IoT Based E-Health Monitoring System

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Abstract— Design and implementation of an e-health smart Networked system. Particularly in the case of e Health monitoring applications for chronic patients, Where Patients monitoring refers to a continuous observation of patient's condition (physiological and physical) traditionally performed by one or several body sensors. The system is aimed to prevent delays in the arrival of patients' medical information to the healthcare providers, particularly in accident and emergency situations, to stop manual data entering. The architecture for this system is based on medical sensors which measure patients' physical parameters of patient by using wireless sensor networks (WSNs). These sensors transfer data from patients' bodies over the wireless network to the cloud environment. Therefore, patients will have a high quality services because the e heath smart system supports medical staff by providing real-time data gathering, eliminating manual data collection, enabling the monitoring of huge numbers of patients. Enable remote monitoring and assistance of patients with chronic diseases.

Key words: Frequent Pattern Mining, High Utility Itemset Mining, Transaction Database

I. Introduction

Wireless Sensor Networks (WSNs) have facilitated the way for development of various aspects of sensing. WSNs have been applied in different applications such as military applications, climate monitoring applications, underwater networks applications, and structural health monitoring applications. WSN are facing many challenges such as limited computing power, memory capacity and data transmission capabilities. Thus, using cloud computing would be an appropriate solution to improve sensors efficiency.

Cloud Computing is a general expression for any technological services provide through the Internet [1]. Cloud computing provides compatible and on-demand network access for numerous computing resources such as networks, systems, applications, and services. Moreover, cloud computing are using modern and flexible methods to provide, manage, and pay for information technology services with minimal management effort and cost. Cloud computing technology has several advantages such as flexibility, highly auto-mated, low cost, fast services providing, and a huge storage capacity. The Cloud's features enable customers to build, test, and deploy their applications on virtual servers using different infrastructures and multiple operating systems. Cloud service providers offer three different types of services in order to obtain their customers more flexibility, which are Software as a Service (SaaS), Platform as a Service (PaaS), and Infrastructure as a Service (IaaS). SaaS provides remotely access to software applications and their functions as a Web based service. (PaaS) offers application frameworks and operating systems, obtains to minimize the development efforts, and provides many applications in the cloud for users without installing any framework or software on their machines. (IaaS), offers a pool of cloud computing resources, including hardware, servers, networking components, and a massive storage space. Finally, cloud computing offers unlimited data storage. Therefore, the organizations and users who are using the cloud do not need to be concerned about the size of their files.

Bebotte is cloud platform for real-time connected objects connecting anything and everything in real-time using rich API supporting REST, Web Sockets and MQTT. Design to empower Internet of Things and real-time communicating applications. Beebotte brings you a platform as a service connecting thousands of objects and delivering millions of messages. One platform suited for diverse applications like instant messaging, dashboards, online gaming and score boards, domotics, Internet of Things and reporting. Seamless scalability to meet your growing demands. Redundant architecture hosted with Amazon's AWS for high availability

In this paper, focus on the idea of integration between wireless sensor network and cloud computing. After health sensors that are connected to patients' bodies collect and transmit data to the cloud, services which are available in this cloud are responsible for receiving, storing, processing, and distributing this data. Suppose that this solution offers an appropriate scenario to provide a comprehensive telemedicine service which automates the processes from collecting patients' data to delivering compatible medical decisions based on patients' current conditions and their historical medical data.

The contributions of this paper are:

- A framework for integrating WSN and cloud computing.
- A prototype implementation using e-health sensors and the Raspberry Pi.
- Improve the sensor Efficiency
- Applying data mining technique to extract an appropriate decision based on patient's condition and historical data.

II. Motivation

Providing healthcare services is very important for people specially who have chronic diseases. Those people need continuous healthcare which cannot be provided outside hospitals. There are a variety of technologies around us, so to get benefits from connecting such technologies to build a new e-health system platform could help to achieve high quality health care services. There are many reasons which motivate us to build this platform: (1) making healthcare more accessible for people who do not have access to healthcare providers in their communities; (2) making healthcare easier for people who do not have access to public transportation in order to go to hospitals; (3)

increasing bed capacity in hospitals, especially during public events where a large number of people are meeting in one place; (4) giving medical staff more time to be attentive to patients who need more care; (5) preventing delays in the arrival of patients' medical information to the healthcare providers, particularly in accident and emergency situations; and (6) reducing manual data entry for patients' data which prevents real-time monitoring and restricts medical staff to monitor their patients.

III. RELATED WORK

Mohammad et al. [1] The system is aimed to prevent delays in the arrival of patients' medical information to the healthcare providers, particularly in accident and emergency situations, to stop manual data entering, and to increase beds capacity in hospitals, especially during public events where a large number of people are meeting in one place. The main objective of the system architecture is to provide high quality services because the e-heath smart system supports medical staff by providing real-time data gathering, eliminating manual data collection, enabling the monitoring of huge numbers of patients.

Fakhrul et al. [2] focused on huge amount of data that is generated by different sensors and uploaded into the server through Wireless Sensor Network (WSN) faces a several types of security, privacy, flexibility, scalability, and confidentiality challenges. Existing architectures for patients' health data collection lack of different types of security issues. The main objective is to obtain secured Health cloud architecture for patients' health data collection. Where WSN are integrated with Cloud computing technology, have Cypher text Policy-ABE within our cloud infrastructure to guarantee data security, privacy and fine grained access control of data.

Swathi B S, et al. [3] offers a novel design for Integration of Wireless Sensor Networks and Cloud Computing. The main objective architecture of cloud environments is mainly used for storage and processing of data. Cloud computing provides applications, platforms and infrastructure over the internet. Wireless Sensor Network is an very important technology in which sensor are placed in distributed manner to monitor physical and environment changes such as temperature, pressure etc. Combining these two technology helps in easy management of remotely connected sensor nodes and the data generated by these sensor nodes. For security and easy access of data, cloud computing is widely used in distributed/mobile computing environment.

Lounis et al. [4] offer a novel design for gathering and accessing a huge amount of data generated by WSNs. The main objective of their architecture is to overcome the challenges of dealing with a huge amount of data and makes sharing of information easier for healthcare professionals. The paper focuses on data management in WSNs, specifically sensors' data gathered that have been generated from medical sensors which introduce many challenges for the existing architectures.

Rolim et al. [5] focused on developing patients' data gathering technique. This paper presents a novel framework to solve the problems of taking notes manually which is a slow process. Besides, they cause lateness for accessing real-time data and that restricts the capability of clinical monitoring and diagnostics. Thus, authors proposed a system to automate collecting patients' information process using wireless sensor networks which are connected to medical equipment, and then transferring this data to the healthcare provider centers in the cloud to store, process, and analyze patients' data. However, this paper does not take security risk in consideration, practically in the architecture of proposed solution.

Fortino et al. [6] state that the integration of cloud computing and wireless sensor networks can provide scalable powerful data storage, and improvement of processing infrastructure and analysis of body sensor data. This paper presents the management and monitoring of sensor infrastructure. In addition, this study also considers some components in the architecture of cloud computing such as data management and using APIs for communication between sensor data streams and the cloud. The authors implement their system by using an application of the Google App Engine (GAE) which is one of the cloud computing providers for hosting and developing web applications in the cloud.

Hwang et al. [7] presents an interesting business model for cloud computing based on the concept of performing the encryption and decryption technique, and a cloud provider must ensure that the information has been stored in encrypted format. Moreover, after the computation operations are completed, all data must be deleted. This study discusses many points related to encrypting data in the cloud. However, this paper did not discuss the security part during uploading and downloading operations in terms of securing the channel between the client and cloud provider.

IV. E-HEALTH MONITORING ARCHITECTURE

The architecture consists of three major layers which act as the backbone for our system. We have broadly categorized the architecture of our system into three layers based on the functionality of the components being used. Fig. 1 illustrates the three layers used in our architecture.

A. *Perception Layer*

The first layer at the bottom of the hierarchy consists of various types of sensors which collect real time data. These wearable sensors are embedded in and around the environment surrounding the patient and in his/her body.

They can be broadly classified into two types, viz. medical sensors and environmental sensors. The medical sensors monitor vital parameters of the patient whereas the environmental sensors monitor parameters of the room including room temperature, oxygen levels and beyond. The data accumulated by the sensors are relayed to a processing device which attaches several data like unit, timestamp etc. and thereby creating metadata. With that, one unique id is attached to each unit data in order to distinguish which report is for which patient. The data is sent to the next layer in the hierarchy through Gateway 1. The communication between the sensors and the gateway are conducted through short range communication systems including Local Area Network (LAN).

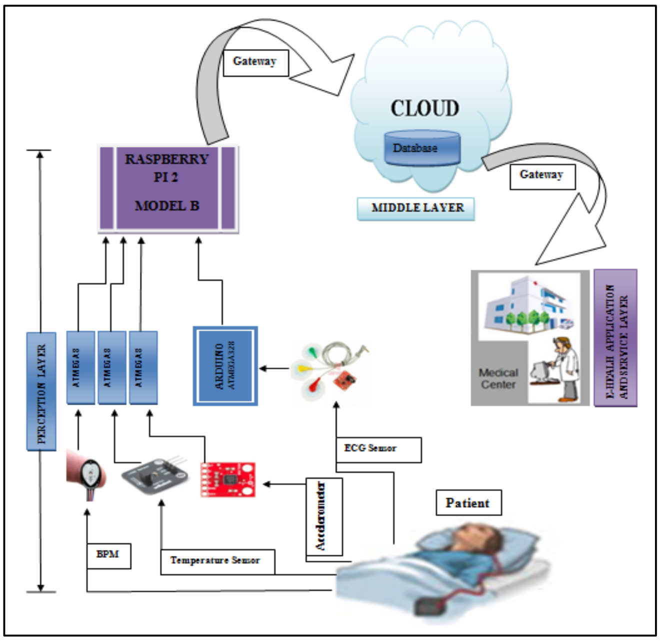

Fig. 1: e-Health Monitoring Architecture

B. *Middleware and APIs layer*

This layer is the pivotal layer of the system consisting of various APIs (Application Programming Interfaces). The cloud storage stores the medical history of the patient as well as current records of the monitored parameters. This storage plays a central role in the emergency response and hospital monitoring system to correlate the data collected from the sensors to the stored thresholds for the parametric values. The cloud storage is instrumental in analyzing an emergency and declaring a state of emergency for the patient. Whenever a patient is registered in the system one API creates the profile for that patient. Another API can also be developed which would fetch the patient history for a patient who is already using the system and analyze the report. These APIs support the profile creation, storage, queries regarding patient history and other reports synchronizing with the whole system. The data from the cloud is relayed to the Gateway 2 over UMTS, optical fibers or over Wi-Fi. The data is then relayed to this layer for outsourcing applications and services from the Gateway 2 or E-Health Service Capability module.

C. *E-Health Application and Service Layer*

The third layer of the system is a terminal layer offering outsourcing services for the monitored data. This layer offers E-health Advice services to the patient. This process involves prescribing medicines or providing suggestions to the patient correlating to the values of parameters that are being received from the sensors. The system plays the role of informing the doctors and the caregivers in accordance with the level of emergency. Depending on the level of emergency the response team takes required action. The hospital module monitors the patient remotely from the location of the patient, if the monitored patient is at home or a remote location. This module also allows analysis of all patients under monitoring centrally in the hospital or health care centre.

V. FUNCTIONAL COMPONENTS OF THE ARCHITECTURE

A. *Raspberry pi*

The Raspberry Pi is a Linux-based microcomputer that connects with a computer monitor or TV, and uses a keyboard and mouse. It includes 2 USB ports, HDMI and Ethernet port, SD card slot, memory, video/audio outputs, and power source. We used C++ to implement the application (on the raspberry pi) for reading the data from the sensors and sending it to the cloud. We utilized TCP sockets to establish a connection between the Pi and the application in the cloud. The server program was written in C#. In the cloud, we selected Amazon Web Services (AWS). AWS is one of the widely used cloud providers which provides infrastructure as a service known as Amazon Elastic Compute Cloud (EC2). Amazon EC2 is a web service that is designed to make web-scale computing easier for developers and to provide flexible compute capacity in the cloud. For the EC2 instance, we installed Windows server 2008 as an operating system. To build the application on this instance we used C# language, and Microsoft SQL server database to achieve e-health smart system which is responsible for receiving, managing, and processing patients' data, then store this data in the database.

B. *ATMEGA8-PU*

ATMega8 is 8kb 8-bit microcontroller with 28-pins which has operating frequency of 16MHZ. It is controller with architecture RISC has 130 commands where all commands execution takes single clock cycle. It has 32x8 GPWR which can achieve throughput of 6 MIPS at 16MHz and 2 cycle multiplier on chip. It includes peripheral features like analog comparator, watchdog time with programmable and separate oscillator, serial SPI interface, 2 counters/timer 8-bit, One 16 bit timer/counter, 3 PWM channels, serial USART programmable, 10-bit ADC with 6 channels, serial interface which is two-wired.

C. *The LM35 Temperature Sensor*

The LM35 series are precision integrated circuit LM35 temperature sensors, whose output voltage is linearly proportional to the temperature in Celsius (Centigrade). The LM35 sensor thus has an advantage over linear temperature sensors, calibrated in °Kelvin, as the user is not required to subtract a large constant voltage from its output to obtain convenient centigrade scaling. The LM35 sensor does not require any external calibration or trimming to provide typical accuracies of ±¼°C at room temperature and ±¾°C over a full -55 to +150°C temperature range. The LM35's low output impedance, linear output, and precise inherent calibration make interfacing to readout or control circuitry especially easy. As it draws only 60 µA from its supply, it has very low self-heating, less than 0.1°C in still air.

D. *Heart Beat Sensor*

Heart beat sensor is a device designed to calculate heart rate in digital form output. Digital output is calibrated whenever the finger is placed on it. Whenever heart beat is detected the LED is made to flash at every beat detected. The output pin of the sensor is directly connected microcontroller to calibrate the heart rate that is BPM rate. Whenever there is heart beat there is rise and fall in the blood, so this flow of blood is measured using light modulation principle at every pulse through finger. Average heart beat of normal person ranges from 50 to 85.

E. Accelerometer

ADXL345 is semiconductor device uses MEMS technology which integrates electrical and micromechanical structure into chip of silicon. The device can sense three axis and produces digital or analog values. ADXL345 is device which sense 3 axis with digital output. Very low power consumption, flexible for serial and digital interface SPI. Accelerometer is used to find the position of patient wether the patient is lying on bed, patient trying to get up, patient turns towards left and patient turns towards right.

VI. PROTOTYPE

Prototype system built used commercial wireless health sensors that are connected with ATMEGA8 microcontroller that allows Raspberry Pi developers to perform biometric and medical applications to measure patient's physical parameters. In our implementation, we used three types of sensors which are Heart-Beat Sensor (BPM), Temperature Sensor and Accelerometer (Position) Sensor.

In the cloud, we selected Bebotte which is cloud platform for real-time connected objects connecting anything and everything in real-time using rich API supporting REST, Web Sockets and MQTT. Design to empower Internet of Things and real-time communicating applications. Beebotte brings you a platform as a service connecting thousands of objects and delivering millions of messages. One platform suited for diverse applications like instant

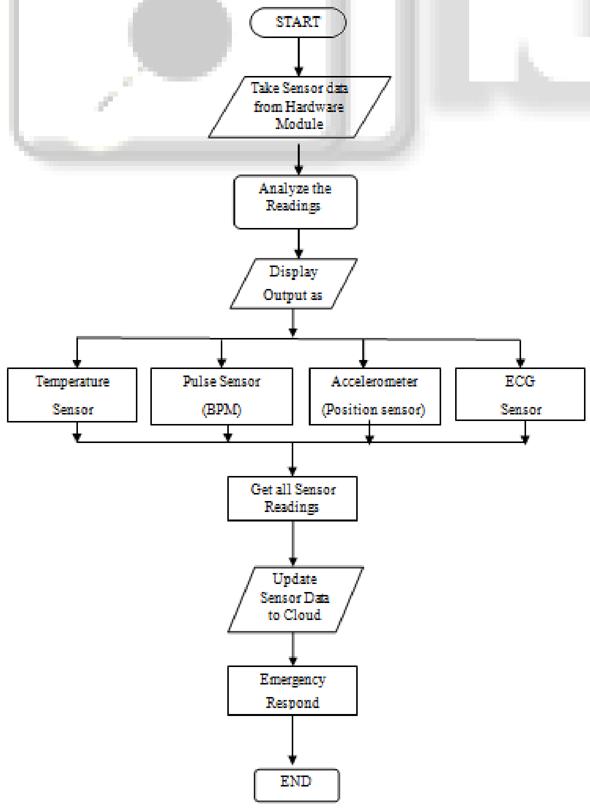

Fig. 2: System flow chart

Bebotte is the public cloud platform Services is one of the widely used cloud providers which provides infrastructure as a service. All the calibrated sensor data are collected in Raspberry pi which is connected to internet. These sensor data is updated to bebotte cloud platform. Bebotte establish a channel between the Raspberry pi and the cloud with Secret key and API key. Sensor data is transmitted through this channel and can be displayed on Dashboard of Bebotte application. Python language code is used to update the data to cloud and C# language for calibration of sensor data in ATMEGA8 microcontroller. Sensor data can view on python terminal and also in Bebotte dashboard. Raspberry pi is responsible for receiving, managing, and processing patients' data, then store this data in the database.

VII. IMPLEMENTATION RESULTS

Prototype system was built using temperature sensor, Heart-beat sensor (BPM), Accelerometer (Position) Sensor, functions because wanted to minimize the cost of the experiment. As a test sample, have used 3 sensors to patients' body and calibrated the readings. Theses sensor reading can be view on the Raspberry pi python terminal and also is updated to the IoT platform. The IoT platform is beebotte in which all the sensor data is updated for every second. Medical staff can easily view the health parameters of the patient even the patient is out of hospital or in home itself through IoT platform. Result obtained on the IoT platform is shown in the figure 4 body temperature which is around 27 Celsius.

As shown in figure 4 we collected body temperatures for one patient in different times from time 6.25 to 6.35 where the temperature varies from 25 to 28. Thus, medical staff can monitor the patient easily during the day. The medical staff also can make decisions based on the patient's condition if they notice that the patient has an emergency.

Fig. 4: Body Temperature Monitor of Patient

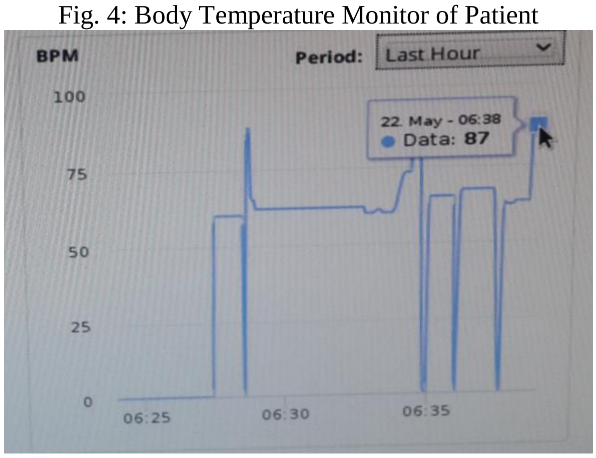

Fig. 5: BPM of Patient

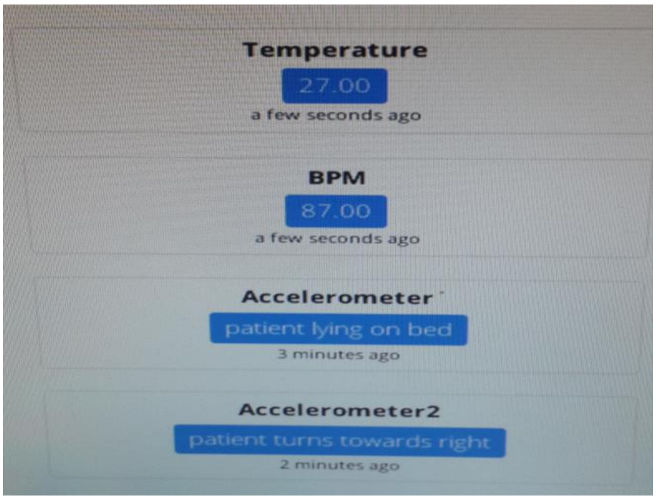

Fig. 6: Body Temp, BPM and Position of patient

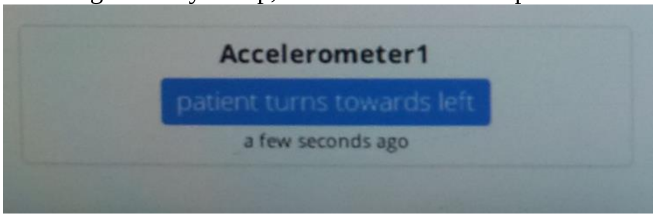

Fig. 7: Position of patient turns towards left.

Figure 5 shows the BPM of the patient that is Beats Per Minute calibrated the BPM from time interval 6.25 to 6.45 on 22nd May. where the highest BPM occurred at 6.38 as shown in above figure.

Figure 6 shows the body temp, BPM and Position of patient layong on bed 3 minutes ago and position of patient turns towrads right 2 minutes ago. Figure 7 shows the position old patient turns towards left fewseconds ago.

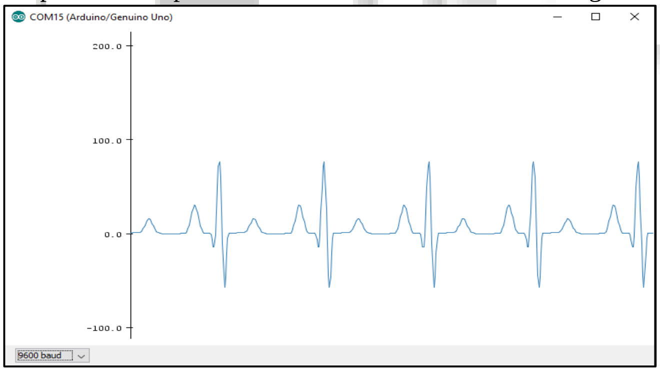

Fig. 8: ECG signal

As shown in Figure 8 collected ECG of the patient body. The objective of collecting this data is to compare the effectiveness of using body sensors against the traditional way of measuring the body's parameters manually. We noticed that every patient needs about one minute to read his body's temperature which is a very short time compared with the traditional technique. We also applied a delay technique because we wish to obtain a high accuracy of body temperature because the body temperature sensor we have experimented with takes time to generate the correct body temperature. Therefore, we noticed that 30 seconds delay for collecting body temperature will assist in obtaining a high accuracy.

VIII. CONCLUSIONS AND FUTURE WORKS

The integration between wireless sensor networks and cloud computing will create a new generation of technology in many aspects such as patient monitoring with minimal cost, reducing the number of occupied beds in hospitals and improving medical staff performance, making healthcare easier for people, who do not have access to public transportation in order to go to hospitals. Giving medical staff more time to be attentive to patients who need more care, preventing delays in the arrival of patients' medical information to the healthcare providers, particularly in accident and emergency situations and reducing manual data entry for patients' data which prevents real-time monitoring and restricts medical staff to monitor their patients.

The system introduced in this paper provides decisions based on patients' historical data, real-time data gathering, and thus eliminating manual data collection. For future work, we are planning to enhance the functionality of the system by adding more sensors and using it to collect data from a larger sample size of patients.

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