Intelligent Multi Agent Application System in AI System

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Abstract

In this paper, I will present about the intelligent multi agent application system in AI. The research trend of multi agent is changed from centralized computing environment to distributed computing environment. Also, the research of multi agent can be changed to mobile environment. Initially, the study of multi agent is from the research of the human modeling.

Therefore, I will present a brief the concept of mobile multiagent, and present some application areas of mobile multi agents, especially in bioinformatics, control, and information retrieval etc. And finally I will present the research theme of multiagent in AI.

I. Introduction

Artificial Intelligence Artificial Intelligence (AI) is the area of computer science focusing on creating machines that can engage on behaviors that humans consider intelligent. The ability to create intelligent machines has intrigued humans since ancient times, and today with the advent of the computer and 50 years of research into AI programming techniques, the dream of smart machines is becoming a reality. Researchers are creating systems which can mimic human thought, understand speech, beat the best human chess player, and countless other feats never before possible.

Recent developments of the internet and network technologies evoke the technical change of the data processing from a conventional centralized and local processing system to the distributed processing system. The research about this network and the various approaches have been studied in order to efficiently manage mutual operations in such a network environment.

Many studies have been actively carried out in a distributed processing environment by using agent systems for efficient network management. An agent system has the following characteristics: multi agents in the distributed environments promote efficiency by solving one problem through any cooperation. Each agent manages the problem by dividing a common work into the number of agents, or each agent manages it independently, and then they solve the problems by analyzing the results. In addition, it has some advantages such that intelligent agents reflecting the tendency of users make no limitation of movement in a network, and it remarkably decreases the network traffic [1].

The study of multiagent systems focuses on systems in which many intelligent agents interact with each other in distributed environment. The agents are considered to be autonomous entities, such as software programs or robots. Their interactions can be either cooperative or selfish. That is, the agents can share a common goal (e.g. an ant colony), or they can pursue their own interests (as in the free market economy).

Multiagent system researchers develop communications languages, interaction protocols, and agent architectures that facilitate the development of multiagent systems. For example, a multiagent system researcher can tell you how to program each ant in a colony in order to get them all to bring food to the nest in the most efficient manner, or how to set up rules so that a group of selfish agents will work together to accomplish a given task. Multiagent system researchers draw on ideas from many disciplines outside of AI, including biology, sociology, economics, organization and management science, complex systems, and philosophy.

In this paper, I will explain the distributed multiagent system which is a modern AI approach and their applications as an example case.

This paper is composed of the followings. Multiagent digital library is explained in chapter 2, and the application areas in multiagent are explained in chapter 3, and finally I will conclude this research in chapter 4.

2. Multiagent Digital Library

2.1 Distributed Agent Framework

There are so many application areas of agents in the real world. One of these areas is a digital library system. The digital library is called an *electronic library* or a *virtual library*. This is a library developed to replace the conventional library, in order to serve information from databases on the web to users, according to the development of computers and the related fields.

However, there are several problems in the searching of data of the existing digital libraries.

First, as the searching method is one dimensional and distinguishes the existence of the searching keyword from the database, the result is very simple. Second, the results may contain unnecessary information under a condition that was not given the prior information about the user. Thirdly, whenever a client connects to the servers, he has to receive the certification and be under the dominant power of the influence of network.

To overcome such problems, a new platform of mobile multi agents for a personal digital library is necessary.

For the user's preference, some modular clients are applied to a neural network. A multi agent platform and a mobile agent platform are combined to develop a new mobile multi agent platform so as to decrease a network burden. Also, a new negotiation algorithm and a scheduling algorithm are activated for the effectiveness of PDLS.

DECAF is a kind of operating system including agent communication, planning, scheduling, monitoring, coordination, diagnosis, and learning among agents[2]. DECAF makes a socket program by itself, and presents some building blocks which makes messages and communicates between agents. Therefore, users or programmers can produce agents without having some knowledge about API approaches. Also, users or programmers do not need to make the communication codes directly to communicate among agents. Agent systems have been developed using various languages and platforms, and they are classified into so many types by purpose. In DECAF, many agents' tasks are divided by both GPGP (Generalized Partial Global Planning) and TAEMS (Task Analysis Environment Modeling and Simulation) algorithms.

GPGP is for improving of PGP which acts as a coordination algorithm of multiagents [3]. The first advantage of GPGP is that it reduces the system overhead which occurs by overlapping interaction among agents. And the second advantage of GPGP is that it is independent from some specific domain areas. Therefore, GPGP can make heterogeneous multi agents system having different functions. User's requirements can be decomposed by GPGP, and be structured by TAEMS [4]. User's requirements can be decomposed by GPGP, and be structured by TAEMS [4]. The root task can be decomposed into subtasks, and the subtasks can be decomposed into methods. The leaf node acts as a method which means actually acted elements.

Voyager [5] is a distributed mobile agent's framework for developing agent's applications, whereas DECAF is a non-mobile agent's framework. Voyager is an interactive framework with Java programming. Also, Voyager can activate any Java class in remote sites, and it makes use of network bandwidths effectively.

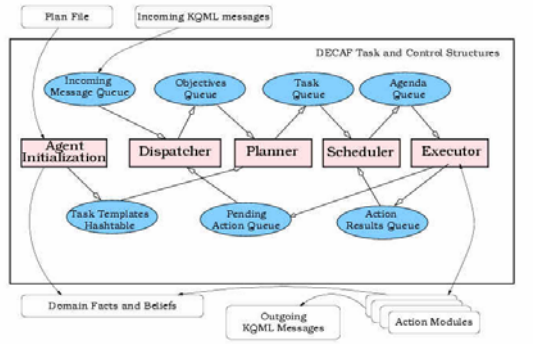

Figure 1. DECAF

2.2 The Concept of Agent-based Digital Library

A digital library serves a lot of information on-line [6,7]. The advantages of digital libraries are user friendly, on-site service and accessibility. However, in case of not having standardized platform, the search of heterogeneous information from digital libraries may be hard, as well as impossible. If it does not have or learn about the user's information, unnecessary or useless information will appear in the searched results from the digital library. Each agent can access DBMS and search documents according to the user profile. And then each agent categorizes the searched results.

The proposed system PDLS based on a new multi mobile agent platform. The system combines a mobile system and a distributed processing system to make an optimization of behaviors in a distributed environment. To establish a distributed environment, DECAF is used, and to activate a mobile framework, Voyager is used here.

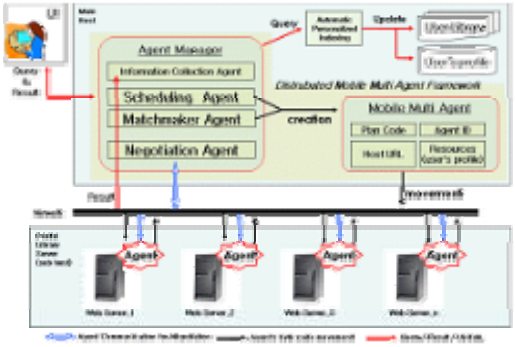

Figure 2. PDLS Structure

As shown in Figure 2, PDLS has two modules and two databases. The monitoring agent module is composed of Voyager and DECAF, and it monitors the agents' movements and controls their executions. When the user's requirements are transferred to the PDLS, the monitoring agent module checks whether the servers are available or not. After that, it makes some agents, and passes them to the servers. The searched results are saved in a temporary repository. They are filtered by negotiation agents, and the final results are saved in the result repository.

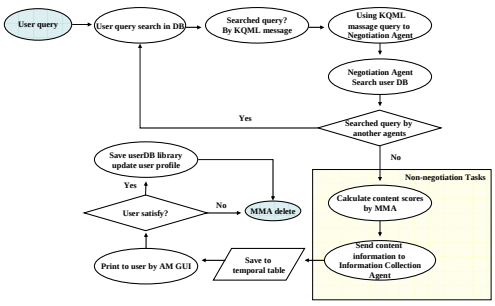

Figure 3. Negotiation Algorithm among Multiagent

The construction of the initial user's profile is constructed by the user's first input information. According to the user's searched results, PDLS endows the user's keywords to weight values, and updates user's profile information by SOM (self organizing map) network in real time [8]. SOM is an unsupervised neural network. In this paper, 2-layered SOM network is used here.

2.3 Simulation Results

The scenario is the followings. User can login by user interface. The monitoring agent(MA) is activated, and MA check the current connected remote digital library. At the same time, a user profile is read from database. The queries according to users are sent to PDLS. MA makes a search agent 1and registers it in ANS. The search agent 1 is sent to the remote library. The agent 1 is activated by receive the parameters from PDLS. The results from the agent 1 with information such as name and index and abstract of the remote library are sent to PDLS. And then they are sent to the negotiation agent(NA) for negotiation. At the same time, they inform to the MA and ANS. MA is clustered using SOM network according to the received results. The results by the user profile can be shown in the remote plane. user can move to his local library after receiving his necessary results. The user profile's update is activated.

As time passed, the searching times between the proposed PDLS and the traditional client-server model PDLS showed a faster search time as well as a much safer search than the client-server model. The result showed that as the numbers of servers were increased, the searching time was decreased in PDLS.

3. Multiagent Heath System

3.1 TMA(Tissue Mineral Analysis)

TMA[9] is a very popular method in hair mineral analysis for health care professionals in medical centers in over 48 countries[10,11]. The assessment of the relative relationship between nutritional minerals and toxic elements in hair is very important for determining adequacy, deficiencies, or the unbalance of nutritional minerals in the body.

There are some problems in the TMA method. The TMA method, which uses a TMA database, applies a pattern matching method in producing outputs when the mineral ratios and the properties of a patient are entered into the database for requesting. This pattern matching method may be effective if the database of TMA has a large-scale data, but it may produce inaccurate results if the database of TMA consists of a small number of data. Secondly, because there are insufficient health information databases for TMA in KOREA, it could not get the effective medical information. Also, it can cause some problems in the reliability of the TMA results, since the TMA results are based on the database of western health and mineral standards.

For these reasons, I propose the first Intelligent Medical Health Information System (IHIS). The IHIS uses a new TMA method. In the TMA method, a new multiple fuzzy rule base is proposed for intelligent inference. A multi-level statistical analysis is used to reduce some errors in statistical analysis, so that a new TMA database is developed and some medical data inferred from the TMA database. Also, this system can produce Korean reports about both patients' reports and doctors' reports as well. The effectiveness of the proposed method is verified through a series of simulation using some real clinical data.

3.2 IHIS Overview

The proposed Intelligent Health Information System(IHIS) is composed of 3 modules as shown in Figure 4: TMA statistical analysis module, TMA health information system module, and the

intelligent inference system module. After finishing the statistical analysis module, TMA database can be developed and it can receive feedback with real medical data for verification.

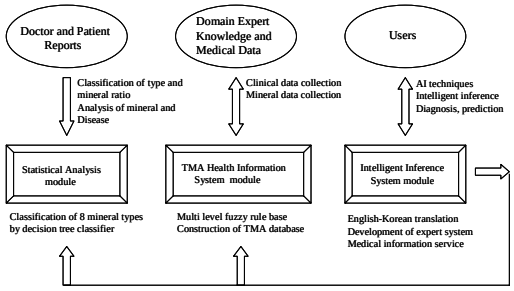

Figure 4. System Overview

In the Statistical Analysis module, the 8 type of metabolic types such as 4 slow metabolic types and 4 fast metabolic types, and mineral ratios are classified by a decision tree classifier[12,13]. The decision tree classifier can be adopted for the following reasons. The first step of the classifier makes use of the combination of the characteristics that is a maximum mean value among classes. However, the combination of characteristics does not represent an optimal classification among classes. Therefore, several repeating classifications between two types of decisions should be adopted so that it can be decided into input patterns correctly.

In the classification process of input patterns by a decision tree classifier, four types of slow metabolic types $\{S_1, S_2, S_3, S_4\}$ and four types of fast metabolic types $\{F_1, F_2, F_3, F_4\}$ are classified in root node on the basis of a mineral ratio of $Ca/P(=2.63)$. And in the second step, the sub slow metabolic types $\{S_1, S_2\}$ and $\{S_3, S_4\}$ are classified on the basis of a mineral ratio $Ca/K(=4.2)$, and the sub fast types $\{F_1, F_2\}$ and $\{F_3, F_4\}$ are classified on the basis of a mineral ratio $Na/Mg(=4.0)$. And in the final step, $\{S_1\}$ $\{S_2\}$ $\{S_3\}$ $\{S_4\}$ are finally classified on the basis of a mineral ratio $Na/Mg(=4.0)$.

Likewise, $\{F_1\}$ $\{F_2\}$ $\{F_3\}$ $\{F_4\}$ are finally classified on the basis of a mineral ratio of $Ca/K(=4.2)$, too. In this paper, I have classified the basic metabolic types and the correlation of nutritional minerals and toxic minerals by correlation analysis among minerals over coefficient of correlation 3.0.

The metabolic type classification shows the same results when using class type distributions about characteristics variables such as Ca/P, too. Figure 5 show the classifications of metabolic type using class distributions by adopting some characteristics variables.

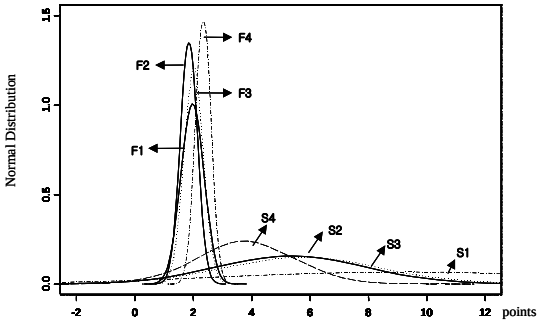

Figure 5. Metabolic Type Classification by Mineral Ratio of Ca/P

3.3 TMA IHIS Development Steps

I propose a new multiple fuzzy rule base system based on a statistical analysis method, which is designed for an intelligent inference from a lot of uncertain health information data. The purpose of the multiple fuzzy rule base system is following. In case that the complicated decisions by a lot of minerals are necessary, a rule base may be complicated in the conventional fuzzy rule base system. Therefore the rule base should be distributed so that it can be found, searched, and inferred by some multi-level relations among rules in the multiple fuzzy rule base.

Due to this, IHIS is composed of multi level tree structures which represent relations between the conclusion parts of a rule and the conditional parts of other rules, so that IHIS is appropriate for representing more complicated fuzzy rules.

The reason why the fuzzy theory is adopted as an uncertain handling method in IHIS, is that a fuzzy theory is appropriate for inference as well as representing the clinical minerals than any other uncertain handling techniques [9, 10]. The implemental steps of the multiple fuzzy rule base are the followings.

<Step 1> Classification of Metabolic Types and Development of a Fuzzy Rule base

The <Step 1> is an initial implementation step of a multiple fuzzy rule base on the basis of the correlation analysis of minerals by which defines fast metabolic types and slow metabolic types. To implement the multiple fuzzy rule base in this paper, I analyzed the following mineral types: nutritional mineral 30 types, toxic mineral 8 types, the relations between nutritional minerals and

toxic minerals, the ratios of nutritional minerals, the ratios of toxic minerals, the tendencies between all types of diseases and minerals.

The linguistic values which are in the mineral ratio's analysis, such as 'high', 'low', and 'acceptable', can be represented by fuzzy membership functions as shown in Figure 8. In Figure 8, X axis represents mineral ratios and Y axis represents fuzzy membership function values. These values are obtained by a statistical analysis method using a decision tree classifier.

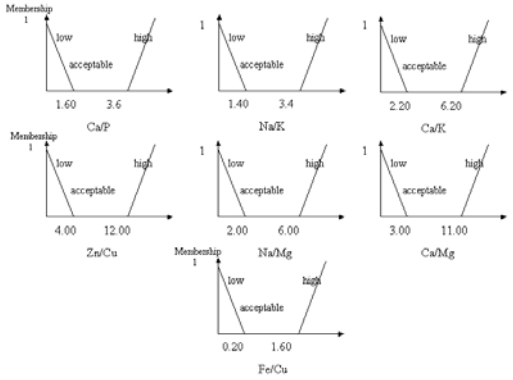

Figure 6. Fuzzy Membership Functions of Mineral Ratios

Not only those above minerals ratios but also all of the minerals such as 15 types of nutrient minerals (Ca, Na, Mg) and 8 types of toxic minerals (Hg, Pb) and other 15 types of minerals can be represented by fuzzy membership functions as shown in Figure 4.

<Step 2> Development of relations between endocrine glands and minerals by measuring the amounts and ratios of minerals

The <Step 2> is a refinement step of the multiple fuzzy rule base that implemented by <Step 1>. And also it implements a database about correlations between endocrine glands and minerals. The results of this analysis, shown in Figure 5, are used in designing the multiple fuzzy rule base. For example, if some mineral ratios are increased, such as $Ca/P, Ca/Mg$ $Ca/Na, Ca/K, Ca/Fe$, then parathyroid is increased. However, if Fe/Cu is increased, then parathyroid is decreased. If $Na/Mg, Fe/Cu$ are increased, then thyroid is increased. If $Zn/Mg, Fe/Cu$ are increased, then progesterone is increased. If $Ca/P, Ca/K$ are increased, then thyroid is decreased. If $Na/K, Ca/K$ are increased, then progesterone is decreased. If $Ca/P, Ca/Mg.Ca/K, Ca/Fe, Ca/Na$ are increased, then pancreas is increased. However, if $Zn/Mg, Fe/Cu$ are increased, then pancreas is decreased.

If $Ca/Mg, Ca/P, Ca/K, Ca/Na, Ca/Fe, Na/K$ are increased, then Estrogen is increased. However, if $Zn/Cu, Fe/Cu$ are increased, then estrogen is decreased. If $Zn/Cu, Fe/Cu$ are increased, then progesterone is increased. However, if $Na/K, Ca/K$ are increased, then progesterone is decreased. The other results of statistical analysis are used to implement the multiple fuzzy rule base.

<Step 3> Paragraph Analysis by Mineral Distribution

Patient and doctor's report have so many paragraphs explaining a patient's examination by TMA. Since a doctor's report contains extra information plus the contents of a patient's report, the doctor can explain the patient's examination to the patient very effectively. Patient and doctor's report have so many paragraphs explaining a patient's examination by TMA. Since a doctor's report contains extra information plus the contents of a patient's report, the doctor can explain the results of the patient's examination to the patient very effectively.

For the implementation of the refined fuzzy rule base, I analyzed the paragraphs explaining a patient's examination according to mineral distribution.

The rule type of the proposed multiple fuzzy rule base and the rule type of conventional simple fuzzy rule base are very different. In the multiple fuzzy rule base, only 3 propositions (fuzzy membership functions) are in antecedent part of a rule to make a multilevel inference effectiveness. Also, because of a hierarchical structure in the multiple fuzzy rule base, the system can infer the next relative rules from the multiple fuzzy rule base. However, in a conventional simple fuzzy rule base, there are so many propositions being represented by fuzzy membership functions in antecedent part of a rule. Even though it can be represented by small sized propositions, it is necessary to have some intelligent techniques, such as time scheduling or optimality, as well as some intelligent fuzzy inference techniques, because the medical minerals are very huge as well as complex, and they have so many relations among them.

3.4 Implementation Step

The format of the multiple fuzzy rule base is as

follows. The antecedent part of a rule is composed of mineral ratios, and the conclusion part of a rule is composed of both metabolic types and mineral ratios entering antecedent of the rules. In this paper, rules in a fuzzy rule base which has been implemented so far are more than 1000 cases.

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<Format of Fuzzy Rule base>

Rule 1: IF X_1 *is* A_1 and Y_1 *is* B_1 and

…… Z_1 *is* C_1 THEN K_1 *is* R_1

Rule 2: IF X_2 *is* A_2 and Y_2 *is* B_2 and

…… Z_2 *is* C_2 THEN K_2 *is* R_2

…….

Rule n: IF X_n *is* A_n and Y_n *is* B_n and

…… Z_n *is* C_n THEN K_n *is* R_n

Where, X_1, Y_1, Z_1, K_1: mineral, mineral ratios, endocrine gland etc. A_1, B_1, C_1, R_1 : fuzzy sets(*high*, *low*, *medium* etc.)

In this paper, the multiple fuzzy rule base makes use of TAEMS in order to be an effective fuzzy inference using data gained from multi-level statistical analysis.

Each rule in the fuzzy rule base has an interrelationship like Figure 7. The fuzzy implications that are composed of fuzzy antecedent and conclusion parts of a rule have some interrelationships which send to other antecedent parts of rules in the fuzzy rule base. The reason is that TMA mineral data is classified by the complicated interrelationship and not simple mineral data.

To infer the ID paragraph, the three rules should be interconnected as shown in Figure 7. The conclusion part of 'THEN' such as $'S_1'$, $'Ca/K\ is\ low'$, $'Na/Mg\ is\ high'$, are entered to the antecedent part of a Rule #2. And the relative ID paragraphs are inferred by multilevel scheduling process using TAEMS. In the IHIS system, each conclusion part of rules is repeatedly finding the antecedent parts of the upper level rules, and finally it finds the appropriate ID paragraphs of the conclusion part of rules. The inferred relative ID paragraphs are as follows.

Therefore, according to the inferred ID paragraphs by mineral amounts and ratios, the translated paragraphs in Korean are inferred from the TMA database, and they finally served to patients and doctors as a format of reports.

Since USA-TMA consists of simple structured RDB with approximately 0.35 million cases, it could be carried out by the inference of some required data via just pattern matching. Even though the IHIS has small-sized database with about 2000 cases, it could successfully find out the desired results by using the statistical classification and the intelligent multiple fuzzy rule bases. If it is compared with the simple fuzzy rule basis method, the proposed multiple fuzzy rule basis method has increased the effectiveness of the IHIS where the size of the sample is about 2000 cases.

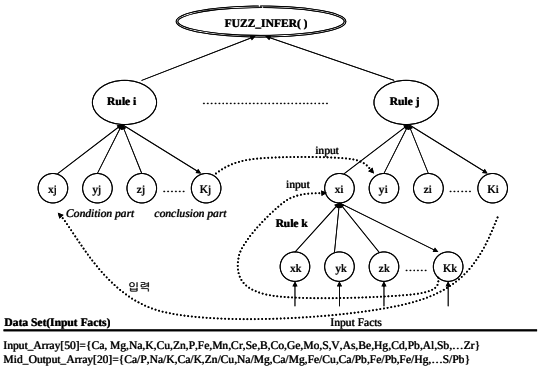

Figure 7. Interrelationship of Rules in Multiple Fuzzy Rule Base

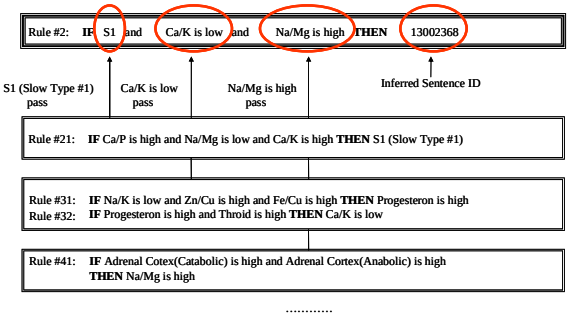

Figure 8. Inference Process in Multiple Fuzzy Rule Base

<ID: 13002312 English Paragraph>

"*Magnesium deficiency has been shown to be associated with decreased antibody production. Published studies have revealed that the lymphocytes, which are the body's defence against foreign invaders, are inhibited when there is a deficiency of Magnesium*"

The average processing speed of the proposed system means, the rate of searching the literal sentence matching with the mineral data of TMA, at which must be inserted in the initial menu of the IHIS. While the processing speed of the simple fuzzy rule basis method is considerably slow due to frequent comparison between input data of rules, the proposed multiple fuzzy rule basis method has been increased 5 times by

decreasing the number of comparison of input data of rules and reinserting the resulting data.

In order to measure the accuracy of output in the IHIS, I inspected the matching sentences between the resultant documents (set of paragraphs) from the proposed IHIS system and those from TMA in the US for about 2000 cases of domestic patients' clinical data occurred from July 2001 to February 2002. For 50 sentences of a result document per patient, the simple fuzzy rule base's method resulted in 30 matched sentences in average, but the multiple fuzzy rule base's method resulted in 46 matched sentences. The accuracy of the proposed multiple fuzzy rule base's method has been increased by 32% than that of the simple fuzzy rule base's method. Presently, the total number of result sentence saved in the database of the IHIS is approximately 700 per each metabolism and mineral. Consequently, the performance of the inference by the proposed multiple fuzzy rule basis method, having only 2000 cases, is exceedingly better than that of the conventional method with 0.35 million data.

I have analyzed the degree of satisfaction, which means the ratio of the degree of the application and the efficiency of the IHIS. Usually, the proper time required for a patient is three minutes. Here, I set the basic processing time to 3 minutes and counted the over time for evaluating the degree of the customer's satisfaction.

4. Conclusions

In this paper, I will present about the intelligent multi agent application system in AI. The research trend of multi agent is changed from centralized computing environment to distributed computing environment. Also, the research of multi agent can be changed to mobile environment. Initially, the study of multi agent is from the research of the human modeling.

Therefore, I will present a brief the concept of mobile multiagent, and present some application areas of mobile multi agents, especially in bioinformatics, control, and information retrieval etc.

In this paper, I proposed a Personal Digital Library System. PDLS is designed based on a new mobile multi agent platform using Voyager and DECAF agent framework. The new platform is a hybrid system of a mobile and a distributed system in order to achieve an optimality in distributed. Also, I have developed the new TMA System, named IHIS.

In the future, PDLS needs to be compensated in order to be activated in the real world. Also, IHIS will be constructed the eastern style medical database not western style database as time passed. Also, I anticipate the system could be served on the World Wide Web very soon.

Acknowledgements

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