An Intelligent Architecture for Multi-Agent Based m-Health Care System

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***Abstract* —In this paper, we propose a multi-agent based mobile health monitoring system which is the combination of a wireless medical sensor module with data mining techniques. Mobile Health Care is the application of mobile computing technologies for improving communication among patients, physicians, and other health care workers. Here we separate Association rule exploration into two data groups: 1) Real time sensory data collected from patient's body 2) Historical data collected in past. This system collects the diagnosis patterns, classifies them into normal and emergency terms and declares emergency by comparing the two data groups as mentioned earlier. Thus suggests methods to analyze and model patterns of patient's normal and emergency status.**

***Keywords*— Wireless Sensor Networks, Multi-Agent System, Ubiquitous Computing, Data Mining, Health Care System**

I. INTRODUCTION

Pervasive computing has made the interaction between humans and computational devices completely natural and user can get the desired data in a transparent manner. The newly introduced devices like mobiles, laptops, PDAs, etc have made ubiquitous computing possible [1] i.e. they are available anywhere at anytime. Pervasive computing is used in hospitals, emergency and critical situations, industry, education, or the hostile battlefield. Here we proposed a Multi-Agent based Healthcare System (MAHS) which is the combination of a medical sensor module and wireless communication technology as an integration of mobile computing to pervasive health care. By comparing patient's historical data and real time sensory data [2] it provides the patients with smarter and more personalized means through which they can get medical feedback which will save their valuable time and lower the cost of long term medical care.

II. RELATED WORK

CAST (Center for Aging Services Technologies) [5] is organizing multiple projects i.e. a safe home that will help debilitated elderly to keep track of their activities, a sensor-based bed to track the sleep and weight, which will later be used in detecting diseases.

The Centre for Future Health [6], a five-room house has been implanted with several infrared sensors, monitoring devices and bio-sensors. The ultimate goal of the project is to provide a unified solution for the seniors in the home, enabling them to closely participate in disease detection and health management by themselves.

The Terva [7] monitoring system had been introduced to collect data related to health condition four times a day (morning, noon, evening and night) and saved in the form a TOD (time-of-day) matrix and analyzed later.

MobiHealth project [8] can monitor crucial health signals through tiny medical sensors and transmit them to health care professionals through highly powerful and cheaply available wireless system.

The JADE (Java Agent DEvelopment Framework) provides advantage of the multi-agent system for parallel processing with many agents and enables the system to provide complicated services that couldn't be processed by a single agent. The addition of new agents enables the system to be easily extended to handle new services.

The LEAP (Lightweight Extensive Agent Platform) is a multi-agent system that runs seamlessly on both mobile and fixed devices over both wireless and wired networks. In our proposed architecture we take an advantage of both wireless and muti-agent technology for the application of mobile health care.

III. SYSTEM ARCHITECTURE

The system architecture is mainly divided into-

- Body Area Network (BAN).
  - Wearable Body Sensor Network.
  - Patients Personal Home Server.
- Intelligent Medical Server.
- Hospital System.

The detailed system architecture is shown in figure 1.

A. *Body Area Network (BAN)*

In BAN system sensors are attached to body area in order to capture bio-signals, including blood pressure, body temperature, pulse and breathing. It is mainly divided into two parts i.e. WBSN and PPHS.

WBSN

The wearable Body Sensor Network is formed of wearable or implantable bio-sensors in [3] patient's body. The sensors collect necessary readings from patient's body and sends to the central node in form of low frequency electromagnetic waves.

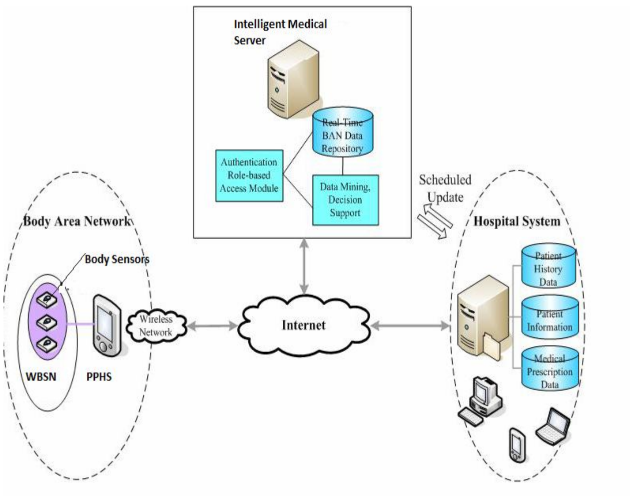

Figure1. System Architecture

The typical Wireless body sensor network is depicted in figure 2.

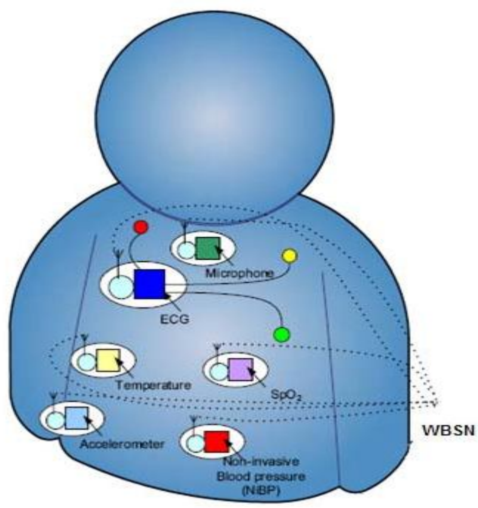

Figure 2.WBSN

The flow of information from sensors to cell phones is shown in figure 3.

PPHS

The patient's Personal Home Server can be a personal computer or a cell phone or PDA device. It gets information from WBSN by means of Bluetooth or Zigbee. PPHS contains logics to determine whether to send this information to IMS or not. Personal Computer based PPHS communicates with the IMS using Internet. Mobile devices based PPHS communicates with the IMS using GPRS / Edge / SMS technology. The IMS will act as the service provider and the patients PPHS will act as the service requester.

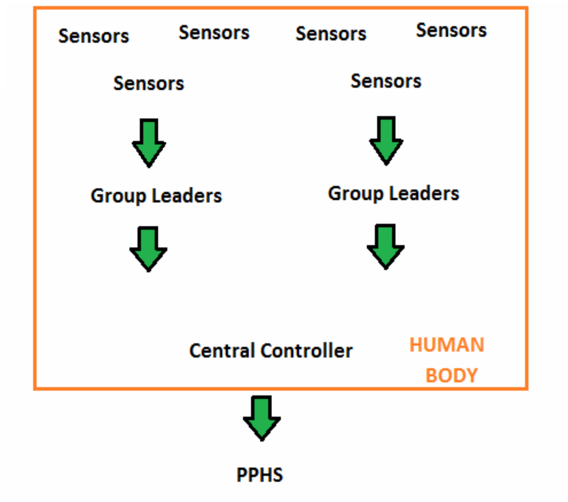

Figure3. Flow of data in BAN

B. *Intelligent Medical Server [IMS]*

The second part is the Intelligent Medical Server (IMS) which receives information from the BAN. It serves as a hub between the patient and hospital. It is the backbone of the entire system and is capable of learning patient's specific thresholds. An agent determines whether a patient is in a critical condition based on medical data transferred from the BAN System. If it is determined that there is an emergency, the data is transferred to the hospital system for enacting emergency measures, immediately after being stored in the IMS system. If it is not an emergency, the data is merely stored in the IMS. For data stored in the IMS, necessary data is regularly saved to the central database of the hospital. These real-time data will be deleted after a certain period of time unless there is an emergency. Data stored in the IMS is available to doctors and support staff in the hospital.

C. *Hospital System*

The third area is a hospital sub-system. If necessary, data is registered, retrieved, changed, updated and deleted by doctors, patients and hospital support staff. Depending on the IMS output or report the hospital staff will take the preventive or corrective actions for the corresponding patient.

Multi-Agent System

The Multi-Agent System consists of 6 main agents as shown in the diagram.

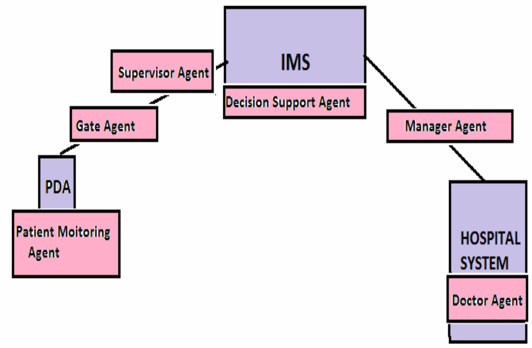

Figure 4. Block diagram of Multi-Agent system

1) ***Patient Monitoring Agent***

The Patient Monitoring Agent operates on a mobile device with the following functions: Firstly, it uses sensors to detect medical data from a patient, and peripheral data, including temperature and humidity. Secondly, it transfers the detected data along with details about the sender and device information to a IMS via the supervisor agent. Thirdly, it delivers a doctor's observations and diagnosis to his patient via the user interface.

2) ***Gate Agent***

The Gate Agent verifies a patient's authentication of his request for services. Patients have different access rights to the system, in accordance with various privileges given by their roles.

3) ***Supervisor Agent***

The Supervisor Agent operates between the mobile device and the hospital system, controlling the entire IMS. Firstly, it receives real-time medical data from a patient including the blood pressure (systolic/diastolic), body temperature, breathing and pulse. It saves the data into a repository, and then uses a specific pattern recognition module to analyze the data and compare it with normal conditions. If the value of data exceeds normal range (threshold), the agent sends an emergency alert message to a doctor or any other person with authority in the hospital via the manager agent, to take the appropriate emergency measures. If the value falls within the normal range (threshold), services will be discontinued when data is saved in a repository.

4) ***Manager Agent***

The Manager Agent operates on a hospital sub-system. If the supervisor agent requests emergency measures, it searches for the doctor in charge, and related hospital support staff. This agent sends a message including the patient's historical data and which requests a diagnosis about a patient by the doctor in charge. This agent stores the diagnosis and opinion in the medical prescription database, including a timestamp and result-id. In addition, this Medical History database stores bio-signal information about a patient from the Supervisor Agent. It also manages necessary data for data retrieval, registration and update, and deletion.

5) ***Doctor Agent***

The doctor's diagnosis of a patient is aided by messages from the Manager Agent. As well as this diagnosis, the Manager Agent sends an opinion to the patient. This diagnosis and the prescription data is stored in the Medical Prescription database. The stored diagnosis and prescription data are managed and maintained as historical records, which are used when required by patients.

6) ***Decision Support System***

The data in normal conditions of patients is not so important but the data collected in abnormal conditions is not so frequent but important. Therefore association rule in [4] is very important for predicting occurance of less frequent but important data.

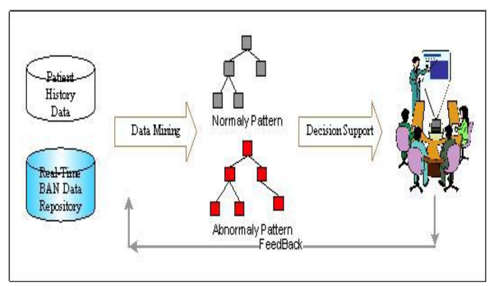

Figure 5. Decision Support System

Consider an example, one patient having normal temperature 99F while 99F temperature is severe fever for the other one. So we divide the database into two groups i.e. patient's historical data and real time sensory data. By this we can detect patient's emergency status. Data is mined in such a manner that even its occurrences are not frequent but the conditions represented by it are abnormal. Such data plays important role while taking decisions during case of emergency. This can be shown from example below:

TABLE I

SAMPLE DATABASE

Data item	T1	T2	T3	T4	T5	T6	T7	T8
A	A1	A2	A3	A4	A5	A6	A7	A8
B	B1	B2	B3	B4	B5	B6	B7	B8
C	C1	C2	C3	C4	C5	C6	C7	C8

- Abnormal value
- Normal value

By using advanced mining rule, only the data having abnormalities is mined.

TABLE III

MINED DATABASE

ata item	T1	T2	T3	T6	T8
A	A1	A2	A3	A6	A8
B	B1	B2	B3	B6	B8
C	C1	C2	C3	C6	C8

IV. SCENARIOS

In ICU patients are under continuously monitored. But in many cases patients are treated and sent home but their disease may return and may cause severe death. In these cases patients should be under observation for several years even after curing of the diseases. Here E-Healthcare[10] is handy. Patients suffering from blood pressure face the same problem. Their blood pressures change suddenly and can be life-treating. Using E-Healthcare System, they can get alerts when their blood pressure just starts to become high or low. Normally glucose level will be sent after several days or a week. Heart rates can be sent every minute and temperatures can be sent after half an hour etc. But these can be parameterized to ensure that when a patient is normal, not many readings will be sent so that sensors have a longer life-time. But when the patient is ill, readings will be taken frequently and sent to PPHS. The most important fact about IMS is that it can help stop the spread of diseases. Whenever it finds that several people from same locality over a small period of time are having the same disease, it will predict that the disease is spreading out in that locality so that authority can take immediate action. Say, when some people of the same area report that they are having high fever, pain over body and rashes, IMS will report this which the doctors can interpret that dengue is breaking out in that area and the authority has a chance to take actions at the very first stage so that epidemic can be avoided.

V. CHARACTERISTICS

The proposed system comprised of following characteristics:

Simplicity:

The architecture of IMHMS is simple.

Cost-Effective:

Low cost biosensors, cheap way of transmission like Bluetooth and Zigbee and easy availability of cellphones make IMHMS cost-effective.

Secure:

Each patient will be provided RFID tags that will be used to uniquely identify the patient. The IMS will maintain patients profile information with the RFID in the central database. So malicious attacks can be blocked.

Flexible communication protocol:

Communication protocol of IMHMS is flexible. (Bluetooth, Zigbee, WLAN)

Capability to predict spread of diseases:

The intelligent IMS can predict spread of diseases in a specific locality.

Capability to help authority to determine general health policies:

The IMS is capable to help authority to determine general health policies.

VI. FUTURE WORK

The whole system of mobile health care using biosensor network places forward some future works such as finding the most effective mechanism for ensuring security in biosensors considering the severe restrictions of memory and energy. Representing the collected data in the most informative manner with minimal storage and user interaction is necessary. Data is to be modelled so that the system will not represent all the data but only relevant information thus saving memory and develop an advanced sensor technology.

VII. CONCLUSION

This paper proposed a ubiquitous healthcare system by modelling real-time diagnosis and prescription services provided by a hospital system, based on collected medical and peripheral data. The proposed system provides an interconnection of patients and a hospital in a ubiquitous computing environment. In
our multi-agent system, agents are involved in functions, such as using sensors to collect medical and peripheral data in real-time, storing the collected data in the IMS, determining whether a patient is in a critical condition, transferring to the hospital system data about the patient that has been determined to be critical, and finally delivering the doctor's diagnoses and prescriptions to the patient. However, determination of the patient's condition in medical terms based on the collected data requires further investigation. Once the technology is refined, medical costs for correcting chronic medical conditions will be reduced .Our goals will be fulfilled if the E-Healthcare System can help a single individual by monitoring his or her health and cautions him to take necessary actions against any upcoming serious diseases.

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