Fuzzy Personalized Wireless Information Agents

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Abstract- **In this paper, the basic design of the fuzzy personalized wireless information agent for mobile phones is proposed based on wireless fuzzy Web intelligence, wireless mobile computing, Internet computing, intelligent agent technology, Web databases, and personalization. The basic personalized wireless information agent's middleware is implemented by using WAP, WML, Java Servlets and intelligent information agent techniques, Oracle databases, client-server technology and personalized profiles. Typical applications such as personalized search for weather, traffic and others are demonstrated. . In addition, Computational Web Intelligence (CWI) techniques can be used to design more intelligent wireless mobile agents to better serve wireless mobile users. In the future, the fuzzy wireless intelligent multi-agent system will have more applications**

Index Terms—**Fuzzy Logic, Fuzzy Web Intelligence, Wireless Fuzzy Web Intelligence, Wireless Agents, Mobile Agents.**

I. Introduction

With the fast development of mobile computing technology and the rapid growth of the number of mobile users, there is a huge market for smart mobile wireless information services using intelligent techniques. The criteria of today's markets are information should be available whenever and wherever it is needed, and intelligent wired and wireless techniques are critical for future e-Business. However, because of limitations of wireless mobile Hand-held Devices (HHDs) such as small memory, low speed and small screen, there are challenging technical problems of wireless mobile HHDs. This paper only focuses on smart wireless information agents for mobile phones. Some special protocols and techniques for wireless applications are developed [4][5]. www.wap.com provides us with a review of several good wireless sites, and introduces the basic issues about Wireless Application Protocol (WAP) [13]. Basic criteria for evaluating Quality of Service (QoS) of wireless mobile HHDs are related to convenience, efficiency and effectiveness for users. In this sense, intelligent techniques can enhance QoS of wireless mobile systems if the intelligent techniques can improve convenience, efficiency and effectiveness for users. Soft computing techniques can be used in enhancing QoS of wireless mobile systems in terms of dealing with uncertainty of wireless mobile data and personal information. Here, fuzzy logic is used for this purpose.

In addition, intelligent software agents such as wired agents and mobile agents [2][3][6-12] can be used to enhance QoS of wireless mobile application systems because these smart agents can do tedious daily work, provide useful information, and give decision-making suggestions for a user.

In general, Computational Web Intelligence (CWI) is a hybrid technology of Computational Intelligence (CI) and Web Technology (WT) dedicating to increasing QoI (Quality of Intelligence) of e-Business applications on the Internet and wireless networks [15]. CWI uses Computational Intelligence (CI) and Web Technology (WT) together to make intelligent e-Business applications on the Internet and wireless networks. Especially, how to effectively handle uncertainty of smart e-Business systems to make the Internet and wireless networks intelligent is the key thrust of CWI. Fuzzy logic, probabilistic methods, rough sets, neural networks, granular computing and evolutionary algorithms are major techniques to solve the uncertainty problems on the Internet and wireless networks. CWI techniques can be used to design more intelligent wireless mobile agents to better serve wireless mobile users.

The rest of the paper is organized as follows. The wireless fuzzy Web intelligence techniques are discussed in Section II. The design of the fuzzy personalized wireless information agent is described in Section III. The relevant wireless applications are given in Section IV. Finally, conclusions are given in Section IV.

II. Wireless Fuzzy Web Intelligence

Currently, seven major research areas of CWI are (1) Fuzzy WI (FWI), (2) Neural WI (NWI), (3) Evolutionary WI (EWI), (4) Probabilistic WI (PWI), (5) Granular WI (GWI), (6) Rough WI (RWI), and (7) Hybrid WI (HWI) [15].

FWI has two major techniques that are (1) fuzzy logic and (2) WT. The main goal of FWI is to design intelligent fuzzy e-agents that can deal with fuzziness of data, information and knowledge, and also make satisfactory decisions like the human brain for e-Business applications effectively [15].

The Wireless Fuzzy Web Intelligence (WFWI) focuses on using fuzzy technology to build intelligent wireless systems for smart wireless applications and mobile applications. Since a fuzzy logic system has good advantages such as high speed, a small fuzzy knowledge base and easy

implementation, it is very useful for wireless applications because many wireless handhelds such as cell phones and PDAs have very limited capacity like small memory, small screen and low communication speed. In other words, it is necessary to build a small and effective intelligent wireless system on the handhelds to make users more convenient and more efficient.

In summary, using fuzzy techniques in intelligent wireless and mobile applications effectively and successfully is a long-term challenging goal of the WFWI.

III. Fuzzy Personalized Wireless Agents

A mobile phone is a very personalized device. Therefore, it is reasonable to implement a personalized wireless information agent based on a user's profile in a mobile phone service database. Personal traffic information is very useful for the user. For example, a user is going to pick up his friend at an airport this afternoon. He sets up the route from his home to the airport, checks his friend's flight information on his cell phone to know the arrival time of his friend's flight. He checks the route information in order to let him have plenty of time to get to the airport. All these tasks can be done by different wireless mobile agents.

Human agents such as insurance agents and travel agents focus on a special task, access information relevant to a task, and provide the service based on customer's requirements. An intelligent agent can mimic a human agent's functions. So the software agent is useful for HHD users.

Currently, some "fuzzy" Web search engines don't use fuzzy logic, but they can just search approximate results. Here fuzzy logic is used to design a fuzzy-logic-based wireless information agent (a fuzzy wireless agent in short) for better QoS of wireless applications. The fuzzy technique proposed here can use not only traditional fuzzy-key-word-based search method but also fuzzy-user-preference-based search algorithm so as to get more satisfactory personalized search results for a particular user. In this sense, if user A and user B type in the same search conditions with fuzzy operators such as fuzzy AND or fuzzy OR, user A and user B will get two different search results because user A has a different interest from user B. Clearly, personalized fuzzy wireless agent is useful because a user's profile can be used to reduce the number of final results. The logical architecture of the Personalized Fuzzy Wireless Agent (PFWA) is given in Fig. 1. In general, the personalized fuzzy wireless agent consists of the basic Fuzzy Wireless Search Engine (FWSE), the basic Wireless Fuzzy Inference Engine (WFIE), Fuzzy Knowledge Base (FKB), the Personal Data Base (PDB), the Fuzzy Relational Information System (FRIS) and the Fuzzy Decision System (FDS). In Fig. 1., WFIE can provide data for FDS based on inputs from FWSE, PDB and FKB, then FDS will make the final decision based on results generated by the FWSE and information from FRIS.

How to make a better fuzzy decision is still a challenging problem. Usually, the designers need to extract useful fuzzy rules from experts and users, then test these fuzzy rules to check if these fuzzy rules can really work.

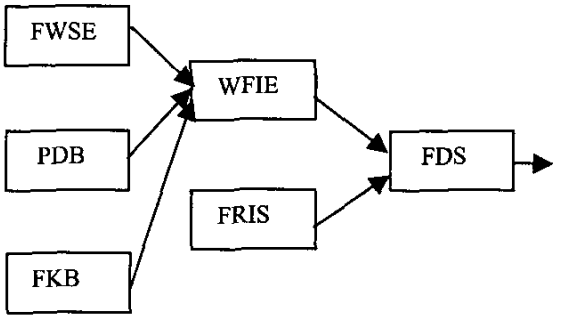

Fig. 1. Logical Architecture of the PFWA

A fuzzy relational information matrix in the FRIS is used to show similarity between two fuzzy search terms. A problem is the fuzzy relevancy matrix could be very large. To reduce complexity of the fuzzy relevancy matrix, a personalized fuzzy relevancy matrix is used to actually design a personalized fuzzy wireless search algorithm. Since a user has a small number of frequently used search words, the personalized fuzzy relational information matrix will be small. The personalized fuzzy relevancy matrix is updated dynamically based on the PDB that is also updated periodically by mining the user's usage and preferences.

The PFWA in Fig. 1 works as below:

Begin

Step 1: WFIE uses fuzzy rules in FKB to generate fuzzy inference results based on inputs from FWSE and PDB;

Step 2: the fuzzy results are analyzed by FDS based on fuzzy relational information provided by FRIS;

Step 3: the final results in the ranked order are displayed on a mobile device such as a cell phone.

End.

III. Design of Personalized Wireless Middleware

From the design and analysis point of view, researchers have paid attention to agent-oriented technology in telecommunications [1]. An intelligent software agent is a special piece of software that could help user do specific jobs efficiently.

A. Wireless Information Agents

The major problems of current WAP application include limited screen size, navigation, data entry, and latency on HHDs. A wireless information agent is a program running on the server to help wireless users quickly find out what they need. For example, in weather service, users could use zip code, telephone area code, or even highway exit number to pinpoint their positions and then to get weather information they need. Wireless information agents provide user with a hint at any time. For instance, if a user provides a telephone area code, there could be several zip codes. The wireless information agent will provide a user with a list of all zip code areas together with their names (hints), and then the user could choose one from the list.

B. Design Methods

Because of low computation power and small memory of a mobile phone, the wireless mobile information agent is implemented on the server, unlike traditional information search engine agent that could consult several web servers. Figure 2 shows the architecture of the fuzzy wireless mobile information agent system. In real world, there are two kinds of methods that the server render WML to wireless devices: (1) through WAP gateway, filtering or translating HTML or HDML into WML, and (2) bypass the WAP gateway, making the server directly generated and encoded WML.

The later method is chosen in this paper. Apache Jserver is built on the top of Apache server. To provide real WML services, the Web server is configured to serve WML and other WAP file types.

As stated early, the fuzzy wireless information agents will be set in the server side, the mobile phones only send querying request and receive results that generated by the agent. The agents will treat the results based on the requirement of WML and wireless transportation.

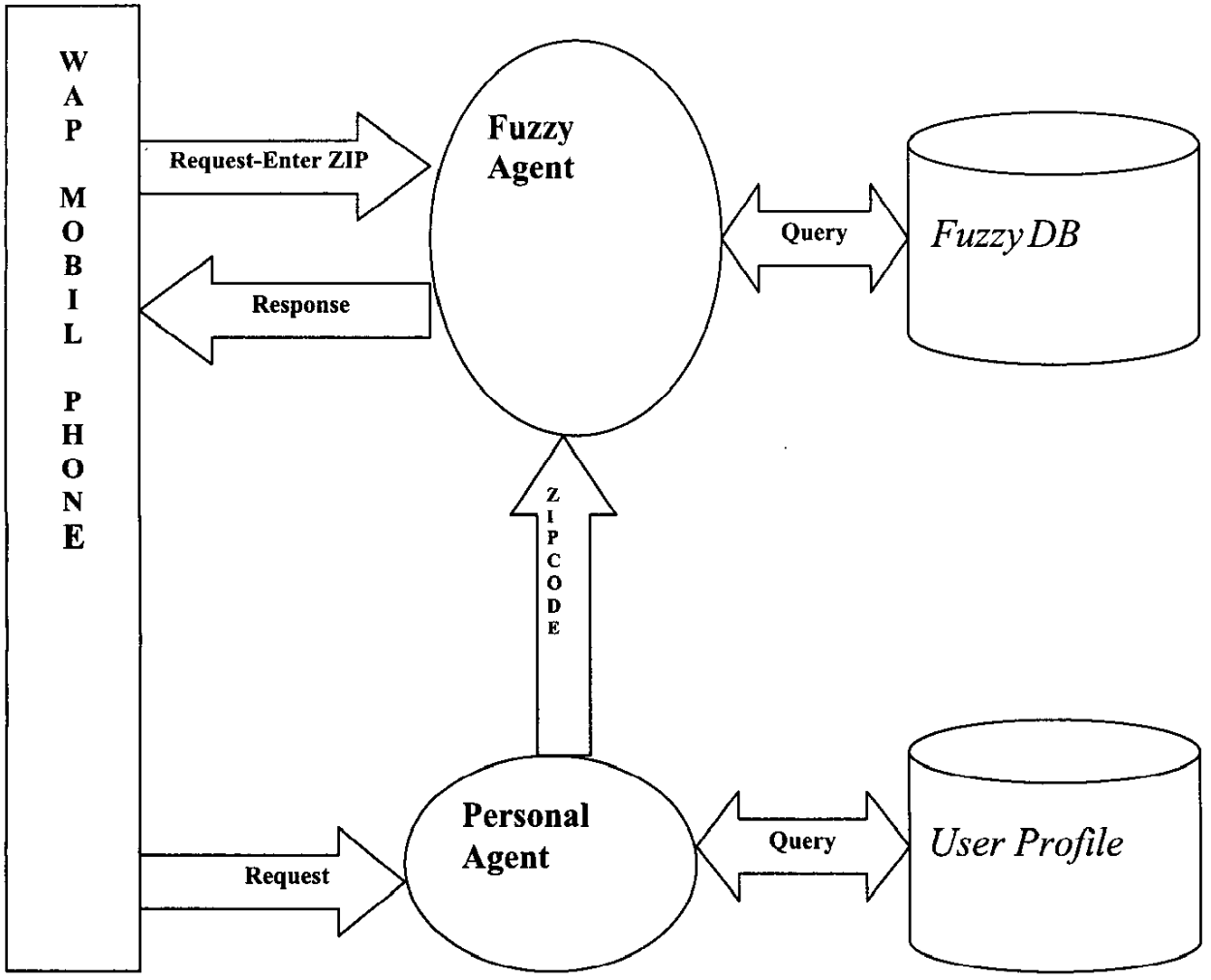

Fig. 2. The fuzzy personalized wireless agent

IV. Wireless Applications

Mobile phone is a very personalized device. One of the major features of the software agent is personalization. The personalized service in our application provides two major functions, my weather and my traffic. the member menu with the two major functions. From member menu, a user can check either weather or traffic. Figure 3 shows the main page of the application. These agents can provide a wide range of information services.

The Agent can automatically provide the user with the weather information of his or her living area. So the agent can use a user's personal information to provide the user with personalized information. Personalized service is greatly reducing the amounts of both data and navigation.

There are two services of my traffic category. The first one is very general one, just like my weather services. The agent can present a user with the highway exit's traffic information. For example, a user lives in the area with zip code 30319. When he or she begins to check traffic, a list will be provided.

Another service is more powerful. The personalized traffic agent can let a user name his or her own route, the highway, the start exit number, or the end exit number. The user can directly check the route information, which includes the name, the distance, and the approximate travel time. The approximate travel time is computed by the real time data from the database, so we can imagine, at different daily times, travel times may be different. It also tells the user where the travel speed on the route is the lowest, so that if it impossible, he or she may bypass that part. The accident or alert will only be presented if applicable. So these inputs can be converted into fuzzy outputs, and the FDS will generate the final decisions. However, a user has to analyze the decisions, and then make final personal decisions because the smart agents can provide partial knowledge and initial decisions using limited internal knowledge bases.

To find a better hotel, the fuzzy wireless information agent of the cell phone can allow a user to type in fuzzy key words like "about $50" to search out a list of fuzzy hotels.

The basic features and problems of wireless mobile devices are small screen size, navigation problem and data entry. One of major function of agents is to minimize the number of navigations and data entries. Another function is to cleverly format WML, which only allows critical, succinct information to be presented. On the other hand, personalization forms a strong connection between an agent and wireless applications. Designing a personalized application is not only the natural requirement of wireless applications but also an efficient way to cope with basic problems of wireless applications. Personalization can significantly minimize information overload and wireless communication traffic.

V. Conclusions

Wireless information has to be short and light-weighted because of small screen size and a small keyword of a HHD with small RAM and low speed. The smart design of wireless information agent can reduce the number of navigations and data entries. Personalization can minimize information overload. Development of smart personalized wireless software agents is one future trend of the intelligent wireless mobile information technology.

Fig. 3. Main Page of the fuzzy wireless information Agent

Java servlets are used to generate dynamic WML from traditional relational databases. From system modeling point of view, converting HTML to WML is a tedious work, especially converting commercial HTML pages to let it fits for WAP devices. However, it would be better if we could generate a single form of data then translate it into different forms. XML and XSL (extensible style sheet language) seem to be the answer. With the generation of XML data, it is very easy to translate it into WML or any other kinds of markup language such as HDML.

The fuzzy wireless intelligent multi-agent systems have more applications. In addition, new WFWI techniques will be used to design more intelligent wireless mobile agents to better serve wireless and mobile users. In addition, the comparison between the fuzzy wireless intelligent agent system with other fuzzy Web agents based on real simulation results will be done in the future.

In the future, the hybrid soft-computing based learning algorithms such as genetic fuzzy neural learning algorithms [14] will be incorporated into the wireless mobile phone agent to make it have learning functionality (i.e., it can automatically learn new information and knowledge from current on-line data). In other words, intelligent data mining techniques will be used in it to save much time of a user.

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