion. The number indicates those participants capable of completing any particular task in the test script. We take the word "complete" to mean both finished and accurate.

3.4 Test Script and Results

TASK1: Participants were asked to Find out how many emails there are in the 'This Week' structure. This task was relatively simple, and required the participants to be able to read straight off the line diagram, or if need be, from the contents of the Virtual Folder named "This Week". The question tests the participant's ability to determine two things: (i) if he/she understands the notion of intents and extents within the concept lattice; (ii) if he/she understands the meaning behind the numbers attached to nodes in the concept lattice.

It was worrying that only 10 out of the 16 participants could accomplish this task. On closer examination, two recipients didn't give a written answer to this question. Two participants gave the answer 9, which could very well have been accurate as a result of changing mailbox data due to real-time usability testing, and the other two gave the answer 2, which meant that they hadn't understood how contingents work within the concept lattice. Therefore, we conclude that as few as only 2 participants failed **TASK1**.

TASK2: Required the user to find all the emails that contained both .DOC and .PPT attachments, and to open the email and browse it. This question tested the participants ability to: (ii) drill down on the folder structure, and understand the nature of conceptual scales within the concept lattice; (ii) read the concept lattice and understand how to read intents and extents; (iii) Retrieve the folder contents of the folder containing this item and open the email within it.

The subject should ideally notice that they were able to retrieve all emails that contained .PPT and .DOC documents from two locations. They could have clicked on the concept "PPT" in the top-level lattice, or they could have scaled

their diagram by clicking on the mail with documents drill-down node to reveal a reduced lattice. At this point the user should have seen that all emails in the PPT's concept also contained DOC attachments. For this task, 12 people were able to identify the email as having the subject "Secure Pay Information" sent by Collins. Of the other 4 participants, only 1 person was unable to complete this task and 3 others either completed the task and didn't respond.

TASK3: The purpose of this task was to encourage the participant to use the folder manager to Create a new virtual folder using the "Create Structures from Keywords" functionality in MAIL-STRAINER.

In 14 cases, users were able to test this functionality and create a structure relevant to the user's Inbox. The users that could perform this task also understood that they needed to refresh the left tree pane in order to reveal the new structure they had just added. In the other 2 cases there was no response from the user.

TASK4: This task required users to understand the nature of derived concepts within the concept lattice. In particular, they needed to be able to use the lattice to find "how many emails containing image attachments arrived in the last week".

Only 7 were able to come to the conclusion that there was one email containing an image attachment that arrived in the last week. There were 5 participants that said there were 2 emails that contained these two attributes because they were reading the contingent off the wrong lattice node.

TASK5: This task tested the participants ability to recall and act on what had been learned in TASK3. In this step subjects needed to count how many emails existed in their inbox, sent by "Jon Ducrou". The user was tested on their ability to: (i) create a structure from keywords, or create a folder structure manually; (ii) find this newly created structure within the folder structure within the top-level lattice, or as a conceptual scale; (iii) count how many emails in total were from the user "Jon Ducrou" using the lattice node labelling.

There were two emails embedded within this mailbox that were from "Jon", and 23 emails from the contact name "Jon Ducrou". However, we only wanted the emails that came from "Jon Ducrou" which meant that the user had to be able to understand that the bottom-most concept, or greatest subconcept contained in the lattice contained the number of emails from the contact "Jon Ducrou", namely 23.

There were a total of 6 people who said that 25 emails were from Jon Ducrou, which is correct because Jon Ducrou (the person) actually sent these extra two emails with an email-id "Jon" but incorrect in terms of the emails that came from the email identity "Jon Ducrou" read from the line diagram. The other person that got this question wrong answered with the answer 4. We cannot ascertain how the participant came to this conclusion. The 7 people who got this question wrong were still having problems reading the llne diagram at this point of the testing session.

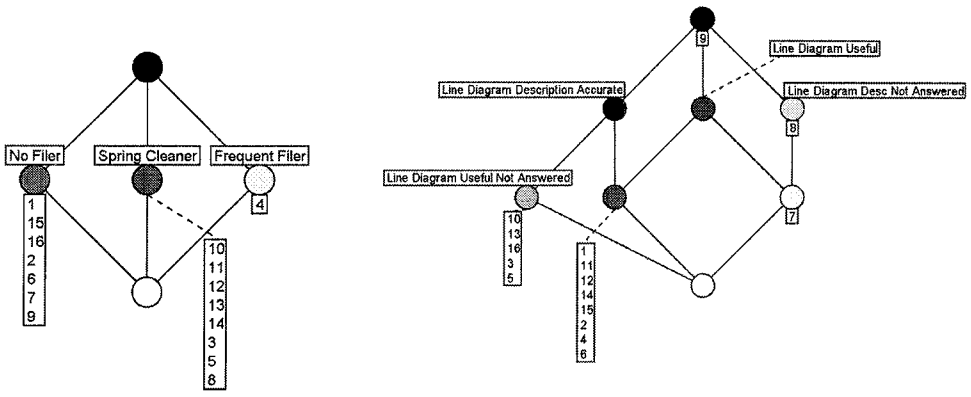

Fig. 4. (left) The concept lattice shows the distribution of email type by self-assessment of the subjects: 3 recognised email behavior types are frequent filer, spring cleaner and no filer (right) Question 9 in the self-assessment survey presented in Table 3 shows the distribution of subject responses on the key issue of the usefulness of the line diagram.

TASK6: This task was similar to that of **TASK5**. It introduces an extra concept to examine, appearing within the scale of "Mail with Documents". The user was asked to "find all emails that contain PDF and DOC attachments". This question clearly asks the user to find the emails that contain a conjunction of PDF and DOC attachments. In a similar way to **TASK5**, the user had to undertake the following tasks to retrieve the answer: seven. (i) use the top-level concept lattice (MAIL-STRAINER Folders drilldown node) to depict a count of all emails containing PDF and DOC attachments, or the easier way was to use the MAIL-STRAINER tree to find the drilldown folder "Mail with Documents"; (ii) If the scale "Mail with Documents" was used, then the user would find a much reduced lattice. The user had the simple task of then determining that there were 7 emails containing PDF and DOC attachments, not 10 or 9 or a mixture of responses as some participants recorded. All objects within the concept "PDFs" inherited the attributes "DOCs".

Two participants said that there were a total 9 documents containing PDFs and DOCs. This means one of two things. Either the 2 users were not aware of the conjunction in the question or they thought that the actual way to find a count of the emails was to add the number on the left of the label in each of the upper and lower-right concepts. 3 participants reported that there were 7 PDFs, 2 DOCs, and 1 PPTs. This answer was also completely wrong: it seemed these participants still did not understand the concept that every node in the concept lattice inherited the attributes of its intent. There were 5 participants that either could not complete the task or didn't give a response.

TASK7 This task helped the participants become familiar with manual creation of drilldown nodes and virtual folders, i.e. they were required to make their own structures. This task was impeded severely by the restriction that

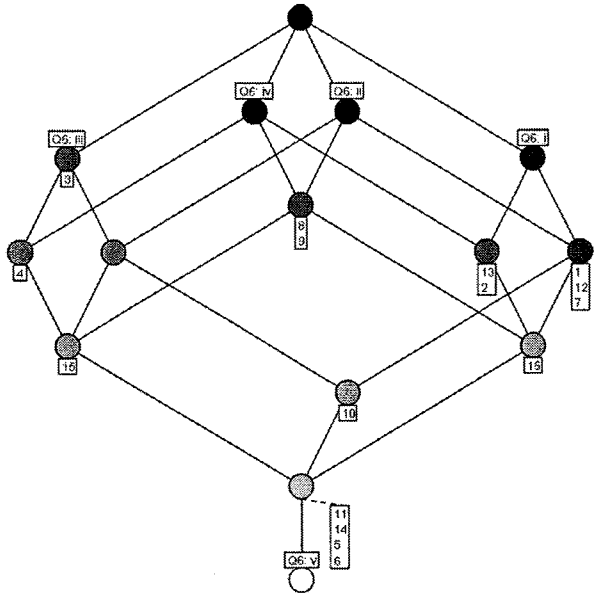

Fig. 5. This concept lattice shows the distribution by subject answer for the 10 questions under survey.

participants were only able to create folders beneath the top level folder: Mail-Strainer Folders. Therefore Virtual Folders, and top-level drill-down folders were able to be created.

Of the 16 participants, 7 participants wrote down that they had achieved this task, and this can be verified. Of the other 9 participants who didn't respond 5 were verified to have manipulated the folder manager, attribute queries to folders, and so forth. In conclusion, a total of 12 people were able complete this task.

3.5 Outcomes

The results of the usability testing and self-assessment surveys lead to the following outcomes:

- users had definite problems reading the line diagram during the testing sessions. These problems were firstly associated with not understanding how to read them, and secondly to do with overcomplicated concept lattices which eventually overwhelmed them.
- further tutorial and help would be vital within any independent system. There is a definite adjustment phase incorporated with reading line diagrams for the novice user. MAIL-SLEUTH incorporates a good on-line help system,

1. What is your home Faculty?
2. Would you say you have a higher reliance on Web-based email (using a Web browser to access your email with things like Mirapoint) or client-based email (using a tool like Outlook Express, Outlook, Eudora) in order to send, receive and browse email?
3. For each of the following locations, please select the method (web-based, client-based or N/A) you would typically use to access your email. University? Work? Home? Friends? Interstate? Overseas? Other?
4. There are supposedly three methods of filing email:
   - Frequent Filer
   - No Filer
   - Spring Cleaner

   Which classification best describes your method for filing email?
5. On a scale of 1-10 (10 is highest), how correct is the following statement? "Mail-Strainer is a tool that gives you more power over searching and browsing your email on the Web".
6. What features of Mail-Strainer did you find helped you complete the tasks listed in the testing session script? (please circle all that apply).
   - Graphical representation of email through the Line Diagram
   - Ability to search email
   - Graphics and Design of Mail-Strainer
   - Virtual Folders
7. What features made it more difficult to complete the tasks listed in the testing session? (please circle all that apply).
   - Graphical representation of email through the Line Diagram
   - Ability to search email
   - Graphics and Design of Mail-Strainer
   - Virtual Folders
8. Which Mail-Strainer features could be used to improve Webmail for use in the future? Please select all that apply and write a couple of words suggesting why.
   - Graphical representation of email through the Line Diagram
   - Ability to search email
   - Graphics and Design of Mail-Strainer
   - Virtual Folders
9. In your own words, please describe what the Line Diagram allowed you to do, and comment on whether or not this tool helped you to complete the allocated tasks in your script. (short answer < 100 words).
10. Please rate your overall experience with MAIL-STRAINER from 1-10 (10 is best).

Table 3. MAIL-STRAINER self-assessment survey questions.

restructured using Formal Concept Analysis and line diagrams, which gives the user practice at reading Line Diagrams while they learn [10].
- there are a number of considerations to take on board in regard to the MAIL-STRAINER interface in relation to the concept lattice (especially the navigational pane).
- envisaging further tutorials, and debugged programming problems, MAIL-STRAINER would be a promising Email Management for Webmail.

4 Conclusion

This paper reports an applied software project to engineer an interactive environment for searching and browsing email in a Web-based architecture, employing MAIL-SLEUTH's component document visualisation technique using applied lattice and order theory. Therefore, the project includes elements of survey, design and software development for the purpose of building a prototype for evaluation:

MAIL-STRAINER. A resultant, yet core component of this research was to examine MAIL-STRAINER's acceptance as an Email Management tool through qualitative evaluation of users within the University of Wollongong domain, where Webmail is a core component of blended learning activities in that institution's undergraduate program. The prospects for novice Formal Concept Analysis users to read and interpret line diagrams remains promising but are not (as yet) considered overwhelming using the present tools.

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