Development of Purchasing Information Process Agent System

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Abstract

It is not easy for business workers to find proper information for his job, because of the following problems: (1) information exist in various information systems both internal and external with diverse formats, (2) he cannot estimate relevance of all the information, and (3) he cannot select proper information among large volume of information. The requirements for the system are the following things: (1) search of relevant information from various internal and external information systems, (2) providing an integrated view of information for workers, and (3) information processing and decision-making are seamlessly integrated for business workers.

We proposed an agent system to fulfill the requirements. We focus on the purchasing job, and developed a prototype system, PIPA (Purchasing Information Process Agent). The PIPA performs not only information processing jobs (information search, gathering, display, business form-making) but also decision-making support job (evaluation of supplier candidates, and apply of sourcing policy) for sourcing manager. The framework of the PIPA can be applied to other information processing and decision-making jobs.

Keywords:

Purchasing Agent System.

1. Introduction

Recently, companies have invested a lot of money in their information systems for ensuring both business process efficiency and strategic competitiveness. Lots of data and information accordingly have been stored in corporate information systems. However, it is not easy for business workers to find proper information for his job because of the following problems: (1) information are scattered in various internal and external information systems with diverse formats, (2) he cannot have enough time to estimate relevance of all information, and (3) information for simple business processing job (for example, information search, integration, sorting) and information for decision making job are not integrated.

On the other hand, Internet may help business workers by providing useful information. But too much volume of information from Internet may be burdensome for workers. Search engine and filtering services that have been developed for general-purpose users could be some help for business workers. But these services are not integrated with his business process and require manual operations.

Requirements for a system to help business workers are following things: (1) search of relevant information from various internal and external information systems, (2) providing an integrated view of information for workers, and (3) information processing and decision-making are seamlessly integrated for business workers.

We proposed an agent system to fulfill the above-mentioned requirements. We focus on the purchasing job, and developed a prototype system, PIPA (Purchasing Information Process Agent). The PIPA is an agent system for purchasing workers, who should perform information process job such as collection of requisition information from internal clients, search of product information, purchasing history and supplier information, making a RFQ (Request For Quotation) form, and perform decision making job such as evaluation and selection of supplier candidates.

In this paper, we will explain the design, architecture, and implementation of the PIPA system with an example of MRO (Maintenance Repair and Operation) product purchase. The PIPA can improve purchasing job processing efficiency and support decision making of purchase managers. The framework of PIPA can be applied to other business information processing and decision-making jobs like employment of new staff, organization of project team, and outsourcing of general affairs management.

2.Related Systems and Researches

There are three categories of related researches: web search agent, information filtering agent, and agent for electronic commerce. Search and information filtering agents have been developed for general-purpose Internet users and EC agents for online consumer's convenience.

The PIPA also uses a search engine function to obtain purchasing related information from Internet web. However, the PIPA is different from general-purpose search engine in two features. First, Information search is initiated by an activity in purchasing job process and controlled by business process agent, not by human being. Second, The outcome information from external (Internet) and internal sources (enterprise DB) are integrated and displayed for the purpose of purchasing job process.

Information filtering agents filters information from various sources reflecting user profile that he stored in advance[1],[2]. Most filtering agent uses a user profile, where he sets his rules how to filter information[3]. There are various filtering schemes from a simple sorting method to a rule inference. The PIPA uses a priority setting and production rules to filter and evaluate information of supplier candidates. Purchase manager's priority on evaluation criteria is stored in his profile and used to evaluate supplier candidates. Production rules stored in rule base are used to reflect contract manager or company's sourcing policy such as 'put high priority on long-term contract suppliers' etc. The PIPA provides ordered (filtered) candidates with evaluation points of each candidate.

Agents for online consumers have been developed to help a consumer with product selection or merchant selection[4]. Comparison-shopping agents provide comparison of merchants with product price, delivery days and payment conditions[5]. Product configuration agents help a consumer select parts and options of product while checking compatibility of selections[6]. The PIPA compares supplier candidates with their price, delivery days, product quality, and reliability.

<Table 1> Comparison PIPA with Related Agents

	Related Agents	PIPA
User	General Users	Sourcing Manager
Information Handled	Mainly Product Information	Product, Supplier, Purchase History Information
System Goal	Convenience of Individual Users	Efficient Purchasing Job Process for Sourcing Manager
Information Source	Internet Web	Enterprise DB, E-mail, Internet Web
Decision Support	Simple Comparison	Priority Setting, Rule Inference
Business Process Support	None	RFQ Making, Evaluation

<Table 1> shows comparisons of related systems with the PIPA. In the sourcing process of a company, the PIPA

helps a sourcing manager with information process and decision-making support, while general-purpose agents help general users with mainly general information processing, not with evaluation and decision-making.
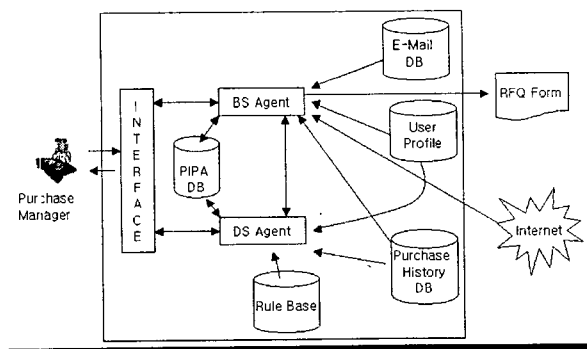
3. Design of the PIPA

Before we go down to the design of the PIPA system, we analyze purchase managers work, which can be classified as two kinds of jobs: information processing and decision making job. Information processing job includes (1) collection of requisitions from internal clients, (2) group summation of requisitions by products, (3) search of product and supplier information from external web, (4) search of internal purchasing history information, (5) analysis of all the information from (1) ~ (4), and (6) making and sending of RFQ. Decision-making job includes (1) setting of evaluation criteria and (2) selection of supplier candidates by evaluation criteria.

The PIPA supports both information processing and decision-making job of purchase manager. Therefore, PIPA is composed of BS Agent (Business Support Agent) for information processing job and DS Agent (Decision Support Agent) for decision-making job.

3.1 System Architecture of the PIPA

<Figure 1> shows the architecture of the PIPA. It composed of two agents, interface and internal and external information sources. BS Agent takes charge of the most above-mentioned information-processing jobs. When BS Agent gets at the decision-making phase, it creates DS Agent and shares the information with DS Agent for decision support.

DS Agent supports sourcing managers with decision-making about supplier candidate selection. DS Agent uses three information sources for decision support: buying history from internal enterprise DB, evaluation priority from sourcing manager's profile and sourcing manager's policy from rule base. With this information, DS Agent evaluates supplier candidates and share evaluation results with BS Agent.

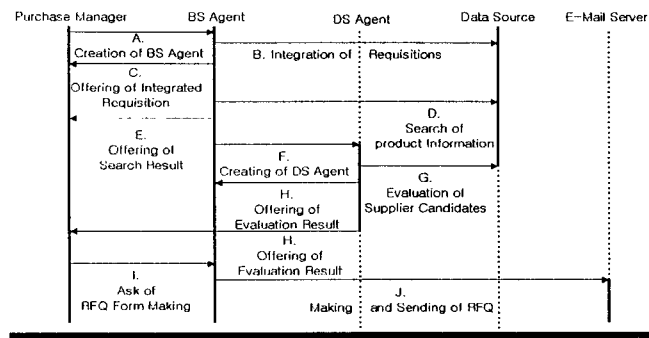*<Figure 1> System Architecture of the PIPA*

The PIPA system is for sourcing manager of a company

and all the interfaces of the PIPA are designed for sourcing manager's business work. Interface module gives a display of information and gets his responses and transmits them to two agents.

3.2 Operation Sequence of the PIPA

<Figure 2> illustrates the operation sequence of the PIPA. We adopt 'Sequence Diagram' method of UML (Unified Modeling Language) to describe operation sequences of the PIPA[7]. Vertical lines imply objects of the PIPA system, and horizontal line with arrow at the end means an event from an event-generating object to an event-receiving object.

Operation of PIPA can be viewed as interactions among 5 objects: purchase manager ('PM' from now on), BS Agent, DS Agent, data sources, and e-mail server. We will explain the operation sequences by the order of event generation.

<Figure 2> Sequence Diagram of the PIPA

A. Creation of BS Agent

After purchasing manager's log in, the PIPA generates and initiates BS Agent.

B. Integration of Requisitions

BS Agent collects requisitions from e-mail files at PM's PC and files at groupware system (Figure 5), and extracts purchasing information like product name, volume and price. Then BS Agent reorders requisitions by product. If there is same product and they have similar due dates of acquisition, they are integrated for volume discount.

C. Offering of Integrated Requisition

BS Agent offers an integrated requisition form (Figure 6) to PM, and PM can proceed with purchasing job by clicking of 'purchase' button.

D. Search of Product Information

BS Agent searches information of the product that PM selects to purchase. Sources that BS Agent searches include purchase history information from enterprise DB, new supplier candidates from Internet web sites.

E. Offering of Search Result

BS Agent provides PM with purchase history

information: name of suppliers, purchasing price, contact point, whether supplier is long-term contractor or not, and web search information: supplier name, price, contact point (Figure 8).

F. Creation of DS Agent

DS Agent is created by BS Agent, and initiated.

G. Evaluation of Supplier Candidates

By using evaluation priority at profile DB, DS Agent applies evaluation criteria to supplier candidates. DS Agent also applies purchasing policies by inference of rules at rule base.

H. Offering of Evaluation Result

DS Agent provides evaluation result to BS Agent and PM.

I. Ask of RFQ Form Making

PM can select supplier candidates with referring evaluation results (Figure 11, Figure 12). Then BS Agent is automatically asked to make RFQ form that will be sent to the selected supplier candidates.
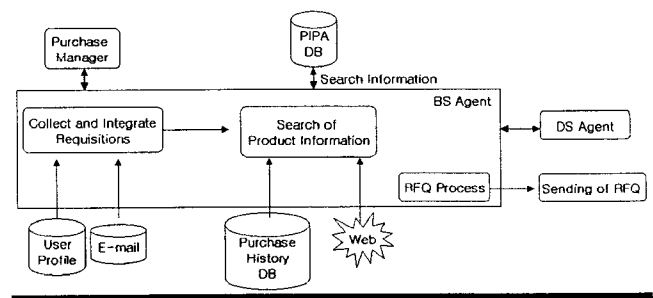
J. Making of RFQ Form

Fields of RFQ are filled by BS Agent with information that BS Agent has obtained. BS Agent sends HTML-formatted RFQ to the selected supplier candidates.

4. Implementation of the PIPA

In this section, we will describe how functions and operation sequences of the PIPA are implemented. BS Agent and DS Agent's structure and functions also described. Several ASP (Active Server Page) codes and HTML Form-based user screens are exemplified.

4.1 BS Agent

We will explain how the BS Agent acts and reacts during operation sequences. <Figure3> is Architecture of the BS Agent. Whenever PM makes a log in the PIPA system, a BS Agent is created. When BS Agent is created, members and methods of BS Agent are initiated. BS Agent brings PM's ID at its member value, because BS Agents will use it as a key to find PM's priority information from profile DB.

<Figure 3> Architecture of the BS Agent

<Figure 4> is a PM's registration screen. 4 items from the bottom in <Figure 4> are for a PM to set priorities of 4 criteria that will be used to evaluate supplier candidates. If he selects 'reliability' as a first priority criterion, he put the highest priority at reliability among 4 evaluation criteria: reliability, price, delivery, and quality. This priority setting is stored in his profile DB, however he can adjust his priorities afterward according to purchase item and sourcing strategy.

BS Agent has a method that collects requisitions, and run it automatically after PM makes a log in. We suppose that a requisition is a HTML-formatted form (Figure 5). Then, BS Agent can access each form fields and extracts such information as user name, product name, volume and price. In our example, the method collects HTML-formatted requisitions from e-mail files at PM's PC. BS Agent saves the extracted information at the PIPA DB.

<Figure 4> Purchase Manager Registration

<Figure 5> Requisition from an Internal Client

BS Agent reorders and integrates requisitions by purchase item. If there are same purchase items and they have similar due dates of acquisition, they are integrated for volume discount.

<Figure 6> Integrated Requisition

<OBJECT   RUNAT=server   PROGID=ADODB.Connection
id=ObjDBConn></OBJECT>;
<OBJECT   RUNAT=server   PROGID=ADODB.Recordset
id=ObjRs></OBJECT>

<% objDBConn.Open "DSN=kost;UID=sa;PWD=;
"SQL="SELECT * FROM Request ORDER BY Item ASC"
                        //Request Table has Requisition information
objRs.Open SQL, objDBConn %>   -- -- (Omit)

<% objRs.movefirst
    R_Item=objRs("Item"); R_cord = objRs("Cord");
i=1; j=0
Do Until objRs.EOF
        R_volume= objRs("Volume");
        R_price = objRs("Price");
        R_cost = R_volume * R_price
            if objRs("cord") = R_cord then
                        //The same purchase cord exists in Request Table
            R_volume_sum_cord(i)   =   R_volume_sum_cord(i)   +
R_volume
            R_cost_sum_cord(i) = R_volume_sum_cord(i) * R_price
            R_Item(i) = objRs("Item"); R_cord(i) = objRs("cord");
            R_price(i) = objRs("price") %> .....(Omit)
                <% else %> .....(Omit)

                <% R_cord = objRs("Rcord")
                i=i+1; R_volume_sum_cord(i) = 0;
R_volume_sum_cord(i) = R_volume_sum_cord(i) + R_volume;
R_cost_sum_cord(i) = R_volume_sum_cord(i) * R_price;
R_Item(i) = objRs("Item")
R_cord(i) = objRs("cord");
R_price(i) = objRs("price") %> ....(Omit);
                <% end if%> ......(Omit)

        <% if objRs("Item") = R_Item then
                        //The same purchase Item exists in Request Table
        R_volume_sum_Item(j) = R_volume_sum_Item(j) + R_volume
        else
        j=j+1
        R_volume_sum_Item(j)= 0;
        R_volume_sum_Item(j) = R_volume_sum_Item(j) + R_volume
        end if %>
        <% objRs.MoveNext ; Loop %> .....(Omit)

<Figure 7> Part of Program Code for Item Integration

<Figure 6> and <Figure 7> shows the item-integrated requisition form and its program code, respectively. This code is a part of an item integration method of BS Agent. You can see the group summation results at the end of each item group at <Figure 6>. If PM quits his job at this moment, the integrated information remains in the PIPA DB and he can restart his job afterward with newly arrived requisitions.

PM can select several items simultaneously by clicking of check boxes at right hand side of <Figure 6>. An event of PM's clicking 'Purchase checked Item(s)' at the bottom of <Figure 6> runs a method that search product information from internal and external sources. At first, BS Agent searches information from purchase history DB. BS Agent can obtain information about price, volume and lead-time from history DB, and this information is useful for evaluating suppliers. From the external Internet web, BS Agent can obtain information about new suppliers who sell the purchase item, item price and contact point. <Figure 8> illustrates the internal and external information that BS Agent collected. <Figure 9> is a sample code of BS Agent's method that searches item information at purchase history DB. All information that BS Agent has collected is stored PIPA DB and shared with DS Agent.
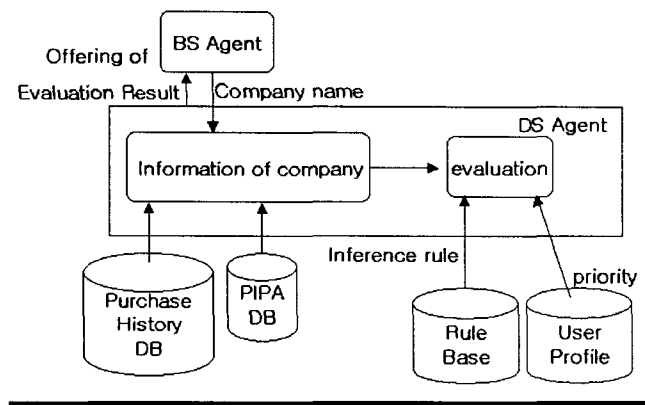

<Figure 8> Search Result

If PM presses the "Evaluate Suppliers" button at <Figure 8>, this event makes BS Agent create DS Agent. DS Agent's members and methods are initiated, and DS Agent starts to evaluate supplier candidates. We will explain the implementation issues of DS Agent at the next section.

The last thing that BS Agent performs is RFQ form making for each selected supplier candidates and sending it to them. If fields of a RFQ form are same with those of the PIPA DB, BS Agent automatically fills out those fields with the value in the PIPA DB. Fields that could be filled automatically include supplier name, contact e-mail, purchase item, volume, price, and delivery days. As we mentioned the above, the RFQ form making is done after DS Agent evaluates and PM selects the supplier candidates.

```
<OBJECT     RUNAT=server     PROGID=ADODB.Connection
id=DBConn></OBJECT>
<OBJECT     RUNAT=server     PROGID=ADODB.Recordset
id=HRs></OBJECT>
<OBJECT     RUNAT=server     PROGID=ADODB.Recordset
id=WRs></OBJECT>

<% DBConn.Open "DSN=kost; UID=sa; PWD=;"
SQL1 = "SELECT * FROM History_Table"
                // History_Table has internal search information
SQL2 = "SELECT * FROM Web_Table"
                // Web_Table has external search information
HRs.Open SQL1, DBConn
WRs.Open SQL2, DBConn
Item = Request("Item")
                // Item value is passed as parameter.
%>.....(Omit)
<%
HRs.movefirst
Do Until HRs.EOF
if HRs("Item") = Item then
                // The same purchaseitem exist in History_Table
%> .......(Omit)
<%
WRs.movefirst
Do Until WRs.EOF
if WRs("Item") = Item then
                // The same purchase item exist in Web_Table
%>......(Omit)
```

<Figure 9> A Sample Code of BS Agent's Search Method

4.2 DS Agent

The mission of DS Agent is evaluation of supplier candidates and support of PM's decision making about selection of supplier candidates. <Figure10> is Architecture of the DS Agent.

<Figure 10> Architecture of the DS Agent

DS Agent uses two kinds of schemes to evaluate suppliers. The first one is business rule that PM or company has as a sourcing policy. 'Suppliers with long-term contract of MRO items should be included in supplier candidates regardless of the evaluation points' is one of sourcing policies. The policies can be represented as a production rule that has if and then clauses, as follows.

```
IF        Long-term Contract of <Company> = True
THEN      <Supplier Candidates> = <Supplier Candidates>
          + <Company>
```

The second scheme is using evaluation priority. PM registered his own priority about evaluation criteria of supplier. DS Agent brings the priority information from profile DB and applies 4 evaluation criteria to supplier candidates. The following text box provides an example evaluation of a supplier.
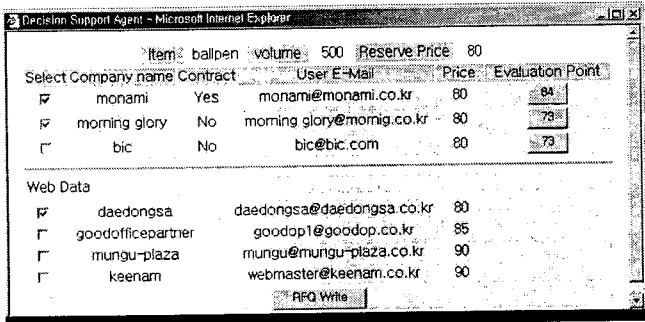
Suppose that the order of a PM's priority of evaluation criteria is reliability, price, delivery, and quality. Then DS Agent gives weight 0.4, 0.3, 0.2, and 0.1 to each evaluation criteria, respectively. DS Agent brings the past evaluation data of a supplier from the purchasing history DB, if the supplier had any transaction in the past.

Suppose that the supplier has evaluation points 90, 80, 70, 90 for each evaluation criteria, reliability, price, delivery, and quality, respectively. And suppose that the reserve price of the product is 700 and the price of the supplier is 750. And suppose that the wanted delivery day is 3 days and the supplier's delivery day is 2.5days. Then we can compute a new evaluation point of the supplier as follows.
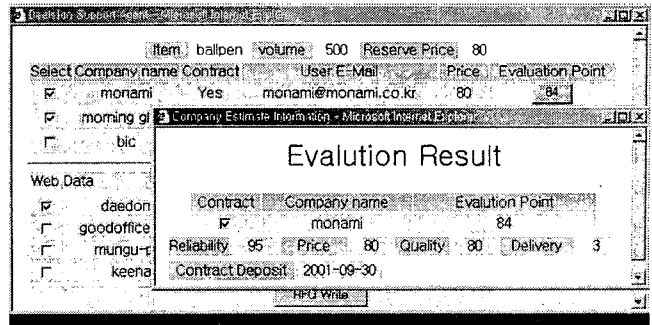
Reliability point = $0.4 * 90 = 36$

Price point = $0.3 * 80\{1 + (700-750)/750\} = 22.4$

Quality point = $0.1 * 90 = 9$

Delivery point = $0.2 * 70\{1 + (3-2.5)/2.5\} = 16.8$

Finally, the evaluation point of the supplier is $36 + 22.4 + 9 + 16.8 = 84.2$

After computing evaluation points of supplier candidates, PM will select suppliers to whom he will send RFQ. At the selection screen of <Figure 11>, PM can select suppliers manually at the left-hand side check box with consulting the evaluation points at the right-hand side.

If the evaluation point is clicked, PM can see the evaluation points in detail with the pop-up window (Figure 12). Suppliers of long-term contract will be selected automatically by rule inference of DS Agent. The information of the selected suppliers is transmitted to BS Agent and BS Agent is ready to make and send RFQ.

<Figure 11> Selection of Suppliers

< Figure 12> Evaluation Result

4.3 Massage of PIPA

We explain the massage flow about BS Agent and DS Agent. BS Agent send the internal information of company which is associated with integrated Items to DS Agent. Then, DS Agent brings Evaluation points to Purchase history DB. DS Agent check the Evaluation Result estimated with Evaluation criteria and long-term contract based an Rule. If long-term contract is checked, it sends BS Agent massages which is composed with Evaluation Result and "Yes" result. If or not, it only sends BS Agent the Evaluation Result and "No" Result. Next list is example about massages, As follow.

```
Form : BS Agent
To : DS Agent
Item : ballpen
Evaluation Company1 : monami
PM ID : c1254a23


From : DS Agent
To : BS Agent
Item : ballpen
Evaluation Company1 : monami
Evaluation Result : 84 .
PM ID : c1254a23
Cheak : Yes        // because long-term contact is checked


Form : BS Agent
To : DS Agent
Item : ballpen
Evaluation Company2 : morning glory
PM ID : c1254a23


From : DS Agent
To : BS Agent
Item : ballpen
Evaluation Company2 : mornig glory
Evaluation Result : 73
PM ID : c1254a23
Cheak : no
.....(Omit)
```

The PIPA was developed with Visual Basic 6.0 and ASP (Active Server Page) language at Internet Information Server 5.0 on Windows 2000 operating system. MS SQL 7.0 is used as DBMS.

5. Concluding Remarks

The PIPA system makes some contributions to architecture and business application point of views. As an independent agent, BS and DS Agents provide flexibility to the purchasing information process job. System developer can add new purchase-related functions to BS and DS Agent by adding new methods. Sourcing policies that DS Agent uses are easily modified without any change of DS Agent structure and method code.

In practical point of view, PIPA provides PM with integrated view and business process support. Information process job and decision-making job is seamlessly linked by agent message passing and information sharing. For information processing job, BS Agent collects the purchase information scattered inside and outside company. For decision-making job, DS Agent evaluate with user preferences and company policies.

We expect the PIPA can be applied to other business process jobs that needs both information processing and decision-making. However, we have further things to do. First, we should integrate with purchase workflow functions like purchase approval and disapproval process. In the ERP (Enterprise Resource Planning) package, purchasing process is supported, so we can consider plug of the PIPA agent into ERP. Second, we will implement the PIPA with agent software tools such as JESS, Aglet that will make implementation easier.

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