On a Decision-Making Mechanism of an Intelligent Shopping Agent

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A multi-agent system could facilitate purchase of products on the Internet by executing required buying activities. To make the multi-agent system intelligent, we propose an Information Evaluation Mechanism which adopts colleague consumers' opinion. It uses Information Exchange Partners' Trust Points to calculate Comparison Points of alternatives for adopting the opinion as the user's own. We have implemented Information Evaluation Mechanism and Information Exchange Protocol in GrocShop and carried out information exchange experiments. The results thereof show that GrocShop changes its preference and purchases different goods after adopting colleague consumers' opinion. It shows that proposed Information Evaluation Mechanism and Information Exchange Protocol are effective and useful for adopting colleague consumers' opinion.

KEYWORDS: E-Commerce, intelligent agents, cooperative protocols, distributed processing system

1 Introduction

Participants in E-Commerce are suppliers and consumers. They cooperate with each other to achieve their goals. As consumers, they visit the web-based shopping malls to purchase products, or visit colleague consumers' home pages to refer to their evaluation on stores and products. But shopping on the Internet is not an easy task because (1) it requires user's direct intervention, (2) it is time-consuming, and (3) product comparison is difficult. A multi-agent system could facilitate purchase products on the Internet by executing required buying activities for them. To make the multi-agent system intelligent, the following points are to be satisfied: (C1) how to determine what to buy, (C2) how to adopt colleague consumers' opinion, (C3) how to reflect information of a store's special offer like discount sales information, (C4) how to find an IEP (Information Exchange Partner), and (C5) how to manage the IEPs. (C4) and (C5) are closely related to (C2).

Joo et al. (2000b)[13] proposed GrocShop, an agent-based grocery shopping system, which automates the grocery shopping process. In GrocShop, a user's agent determines purchases by gathering grocery information from several store server agents and comparing it with the user's preferences of products and stores. Product selection based on preferences would be one of the most effective mechanisms which satisfies (C1).

In this paper, we propose an Information Evaluation Mechanism which adopts colleague consumers' opinion, and so satisfies (C2). We implement it in GrocShop and show that the enhanced GrocShop can adopt colleague consumers' opinion through experiments. We have newly devised Trust Point and Comparison Point for evaluating colleague consumers' opinion in a dynamically changing E-Commerce environment. In addition to the Information Evaluation Mechanism, we implement Information Exchange Protocol, P3, of Agent Communication Protocols.

Section 2 discusses an Information Evaluation Mechanism, Trust Point, and Comparison Point. Section 3 shows what we have done to make GrocShop satisfy (C2). Section 4 demonstrates that the Information Evaluation Mechanism satisfies (C2) by referring to the experimental results. In Section 5, we draw conclusion and refer to our future plans.

2 Information Evaluation Mechanism

We have proposed a multi-agent system which uses the user's preferences as a criterion of comparison in the paper, Joo et al. (2000b)[13]. But, user's preferences are changing easily. Economic situation, change in social status, discovery of uncontrollable circulation of defective goods, and general reputation of goods and stores may affect one's preferences. One may change them by his/her own decision based on his/her own experience, or following general social reputation. The agent system may enhance its owner's decision-making or change his/her preferences knowledge embed in it on his/her behalf using its high speed information processing and communication capability.
2.1 Information Evaluation Mechanism

To make the multi-agent system assist its owner in decision-making, we propose the Information Evaluation Mechanism. A user’s agent evaluates several alternatives gathered from other users’ opinion and adopts one as its own. The Information Evaluation Mechanism is composed of following four steps as shown in Figure 1.

**Step 1.** Gathering IEPs’ opinion: The user’s agent gathers other users’ opinion on a product or a store. An Information Exchange Partner (IEP) is an agent who exchanges the opinion (information and knowledge) on the requested product or store with a user’s agent in Figure 2.

**Step 2.** Driving alternatives: The user’s agent derives several alternatives from the gathered opinion as candidates of his/her own opinion.

**Step 3.** Calculating comparison points of alternatives: The user’s agent calculates comparison point of each alternative using the IEPs’ opinion and their Trust Points.

**Step 4.** Rearranging the owner’s opinion: The user’s agent sorts out the comparison points and updates its database based on the comparison results.

The Information Evaluation Mechanism gives decision making capability to the user’s agent by referring to other user’s IEP. IEM introduces the concept of IEP, Trust Point and comparison point that are described below.

2.1.1 Information Exchange Partner

The user’s agent should have enough number of IEPs to maintain the precision of calculation. Many people throng the Internet with a wide range of different preferences. To get a meaningful opinion from them, the agent should confine the opinion providers to only those who share similar tastes and preferences with it. In a dynamically changing E-Commerce environment, the agent should manage IEPs drawing on the results of information exchange experience with them. In this paper, Trust Point is used for expressing the significance of each IEP and keeping track of result of information exchange experience with an IEP.

2.1.2 Trust Point

Trust Point is a value that a user’s agent assigns to IEPs. It is used for calculating Comparison Point of alternatives and as a criterion of Information Exchange Partner qualification. It expresses the degree of similarity of tastes and preferences between the user’s agent and the IEP. It reflects the information exchange experience between them.

A user’s agent assigns Initial value of Trust Point, $T_{ini}$, to a new IEP introduced by the store server in reply to the request of a user’s agent. Figure 3 shows manipulation of IEP’s Trust Point. The user agent raises an IEP’s Trust Point by an increment, $T_{inc}$, when its opinion has been selected as a user’s new preference, or lowers it by a decrement, $T_{dec}$, when it has been rejected. It would be reasonable that $T_{inc}$ is greater than $T_{dec}$, because only one alternative will be chosen from multiple choices. By establishing a lower limit of Trust Point for IEP, the user’s agent may sift out reliable IEPs from its long list of IEPs.

By employing Trust Point, the user’s agent discerns the significance of each IEP’s opinion and reflects its opinion by its significance.

![Figure 1](image)

**Fig. 1** Decision making in the Information Evaluation Mechanism.
2.1.3 Comparison Point

It is calculated from IEPs’ opinion and their Trust Points. There are two kinds of Comparison Points: “Simple” and “Weighted”, depending on the type of input from IEPs. They are devised to reflect significance of each IEP’s Trust Point and the effect of the number of votes.

Simple Comparison Point

Simple Comparison Point is used when IEPs send in their highest preferences only. The user’s agent calculates the Simple Comparison Points using the following formula:

$$ CS(AL_a) = \sum_{i=1}^{n} \frac{T_i}{i} $$

(1)

CS: Simple Comparison Point

$AL_a$: Alternative $a$
$T$: Trust Point of IEP  
$i$: Position sequence in the alternative group.

The user's agent groups IEP's opinion by alternatives. It sorts out each alternative group by the significance of each IEP's Trust Point. Each alternative group has different number of IEPs' opinion. Summation or average is not a proper measurement for comparing alternatives, because the measurement should reflect the significance of IEP's Trust Point firstly and the number of votes next. Simple Comparison Point reflects the largest IEP's Trust Point in each alternative group by accepting it as it is. The formula reduces the effect of the opinion from the second largest one by dividing IEP's Trust Point by its sequence of position in an alternative group. By reducing the effect, the formula protects the Comparison Point of an alternative that has small number of IEPs' votes.

**Weighted Comparison Point**

Weighted Comparison Point is used when IEPs send in their preference lists for requested goods. An IEP's preference list is a sequenced element of preference category such as store names as an example. In this paper, position of each element in preference list stands for the preference weight of the element. As each IEP's preference list has different number of elements, its preference weight differs. For fair comparison, the user's agent normalizes each IEP's opinion by dividing each preference weight of element by the number of element in the preference list. These values are named "Normalized Preference Weight" and used for calculating Weighted Comparison Point. The User Agent calculates Weighted Comparison Points using the following formula:

$$CW(Al_a) = \sum_{i=1}^{n} \frac{1}{i} \times NPW_i \times T_i,$$  \hspace{1cm} (2)

$CW$: Weighted Comparison Point  
$Al_a$: Alternative $a$  
$NPW$: Normalized Preference Weight  
$T$: Trust Point of IEP  
$i$: Position Sequence in the alternative group.

The user's agent also groups IEPs opinion by alternatives, and sorts out each alternative group by the product of NPW and Trust Point. The Weighted Comparison Point reflects the largest product of NPW and Trust Point firstly. The formula reduces the effect of opinion from the second largest one by dividing the product of NPW and Trust Point by its sequence of position in an alternative group. By reducing the effect, the formula protects the Comparison Point of an alternative that has small number of IEPs' votes.

### 2.2 Design Objectives of Information Evaluation Mechanism

We have three objectives in designing Information Evaluation Mechanism. Firstly, the Information Evaluation Mechanism makes the user's agent change its preference knowledge autonomously. This Mechanism automates the information evaluation procedure and provides a reasonable algorithm for evaluation. Secondly, this Mechanism respects the reliable IEP's opinion first. Decision-making in this Mechanism reflects the significance of each IEP. Finally, this Mechanism promotes the continuity of relationship between the user's agent and the reliable IEP. The Mechanism feedbacks the result of information evaluation and keeps track of information exchange experience with IEPs.

### 3 Enhancement of GrocShop to Adopt Colleague Consumers' Opinion

#### 3.1 Structure of GrocShop

GrocShop is composed of three kinds of role agents: a user agent (UA), an information management agent (IMA), and a store server agent (SSA). They are independent software entities that have their own roles to play autonomously. Figure 4 shows the structure of the grocery shopping system. The indispensable two agents in grocery shopping system are a buyer agent that acts as a buyer, and a store server agent (SSA) that acts as a seller. The buyer agent is divided into two agents, UA and IMA, because the buyer's shopping process is composed of real purchasing and information gathering activities. UA conducts purchasing activity on behalf of the user only when it is asked to do so. IMA manages all the required information and knowledge for grocery shopping. SSA provides product information to UAs. The three role agents are composed of multiple small task agents. Figure 5, 6, and 7 shows the structures of UA, IMA, and SSA respectively.

#### 3.2 GrocShop Enhancement

We have enhanced GrocShop to satisfy (C2): how to adopt colleague consumers' opinion. Figure 8 shows the enhancement of IMA.
We have implemented Information Evaluation Mechanism in Evaluation agent of IMA and added an IEP Trust Point agent that manages IEP list and its Trust Points. We have proposed four protocols for intelligent grocery shopping and implemented two of them, P1 and P2, in the previous paper [13]. In this paper, we have implemented Information Exchange Protocol, P3, between IMA and the other users' IMA for exchanging information. Figure 9 shows the four protocols and our implementing protocol, P3. We have defined performatives for P3 as shown in Table 1.
IMA

Enhanced IMA

- \( P1 \): Internal Protocol
- \( P2 \): Grocery Exchange Protocol
- \( P3 \): Information Exchange Protocol
- \( P4 \): Information Gathering Protocol

**Table 1. Performatives for P3**

<table>
<thead>
<tr>
<th>Performatives</th>
<th>Meaning</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td>RequestOpinion</td>
<td>Request for opinion</td>
<td>Followed by requesting item and reply type</td>
</tr>
<tr>
<td>RequestInfo</td>
<td>Request for information</td>
<td>Followed by requested item</td>
</tr>
<tr>
<td>OpinionHighest</td>
<td>Opinion on requested item</td>
<td>Followed by most preferable opinion</td>
</tr>
<tr>
<td>OpinionWhole</td>
<td>Opinion on requested item</td>
<td>Followed by whole list of opinion</td>
</tr>
<tr>
<td>Information</td>
<td>Information on requested item</td>
<td>Followed by information</td>
</tr>
</tbody>
</table>
P3: Information Exchange Protocol

An Information Exchange Protocol deals with two kinds of exchange: one is "opinion" and the other is "information". A user agent requests opinion when it wants to make a decision. It is a kind of free vote. The evaluation agent of IMA sends Request Opinion with requested item and reply type. There are two types of reply: one is the "highest only reply" and the other is "whole reply". IEP sends its most preferable answer only in highest only reply type, whereas it sends its complete answer to requested item in whole reply type.

4 Opinion Adopting Experiments

We have made experiments in our laboratory to show that the enhanced GrocShop can change its owner's preferences by evaluating the IEPs' opinion and that the Information Evaluation Mechanism and Information Exchange Protocol satisfy (C2). There are five Store Servers and 15 user's agents in this experiment. Figure 10 shows the experimental configuration.

4.1 Experimental Procedure

To show that a user's agent may change its owner's preferences according to other users' opinion, we have done some experiments. The experimental procedures are composed of the following three steps:
1. Buy groceries based on original preferences.
2. Change preferences using other users' opinion.
3. Buy groceries again based on changed preferences.

We have used the purchasing result of a lump of beef to explain the experimental results. We have manipulated one variable, preference of store, to observe the change of preference.

4.2 Initial Conditions

With an eye to obtaining a basis of shopping result comparison, we have executed grocery purchasing process with current preferences. We have observed User A's behavior. His/her original preference for a lump of beef is:
- Origin: Yamagata > Miyagi > Hokkaidou > Aomori
- Store: StrE > StrB > StrA > StrD > StrC
- Production Date: Less 1
- Expiry Date: More 2.

And his/her choice with original preference has following characteristics:
- Origin: Miyagi
- Store: StrB
- Production Date: 99/2/1
- Expiry date: 99/2/5
- Satisfaction Ratio: 87%

User A has 15 IEPs and table 2 shows their Trust Points.

4.3 Experimental Results

We have conducted two experiments with different reply types for opinion: one is "highest only reply", the other is "whole reply". The results of both cases are shown below:

![Experimental configuration.](image-url)
Table 2. User A’s IEPs and their trust points.

<table>
<thead>
<tr>
<th>IEP</th>
<th>IEP1</th>
<th>IEP2</th>
<th>IEP3</th>
<th>IEP4</th>
<th>IEP5</th>
<th>IEP6</th>
<th>IEP7</th>
<th>IEP8</th>
</tr>
</thead>
<tbody>
<tr>
<td>TrustPoint</td>
<td>0.80</td>
<td>0.95</td>
<td>0.75</td>
<td>0.90</td>
<td>0.90</td>
<td>0.85</td>
<td>0.85</td>
<td>0.75</td>
</tr>
<tr>
<td>IEP</td>
<td>IEP9</td>
<td>IEP10</td>
<td>IEP11</td>
<td>IEP12</td>
<td>IEP13</td>
<td>IEP14</td>
<td>IEP15</td>
<td></td>
</tr>
<tr>
<td>TrustPoint</td>
<td>0.85</td>
<td>0.90</td>
<td>0.95</td>
<td>1.00</td>
<td>0.85</td>
<td>0.80</td>
<td>0.90</td>
<td></td>
</tr>
</tbody>
</table>

Table 3. IEPs’ opinion of stores.

<table>
<thead>
<tr>
<th>IEP</th>
<th>IEP1</th>
<th>IEP2</th>
<th>IEP3</th>
<th>IEP4</th>
<th>IEP5</th>
<th>IEP6</th>
<th>IEP7</th>
<th>IEP8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Opinion</td>
<td>StrC</td>
<td>StrE</td>
<td>StrC</td>
<td>StrB</td>
<td>StrA</td>
<td>StrE</td>
<td>StrB</td>
<td>StrA</td>
</tr>
<tr>
<td>IEP</td>
<td>IEP9</td>
<td>IEP10</td>
<td>IEP11</td>
<td>IEP12</td>
<td>IEP13</td>
<td>IEP14</td>
<td>IEP15</td>
<td></td>
</tr>
<tr>
<td>Opinion</td>
<td>StrB</td>
<td>StrA</td>
<td>StrC</td>
<td>StrC</td>
<td>StrD</td>
<td>StrB</td>
<td>StrD</td>
<td></td>
</tr>
</tbody>
</table>
* Str: Store.

Table 4. Result of information evaluation.

<table>
<thead>
<tr>
<th>Alternative</th>
<th>Store A</th>
<th>Store B</th>
<th>Store C</th>
<th>Store D</th>
<th>Store E</th>
</tr>
</thead>
<tbody>
<tr>
<td>IEP</td>
<td>TP</td>
<td>IEP</td>
<td>TP</td>
<td>IEP</td>
<td>TP</td>
</tr>
<tr>
<td>Opinion</td>
<td>IEP5</td>
<td>0.90</td>
<td>IEP4</td>
<td>0.90</td>
<td>IEP12</td>
</tr>
<tr>
<td></td>
<td>IEP10</td>
<td>0.90</td>
<td>IEP7</td>
<td>0.85</td>
<td>IEP11</td>
</tr>
<tr>
<td></td>
<td>IEP8</td>
<td>0.75</td>
<td>IEP9</td>
<td>0.85</td>
<td>IEP1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>IEP3</td>
</tr>
<tr>
<td>CS</td>
<td>1.6</td>
<td>1.808</td>
<td>1.929</td>
<td>1.325</td>
<td>1.375</td>
</tr>
</tbody>
</table>
* TP: TrustPoint.

Simple comparison Point
15 IEPs that belong to User A send in their opinion of stores in response to User A’s request. IEPs send in only their highest preferences in “highest only reply” type. Table 3 shows the responses.
User A’s agent sorts them out by stores and calculated Simple Comparison Point, CS, of each store. Table 4 shows the results of information evaluation.
User A’s agent changes its preference of store for a lump of beef in accordance with the order of evaluation. Its new preferences for a lump of beef are:
Origin: Yamagata > Miyagi > Hokkaidou > Aomori
Store: StrC > StrB > StrA > StrE > StrD
Production Date: Less 1
Expiration Date: More 2.
Table 5 shows User A’s evaluation of a lump of beef at each store. According to this result, its choice has changed to show the following characteristics:
Origin: Yamagata
Store: StrC
Production Date: 99/1/31
Expiration date: 99/2/3.
Satisfaction Ratio: 100%

Weighted Comparison Point
15 IEPs send in their opinion of stores in response to his/her request. IEPs send in their complete preference list of requested grocery in “whole reply” type. Table 6 shows the responses.
User A’s agent sifts through them by stores and calculated weighted comparison point, CW, of each store. Table 7 shows the result of information evaluation.
User A’s agent changes its preference of stores for a lump of beef in accordance with the order of evaluation. Its new preferences for a lump of beef are:
Origin: Yamagata > Miyagi > Hokkaidou > Aomori
Store: StrB > StrC > StrA > StrE > StrD
Production Date: Less 1
Expiration Date: More 2.
Table 5. User A’s evaluation of a lump of beef at each store.

<table>
<thead>
<tr>
<th>Store</th>
<th>Origin</th>
<th>Prod.D</th>
<th>Exp.D</th>
<th>Price (400 g)</th>
<th>EP</th>
<th>Sat.Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Store A</td>
<td>Hokkaidou</td>
<td>99/1/28</td>
<td>99/2/1</td>
<td>300 Yen</td>
<td>5</td>
<td>33%</td>
</tr>
<tr>
<td>Store B</td>
<td>Miyagi</td>
<td>99/2/1</td>
<td>99/2/5</td>
<td>343 Yen</td>
<td>13</td>
<td>86%</td>
</tr>
<tr>
<td>Store C</td>
<td>Yamagata</td>
<td>99/1/31</td>
<td>99/2/3</td>
<td>390 Yen</td>
<td>15</td>
<td>100%</td>
</tr>
<tr>
<td>Store D</td>
<td>Akita</td>
<td>99/1/31</td>
<td>99/2/4</td>
<td>307 Yen</td>
<td>7</td>
<td>47%</td>
</tr>
<tr>
<td>Store E</td>
<td>Fukusima</td>
<td>99/2/1</td>
<td>99/2/5</td>
<td>304 Yen</td>
<td>8</td>
<td>53%</td>
</tr>
</tbody>
</table>

* Prod.D: Production Date.
* Exp.D: Expiry Date.
* EP: Evaluation Point earned by comparing with user’s preference.
* Sat.Ratio: Satisfaction Ratio defined as the ratio of earned EP to the largest value of EP expected.

Table 6. IEP’s opinions of stores.

<table>
<thead>
<tr>
<th>IEP</th>
<th>Opinion</th>
<th>IEP</th>
<th>Opinion</th>
</tr>
</thead>
<tbody>
<tr>
<td>IEP1</td>
<td>StrC &gt; StrA &gt; StrB &gt; StrE &gt; StrD</td>
<td>IEP9</td>
<td>StrB &gt; StrA &gt; StrE &gt; StrC &gt; StrD</td>
</tr>
<tr>
<td>IEP2</td>
<td>StrE &gt; StrB &gt; StrA &gt; StrD &gt; StrC</td>
<td>IEP10</td>
<td>StrA &gt; StrE &gt; StrB &gt; StrC &gt; StrD</td>
</tr>
<tr>
<td>IEP3</td>
<td>StrC &gt; StrB &gt; StrD &gt; StrA &gt; StrE</td>
<td>IEP11</td>
<td>StrC &gt; StrD &gt; StrB &gt; StrE &gt; StrA</td>
</tr>
<tr>
<td>IEP4</td>
<td>StrB &gt; StrA &gt; StrC &gt; StrD &gt; StrE</td>
<td>IEP12</td>
<td>StrC &gt; StrB &gt; StrA &gt; StrE &gt; StrD</td>
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<tr>
<td>IEP5</td>
<td>StrA &gt; StrB &gt; StrC &gt; StrD &gt; StrE</td>
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<td>StrD &gt; StrB &gt; StrE &gt; StrA &gt; StrC</td>
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<td>IEP6</td>
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<td>IEP7</td>
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<td>IEP15</td>
<td>StrD &gt; StrB &gt; StrA &gt; StrC &gt; StrE</td>
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<tr>
<td>IEP8</td>
<td>StrA &gt; StrB &gt; StrE &gt; StrC &gt; StrD</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 7. Result of information evaluation.

<table>
<thead>
<tr>
<th>IEP</th>
<th>TP</th>
<th>Store A NPW</th>
<th>Store B NPW</th>
<th>Store C NPW</th>
<th>Store D NPW</th>
<th>Store E NPW</th>
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<tbody>
<tr>
<td>IEP1</td>
<td>0.80</td>
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<td>0.6</td>
<td>1.0</td>
<td>0.2</td>
<td>0.4</td>
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<tr>
<td>IEP2</td>
<td>0.95</td>
<td>0.6</td>
<td>0.8</td>
<td>0.2</td>
<td>1.0</td>
<td>1.0</td>
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<tr>
<td>IEP3</td>
<td>0.75</td>
<td>0.4</td>
<td>0.8</td>
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<td>0.2</td>
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<td>IEP4</td>
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<td>0.6</td>
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<td>0.4</td>
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<td>0.4</td>
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<td>0.6</td>
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<td>0.4</td>
<td>0.2</td>
<td>0.8</td>
</tr>
<tr>
<td>IEP11</td>
<td>0.95</td>
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<td>0.6</td>
<td>1.0</td>
<td>0.8</td>
<td>0.4</td>
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<tr>
<td>IEP12</td>
<td>1.00</td>
<td>0.6</td>
<td>0.8</td>
<td>1.0</td>
<td>0.2</td>
<td>0.4</td>
</tr>
<tr>
<td>IEP13</td>
<td>0.85</td>
<td>0.4</td>
<td>0.8</td>
<td>0.2</td>
<td>1.0</td>
<td>0.6</td>
</tr>
<tr>
<td>IEP14</td>
<td>0.80</td>
<td>0.2</td>
<td>1.0</td>
<td>0.4</td>
<td>0.8</td>
<td>0.6</td>
</tr>
<tr>
<td>IEP15</td>
<td>0.90</td>
<td>0.6</td>
<td>0.8</td>
<td>0.4</td>
<td>1.0</td>
<td>0.2</td>
</tr>
</tbody>
</table>

CW | 2.37 | 2.65 | 2.41 | 2.16 | 2.27 |

Table 8. User A’s evaluation of a lump of beef at each store.

<table>
<thead>
<tr>
<th>Store</th>
<th>Origin</th>
<th>Prod.D</th>
<th>Exp.D</th>
<th>Price (400 g)</th>
<th>EP</th>
<th>Sat.Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>StrA</td>
<td>Hokkaidou</td>
<td>99/1/28</td>
<td>99/2/1</td>
<td>300 Yen</td>
<td>5</td>
<td>33.3%</td>
</tr>
<tr>
<td>StrB</td>
<td>Miyagi</td>
<td>99/2/1</td>
<td>99/2/5</td>
<td>343 Yen</td>
<td>14</td>
<td>93%</td>
</tr>
<tr>
<td>StrC</td>
<td>Yamagata</td>
<td>99/1/31</td>
<td>99/2/3</td>
<td>390 Yen</td>
<td>14</td>
<td>93%</td>
</tr>
<tr>
<td>StrD</td>
<td>Akita</td>
<td>99/1/31</td>
<td>99/2/4</td>
<td>307 Yen</td>
<td>7</td>
<td>46.7%</td>
</tr>
<tr>
<td>StrE</td>
<td>Fukusima</td>
<td>99/2/1</td>
<td>99/2/5</td>
<td>304 Yen</td>
<td>8</td>
<td>53.3%</td>
</tr>
</tbody>
</table>

* Prod.D: Production Date.
* Exp.D: Expiry Date.
* EP: Evaluation Point earned by comparing with user’s preference.
* Sat.Ratio: Satisfaction Ratio defined as the ratio of earned EP to the largest value of EP expected.

Table 8 shows User A’s evaluation of a lump of beef at each store. GrocShop algorithm chooses a product in the order of store preference when multiple products have the same Evaluation Point. According to this result, its choice is the same as original one. Satisfaction ratio, however, was improved to 93%. Shopping result would be changed if this user changes his/her preference on “origin” together.
4.4 Evaluation of Experiments

Experimental results show that GrocShop changes user’s preferences by adopting other users’ opinion. They show that proposed Information Evaluation Mechanism satisfies (C2) described in Section 1. The formulae for simple and weighted comparison point are designed to reflect the significance of trust point and the number of votes. In most of cases, decision making by “simple” mode and “weighted” mode show the same results, because Comparison Points reflects the largest value most significantly. The more research should be done to determine when “simple” or “weighted” Comparison Point is applied. By applying Trust Point, we have come to respect the opinion of those IEPs who not only have long information exchange experience but also share similar tastes with us. The satisfaction ratio increased from 87% in both experiments. But this does not mean that we can always improve satisfaction ratio. The more research should be done to control the direction of change.

5 Conclusion and Future Works

We have taken up a challenge to make the multi-agent shopping system intelligent. We have proposed the Information Evaluation Mechanism for satisfying (C2): how to adopt colleague consumers’ opinion. Trust Point and Comparison Point have been introduced for Information Evaluation Mechanism to evaluate colleague consumers’ opinion and compare alternatives. Trust Point stands for the reliability of each IEP and significance of IEP’s opinion. There are two kinds of Comparison Point: “Simple” and “Weighted” Comparison Point. We have devised them to reflect the significance of IEP and the number of votes for that alternative. We have enhanced GrocShop, an agent-based grocery shopping system, to adopt IEPs’ opinion and implemented Information Exchange Protocol, P3, of Agent Communication Protocols for GrocShop. By experiments using enhanced GrocShop, we have shown the Information Evaluation Mechanism is useful for making a decision based on other user’s information and knowledge. The results confirm that Trust Point and Comparison Point work effectively to adopt colleague consumers’ opinion. The results also show that Information Exchange Protocol carries out effectively the communication required for information exchange.

We have focused on (C2) in this paper. We will continue working on intelligent multi-agent systems for E-Commerce to meet the other challenges stated in Section 1. We are trying to make agents that imitate our behavior at this moment. Our ultimate goal is to enhance the agents to reflecting our mental status. It is not confined only to technical improvement but envisages the social ability of agents such as group behavior of agents coming from Information Exchange among them.

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