CHAPTER 4

INTELLIGENT PATIENT MONITORING SYSTEM

4.1 INTRODUCTION

Monitoring and diagnosis of patients without directly accessing them is very important in medical application of wireless sensor network. But, collecting, transferring and maintaining of data is challenging task. So, there is an immense need to handle all these information in a quickly and effectively way. In this research, we utilize agents in different processes such as, data collection from the different sensors, analyse the data, transferring, storing to the appropriate servers, classifying the data with more accuracy and give the prescriptions to the patients.

The aim is to develop a reliable, efficient and easily deployable distant patient monitoring system that can play a very important role in providing basic health services to the patients. This system enables expert doctors to monitor patients in remote areas of hospital. Mobile phones or personal digital assistants (PDAs) with wireless networking capabilities may serve as gateways that process, store and transfer measured parameters to clinicians for more psychoanalysis or diagnosis. The well-timed manner of conveying the real time monitored factors to the physician is given high precedence which is very much needed.
The research related to the use of a wireless sensor network which consider in the form of a body sensor network monitoring patient’s condition in a health application. In the light of this, we would like to briefly go through some of the familiar wireless sensor networks which could be considered as a body sensor network for our application. The architecture of the proposed system is given in Figure 4.1.

Figure 4.1 System Architecture

The architecture of the proposed approach is prearranged in to three layers as body area network layer, conveyer layer, data analyst layer. The body area network consists of a set of body sensors and updation agent. To sense the significant parameters of the patient and it sends the sensed data to the updation agent for each particular time interval the body sensors are used.
From the body sensors, the updation agent, stores the received medical information of the patient.

The next layer is the conveyer layer, this layer consists of two agents first one is collection agent and the second one is nurse agent both agents are primarily used for transmitting the medical information from one layer to another layer. From different upatation agent, the collection agent helps to collect the medical information from the every updation agent also merges the appropriate medical data and sent to the data analyst layer.

The analyst layer consists of three parts first one is data repository, the second one is classifier and third is physician. The use of data repository is store the medical information of every patient and the classifier helps to analyse the medical data of the patient and the physician gives prescription. At last the prescription is send to the patients through the nurse agent in the conveyer layer.

4.2 BODY AREA NETWORK LAYER

In Body Area Network (BAN) layer, the sensors are attached to patient’s body with the aim of obtain the bio-signals including blood pressure, body temperature, pulse and breathing. This body area network is mainly divided into two parts first one is Wearable Body Sensor Network and the next one is Updation agent. The main purpose of this BAN layer is to collects and updates the sensed data from the WBSN and sends those data to the conveyer layer. Figure 4.2 illustrates the Body Area Network layer. The BAN layer collects the patient data using body sensors then sends the data to the updation agent by using the ZigBee wireless data transmission technique.
4.2.1 Wearable Body Sensor Network

The WBSN is the sensors which are formed wearable or implantable in patient’s body since the name is wearable body sensor network. From the patient’s body, the bio-sensors accumulate the essential readings and send that to the Updation Agent.

The WBSN used to collect vital signs from the patient’s body. Each node has capability to sense, process and forward the information. At each time interval T the nodes sends their sensed data from the patient’s body with its id to the Updation Agent.

\[ S = \{ \text{Sid, data, d/t} \} \]

Where

\[ S \rightarrow \text{Sensor,} \]

\[ \text{Sid} \rightarrow \text{Sensor ID,} \]
data → sensor reading
and d/t → date and time of sensed data.

A sensor can send their sensed data to at a particular distance because of limited power. Hence we use an Updation Agent for every patient. In order to send those data to Updation Agent, the sensor node sends request to Updation Agent and the transmitting is starts when the responds received from the Updation Agent.

### 4.2.2 Updation Agent

The main purpose of the Updation Agent (UA) is to receive the medical information $D$ from the sensor connected with the patient and store the received medical information on the corresponding sensor id.

An Updation Agent is a Personal Digital Assistant housed with intelligent agent program. The UA which is in charge of collecting the arrival signals from the body sensors, analyzing them, if any abnormality occurs then transmit alerts by message, otherwise send all these data to the Collection Agent. The UA receive the medical information from various sensor nodes $S$ and store that on the corresponding sensor id. Figure 4.3 shows the works of updation agent.

The UA received the set of medical information (Updated Data) $UD = \{S_1, S_2, \ldots, S_n\}$ from WBSN, where $n$ is number of nodes which are connected with a patient.
Figure 4.3 Works of Updation Agent

If a patient connected with more than one sensor then the Updation Agent note down the id of the sensor when it receives the request from the sensor and the UA checks, if the id of the sensor is exist or not. If the id of the WBSN is already exist, then the UA updates the data of that WBSN else makes a new place to store the data for new WBSN id.

Each UA is identified by a unique ID which is used to identify the patient location in the network. Finally, it delivers a doctor’s observations and diagnosis to the patient via the Nurse Agent.

The UA Agent works

- Continuously monitor the patients with the sensor system.
- Check the patient status as Normal or Abnormal by using simple rule based technique. (Example monitors the temperature of the patient by using simple Fuzzy Rule. If the temperature is less than 99° then the status is normal the temperature is greater than 100° than predict the status is abnormal and send the alert message.
• Send the Alert message by using GSM Modem in built with the UA system.

4.3 CONVEYER LAYER

The main purpose of the Conveyer Layer (CL) is to collect and transmit the medical information from one layer to another layer. This CL is mainly divided into two parts; the first one is Collection Agent and the next one is Nurse Agent. The Updation Agent stores the information from various WBSN, the stored information of the Updation Agent would certainly goes to the Data Analyst layer. If we send the information of the sensors of the patient directly through the Updation Agent some of the information become loss since the patient is dynamic. So for here we use the collection Agent.

4.3.1 Collection Agent

The Collection Agent (CL) is used for collects the sensed data of the each patient from the updation agent in the BAN layer and it transmit the collected data to the Data Repository (DR) in the Data Analyst layer (DAL).

We generate the Collection Agents for each $N$ number of updation Agent. The collection agent collects the set of medical information $UD$ (Updated Data) from the $N$ number of Updation Agent. At each Time interval $T^{++}$, the collection agent collects the $UD$ data from the each Updation Agent. Subsequently the collection agent merges the $UD$ data which has same WBSN id.

The Collection Agent is a sink node used for collecting the sensed data from the UA. For each ward in hospital a CA is available to collect the data from that particular area and then transmits it to the DR. Number of wireless relay nodes used to forward the data to the Collection Agents with
the help of Wireless Technology. Figure 4.4 illustrates the concept of Collection Agent.

![Figure 4.4 Collection Agent](image)

4.3.2 Nurse Agent

The Nurse Agent helps to transmit the medical information from the physician (Doctor) in the DAL to correspond UA in the BAN. The nurse agent conveys the medical information to the corresponding patients when receives the data from the physician.

4.4 DATA ANALYST LAYER

The Data Analyst Layer (DAL) helps to analyse the medical information of the patient and also used for store the medical information. The collection agents send the data to DAL for store and analyse the data. The medial information is stored in the data repository helps to Decision Support System for effective prediction of patient health status. The physician analyses the DSS information and also analyses the earlier medical history of the patient from the data repository. By analyzing the above both data, the
physician gives the prescription to the nurse agent and the data repository stores those prescriptions of the patient.

4.4.1 Data Repository

The data repository helps to store the medical information of the patients. The data repository consists of patient id, medical data, results of the DSS and the prescriptions of the physician. Figure 4.5 Illustrates the Data repository system. The data repository updates the patient’s information in the following steps:

- Whenever the UD data received from collection agent.
- Whenever the DSS predicts the patient status.
- Whenever the physician gives the prescriptions.

![Data Repository System](image)

Figure 4.5 Data Repository System
With the help of the data repository, the physician can evaluate the past medical history of the patient. By considering the past medical histories of the patient and the current sensor data, the physician gives the prescriptions.

### 4.4.2 Decision Support System

Computer Aided Decision Support System plays a major role in medical field. A novel Decision Support System (DSS) is developed here by using data mining techniques back propagation and K-Nearest Neighbour classifier to diagnose the disease with more accuracy.

The DSS works by a Data Analyst Agent (DA Agent), the DA Agent receives the patient medical data from the data repository and if necessary the physician makes some changes in patient data for accurate result. Then the DA Agent predicts the patient status. The new hybrid algorithm based decision support system explained in the Chapter 6.

![Figure 4.6 Data Analyst Agent](image)

### 4.4.3 Physician

The physician helps to gives the prescriptions by analyse the result of the DSS and the past medical histories of the patient which helps to the patient to protect from the risk of the disease.