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Using Knowledge-Based E-mail System to Support Office Workflow Management: A Scenario-Based Approach

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Abstract

Computer-based information technologies and the communication they facilitate are the essential foundations for supporting and managing distributed work teams. One such technology is Electronic Mail System (EMS). Particularly, Knowledge-based Mail System (KMS) can effectively manage the dissemination and receipt of EMS messages via management rules on the contextual information and the content of messages. Recent research show that the scenarios of message processing might be especially advantageous in office workflow management. However, very little research has been conducted on the effect of using contextual scenarios with KMS to manage work processes of distributed teams. This paper presents a scenario-based approach for message management, which provides an alternative to knowledge-based mail system in support office workflow management. The scenario-based approach improves the prior KMS designs by (1) managing the messages as a task-based sequence rather than an individual message, (2) scheduling group activities not only based on relatively static knowledge of organizational policies but also the knowledge of work processes or activities that are often dynamically formed and changed, (3) managing documents routine via the contextual information of messages. Experience with a prototype demonstrates the viability of integrating the scenarios-based approach with the knowledge-based mail system.

Key Words: Workflow, Scenarios, Knowledge Base, Message Management, Email

1. Introduction

In today’s organizations, teams working on joint projects are often spatially dispersed and have to communicate across space and time zones. Computer based information technologies facilitate the communications that lay the essential foundation for supporting and managing these distributed teams (Franz, 1999). The Electronic Mail System (EMS) is an important part in these technologies.

Many methodologies and systems dealing with dissemination and receipt of EMS messages have been proposed. Among the various approaches, the Knowledge-Based Mail System (KMS), which involves the use of knowledge-based techniques, can effectively manage the dissemination and receipt of EMS messages via management rules on contextual information of messages (such as its sender’s information and receiver’s information) and content description of messages (such as keywords or other representational systems). A detailed review of existing KMS systems can be found in (Motivalla and Nunamaker, 1994) where KMS systems have been classified under three categories: Low-road approaches, Medium-road approaches, and High-road approaches. Low-road approaches, like Conversation-Based
Mail (Comer and Peterson, 1986), Structured-Message Management system (Tsichrizis, et al., 1982) and Logical Routing Message-Management System (Mazer and Lochovsky, 1984) focus on embedding intelligence into the structure of the message to assist users in routing and categorizing messages. This approach is based-on structured messages, which are specified manually by the users. Therefore, the flexibility and effectiveness of such a system are questioned. Medium-road approaches, like Knowledge-Based Message Management System (Chang and Lueng, 1987), Object Lens (Lai, et al., 1988) and MMS/FLBC (Moore and Kimbrough, 1995), focus on representing the intelligence explicitly in the separated knowledge base, then infer with the message header, to process the messages. However, the intelligence required by the message management is often complex and difficult to be represented by an isolated knowledge structure. High-road approaches, like ISCREEN (Pollock, 1988), Knowledge-Based Message Dissemination System (Higa, et al., 1994), and MAIL-MAN (Motiwalla and Nunamaker, 1992) focus on providing complex knowledge structures for higher-level message management.

Recent research show that the increasing managerial workforces in distributed teams leads the requirement of extending EMS functionality from improving group communications to exchanging information more efficiently, scheduling group activities, and partitioning work to decrease information overload and increase workers’ productivity (Franz, 1999). However, the aforementioned systems only focus on the relatively static organizational knowledge and the information embedded in the isolated message. The information related to users’ activities or behaviors and their histories are barely recorded officially. Therefore, the message processing performed by these systems is considerably isolated from the work processes. The research on office activity modeling and workflow support suggests that work processes are “chunks” of work, it makes more sense to provide a more complete view of work than do isolated information acts (Gordon and Moore, 1996). The isolated message processing might be enough for managing simple and static managerial work, but not enough for managing dynamic managerial work sequences in business process.

On the other hand, the research in scenarios analysis, office activities modeling and knowledge base/database coupling has provided the useful background:

- The study of scenarios (Potts, et al., 1994; Weidenhaupt, et al., 1998; Hickey, et al., 1999) illustrates the basic idea: “…scenarios might be used as bridges to relate system functionality to business process, and vice versa…”
- The study of information act (Gordon and Scott, 1999) is an approach to deal with the formal description of contextual information of messages.
- The work in office activities modeling (Tueni, et al. 1988) has provided useful studies for the representation and execution of workflow knowledge.
- The study of Structured Object Model (SOM) (Higa et al., 1992) and its applications provides a useful methodology for flexible and dynamic representation of organizational knowledge.

The focus of this research is the integration of the methodology referred to above into KMSs. Our aim is to demonstrate the viability of a KMS, which permit the following desirable features to be modeled based on message dissemination scenarios:

1) Formal Description of work process, which allows the transitions of the work processes can be captured and the work process can be captured, traced and modeled.
2) Representation and execution of workflow corresponding to the transition states of work processes as well as the organizational policies.

2. Related Work
2.1 Documentary act

Gordon and Moore (1999) defined documentary acts as a communication act involved in sending and receiving a document. Documentary acts are an analogous concept of speech acts. The phrase documentary act is used to mean “do something with documents.” It takes effect only when a message is sent to one (or many) recipient(s).

Gordon and Moore argued that there is many different kinds of documentary acts, which differ based on their illocutionary force that defines the document’s function or purpose – that is, what the document is supposed to accomplish. They proposed a typology of illocutionary forces: confirm, inform, offer, permit, predict, promise, question, require, and retract, and suggested that most business transactions could be meaningfully classified by a typology in this list. The concept of documentary act provides a useful methodology to describe the contextual information of task related messages and the possibility retrieve the information required for transition states modeling from message dissemination.

2.2 Scenarios

Scenarios are narrative descriptions of the sequence of activities that a user engages in when performing a specific task (Hickey, et al., 1999). Hsia, et al. (1994) proposed scenarios tree as a graphical representations of scenarios. In this mechanism, scenarios consist of events, specific stimuli that change the system state, trigger another event, or do both. The nodes in the scenarios tree are system states; edges between nodes are events. This research was inspired by the study on the scenarios analysis.

2.3 Office Task Representation

Tueni, et al. (1988) proposed the Activity Manager System (AMS) for task representation and execution. In this system, any task performed by an office worker within an organization is represented as an Activity concept. The concept of Activity-Network(AN) is proposed as a graphical representation of complex office tasks. It consists a set of nodes and a set of edges between the nodes. A node is a specialization of an activity, and the edges represent the precedence relations between the nodes. Tueni argued that three types of information must be encapsulated by the activity concept: (1) Start-State, describing the information to be checked before performing the activity, (2) Caused-State, describing the effect (or the reached goal) caused by the activity execution, and (3) The Body, describing how the activity will be performed. The AN provides the knowledge-based approach to represent office activities and their activation conditions. They also proposed the concept of Memory Organization Packet for Activities (MOPA) for knowledge composition. However, since the organizational knowledge, which is often stored in the organizational profile, is not conducted in AMS, the efficiency of task management is limited to the static knowledge components, such as the abstract activity and the MOPA.

2.4 Representation of Organizational Knowledge

The Structured Object Model (SOM) (Higa et al., 1992) representation schema provides a useful approach to represent organizational knowledge for both structural and procedural knowledge. In SOM, the organization structure is divided into substructure and the organizational procedural policies corresponding to each substructure are then identified. The substructure and the policies form a template of the organizational knowledge. Therefore, the organization knowledge can be represented as a collection of templates. The examples of
applying SOM to KMS can be found in Knowledge-Based Message Dissemination System (KMDS) (Higa, et al., 1994) and MAIL-MAN (Motiwalla and Nunamaker, 1992).

3. Scenarios-Based Message Dissemination Model

3.1 The Description of Work Processes

In work-related communication contexts, many messages are parts of larger conversations or handling procedures involving two or more participants. Each of these messages contributes to the same end or a specified task. A work process is a set of specific message scenarios as seen by a certain user group within a certain task. The scenarios involved in a work process consist of a set of documentary acts and the partial ordering relations between the documentary acts. Each documentary act consists of a specified force, a specified message content, and the context. A documentary act is represented formally in the form:

\[
doc\_act\ (<force>, <content>, <context>)
\]

Where,

- \(content\) refers to the propositional content of the message, in which the content is abstracted by message type such as “travel order”.
- \(force\) refers to the illocutionary force of the message. It determines the purpose of the message. This paper uses the following typology of illocutionary forces: “CONFIRM,” “INFORM,” “OFFER,” “PERMIT,” “PREDICT,” “PROMISE,” “QUESTION,” “REQUIRE” and “RETRACT”.
- \(context\) is defined as below by the terms sender, recipients, time, and precedence:

\[
context\ (<sender>, <recipients>, <time>, <precedence>)
\]

The first three terms are self-explanatory. They define a context in which a sender sends a message to a (or some) recipient(s) at time \(t\).

The precedence refers to the document acts that happened before and lead to the current documentary act.

The examples of documentary acts:

- “Susan sends Lodge a message to ask an arrangement of group meeting” can be represented as:
  
  \[msg1(context(Susan, Lodge, 2000/02/02 05:00:00, none), question, group meeting)\]

- “Lodge sends Susan a message to reply Susan’s question and inform her about a group meeting” can be represented as:
  
  \[msg2(context(Lodge, Susan, 2000/02/02 05:05:00, msg1), inform, group meeting)\]

Let \(\Rightarrow\) (read “precedes”) be a relation on documentary acts, denoted \(A\), such that \(a \Rightarrow a’\) if and only if documentary act \(a\) is in the precedence of context of \(a’\).

It has if act \(a\) precedes act \(a’\) (\(a \Rightarrow a’\)) and act \(a’\) precedes act \(a’’\) (\(a’ \Rightarrow a’’\)) then act \(a\) precedes act \(a’’\) (\(a \Rightarrow a’’\)).

The scenarios tree is the graphical representation of \(\Rightarrow\).

Figure 1 is an example of scenario tree that describes the precedence order of the paperwork for a business trip. Based on the scenario tree the transition states of work processes can be captured and modeled. In capturing the transition states, a query can be performed to the scenario tree on the specified work process and the activity, if the activity can be retrieved from the scenario tree then it has been completed otherwise it is either suspended or ongoing. In modeling the transition states, the activation conditions can be represented based on the query for capturing the transition states of a certain work process. For instance, “Send a travel
order to the persons manager for approval when he required a business trip” can be represented as:

IF EXISTS (SELECT act FROM scenario_tree
    WHERE force='require'
    AND content='business trip')

THEN SEND ‘require: travel order’ TO manager_of (sender)

In this example, the activation condition is represented using the query statement on scenario tree. To be mentioned, the term “manager_of” is a query function that retrieves managers name from organizational profile according to the sender’s name through a corresponding template. The details about the template are described in next subsection.

[Figure 1] An Example of Scenario Tree

3.2 Representation of Workflow Activities

The scenario tree allows the modeling of transition states. As we mentioned in section 2, neither AMS nor KMDS is designed for supporting workflow related message management. In this subsection we will show how the integration of the states modeling based on scenario tree, AN and the template-based approach to enable the advanced workflow support.

3.2.1 Activity Template

Based on activity concept in AN, we define that any workflow consists of a set of activities and the precedence relations between the activities. The activity is an abstracted representation of the description for certain message act and its activation conditions. An activity can be represented by the concept of Activity Template(AT), in which five types of information are encapsulated:

1. Identification of the corresponding group, describing the corresponding group, which contains all members who are related to the current activity. For example, “the activity is performed within the members belongs to project group.”
2. Actor Definition, describing the constraints of the actors who are allowed to perform the current activity. For example, “Only a manager can permit travel order.”
3. Start-State, describing the constraints to be evaluated before performing the activity. For example, “The group leader is able to submit the working file to the project leader only when all group members have confirmed it.”

4. Caused-State, describing the information that indicates an activity is completed/suspended caused by a certain activity execution. For example, “the project leader is no longer able to issue job assignment after he submits the project report to declare the end of project.”

5. Activity Definition, illustrating how the activity will be performed. The definition consists of by the illocutionary force, the abstraction of desired message content and the definition of message receiver. For example, “offer working file to any other group member.”

[Figure 2] the example of an Activity Template

Figure 2 shows the example of an Activity Template. The corresponding group is identified to “project group” which indicate that each project has a manager and many members, each member has name, project name, title and so on. The actor policy indicates that only the manager of the project of the sender who sends the message of “require: business trip” can
perform this activity. The caused-state indicates that the activity is suspended when a reply message of either “permit: business trip” or “retract: business trip” has been sent to the receiver. The activity indicates that a message of “permit: business trip” should be sent to the sender of “require: business trip”.

3.2.2 Activity Network

As pointed out in introduction, workflow procedures are sequences of activities. This sequence is represented by an activity network (AN). An AN consists of one starter, one terminator, a set of nodes, and a set of edges between starter, terminator and nodes. The edge always starts from the activity that precedes the target activity. There is at least one node connected with starter. There is at least one node connected to the terminator. From the view of implementation, the transition states are changed when an assigned message is sent out. Therefore, the activity that assigns the message and all the activities that follow that activity should be evaluated with the start-states and caused-states. Figure 3 shows an example of a simple AN.

The work process is invoked by sending the secretary a travel request for formal filing, then the secretary send the request to sender’s manager for an approval. When the manager retracts this request, secretary directly informs the sender by sending message to him/her who
requests the trip and completes the work process. When the manager permit this request, the secretary sends cash request to finance, then sends a message to order ticket, and then sends a message to reserve hotel. Finally the secretary sends a message to inform the person who requested the travel arrangement and completes the work process.

4. Implementation Issue

4.1 Architecture

The architecture of Scenario-based Mail System (SMS) is designed to support message dissemination management through recording and analyzing user’s message dissemination activities. As a major function, the SMS applies the workflow and organizational managerial knowledge automatically and enforces the workflow procedures to be followed by the users. The major components of SMS are developed as several independent service programs. This architecture allows easy integration with other office applications, and permits the functions of SMS to be upgraded without major redesigning. Figure 4 illustrates the architecture of SMS.
The architecture as shown in Figure 4 consists of several internal components including: (1) process management database: containing the information about the scenario tree and activity list for each user, (2) corporate knowledge base: containing the organizational communication policies and workflow procedure policies, (3) user interface module: allowing user to interact with the system via a browser, (4) EMS interface module: sending and receiving messages to and from the existing EMS, (5) process management module: applying the policy stored in corporate knowledge base and recording the scenarios into process management database, and (6) knowledge management module: identifying and instantiating the management policies according to the parameters extracted from the mail header. The external components consist of EMS, a corporate database, and DBMS interface.

4.2 Message Header Design

The message header is designed for the system to determine the specific act and the responsible activity template for analysis of the workflow states. This design inherits most features from header design in the KMDS. The construction of SMS’s mail header can be expressed in the following terms:

The address line:
TO: [r],{q->{t,c,g,n,s}…}
where:
q∈Q: Quantifier, e.g., [ALL, ANY, ONLY]
t∈T: Title, e.g., {director, researcher, secretary}
c∈C: Classification, e.g., {faculty, staff, student}
g∈G: Group type, e.g., {committee, project, task_force}
n∈N: Group name, e.g., {finance, accounting, personnel}
s∈S: Special topics, e.g., {AI, DB, GDSS,…}
r∈R: EMS user name of the receiver, e.g., {LODGE, SUSAN}

Q, T, C, G, N, S, and R are sets consisting of a predetermined maximum number of components, and t, c, g, n, s, and r are proper subsets of their respective supersets.

The subject line:
SUBJ: [f:m (g, n, s)], (m,g,n,s)
where:
f∈F: Illocutionary force, e.g., [REQUIRE, PERMIT, OFFER, …]
m∈M: Message type, e.g., {travel order, project assignment, job assignment, …}

See KMDS (Higa, et al., 1994) for additional information about analysis of message header above.

In order to identify the relation between different messages, SMDS uses the following header item, which is hidden from user’s view, to identify the message and the precedence message:

The message-id line:
Message-ID: [unique id]
Reference: {[message-id]}
ACT-ID: {[Act-id]}

The system assigns a unique id to each message automatically when user sends a new message. The message-id in reference field refers to the precedence message of current message. The Act-id refers to the documentary act that user is applying by sending the current message. An SMS user can specify the reference and act-id through a simple operation on the SMS screen, such as selecting a certain task in task list. In case that a user is
applying a documentary act that starts a new workflow, the parameters f and m will be verified corresponding to the desired documentary act.

For Example a typical SMS message header can be:

- From: lodge
- TO: Smart Mail Group Leader
- Subject: Offer: job assignment
- Message-ID: 20000623172650.Y6uOl13
- Reference: 20000623173032.ZvwQec8
- Act-ID: Offer_Job_Assignment

The following parameters can be determined from the header:

- \( g = \text{research\_group} \)
- \( n = \text{smart\_mail} \)
- \( t = \text{group\_leader} \)
- \( f = \text{offer} \)
- \( m = \text{job\_assignment} \)

By using parameters \( g = \text{research\_group} \), \( n = \text{smart\_mail} \) and \( t = \text{group\_leader} \) the system can instantiate the organizational profile template for all persons who are members of the smart mail group and have a title of group leader. By using the parameters \( f = \text{offer} \) and \( m = \text{job\_assignment} \), the system can identify the activity template for “offer job assignment” to start a new workflow process. Or in this example, the precedence message is defined in the reference field; therefore, instead of using parameters \( f \) and \( m \) to instantiate the activity template, the system can use the Reference and Act-ID to identify the workflow process and the activity template for the process.

4.3 Message Sending

The first step in sending a message is to determine if the message belongs to a specific workflow activity, i.e., the available act-id can be determined directly from message header. In the prototype system, an interface named “task board” can help the user to view the states of all activities involved in certain workflow. This interface also allows the user to compose a new message through the shortcut, in which the relative act-id is embedded, for the ongoing activities. However, the system can also use the \( f \) and \( m \) parameters in the subject field to identify the activity that starts a new workflow.

When an activity template is identified, the system first instantiates the template using the parameters in the message header. Then the system will investigate the actor definition using sender’s information. If the investigation is failed, the system will directly send out this message without recording the new act into scenario tree. Otherwise, the system investigates the start-state and caused-state using the information in scenarios tree to determine if the current act can be performed. If an activity can be performed, the system asks the user to verify the generated list of receivers’ names. After the message has been sent to the receivers, the new message is registered to the scenario tree to change the transition states.

5. Experiment and Results

This section describes an initial test on the prototype system, which is running on one host at Tokyo Institute of Technology. The test compared the effects on information overload of using the prototype system and the regular email system to complete same workflow procedures. According to the research on information overload, the amount of information and the time required to process information are the factors influencing information overload.
(Rudy, 1988; Speier and Price, 1998). Therefore, three measurements were measured for each system:

1) Non-task-related message, which was measured by the number of messages that are logically unnecessary for the result of a task, such as a message to ask the question about the task.

2) Unwanted message, which was measured by the number of messages that are produced by mistakes or the messages that disrupt the workflow, such as an overhead message.

3) Preparing time, which was measured by the amount of time that the subjects spent on the collecting the relevant information before he/she was ready to work. For example, every subject spent some time to verify the receipts list for each message.

A total of 16 individuals participated in the test. They are undergraduate students and graduate students. They were asked to perform the activities of a specific role in two pre-defined workflow, e.g., the secretary in the travel arrangement workflow, using the prototype and the regular mail system in turn. The subjects selected the regular system that was normally used in their daily work. Therefore, the skills of sending and receiving message via the regular mailer were considered no different effects to the result. On the other hand, the organization, which the workflows were employed, was pre-defined as well. Neither workflow nor organization used in the experiment was related to the subjects. Therefore, the knowledge about the tested workflow and organization was considered to be same for all subjects. A simple training for both workflow procedures and the operations of the prototype system was conducted for each subject before the experiment. During the experiment, the subjects were fed with the same responses according to the definition of workflow. The total number of messages that each subject composed during the experiment and the total amount of the time in minutes that each subject spent on processing messages for each workflow was counted for each workflow. The messages were then classified according to the following standards:

1) The messages that were sent for the purpose of acquiring the information about workflow requirements, such as looking for the receiver’s names and mail addresses, were classified as non-task-related messages.

2) The messages that were sent by mistakes, such as the message with wrong definitions of receivers, and the messages that disrupted the workflow, such as the overhead messages, were classified as unwanted messages.

<table>
<thead>
<tr>
<th>Task</th>
<th>Non-task-related Messages (pcs)</th>
<th>Unwanted Messages (pcs)</th>
<th>Preparing Time (mins)</th>
<th>SMS</th>
<th>RMS</th>
<th>$t$-stat.</th>
<th>$P$-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Task1</td>
<td>0 (0)</td>
<td>0 (0)</td>
<td>223(13.94)</td>
<td>0(0)</td>
<td>118(7.38)</td>
<td>2.77</td>
<td>0.014</td>
</tr>
<tr>
<td></td>
<td></td>
<td>159(9.94)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>763(47.69)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Task2</td>
<td>0(0)</td>
<td>0(0)</td>
<td>133(8.31)</td>
<td></td>
<td>37(2.31)</td>
<td>6.83</td>
<td>0.000</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>223(13.94)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

[Table 1] Non-task-related Messages, Unwanted Messages, and Preparing Time
During the test, the subjects produced over 2000 messages in total. An independent samples t-test was performed to analyze the differences between the effects of the two systems using the aforementioned measurements. The number of non-task-related messages, unwanted messages, and preparing time in minutes are shown in Table 1. All three measurements showed that the subjects performed better using SMS than the Regular Mail System (RMS). The result of the difference on the three measurements indicates that two systems have significant different effects on message dissemination for the messages related to workflow procedures.

The results indicate that the information overload can be alleviated by providing user with rich information related the message to be handled, and enforcing the users to handle messages according to the workflow management regulations.

6. Discussion

Our experience on scenario-based mail is limited, we only comment on our initial observations of the efficiency of scenario-based mail system via the test and on the lessons we learned about building message systems.

First, the successful of implementing the scenario-based approach with the KMS confirms that the formalized message dissemination scenarios contains plenty information about business processes. It can help provide automatic aids for (1) organizing the related messages to the same sequence, and providing the surrounding context for late replies; (2) retrieving information base on the facts, hierarch of messages, timing relationships and so on, for example, it can help to answer the question “Who send the purchase request before Lodge issues the purchase order? ”; (3) providing description about the workflow states; and (4) suggesting likely response to the other messages.

Second, we observe two complex procedures, which are frequently appeared in real world business processes: iterations, the execution of one or more steps within a procedure might be repeated several times; compound steps, the same sub-procedures might be assigned to certain user several times. Both procedures increase the difficulty in coding the workflow.

Third, the management of business processes and the handling of message itself are two aspects for message management. Since the features and concerns for the two aspects are considerably different, the mixture of two types of processing are often increase the complexity and difficulty of message system design. Therefore, separating the process management from message processing can reduce the complexity and difficulty of message system design.

7. Conclusion

This paper presented the SMS system that deals with the requirements of workflow support and allows the capturing and analysis of the transition states in work processes. It is a KMS that addresses the following issues:

- Formal description of work processes and its transition states. The representation of message dissemination scenarios allows the transition states in the work processes to be captured and monitored dynamically.

- Integration of activity network and knowledge base/database coupling template. The rich knowledge structure allows the complex workflow activities and their activation conditions to be represented flexibly and dynamically.

The prototype implementation and experiment results demonstrate the viability of using message dissemination scenarios with KMS to support workflow management. The SMS enforces the workflow related message processing procedure to follow the workflow
management rules. Therefore, the purely task-related messages will reach the intended receivers with fewer overheads.

Our experience suggests that the message scenarios provide the powerful tool for managing office workflow procedures and retrieving relevant information. This paper provides a prima facie study for office workflow support using KMS. Although the sample size for the experiment was small, the preliminary analysis showed a promising result for the use of SMS on workflow management. The methodology for knowledge acquisition in the distributed environment and dynamic knowledge construction are planned to the future research for the proposed SMS.
References:


