Intelligent Form and Workflow Management System for Business Process Re-engineering

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Abstract

Business Process Re-engineering is a hot issue in information systems research. However, little research has been done that seeks an effective way of implementing the re-engineered processes. In this study, we propose an Intelligent Form and Workflow Management System (IFMS) that can implement new processes by re-engineering knowledge in intelligent forms and agents. The notion is illustrated with a purchasing procedure, and a prototype UNIK-IFMS under development is described. IFMS can be an important research paradigm for the business process re-engineering.

1. Introduction

Business Process Re-engineering (BPR) is a hot issue in information systems research. The employed research paradigms for BPR so far may be classified into three categories.


2) Case Studies: Collection of BPR cases (Hammer and Champy, 1993).


In this study, we contribute to the third category of research by developing an Intelligent Form and Workflow Management System (IFMS) that can attain the following goals.

1) Develop intelligent that perform the contingent routing; call necessary database, expert systems, and humans; report the status to monitor; protect security; and share the information with corporate databases.

2) Develop intelligent agents that have the capability of basic expert systems along with the extended capability of communication control and meta-problem-solving.

3) Monitor and evaluate the status both dynamically and periodically. Identify the problematical points to be reviewed for re-engineering.

4) Let the re-designed business process be implemented by changing the knowledge in the intelligent form and intelligent agents without significantly changing the entire software structure. We call this paradigm "BPR by Knowledge Re-engineering(KR)."

5) Seek a standard that can cover the intelligent forms, messages of intelligent agents like KQML(Knowledge Query and Manipulation Languages) and Electronic Data Interchange(EDI).

6) Apply this approach to real-world problems. The first attempt illustrated in this paper is the purchasing procedure.

To proceed toward the goals, we study the purchasing procedure (section 2) and review literature on BPR, form management, business procedure specification, image processing, workflow management, and intelligent agents (section 3). Then the explicit and implicit factors to be stored in the intelligent forms are represented in the objects (section 4), and the procedures are represented at class and instance levels (section 5). BPR implementation by knowledge re-engineering is illustrated (section 6) along with the monitoring and evaluation of processes (section 7). Finally, the implementation of a prototype UNIK-IFMS is described (section 8).

2. A Scenario for Purchasing Procedures

2.1 A Traditional Purchasing Procedure

To illustrate a purchasing procedure in an organization, consider a case with the following purchase requisition form that is under use in the Korea Advanced Institute of Science and Technology (KAIST). At the outset, the requisition form in Figure 1 is filled in by an initiating user who owns his own account along with at least a price quotation about the desired item. Then the academic departmental chair and dean consecutively approve the requisition unless the items are irrelevant to
the purpose of the account. The form is then passed to the budgetary controller who checks the balance of the account, authority to purchase such an item by the account, and the adequacy of purchasing source and method. If any defect is detected in this process, the form will be returned back to the originating department and in turn to the requester. If the budgetary controller does not find any defects, then the form is passed to purchasing administrator. He collects the new quotations again, negotiates prices, selects the items and vendors, and contracts with and orders from the suppliers. Finally, the item will be delivered and inspected. This process is depicted in Figure 2.

2.2 Database and Knowledge Bases

To process the purchasing requisition, the budgetary controller needs to refer to databases to check the account
balance and to knowledge bases to check purchase authorizations and the adequacy of purchasing source and method. Both the requester and purchasing administrator need to refer to the knowledge bases and databases for the selection of appropriate models that meet the required specifications at the best prices. For instance, in bidding, the following rules are applied to determine whether multiple price estimations are required.

\[
\begin{align*}
\text{IF} & \quad \text{Private Contract} \\
\text{AND} & \quad (\text{Supplier} = \text{One}) \\
\text{OR} & \quad \text{Contract Base} = \text{Unit Price} \\
\text{OR} & \quad \text{Patent Product} \\
\text{OR} & \quad \text{Amount} \leq 800K \text{ Won} \\
\text{THEN} & \quad \text{Single Estimation}
\end{align*}
\]
2.3 Current Problem and Proposing Remedy

Currently, the knowledge bases might have been memorized by humans or may be referred to by consulting printed regulations. The problem with the current system is that initiating requesters do not have sufficient knowledge at the time of initiation. In this light, we attempt to reallocate the knowledge to the necessary positions by employing expert systems technology to prevent inadequate form completion in advance.

To fulfill the above goal, first the forms should be represented in a way that can be understood by intelligent agents which will act as surrogate human experts. We adopt an object-oriented representation for this purpose. In addition, the databases and knowledge bases should be shareable by both intelligent agents and human users. Due to gaps of quoted prices and times between the requester and purchasing administrator, requesters may not be able to spend the remaining balance whose precise amount may be confirmed after the expiration of the effective term. Public information about the products and prices may be obtained either by requiring the potential vendors to provide their information to the purchasing company's own database or by navigating the supplier's databases.

3. Literature Review

Let's review six areas of literature relevant to the purpose of IFMS.

3.1 Business Process Re-engineering

According to Hammer (1990), BPR implies fundamental rethinking and radical redesign of an entire business system to achieve dramatic improvement in critical measures of performance. Organization may seek fundamental change if it is beneficial. However, no organization can continue radical improvements for a long time. In this light, we adopt Davenport and Short's milder definition of BPR: the analysis and design of workflow and processes within and between organizations (Davenport and Short, 1990). The five steps in redesigning business process are (Davenport and Short, 1990):

1) Develop business vision and process objectives.

2) Identify processes to be redesigned (identify critical or bottleneck processes).

3) Understand and measure existing processes (identify current problems and set baseline).

4) Identify information technology "levers" (brainstorm new processes and approaches).

5) Design and build a prototype of the process.

IFMS attempts to help the steps 2 and 3 by monitoring and evaluating the current process and step 5 by knowledge re-engineering.

3.2 Forms Management

Most of forms management research performed during early 1980s as a part of office information systems research has not adopted the expert systems technology. TLA (Toronto Latest Acronym) suggested a condition-action type office procedure language at a conceptual level (Tsichritzis, 1982). FORMANGER is equipped with the facilities for form specification, form processing, and form procedure control (Yao, 1984). PAGES is a distributed form management system that conceives forms as agents which have local functionality, communication, coordination, automation, and interactive sharing. PAGES is focused on the object-oriented representation of form classes and instances, form-oriented rule languages, and management of the form base (Hamm and H., 1990).

We can employ the concepts studied in form management for our research in IFMS. However, a distinction is that form management systems have not incorporated expert systems and distributed artificial intelligence technologies and their application for BPR.

3.3 Business Procedure Specification

Business procedures are to be specified in pseudocode-like syntax in terms of form routing, triggering, and invocation of form processing (Shu, 1982) and condition-action type logical routing (Mazur and Lochovsky, 1984). The literature provides a large portion of concepts necessary to represent procedures with forms described in section 5.

3.4 Image Processing

Printed forms are scanned into optical storage for display purposes, and the data in optical storage are interpreted to be stored in the database for processing as depicted in Figure 3 (Casey and Ferguson, 1990). Recognition of handwritten signatures becomes more reliable.

3.5 Workflow Management

Workflow software is classified into the following three categories (McCready, 1992):

1) Production Workflow:
   - For structured and complex tasks
   - Examples: mortgage loan processing, insurance underwriting, claims processing, credit card correspondence
3.6 Intelligent Agents

In the AI literature, intelligent agents seem the most relevant to IFMS. So far, research on intelligent agents has been performed with various words depending upon the purpose of research: intelligent interfaces, adaptive interfaces, knowbots, knowbots, softbots, userbots, taskbots, personal agents, network agents, and distributed artificial intelligence (Riecken, 1994).

UNIK-AGENT has been developed as an environment for intelligent agent based electronic marketing. In UNIK-AGENT, the agent has the capabilities of a problem solver (problem solving manager, solution engines, knowledge base and database) and communication controller (directory consulting, individual message generation, message queue management, and message gate), and have proposed an extended version of KQML, KQML+ as a message standard (Lee and Lee, 1995).

3.7 Comments on the literature

Prior research provides useful but only partial information for designing IFMS, because each category of research had pursued different objectives. Nevertheless, relevant notions will be adopted whenever necessary. However, no research has attempted the integrated representation of forms and procedures at class and instance levels along with the intelligent agents to aid the BPR implementation.

4. Object-Oriented Representation of Forms

The form displayed in Figure 1 will be represented as an object. The object needs to keep both explicit and implicit items.

4.1 Explicit Items

The explicit items are the ones to be filled in on the paper form. From the form in Figure 1, the explicit items for a purchase requisition can be represented in an object as follows.

```object
{
'Purchase_Requisition
'Requisition_section:
'Use_For:
'Requisition_No:
'A/C_No:
'Date_of_Issue:
'Desired_Delivery_Date:
'Delivery_Point:
'Contents:
'Source_of_Purchase:
```
7) Constraints among items within a form:

For example, \( Amount = Quantity \times Unit\ Price \)

8) Constraint among forms:

For example, the quoted price in a quotation form should be the same as the unit price in the purchasing requisition form.

5. Procedures with Forms and Agents

5.1 Procedure Class Base

It appears that any complex procedure can be constructed from the following seven elementary types of procedures (including the forms and processing agents).

1) Serial Flow

```
   A  --P1--  P2  --A
```

2) Form Merging

```
   A
   B  --P1--  AB
```

3) Form Partitioning

```
   AB  --P1--  Ab  aB
```

4) Conditional Branching (XOR Branching)

```
   A  --P1--   
```

5) Invoked Another Form

```
   A  --P1--  C
```

In our study, the UNIK-FRAME is used to represent the forms as objects.

4.2 Implicit Items

Typical implicit factors that do not appear in the paper forms but must to be stored in intelligent forms are:

1) Contingent Routing Rules:

Conditions include the time lapse, contents of explicit items (particularly the permission of previous processes), and next processors. Actions include "route to next destination," "whether to terminate here," "call relevant databases," and "call relevant intelligent agents." The procedure should be represented with forms and agents together for each task (e.g., purchasing).

2) Access Control:

Authentication of access and subschema concept for each user or user class.

3) Time limitation for each step.

4) Relevant database to recall.

5) Relevant intelligent agents to be checked by.

6) Report of progress to the computerized monitor and/or human supervisor.
6) Reporting Forms

\[ \text{A} \rightarrow \text{P1} \rightarrow \text{P2} \]
\[ \downarrow \text{RPT} \]
\[ \downarrow \text{P5} \]

7) Recalling Forms

\[ \text{A} \rightarrow \text{P1} \rightarrow \text{P2} \]
\[ \downarrow \text{RC} \]
\[ \downarrow \text{DB} \]

The processing agent may be either an artificially intelligent agent or a human. An agent at the class-level may contain more than one instance-level agents. To represent the whole procedure of a task at the class-level, the representation needs to model forms, agents and their relationships together. We call the collections the class-level procedure base. The information for the procedure class base is usually identified by the regulations.

5.2 Procedure Instance Generation

In this section, we illustrate a re-engineered purchasing procedure and generate a procedure instance using IFMS.

Step 1) A procedure instance is initiated by retrieving a task from the list that indicates the procedure class base. Suppose the purchase requisition is initiated by a faculty member, Dr. Han, in the MIS department to buy a printer. The intelligent agent for Han, agent Han, will generate the format of the necessary forms and obtain the account number and requirement of a printer.

Step 2) The agent Han sends a message about the requirement to the agent with the products' and vendors' knowledge base to find the models that meet the requirement and their prices. The agent may use a forward chaining or case-based reasoning approach for this process. Each alternative may be displayed in its own window. If there exist more than one “non-dominated” alternative, the requester must judgmentally select one.

Step 3) The agent Han sends a message to the account agent to retrieve the balance left and to check whether the balance exceeds the required amount.

Step 4) The agent Han sends a message to the purchasing regulation agent to ask about the allowable purchase sources and methods. Then the requester can select among the allowed choices.

Step 5) Dr. Han, an end user, signs if he likes the current plan. Then the requisition form is forwarded to the next destination - the department chair.

Step 6) The department chair consults the requester, items, and account, and sign for approval.

Step 7) If the amount and/or the purpose of account requires the permission of dean, the form will then be forwarded to the dean.

Step 8) Otherwise, the form will be passed to the contract agent which generates the contract form.

Step 9) The contract form will be passed to the purchasing administrator for final approval.

Step 10) Upon approval, a message for the contract will be transmitted to the selected vendor, possibly following an EDI standard.

The above procedure is depicted in Figure 4. The follow-on process of mutual agreement, order, delivery, and inspection can be handled in a similar manner.

6. Business Re-engineering Implementation by Knowledge Re-engineering

Suppose we have re-engineered the purchasing procedure as shown in Figure 4. The key differences from the current procedure in Figure 2 are:

1) The role of budgetary controller - check the account and purchase regulation - is replaced by two agents.

2) The role of purchase administrator - select products and vendors, quote prices, and document for contract - is replaced by two agents. The only role left is confirmation of the generated contract documents.

3) The knowledge of the budgetary controller and purchase administrator is coded to be accessible by the purchase requester's agent. This realizes the reallocation of the knowledge of budgetary controller and purchase administrator to the purchase requester.

4) The entire process may be executed within a day if the department chair and dean are available, whereas the current process takes several weeks.

5) Suppose the purchasing regulation is changed. It can be implemented simply by updating the regulation knowledge base.
6) If the condition of routing is changed (e.g. the dean may want to exempt an account from requiring his approval), the change can be implemented by updating the class-level procedure base.

Recall that the re-engineered process in (5)-(6) can be implemented instantaneously by knowledge revision without changing the structure of software. This notion is what we mean by Knowledge Re-engineering for BPR.

7. Monitoring and Evaluation of Processes

In a client-server environment, a server may monitor the current status of form processing. Forms (or agents) may report to the monitoring agent each time they exchange a message and forward forms. The amount of reporting required will vary depending upon the amount of monitoring undertaken. The summary report for a certain period of time should be useful to pinpoint the bottleneck or delay. Then a revision for re-engineering can be reviewed.

8. Implementation Issues

8.1 A Prototype UNIK-IFMS

UNIK-IFMS is under development using the UNIK (UNified Knowledge) environment. UNIK-FRAME is adequate for representing object-oriented forms and KQML messages. To provide a messaging capability, the
UNIK-AGENT is appropriate because it is equipped with meta-problem-solving and communication control capabilities along with the conventional expert systems capabilities. An extended standard relating to intelligent forms, KQML type messages, and EDI will be investigated in the future.

8.2 Instance Form Base Management

To use the information in the instance forms generated, the forms can be accessed directly. However, to incorporate the information into the common database, the notion of form based database design can be used (Kim et al, 1994).

8.3 An Information System Maintenance Expert System

Since certain regulation knowledge might have been implemented in more than one places (rules in agents and forms and/or program modules), maintaining consistency among the knowledge is difficult without a systematic aid. To allow changes to be made at one place, an expert system for system maintenance is currently under development in KAIST.

8.4 Auditing using IFMS

By using the IFMS, auditing knowledge can be deployed in the knowledge bases to enforce regulations and rules preventively.

9. Conclusion

The notion of intelligent form and workflow management has been proposed as a medium for implementing re-designed business processes by knowledge re-engineering. The prototype UNIK-IFMS is under development with a particular application to purchasing process. UNIK-IFMS should significantly contribute to the (r)evolution of software engineering and to future office information system.

References


