Abstract. Mail-Sleuth is a personal productivity tool that allows individuals to manage email and visualize its contents using line diagrams. Based on earlier work on the Conceptual Email Manager (Cem), a major hypothesis of Mail-Sleuth is that novices to Formal Concept Analysis can read a lattice diagram. Since there is no empirical evidence for this in the Formal Concept Analysis literature this paper is a first attempt to test this hypothesis by following a user-centred design and evaluation process. Our results suggest that, with some adjustments, novice users can read line diagrams without specialized background in mathematics or computer science. This paper describes the process and outcomes based on usability testing and explains the evolution of the Mail-Sleuth design responding to the evaluation at the Access Testing Centre.

1 Introduction

Mixed initiative [15] is a process in human-computer interaction involving humans and machines sharing tasks best suited to their individual abilities. In short, the computer performs computationally intensive tasks and prompts human-clients to intervene when the machine is unsuited or resource limitations demand human intervention. This process is well-suited to document browsing using Formal Concept Analysis (FCA) and has been demonstrated in previous work in the Conceptual Email Manager (Cem) [5–7] and Rental-FCA [8].

Mail-Sleuth, shown in Fig 1., follows these ideas by re-using the interaction paradigm of the Cem embedded within the Microsoft Outlook email client. Other related work demonstrates mixed initiative using line diagram animation,
Fig. 1. 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. 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. Nested-line diagrams are not supported, however it is possible to zoom into object sets at vertices with a similar effect.

notably the algorithms in Cernato [1]. Like, Cernato, Mail-Sleuth does not employ nested-line diagrams [27, 24] instead relying on mixed initiative to reduced line diagram complexity. The client is able to determine trade-offs between attributes and alter search constraints to locate objects that satisfy an information requirement. Because nested-line diagrams are not employed, a major issue is managing the complexity of line diagrams via iterative visualization and zooming. Therefore, keeping the diagram simple needs to be encouraged by the interface. Further, little or no evidence was available in the literature of FCA to support the view that novice individuals could read and interpret line diagrams without specialized training. It was widely assumed that difficulties resulting from novices using a tool like Mail-Sleuth would inevitably result. This assumption needed to be firstly tested and secondly, adjustments made in the event that usability problems arose. This paper follows a user-centred test methodology [17], reports its outcomes and the way in which testing conditioned the design of Mail-Sleuth and the visualization of line diagrams.

This paper is structured as follows. Section 2 surveys computer-based FCA software systems. A common thread among both commercial and open-source

Cernato is commercial software developed by Navicon AG.
FCA tools is the use of a lattice diagram to visualize information content. Mail-Sleuth is situated within this software tools survey. Section 3 covers the background to information landscapes and conceptual knowledge processing. Section 4 describes the evolution of the Mail-Sleuth and Section 5 deals with specific evidence that conditioned its design.

2 Tools for FCA

There are two dimensions of software tools using FCA, these are commercial versus open-source and general-purpose versus application specific.

The longest surviving general purpose platform for FCA is the GLAD system [9] which is a general framework for finite lattices, not restricted to FCA. TOSCANA, developed over many years by various members of the Research Group Concept Analysis (fz’o’bw) in Darmstadt, is better known and specifically targeted to FCA. Toscana-systems, referring to outcomes from the TOSCANA software framework, are based on a four-step task flow that includes establishing conceptual scales, data capture, schema browsing and human interpretation. In the usual configuration of Toscana-systems, a program called ANACONDA serves as the conceptual system editor (to define scales), TOSCANA is then the conceptual system browser and data is stored in Microsoft Access. In Toscana-systems there is usually a separation of roles from the individual creating the scales and the end user of the system. The task flow is often called a “conceptual information system” [14], its roles and participants illustrated in Fig. 2.

Modifications to the TOSCANA program have demonstrated that it can be purposed toward specific application problems [10]. In particular, Groh [13] adapted TOSCANA v3.0 to demonstrate the integration of Prediger and Wille’s [18] Relational Power Context Families in order to represent and process concept graphs. However, during this work it became apparent that some of the software libraries on which TOSCANA v3.0 was based, namely embedded graphics.
libraries from the Borland C++ IDE, would make it difficult for the program to migrate to other operating environments.

In 2000, the GoDa project was established as a collaboration between the Knowledge, Visualization and Ordering Laboratory (KVO) in Australia and the fz o bw in Darmstadt with the vision for a Framework of Conceptual Knowledge Processing. The collaboration produced many outputs, one of which is the ToKit\(^4\) open-source initiative of which TOSCANAJ\(^5\) forms an integral element. TOSCANAJ is a platform-independent (Java-based) re-implementation of TOSCAN A\(^3\) that supports nested-line diagrams, zooming and filtering. TOSCAN AJ follows the conceptual information systems task flow (shown in Fig. 2) with ANACON DA being replaced by two programs, ELBA and SIENA\(^6\). ELBA and SIENA are similar with different emphasis – one is a database schema editor the other edits memory-bound schemas. TOSCANAJ can talk to any RDBMS via the ODBC/JDBC or via an embedded RDBMS. Line diagrams of concept lattices can be exported in multiple-formats, color is widely used and TOSCANAJ has more flexible data display features (allowing more varied numerical data analysis and presentations) than TOSCAN A\(^3\). TOSCANAJ can import legacy file formats from its DOS and Windows-based predecessors, CON- IMP\(^2\), TOSCAN A and CERNATO, as well as the XML-based conceptual schema format (.CSX).

TOSCANAJ is not the only general multi-platform tool for formal concept analysis to emerge in the open-source era. CONExp\(^7\) is another Java-based open-source project that combines context creation and visualization into a single task flow software tool. GALICIA \(^{23}\) is another Java-based research software program (albeit at an earlier development stage to TOSCANAJ and CONExp) with particular emphasis on experimentation with lattice closure and visualization algorithms.

Like Groh’s adaptation of TOSCANA for concept graphs, TOSCANAJ’s source-code has been adapted to various application contexts. Two of these, DOCCO and TUPLEWARE form part of the ToKit framework (found at http://tockit.sf.net). Tilley \(^{21}\) has also adapted the TOSCANAJ code in his SPECTrE transformation engine for formal specifications in software engineering.

Prior to 2000, international collaboration in FCA was less organized and open-source software projects less popular than today. WARP-9 FCA \(^{4}\) was a first attempt at document retrieval based on a faceted hierarchy re-used from a medical ontology and mixed initiative. These ideas were refined and applied to email in CEM \(^{5–7}\) and for the Web in RENTAL-FCA \(^{8}\) and more recently in the commercial email management program, MAIL-SLEUTH. WARP9, CEM and MAIL-SLEUTH owe their origins to earlier information retrieval tools developed by Carpineto and Romano \(^{3}\). Further, this work builds on the idea of FCA for document browsing by Godin and Missouï \(^{12}\). Other work that follows this

\(^4\) http://tockit.sf.net
\(^5\) http://toscanaj.sf.net
\(^6\) The collaboration could not obtain permission to use the name ANACONDAJ.
\(^7\) http://conexp.sf.net
literature thread includes Kim and Compton [16], Rock and Wille [20] and Qian & Feijs [19]. Rapid iteration, direct manipulation to reduce display complexity and the use of conceptual scaling to aid scalability are hallmarks of the later work on document browsing and information retrieval using FCA but there are no existing studies that test the viability of novice users reading and interpreting line diagrams and therefore no indication of the benefit of the work.

3 Information Visualization and FCA

A main attraction of FCA has been its visual utility both for general purpose Conceptual Information Systems frameworks, characterized by Toscana-systems, and also for specialized tools for information retrieval and software engineering. Software engineering has been a strong application area for techniques in FCA and is thoroughly surveyed by Tilley [22, 21]. The emphasis on information visualization follows in a natural way from Wille's vision of “landscapes of knowledge” which helps define conceptual knowledge processing.

“The name TOSCANA (= Tools of Concept Analysis) was chosen to indicate that this management system allows us to implement conceptual landscapes of knowledge. In choosing just this name, the main reason was that Tuscany (Italian: Toscana) is viewed as the prototype of a cultural landscape which stimulated many important innovations and discoveries, and is rich in its diversity ...” [26].

Despite the attraction of line diagrams to those of us within the field, it is apparent that the uninitiated have had difficulties interpreting a line diagram as an information space. The conventions for reading line diagrams are manifest in the earliest literature on FCA and these are (in large) related to lattices being drawn on paper (or on a blackboard using chalk). It is difficult from within the field to understand the difficulties faced by novice users or break tradition to develop new conventions for drawing line diagrams. Even the use of color in TOSCANA attracts critique from FCA-purists but needs to be situated in the context of a move away from a paper-based approach to Conceptual Information Systems to a more screen-based mixed-initiative interactive approach.

In the context of the design of a commercial tool like MAIL-SLEUTH it is possible to break with tradition and invent (or re-invent) metaphors more suitable to individuals without specialist training in FCA. This process follows a form of user-centered design [17]. The usability tests at Access Testing Centre (ATC)\(^8\) requirements and condition the software design to make line diagrams more easily understood as an information space by novice users.

4 Usability Evaluation

4.1 Comparative Functionality Review

The comparative functionality review was conducted by two ATC analysts performing self-determined exploratory testing. The evaluation had a significant

comparative, comparing the ease of executing various key functions in MAIL-SLEUTH against competitor applications.

The May 2003 version of MAIL-SLEUTH had no initial virtual folders when the program was first installed and the user had to go through a folder configuration process from scratch. In FCA terms, MAIL-SLEUTH had no pre-defined conceptual scales. While this may suit advanced users, or users expecting the program to be a general purpose framework for document browsing using FCA, the majority of users are likely to encounter difficulties with this. ATC recommended a number of useful pre-defined Virtual Folders be employed such as “This Week”, and “Attachment” folders for email attachments of different document types and sizes. These form the basis of the Folder List shown to the left of Fig. 1. This recommendation was followed and in subsequent versions pre-defined Virtual Folders were added including the folders mentioned above (various popular document and image attachment types and sizes) and also a “follow-up” folder which tests the Outlook follow-up flag. These serve as examples and a useful starting point from which users can extend the Virtual Folder structure (scale) while benefiting immediately from the software. Other comparable products derive Virtual Folders from reading the mailbox but the structure (once built) cannot be modified or extended as with MAIL-SLEUTH. This advantage is highlighted by including an extensible pre-defined folder structure when the MAIL-SLEUTH program is first installed.

The same time that re-defined Virtual Folders were added, the idea of “User Judgments” (reported in [7]) were eliminated. User Judgments allow the user to over-ride the automatic classification specified in the attached Query of the Virtual Folder. Emails could be drag-and-dropped from regular folders into (or out of) existing Virtual Folders. Access Testing Centre (ATC) found this to be a powerful (and surprising) feature but one that would appeal only to expert users. While the code base for User Judgments still exists under the MAIL-SLEUTH hood it is not presently activated by the interface.

4.2 User-based Evaluation

The user-based evaluation involved one-on-one interviews and was intended to evaluate the ease of use and expectations of the user community. Six users were drawn from the core target demographic. There was a balance of male and female degree qualified individuals who had expressed an interested in new techniques to categorize and handle their email. Ages spread from 25 to 50 – at least one under 30, at least one over 40. Included in the group were a Librarian, an Insurance Manager, a Financial Analyst, a Recruitment Manager, an Imaging Specialist and a Personal Assistant. Later, informal tests carried out according to the ATC script included a Property Development Manager and a Graduate Software Engineer. Each user session lasted at most 90 minutes and was directed by a usability analyst who observed tasks and recorded relevant data. Each session was then analyzed to identify any usability issues and compile quantitative measures.
4.3 Findings and Actions

The majority of participants were able to learn the basic operations associated with MAIL-SLEUTH and complete a small number of pre-defined tasks. With a simple orientation script (in the place of a help system, incomplete at that point), participants could quickly learn to use the software. For example, once introduced to the concepts of Virtual Folders and how they are associated with a Query (or Queries), participants were able to use the application to create their own folders and populate them with appropriate queries. Participants indicated they found the interface reasonably intuitive and easy to use.

“An encouraging finding was that participants were able to read the lattice diagrams without prompting. Subject six even used the word lattice without it having been mentioned to her. Participants correctly interpreted the major elements – for example, how the ‘envelope’ icons related to the mail folders and how derived vertices represented the intersection of two folders”. (ATC Final Report, Usability Analysis, September 2003)

There were still a number of improvements that could be made to the visualization map, in order to present the lattice more clearly:

- **The start and end nodes could be removed from the legend and blue and red arrows could be added.**
  The introduction of the red and blue arrows into the lattice diagram is intended to highlight the interactive nature of the lattice diagram as a tool for querying emails. This compensates the interface for the fact that only named folders can be accessed via the Folder List. The red and blue arrows are clues from the line diagram that the *extent* and *contingent* are available and that Derived Folders can be created by manipulating the diagram.

- **For more complicated structures, less emphasis could be placed on regions that are essentially ‘unmatched’.** This would reduce visual clutter and further highlight the relationships that do exist.
This comment resulted in the elimination entirely of vertices at unrealized vertices in the line diagram. Many of the test subjects expressed this idea in the usability script. The introduction of the reduced line-diagram was included as an option for advanced users.

- **The format for representing total and dispersed emails associated with each folder could be more clearly represented** – some users indicated that the present format (using brackets) represented total and ‘unread’ e-mails. A reference to the format could be included in the legend.

  Tying together the textual representation of extent and contingent to the red and blue arrows (as shown in Fig. 3) resulted and the total (extent) and dispersed (contingent) sizes being represented as a fraction.

- **The initial/default node view could be improved - when elements are close their labels can overlap. An interesting finding was that some users found more complicated diagrammatic representations better conveyed the relationships to the left-hand folder list.**

  The ability to adjust the highlights and font sizes for diagram labels was included (along with the ability to color the layered highlights). The observation that more complex line diagrams more strongly linked the line diagram to the Folder List is because a larger line diagram contains more labels appearing in the Folder List. Thus, the correspondence from line diagram to Folder List is more easily made when there are a larger number of intersecting elements.

Finally, user responses in this small demographic give encouraging indications of an implicit understanding of information visualization using line diagrams. When shown a very large line diagram our librarian found it overwhelming but was certain that there was “value in a lattice of the information space”. More specifically, one user said that she preferred a reduced line diagram, namely she saw “no reason that points without corresponding data should be drawn at all”.

When asked what they liked most about the application users responded with statements such as; “Defined searches - better time management. Ability to separate text from e-mails, program creates folders for you”. We interpret this to mean that this user understands that a permanent standing Query is created attached to a Virtual Folder. The term “Virtual Folder” was also used by another respondent when asked the same question “Drilling down through virtual folders to locate specific emails etc.”, this indicates a familiarity with the idea of a “Virtual Folder”, either pre-existing or learned during the 30-40 minutes using the program. Further, the use of the term “drilling down” in the appropriate context of data mining and visualization suggest an encouraging level of comfort among the target user group with the terminology of the program.

Table 1 shows that the user group could use **Mail-Sleuth** and had a clear understanding of its utility. While questions 8 & 9, which relate to visualization of line diagrams, scored relatively poorly compared to other questions, it is apparent that the results are nonetheless positive and doubtful that other question groups would have been so highly scored if the line diagrams had not been understood. Nonetheless, improvements to the visualization aspects of the
Table 1. Participants were presented with a number of statements and they were asked to select a rating. The range of the ratings went from -2 to +2, to indicate the extent to which they agreed with the statement. Here -2 = 'Definitely No', 0 = 'Uncertain' and +2 = 'Definitely Yes'.

<table>
<thead>
<tr>
<th>Statement</th>
<th>Ave. Resp.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Clear how the application is to be used</td>
<td>1.3</td>
</tr>
<tr>
<td>2 The interface was simple to use</td>
<td>0.8</td>
</tr>
<tr>
<td>3 The application appears to be a useful tool</td>
<td>1.8</td>
</tr>
<tr>
<td>4 I liked the layout of the pages</td>
<td>1.2</td>
</tr>
<tr>
<td>5 I found the icons intuitive</td>
<td>0.5</td>
</tr>
<tr>
<td>6 I found the Quick Search feature was useful</td>
<td>1.0</td>
</tr>
<tr>
<td>7 I found the folder view intuitive</td>
<td>1.3</td>
</tr>
<tr>
<td>8 I found the diagrammatic view intuitive</td>
<td>0.8</td>
</tr>
<tr>
<td>9 Clear relationship, folder view to diagrammatic view</td>
<td>0.7</td>
</tr>
<tr>
<td>10 The configuration functionality was useful</td>
<td>0.8</td>
</tr>
<tr>
<td>11 I would use this application</td>
<td>1.7</td>
</tr>
<tr>
<td>12 I will recommend this application to others</td>
<td>1.7</td>
</tr>
</tbody>
</table>

Considerable time is spent in the development process responding to negative comments by users during software evaluations. Negative comments were solicited when the group were asked “what they liked least” about the MAIL-SLEUTH application. Responses included: “it takes a few moments to understand the 3-D concept as most people are used to a flat & hierarchical folder layout”. The response to this has been to include a careful introductory tutorial/help system to explain Virtual Folders and Structures and introduce specific “simplified” terminology to facilitate an understanding of MAIL-SLEUTH. It is noteworthy that the Virtual Folder idea also appears as one of the features that people liked most. The comment that the “diagram is a bit overwhelming and has badly chosen colors” was addressed by giving people the option of choosing their own color schemes and font sizes and trying to simplify the line diagram as described in the next section.

5 Design Aids for Interpreting Line Diagrams

During the comparative review of MAIL-SLEUTH in May 2003 a comment was made by co-author Peter Brawn that, ”the drawing conventions for a lattice diagram were no different from a graph in Mathematics. What makes this a lattice diagram and not a graph? How do I know that I should read this top to bottom?”

A line diagram (or concept lattice) is a specialized Hasse diagram with several notational extensions. Line diagrams contain vertices and edges with the vertices often labeled dually with the intent (above) and extent (below). Rather than labeling each node in the line diagram with its intent and extent a reduced labeling scheme can be used and each object (and attribute) appears only once.
In many Toscana-systems (and in CEM) a listing of the extent is often replaced with a number representing the cardinality of the extent (and/or the contingent).

In Hasse diagrams, edges (representing the cover relation) are unlabeled. It is well understood in Mathematics that an ordered set is transitive, reflexive and antisymmetric. To simplify the drawing of a ordered set (via its cover relation) the reflexive and transitive edges are removed, and the directional arrows of the relation are dropped. It is therefore meant to be “understood” that the Hasse diagram is hierarchical with the edges pointing upward. In other words, if $x < y$ in the poset then $x$ appears at a lower point that $y$ in the diagram.

“The highlighting of adjoining lines is meant to illustrate relationships within the lattice and this could be clearer. There is a hierarchy within the lattice, which could be reinforced through the use of arrows on connecting lines that appear upon rollover.” (ATC Functional Testing Report, May 2003)

Access Testing Centre (ATC) suggested arrowheads be used in the line diagram to reinforce its hierarchical character. This represents an unacceptable violation of a convention dating back to (at least) to Helmut Hasse’s 1926 book Höhere Algebra, so some other mechanism to reinforce hierarchy without tampering with the edge notation in the line diagram had to be found.

To insinuate structure the idea of a layered line diagram was introduced. The principle is iterative darkening with dark at the top to light at the bottom, shades progressively lighter as one moves from one level to the next. This is shown in Fig. 4. The top and bottom elements of the lattice have also been replaced with special icons indicating “All Mail” and “No Mail” (when the bottom element is the empty set of objects). In combination, layering and icon shapes are intended to suggest the top-to-bottom reading of the line diagram.

Shading does not interfere with the conventions of drawing line diagrams because it operates as a backdrop to the line diagram. It can also be turned off if the line diagram is to be embedded in a printed document. However, the interaction of the layout algorithm and background layering fails (background layers are not aligned) in line diagrams with high dimensionality as shown in Fig. 5 (left) requiring human intervention to produce something readable as shown in Fig. 5 (right). It is possible to use the alignment of the background layers to guide the manual layout process. Nonetheless, once layering was used, it was apparent from test subjects that they were (without prompting) able to explain (and read) the line diagram from top-to-bottom and bottom-to-top.

“It was observed that most nodes in the lattice are depicted using the exact same icon, even though there are a variety of nodes. In particular, the root node, which represents the set of all emails, should be differentiated from all other nodes.” (ATC Report, May 2003)

In Mail-Sleuth (and in CEM) the top of the lattice represents all emails in the collection. Some of the vertices shown in the line diagram correspond with actual Virtual Folders that exist in the Folder List to the left, while other
Fig. 4. A line diagram from the August 2003 version of MAIL-SLEUTH. Layering is evident to suggest a hierarchical reading. Top and bottom elements have been especially iconified as arrowheads. Unrealized vertices are differentiated. Realized vertices have been split into two iconic categories “Named Folders” with an intent label with a white envelop and “Derived Folders”, whose intent needs to be “derived” as an orange envelop. Cardinality labels have been replaced with dual labels for “extent (contingent)”. Users complained that the help system was hard to activate or they couldn’t find it and did not recognize the “?” icon as being related to “help”! Note the inclusion of a Quick Search bar at the top which provides an entry point for search.

Vertices represent derivations of the named Virtual Folders. It is useful to indicate, through different icon types, which vertices are named Virtual Folders (appearing in the Folder List), and which are derived. This led to the idea of a “Derived Folder”, a type of Virtual Folder that does not appear in the Folder List and whose name is “derived” from the named Virtual Folders (attribute names) above it in the line diagram.

The number of e-mails represented in each node could also be more clearly illustrated. For example, where totals for vertices and intersections are concerned, two numbers could be displayed corresponding to the extent and contingent size in the form `extent_size (contingent_size)` in Fig. 4.

When drawing “reduced line diagrams” vertices which are unrealized are excluded but automatic layout can be problematic. Because MAIL-SLEUTH was designed for the non-expert, it was decided early to compromise to ensure that the lattice diagram was always “readable” as a default layout and reduced-line diagrams not used as a default. Where elements of a scale are unrealized, the entire label is excluded from the diagram however what remains is drawn as a boolean lattice with an option for a reduced line diagram. This means that
Fig. 5. The interaction of the line diagram layout algorithm and background layering can produce an odd effect (left) but with human intervention layering can also be used as a guide to adjust the line diagram by hand (right) by moving vertices to align the layers. Note that the buttons in Fig. 4 have been replaced with tabs and that the help system is more consistently located to the top right. The Quick Search bar is visually highlighted and placed toward the bottom of the screen for greater emphasis.

certain combinations of realized scale elements may themselves be unrealized. Convention dictated that these be displayed as a vertex in the lattice somehow distinguishable from realized vertices (or not at all). In Fig. 6 unrealized vertices are the same shape and size as realized vertices, the only difference being the presence or otherwise of an envelop icon within the vertex. To distinguish unrealized from realized vertices they were reduced in size as shown in Fig. 4. Top and bottom vertices (when the bottom was an empty set of objects) were also iconified. In addition, realized vertices are identified in two ways. The first where the intent label matches a “Named Folder” in the Folder List of Outlook (to the left of Fig. 1). The second, where vertices representing the intent labels of the upper covers, these may have common attribute names (Named Folder names) and are colored orange. To avoid cluttering the diagram with labels on all vertices the interface gives scope to query a orange envelop and the result is a new Virtual Folder named after the intent labels of its upper covers appearing in the “Mail-Sleuth search results” in the Folder List.

“.. get rid of the grey blobs...” [User 2]

Because we are dealing with objects that are emails and not ball bearings it was natural to replace the stylized vertices (a legacy of the Hasse diagram) with a literal iconic representation relevant to the domain. In the case where “Derived Folders” were unrealized, no vertex is drawn, where data is present
Fig. 6. A line diagram from the May 2003 version of Mail-Sleuth. Most of the usual FCA line diagram labeling conventions are followed with the exception of iconifying vertices with an envelop. There is no obvious “search point” (meaning no clear starting place to commence the search) and limited visual highlighting in the diagram itself. Structural diagrammatic constraints are imposed, concepts cannot be moved above their superconcepts for instance.

a envelop replaces the envelop/ball icon combination as shown in Fig. 1. Top and (empty) bottom vertices appear at most once in a line diagram and so are removed from the legend (shown in the legend of Fig. 4 but not in Fig. 1) and labeled accordingly in the diagram itself (shown in Fig. 1). The ability to manipulate the line diagram in four directions via the “Pan” widget appears in Fig. 1, and the envelops animate by “appearing to lift” on rollover with drop shadowing helps suggest that vertices in the line diagram can be moved and therefore manually adjusted by the user.

“Hide the lattice-work where no relationships exists.” [User 6]

Edge highlighting has been used to emphasis relationships in line diagrams in both TOSCANAJ and in CEM. This idea is mainly used as a method to orient the current vertex in the overall line diagram so that relationships can be identified. TOSCANAJ allows the edges of the line diagram to be labeled with the ratio of object counts to approximate the idea of “support” in data mining. That program also uses the size of the extent to determine the color of a vertex. A number of other significant functions for listing, averaging and visualizing the extent at a vertex are also provided by TOSCANAJ.
Mail-Sleuth tries to accommodate a new user community to document browsing using FCA. Hiermail (shown above) has a much stronger conformity to diagrammatic traditions in FCA. It is effectively a version of Mail-Sleuth with a ToscanaJ-like skin.

Trying to create a new user community with Mail-Sleuth is an interesting exercise but the original user community also requires attention. Hiermail is a version of Mail-Sleuth for the FCA community that conforms to the diagrammatic conventions of ToscanaJ. It took only a matter of days to rollback the design lessons learned from over four months of usability testing and design refinement with Mail-Sleuth to produce Hiermail as shown in Fig. 7.

6 Conclusion

This paper canvasses a number of usability and visualization issues for interpreting and understanding line diagrams based on the design experience gained from testing Mail-Sleuth. It tests, on a very small scale, the ability of novices to FCA to understand line diagrams. The results are promising and indicate that novice users can read and interpret line diagrams.

The design choices made do not represent the only possibilities for helping novice users understand lattice diagrams but rather are determined by constraints on time, resources and programming utilities available to the Mail-Sleuth platform. Nonetheless, the choices were suitably tested and result in promising outcomes, users untrained in FCA were able to read and interpret line diagrams and this discovery argues for a less complex task-flow for domainspecific applications such as Mail-Sleuth. Naturally, “deep knowledge” can

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9 http://www.hiermail.com
only be gained by complex scale interaction and there is very little of that in Mail-Sleuth at its present stage of development. The test candidates were only confronted with small diagrams, direct products of chains, and did not zoom into vertices (although that functionality exists in Mail-Sleuth).

The results are therefore preliminary and anecdotal but the methodology followed is a limited example of user-centered designed based on a case-study. Some aspects of the presentation of line diagrams are impossible to adjust but other devices can be introduced to give visual clues on the correct meaning of the diagram and its interactivity. In the process of experimenting with these ideas this paper catalogs the design evolution of the Mail-Sleuth program. A much larger usability test needs to be undertaken to verify the findings. These early results are however promising indicators that novice users can read line diagrams.

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