SHARING, EVALUATING AND ORGANIZING E-MAIL: THE KM-MAIL APPROACH TOWARDS A PLATFORM FOR ENTERPRISE-WIDE KNOWLEDGE MANAGEMENT

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Abstract - **Knowledge is gaining importance in the world's economy, and the Internet is playing a significant role in the knowledge economy especially with knowledge sharing tools such as web-based and e-mail discussion groups. Present discussion groups have weaknesses in their effectiveness in knowledge sharing and reuse in many enterprises. To address these weaknesses, alternative strategies can be employed to enhance the knowledge management capabilities of the Internet in general and e-mail in particular. We present a novel knowledge management-based e-mail (KM-Mail) framework that capitalizes on the ubiquitous utilization of e-mail for knowledge sharing and reuse. We will also outline a mechanism to allow the evaluation and organization of knowledge shared via e-mail. Finally, we discuss the incorporation of KM-Mail into a wider enterprise-wide knowledge management platform.**

Keywords: - **E-mail; Knowledge management; Knowledge sharing; Knowledge evaluation; Knowledge crystallization**

1. INTRODUCTION

The world's economy is now entering a new era where knowledge spearheads the delivery of products and services to customers. Knowledge capital is now considered an important means of production without which an enterprise may encounter difficulties in gaining competitive advantage (Housel & Bell, 2001). In regard to this, the field of knowledge management is attracting much research interest especially on how enterprises can identify, capture, store, share and reuse knowledge (also known as the knowledge management processes) more effectively and efficiently (Abecker *et al.*, 1998).

Just as how knowledge is gaining importance in the world's economy, the Internet has also grown in popularity and is fast replacing, if not complementing, traditional communications tools such as the telephone, fax or pager (Red Earth Software, 2001). Due to its ease of use and expressive capabilities, the Internet is playing a significant role in the knowledge economy, especially with knowledge sharing tools such as web-based and e-mail discussion groups.

An e-mail message is fundamentally an electronic text document. Within an enterprise, e-mail is a multi-purpose mode of self-expression with content ranging from factual statements, suggestions and announcements to problem-solving methods, reports, analyses and discussions. These are all very important forms of knowledge in view that these can be utilized for problem-solving and strategic decision-making. In addition to being versatile, e-mail is also a very convenient and natural mode of documentation for recording enterprise-wide knowledge. The documentation of such knowledge is made possible via the use of various e-mail software or clients.

1.1 State of Affairs

A popular software application with e-mail client, calendar, task list, etc. that facilitates project collaboration is Microsoft Outlook and Exchange that runs in the Windows environment. It also provides components such as shared project space and shared contacts, and even allows users to manage each other's e-mail or calendar.

The Web Information Gateway (TWIG) (Heschong, 2005) is a simple, platform- and browser-independent web-based application that provides e-mail, contact management, scheduling, newsgroup, task lists and Internet bookmark facilities. Written in PHP, it is designed to be modular to allow new features to be added later.

Another knowledge management-enabled e-mail client, the Kubi Client (Fontana, 2005), offers extra modularity of components among popular e-mail clients such as Microsoft Outlook and Lotus Notes with the introduction of Kubi Space (a sharable or collaborative folder concept). The existing interface of Microsoft Outlook or Lotus Notes is maintained, thus, minimizing the need for users to adapt to it.

However, present e-mail discussion groups, protocols and e-mail clients (such as those mentioned above) have certain shortcomings that limit their effectiveness in knowledge sharing and reuse in many enterprises. For example, traditional e-mail is usually maintained as archives and is hardly utilized to solve problems, answer queries (Banhan, 2001) or for strategic decision-making. They are also seldom shared beyond their intended recipients and the quality of these e-mail messages is unknown and may contain information and knowledge that

are inaccurate, outdated or not useful. We believe alternative strategies can be employed in enterprises to enhance the knowledge management capabilities of the Internet in general and knowledge-rich e-mail in particular. For our purpose, we would like to go beyond providing a facility to just distribute content. Rather, we hope to facilitate conscious and informed knowledge sharing, reuse and organization.

1.2 Objectives

In this paper, we propose a novel knowledge management-based e-mail (KM-Mail) framework that capitalizes on the ubiquitous utilization of e-mail to address three key areas or processes of knowledge management, i.e. expert knowledge sharing, reuse and organization (O'Dell & Grayson, 1997). For this, we aim to outline practical mechanisms to allow experts to share their knowledge and for non-experts to search for or reuse knowledge in a structured manner via e-mail, especially for problem-solving and strategic decision-making. We will also outline a mechanism to allow the evaluation and organization of expert knowledge shared via e-mail using cellular automata and knowledge crystallization techniques. Finally, we discuss the incorporation of KM-Mail into a wider enterprise-wide knowledge management platform (Cheah *et al.*, 2004).

2. KM-MAIL OVERVIEW: INTEGRATING KNOWLEDGE MANAGEMENT AND E-MAIL

Conventionally, the sending and receiving of e-mail requires the interaction of several e-mail clients and e-mail servers. They also require e-mail protocols such as Simple Mail Transfer Protocol (SMTP) for sending e-mail, and Post Office Protocol (POP) or Internet Message Access Protocol (IMAP) for receiving e-mail.

The KM-Mail framework, however, would require an additional KM-Mail Server that handles its own e-mail traffic (see Figure 1). The conventional e-mail server's main task is mainly to send and receive e-mail of their e-mail users. The KM-Mail Server, however, performs certain intelligent processing on e-mail, i.e. certain knowledge management functions to facilitate the sharing, reuse and organization of knowledge stored in e-mail.

1.3 KM-Mail Architecture

The four-layer KM-Mail architecture consists of three main modules: an e-mail server, an application server (together they form the KM-Mail Server) and an e-mail repository (see Figure 2).

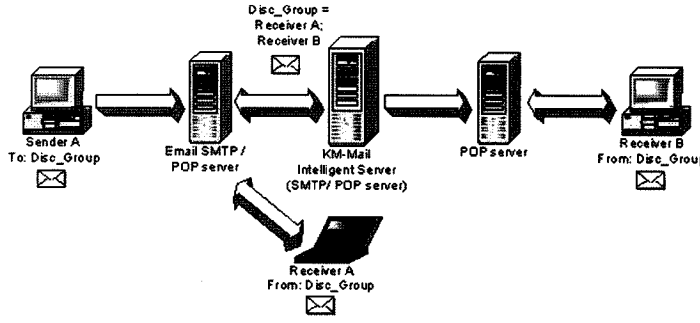

Fig 1. KM-Mail framework

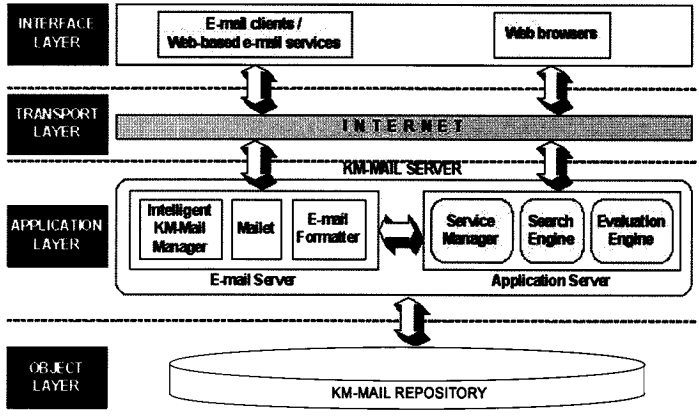

Fig 2. Four-layer KM-Mail architecture

The first module, i.e. the e-mail server, basically supports the basic functions of e-mail transactions from various e-mail clients used by various people. The main components of the e-mail server are as follows:

1. *Intelligent KM-Mail Manager*: This component handles all incoming e-mail and decides the next course of action based on who the sender or recipients are, the e-mail subject or even the e-mail size. It will instruct the Mailets to do specific actions to the incoming e-mail.
2. *Mailet*: This Mailet component receives instructions from the Intelligent KM-Mail Manager. Possible actions include the creation of discussion groups for a particular issue/problem or the forwarding of e-mail to the intended group of recipients. The Mailet effectively provides knowledge sharing functions.

3. *E-mail Formatter*: This component works together with the Mailets to perform intelligent parsing functions to capture relevant message content (i.e. e-mail body content and header information such as sender, recipient, date, time, subject, keywords, etc.) as well as to reformat e-mail before they are forwarded to recipients or before it is stored in the repository. It will intelligently parse through the e-mail content to capture the relevant knowledge e.g. differentiating the reply content and the previous original e-mail content. The inclusion of the keywords field (together with the subject field) would assist in clarifying the context of the e-mail content. This is especially important if the e-mail contains problem-solving knowledge.

The second module of the KM-Mail architecture is the web-enabled application server. It provides a suite of services to KM-Mail users such as user registration, knowledge search, knowledge evaluation and knowledge export. The application server consists of the following components:

1. *Service Manager*: This component receives service requests from KM-Mail users. This can be in the form of registration requests, repository queries, evaluation requests and knowledge export requests.
2. *Search Engine*: The Search Engine performs context sensitive search requests (using the subject and keywords fields) on the repository for certain knowledge content. The function of the Search Engine is extended to facilitate knowledge export to allow experts to extract (i.e. copy out) knowledge from the repository in a required format. The Search Engine effectively allows knowledge reuse.
3. *Evaluation Engine*: This engine allows a recipient to evaluate e-mail content (this may be a reply to a query/problem) in terms of its quality (i.e. usefulness, relevance, accuracy, etc.). The evaluation details are stored together with the e-mail concerned and would facilitate searches for quality answers from the e-mail content

The final module is the e-mail (KM-Mail) repository. It is the main storage mechanism for all e-mail and discussion threads handled by the KM-Mail system. It includes the storage of evaluation details and the details of senders and recipients. Note that KM-Mail does not attempt to extract structured knowledge (e.g. rules, cases, etc.) from e-mail. Rather, the knowledge is stored as it is in free text. However, we use the subject and keywords fields to store the context in which the e-mail was written and this provides some degree of structure to facilitate knowledge sharing and reuse.

3. KM-MAIL PROTOCOL

The KM-Mail protocol can be easily summed up with the 4Rs: (1) Register and Send; (2) Receive; (3) Reply; and (4) Read, Evaluate and Search.

3.1 Register and Send

The main purpose of the registration process is the creation of KM-Mail discussion groups. These groups can be created via an e-mail message to the KM-Mail Server or through a dedicated KM-Mail web page. Details that are required include the sender's and recipients' e-mail addresses, a discussion topic or subject, and relevant keywords.

Registration via web pages is straightforward. A user with a problem to share would submit a form with the above-mentioned details to the KM-Mail Server.

E-mail-based registration would be more complicated as it would involve sending an e-mail to a special KM-Mail e-mail address used for creating discussion groups. The group creator would need to specify the topic in the subject field of the e-mail followed by the question or problem in the e-mail body. The list of members of the discussion group (e.g. a group of domain experts) can be specified in the carbon copy (CC) or blind carbon copy (BCC) fields of the registration e-mail. When a registration e-mail is received by the KM-Mail Server, the Mailet component identifies the registration e-mail and parses the e-mail to extract the relevant information to create the discussion group.

For each successful registration, a new e-mail account will be created for the discussion group complete with a unique e-mail address that is actually an e-mail list containing e-mail addresses of the sender and all recipients. An acknowledgement e-mail will be sent to this e-mail address to inform all participants about the existence of the discussion group.

New members can register to join existing discussions via the KM-Mail web page or e-mail to the KM-Mail Server. New members can view a list of discussion groups in the web and join the group by submitting details through web pages. A special e-mail address will be used here as well to facilitate the process of assigning the new member into the discussion group mailing list. Upon successful registration, the new member will receive the very first outgoing e-mail from KM-Mail. Figure 3 summarizes the Register and Send process flow.

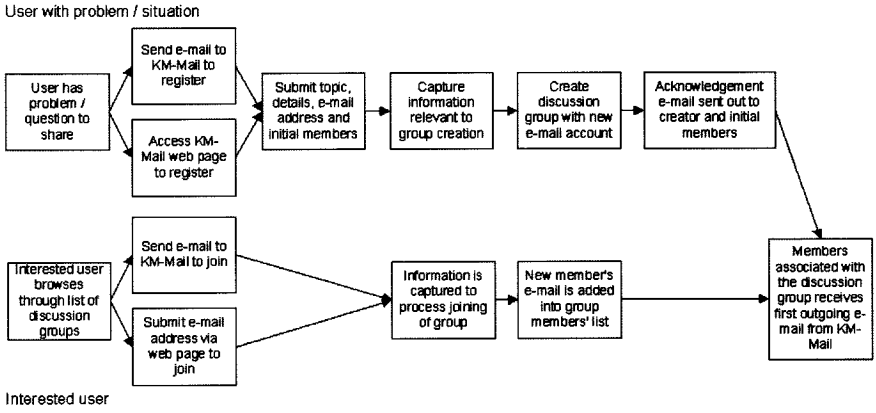

Fig 3. Process flow for 'Register and Send'

3.2 Receive

KM-Mail is accessible anywhere as long as e-mail facilities are available. Therefore, a wide variety of platforms support KM-Mail discussions, e.g. personal desktop computers, notebooks and even personal digital assistants (PDAs).

Following the registration and creation of the discussion group and the question or problem at hand, the next process would be to configure e-mail clients to accept e-mail from the KM-Mail Server. For new group registration, the acknowledgement e-mail would be the first e-mail to be sent from the KM-Mail Server. This acknowledgement e-mail contains the original question or problem as well as instructions on how to utilize the KM-Mail protocol for answering the question or problem and evaluating any potential answers or replies by other recipients. Figure 4 summarizes the Receive process flow.

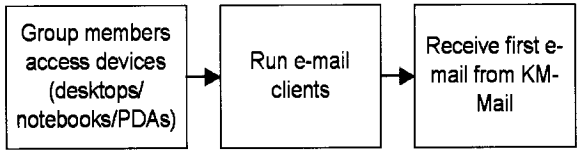

Fig 4. Process flow for 'Receive'

3.3 Reply

After receiving the question or problem of the sender, any of the recipients can then issue replies to answer the question or problem, or to discuss the matter further (see Figure 5). This, in effect, provides the knowledge sharing facility of KM-Mail. This is done by replying to the unique e-mail address that was created for the discussion group. Here, the unique e-mail address acts as the middleman among the group members. When an e-mail for the group is received by the KM-Mail Server, relevant actions will be determined by the Intelligent KM-Mail.

Manager which will invoke the relevant Mailet to process the incoming e-mail. Relevant details of the e-mail (e.g. the reply's sender's e-mail address, the message body, etc.) are parsed and extracted for storage into the repository. In addition to this, evaluation headers and footers are added to the reply e-mail before it is broadcasted to everyone associated with that discussion group (including the original sender of the question or problem). Each outgoing e-mail will be embedded with a KM-Mail-ID for evaluation and searching purposes later.

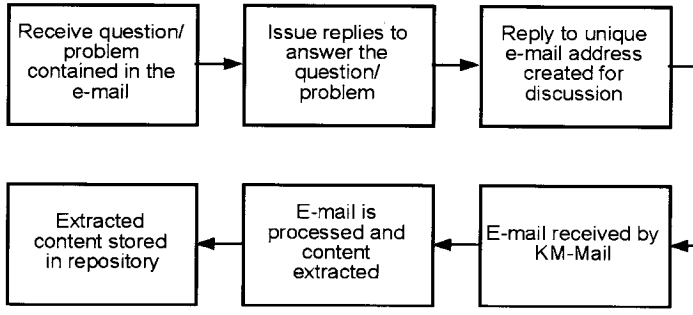

Fig 5. Process flow for 'Reply'

3.4 Read, Evaluate and Search

Upon reading an answer to a question or a problem, the recipient is then allowed to evaluate the quality of the answer in terms of its usefulness, relevance and applicability. In view that e-mail can be sent in HTML format and that many e-mail clients (especially web-based e-mail services) now support HTML e-mail, this is done by embedding an evaluation code into the e-mail's body. This code will cause a small HTML form to appear in the e-mail that allows users to rate or evaluate the e-mail's content on a scale of one (for most useless) to five (for most useful) (Abidi & Cheah, 2001). A textbox will also be provided to accommodate

comments regarding the answer provided. Submission of this evaluation is done via HTTP.

This rating mechanism (especially for non-web-based e-mail clients) is based on the assumption that the user is online when reading and evaluating the e-mail. The process for offline evaluation is more complicated as it requires a script to check the online status of the e-mail client. This is because most active e-mail users download their e-mail and view them offline. If the user is offline, the submission of the evaluation is done via SMTP as its delivery can be deferred until the user goes online later. Therefore, on submitting an evaluation offline, a new e-mail message will be created with a predetermined subject and with the evaluation details (rating and comments) in the body of the e-mail.

The rating and comments will be stored in the KM-Mail repository. As each e-mail has a unique KM-Mail-ID, this ID will be used to link the rating and comments to the respective e-mail replies (or answers). The repository would store a record of all ratings and comments for a particular e-mail together with a total rating or current score for a particular e-mail. This total will be updated continuously, i.e. as soon as new evaluations are made.

The Search Engine will carry out a simple search through the KM-Mail repository. However, this would be refined by matching the keywords fields of the e-mail messages. As knowledge can be structured and categorized for an easier and efficient search mechanism, agent technology may be used in this mechanism. Figure 6 summarizes the Read, Evaluate and Search workflow.

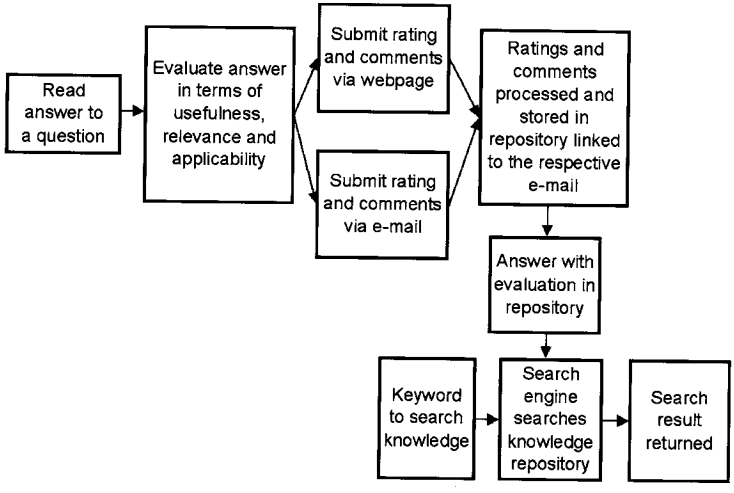

Fig 6. Process flow for 'Read, Evaluate and Search'

Working together, the evaluation facility, the Search Engine and the KM-Mail repository form a tool that can be effectively used for knowledge management. This is where, we argue, that the KM-Mail architecture presents its value-added qualities especially for knowledge reuse. Here, a user seeking solutions to problems via the Search Engine is directed to knowledge-rich e-mail that has been evaluated by like-minded expert users. This evaluation feature increases the credibility of the knowledge stored in the repository and ensures that only 'expert'-quality knowledge in knowledge-rich e-mail is disseminated to users. This facilitates knowledge reuse for other similar tasks.

3.5 E-Mail Organization via Cellular Automata and Knowledge Crystallization Approaches

In extending the functionalities of the KM-Mail protocol further, e-mail that have been evaluated by the community of experts can then be organized according to sub-domains and according to the rating provided by the community of experts.

From the *cellular automata* approach, e-mail can be regarded as knowledge fragments. For our purpose, these knowledge fragments can be organized in a similar fashion as how biological cells interact with one another. Cells, or rather, biological entities, have mechanisms that deal with foreign bodies, deteriorating cells, cell repair, etc. Likewise, we use knowledge-based cellular automata to automate or simulate the organization of e-mail according to their fitness and type.

From the *knowledge crystallization* (Cheah & Abidi, 2000) approach, each knowledge-rich e-mail message is considered a knowledge item that mimics ions or molecules in a chemical solution. The administrator or the KM-Mail repository can then perform *knowledge seeding* (akin to introducing impurities in a supersaturated chemical solution) to specify the characteristics or attributes of a particular *knowledge crystal* or KM-Mail sub-repository. During the knowledge crystallization process, only e-mail that achieves a minimum rating by the community of experts are allowed to crystallize into a particular KM-Mail sub-repository. With a crystallized KM-Mail repository, the search function mentioned earlier can be carried out more efficiently and effectively.

3.6 An Exemplar Scenario using KM-Mail

We now present a brief working scenario using healthcare as an exemplar domain (see Figure 7) to illustrate the interaction between a community of experts.

1. 1. Doctor A intends to perform a coronary artery bypass surgery and wishes to consult other surgeons.

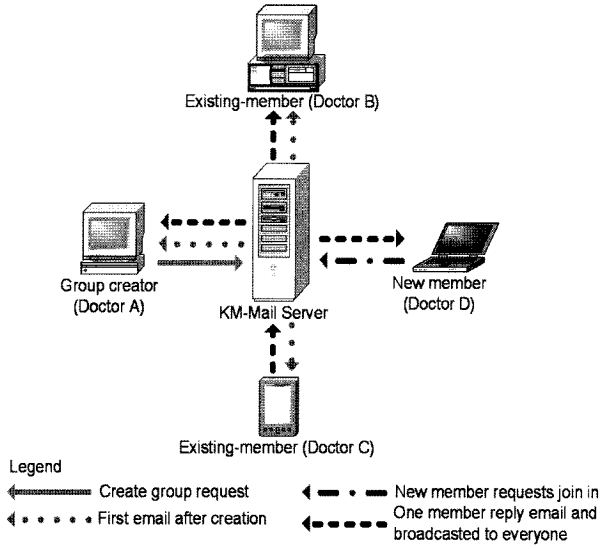

Fig 7. KM-Mail working scenario

2. Doctor A registers with KM-Mail to post his/her concerns. He/she includes a list of surgeons that he/she wishes to discuss with.
3. KM-Mail creates a discussion group and assigns to it a unique e-mail address. An acknowledgement e-mail is sent to Doctor A and the specified list of surgeons.
4. The surgeons receive the KM-Mail acknowledgement/invitation e-mail from Doctor A to participate in the forum to discuss about the bypass surgery.
5. Doctor B has a suggestion to share (e.g. to consider the off-pump coronary artery bypass approach) and replies by using the unique e-mail address that was assigned to the discussion group. Doctor B's reply is captured by KM-Mail and is formatted before it is broadcasted to the group members.
6. Other members in the group receive the formatted reply by Doctor B. Doctor C (and maybe other surgeons) finds the reply by Doctor B interesting and useful for future reference. Doctor C evaluates the reply by giving it a rating via KM-Mail's offline/online rating mechanism. The evaluations are received and stored in the KM-Mail repository and the cycle of replying and evaluating replies continues.
7. Doctor A reads the replies and ratings and is able to make a better-informed decision regarding the intended bypass surgery. Other surgeons and healthcare practitioners, both within and outside the discussion group, would also be able to view the replies (via the search facility).

8. Doctor D wishes to participate in the discussion group and registers e-mail with KM-Mail. Doctor D is free to participate upon receiving an acknowledgement e-mail from KM-Mail of his successful registration.
9. Doctor D browses the KM-Mail system to search for the same issues faced by Doctor A.
10. KM-Mail finds relevant issues (including Doctor B's reply) and sends a list of relevant issues to Doctor D in the order of relevance and rating.

4. IMPLEMENTATION DETAILS

Following the description of the overall protocol of KM-Mail, we now provide some implementation details.

The Intelligent KM-Mail Manager acts as the brain of the whole system. Each e-mail received by the KM-Mail Server will be passed to the Intelligent KM-Mail Manager that matches the unique (group or specialized function) e-mail address to an internal list of all available groups and specialized functions. When a match is found, a dedicated Mailet is invoked. For example, if a discussion Mailet is invoked, the e-mail will be sent to the E-Mail Formatter that will parse and capture any relevant information necessary to forward the discussion e-mail (i.e. questions, problems and solutions) to the intended recipients as well as to store the discussion into the KM-Mail repository in the form of files. Their IDs are also recorded and stored in the repository.

Each e-mail will be given two IDs, a unique KM-Mail-ID and a reference-ID. The KM-Mail-ID is generated by the KM-Mail Server and is different from the message-ID generated by the server of the originating e-mail. The reason for employing a separate KM-Mail-ID is to standardize the ID format as different e-mail servers have different ways of assigning message-IDs. The reference-ID is used as a pointer to indicate to which original e-mail a user is replying to. Therefore, the very first e-mail sent out by the KM-Mail Server will have a null reference-ID (see Figure 8).

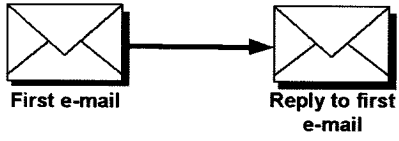

Fig 8. KM-Mail-ID assignment mechanism

These IDs play an important role in the evaluation mechanism because they act as references. E-mail messages with their IDs will be stored in the repository together with their evaluation score. Overall scores and number of ratings of a particular e-mail message will be updated continuously as more evaluations come in.

Traditionally, as e-mail is stored in repositories and archives, searching for a specific e-mail using search keywords is not new as this is one of the basic functionality of any e-mail client. However, retrieving relevant and context sensitive knowledge would require a more detailed search. It is important to note that the keyword field incorporated within the KM-Mail e-mail message actually complements the subject field and it aims to provide e-mail search results that are more context sensitive.

As the knowledge repository grows and expands, an efficient search mechanism is critical for a faster search process. Therefore, agent technology may be considered as a solution but this may give rise to e-mail security and privacy issues. However, we would not discuss these issues here as they are beyond the scope of this paper.

5. REALIZING AN ENTERPRISE-WIDE KNOWLEDGE MANAGEMENT PLATFORM

From an enterprise-wide perspective, e-mail is only one of the many ways that knowledge can be shared and managed. Therefore, we aim to incorporate the KM-Mail approach into a platform, called the KM-Platform (Cheah *et al.*, 2004), that addresses a wider range of knowledge management applications and services. This platform consists of two main groups of applications and services.

The first group is the *Intelligent Agent-Based Knowledge Management Application Suite* which addresses five key knowledge management processes, i.e. knowledge acquisition, identification, sharing, organization and reutilization. It consists of the following components:

- *Knowledge Acquisition Tool:* This component is responsible for acquiring knowledge from experts, a fundamental task in any knowledge-based system.
- *Knowledge Identification and Sharing Tool:* This component facilitates the identification of knowledge by individuals who require knowledge and the sharing of knowledge by experts.
- *Knowledge Organization and Reutilization Tool:* Upon establishing suitable repositories of knowledge via the knowledge acquisition and knowledge sharing tools, this component facilitates the organization, categorization and

reformatting of knowledge so as to allow effective reutilization of knowledge for other purposes or situations.

The second group is the *Strategic Visualization, Planning and Coalition Formation Service Suite*: This service suite complements the functionalities of the application suite where it facilitates decision-making and strategic planning in enterprises. It consists of the following components:

- *Dynamic Knowledge Visualizer:* This component allows effective and intuitive viewing or browsing of knowledge from the repositories. This can be knowledge that has been mined or discovered from the repositories.
- *Dynamic Planner:* This component combines generic plans available for enterprises and individuals and customizes them according to current enterprise and personal needs.
- *Knowledge-Based Coalition Formation Tool:* This component utilizes plans, schedules and resources to form optimum teams to carry out tasks within the enterprise.

The first group of applications would ideally handle a wide variety of structured knowledge (e.g. cases, rules) and unstructured knowledge (e.g. manuals, documents, reports, e-mail) in various file formats. Therefore, the KM-Mail approach can be easily integrated into the first group of applications to specifically address the management of knowledge stored in e-mail.

6.CONCLUSION

Seeing that the KM-Mail protocol may appear similar to existing e-mail protocols, we would like to stress that the value added feature of the KM-Mail framework lies in the fact that it highlights the importance of knowledge stored in the e-mail content, i.e. it emphasizes the availability of e-mail content (e.g. facts, discussions, problem-solving methods, mentioned earlier) that can be considered as knowledge and that can be effectively used for problem-solving. For this purpose, the additional modules and components in KM-Mail capitalizes on the wealth of enterprise-wide knowledge-rich e-mail through evaluation (rating) and search mechanisms. In addition to that, the search mechanism is made more effective via the organization of the e-mail repository using cellular automata and knowledge crystallization (which uses the rating of the domain experts). The development and evaluation of the KM-Mail framework and the KM-Platform is still on-going and there is still much to explore on the potential of knowledge-rich e-mails (Schwartz & Te'eni, 2000; Schwartz, 1998).

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