IJCSE International Journal of Computer Sciences and Engineering Open Access
Research Paper Vol.-7, Issue-6, June 2019 E-ISSN: 2347-2693

A Dynamic Framework for Healthcare Monitoring using Wireless Sensor Network

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DOI: https://doi.org/10.26438/ijcse/v7i6.928932 | Available online at: www.ijcseonline.org

Accepted: 10/Jun/2019, Published: 30/Jun/2019

Abstract- The communication technology is growing day by day to provide instant and enhanced medical facilities to patients regardless of their physical location. Patients can be monitored and provided with quick medication while they are on the move. The existing technology is also capable to provide self-monitoring. Self-monitoring means people can use wireless technology to monitor their health at home on daily basis. The existing system provides home based ECG monitoring that reads physiological data and then convert them into readable format. Internet of Things (IOT) is new era of telecommunication that provides smart communication between human and sensor devices through various wireless technologies such as Wi-Fi, RFID, Bluetooth and ZigBee. Our proposed dynamic framework facilitates people to connect and communicate with healthcare centres in dynamic way while they are moving out of their home location. Secondly, the proposed system also make use of advance data management technique known as NoSQL especially used for un-structured datasets generated through ECG, SCG and other vital parameters of human body with the help of sensor networks. The paper is organised into sections viz. introduction, existing work, use of IoTs in wireless healthcare monitoring systems, proposed system, implementation and conclusion.

Keywords- ZigBee, ECG, Sensor Network, NoSQL, IoT, Bluetooth, Wi-Fi

I. INTRODUCTION

Cardiovascular diseases related to human heart needs continuous and proper monitoring of heart patient time to time for avoiding any causality. Patient has to be checked his vital body parameters such as ECG values, Oxygen level, body temperature and pulse rate.

The hardware such as microcontrollers (ATMEGA-32 bit AVR) [1] and software such as Bluetooth and android app will form a sophisticated system for continuous monitoring of patients. The data base is located at cloud which is directly connected, fetched and updated by physician on his computer. This technology basically concentrates on monitoring of heart beat and body temperature through the interface. Patient has to put finger in the sensor device that takes the signal and converts those signals into values through android application and send to doctor and physician. The doctor and physician can allot IDs to each of his patients. The patients can be tracked through GPS facility. This mechanism uses the following devices for implementation of health care monitoring system:

- Sensors and microcontroller devices
- Bluetooth
- Android App

By using above mechanism, easier and expected results can we achieve patient has to were the sensor device, that device is battery operated. Patient has to connect through wireless communication system. A sensor device, named Arduino UNO [2] is needed where patient will touch the system with finger. This sensor will send the waves or signal to mobile app to Bluetooth then the numerical values would be obtained representing pulse rate and temperature and will be send to web server on cloud. Where database is maintained then the doctor will be alerted about the patient request. Then the physical location through the GPS and the doctor will look after the situation and will prescribed medication or even carry the patient his location to hospital or nursing home. The doctor can manage number of patient through website or mobile app.

II. EXISTING WORK

A huge number of research works has been done in this area of health care monitoring especially cardiac monitoring factors such as, heart-beat, ECG, pulse-rate and temperature through embedded system and software application. We will discuss and analyze some of the research done sequentially.

A. *Residential ECG health care monitoring system using Zigbee :-*

This system uses ZigBee for implementation the researcher make use of ZigBee [1] (IEEE 802.11.15.4) and Bluetooth for providing home health care system ECG works on electrical signals. The wired system used in hospital consist heavy and bulky sensors attached to patient's body and connected to wired-sensor-system. These system measures heart beats of patient in hospital and health care home only [2]. But, home health care system enables people to have wearable device. This wearable device catches the heartbeat and passes the signal to software system. Zigbee is one of the popular IEEE standards that work on radio frequency for capturing data. Zigbee standard works on low cost, battery operated devices. Zigbee also supports completely connected topology low duty cycle preferred for long battery life, center as well as distributed security, encryption, decryption and large number of nodes connectivity for a network. Zigbee architecture includes three basic components such as coordinator, Router and end device (Usually battery operated device).The coordinator communicates with outside world through wireless or mobile networks the router are connected to coordinator and devices. The router makes possible the data transmission between coordinator and end devices. The third component, end devices are normally battery operated devices the part of Zigbee network there are wearable devices held by patient in case of ECG monitoring system.

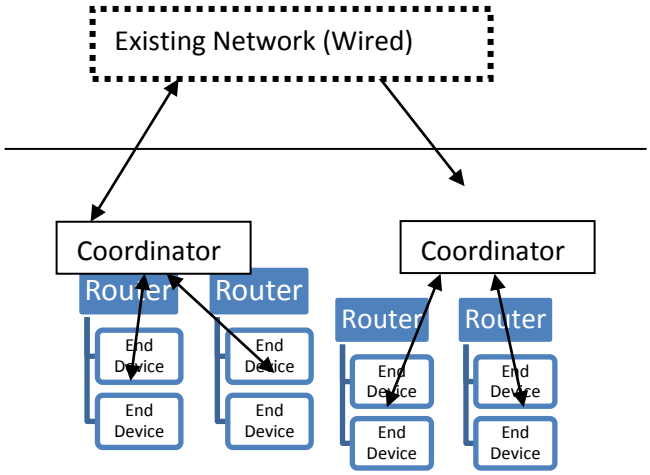

Fig1. Architecture for WSN

This network consists of wearable devices end devices form body area network (BAN). Now there are two ways in which processing is performed. In first way, body area network performs almost complete processing of signals collected by sensors with in local network. In this case, ZigBee system processes the signals and finds out whether any causality occurs, if so, then the alert message with processed values is sent to the server. So, the physician can see the situation and suggest solutions accordingly. This technique requires more power capability within The BAN. In second way, the complete signals collected from sensing devices are transmitted in raw form. This requires much stronger network transmission capacity. The processing is done at the server instantly and displayed on physician's device. So, the above work states the use of wireless techniques especially ZigBee sensor network for transporting the wearer's information such as heart beat, temperature and blood pressure in structured form to main system installed in health care centers, under the direct control of physicians. The outcome of this research shows the applications of two wireless systems that are ZigBee and Bluetooth. ZigBee is short range, low cost wireless techniques which can support more than 60,000 nodes but lacks in transmitting and receiving speed. In case of Bluetooth, it provides long range service, high capacity transmission rate but supports limited number of nodes.

B. *Three-Tier Architecture for Health monitoring :-*

This existing work illustrates 3-tier solution for measuring Body Vital information through wireless sensor network. The components used include Arduino Nano Board, MCU ESP8266 [3] and ThinkSpeak. The 3-Tier architecture consists of following operations as:-

Tier-1:- Arduino Nano Board and ATMEGA328P microcontroller receives sensed data from wearable devices.

Tier-2:- The Sensed data is then transferred to server through wireless technology using ESP8266 technology [4].

Tier-3:- In this phase, the data is transported to network web server through internet [16]. The IOT application ThinkSpeak is used in this phase.

C. *Use of Compression Techniques :-*

This work also stresses on recording of ECG signals using wireless infrastructure. It also highlights the compression of ECG signals while transporting to server. According to WHO, large number of deaths are reported due to cardiovascular Disease attack. People are needed to be monitored continuously through wireless systems. Here in this research, basically two predefined signal compression algorithms are presented and one algorithm is proposed. ECG mainly consists of three types of waves that are P wave, T wave and QRS waves [4]. The Study performs experiment on samples of ECG recording to evaluate the performance of compression techniques. So, Training data is tested to measure the efficiency of all compression algorithms. This research paper first of all describes two pre-defined algorithms from which first one is lossless and other is lossy. The third approach is also a lossy comparison method based on QRS compression produces reliable, efficient and is fully compatible with battery operated devices. The TERMA-based QRS detector is also helpful after compression of ECG signals [5]. TERMA based detector helps to improve ECG

signal analysis reduces memory requirement etc. After that Bit Compression ratio is calculated to evaluate the gap or difference between compressed and uncompressed samples for performance evaluation process [17].

D. Combined analysis of ECG and SCG:-

There are number of effective ways to monitor cardiac health status such as ECG (Electrocardiogram) [6], Magnetic Resonance Imaging (MRI), CT Scan and Echocardiography [14]. ECG is not reliable and efficient in case of severity whereas MRI and CT scan can provide efficient and reliable measurements but are bulky in bigger in size. These heavy weight technologies cannot attend the patient at their door step through wireless sensor technique. Here in this work, SCG (Seismo-Cardiogram) [12] technique is combined with ECG to provide better results. ECG provides only limited information about various heart functions in form of electrical signals. So, new low cost non-invasive SCG is combined to monitor heart health. While measuring cardiac related casualties, information about ECG, blood pressure, respiration rate, temperature and pulse rates are transferred to processor(located at server) with the help of Life-Guard Component, coined in this work. This system blows the alarm if any causality is detected. The new platform called PlaIMos also mentioned here is running to get, analyze and visualize various healthcare symptoms. One more visualization tool named ECG clock Generator, also depicts ECG patterns for the particular time period. Some of the symptoms are clearly depicted when using simple ECG reading such as angina [18].ECG is provided obtain heart beat activities electrically whereas SGC obtains mechanical activities of heart. So, when these two techniques work together, then more beneficial monitoring can be obtained.

III. Use of IoT(Internet of Things) in Wireless Healthcare Monitoring System

Internet of Things (IoT) [7] is new era of telecommunication that provides smart communication between human and sensor devices through various wireless technologies such as Wi-Fi, RFID, Bluetooth and ZigBee. Many applications of IoTs have been found covers Real time Health care monitoring, Grid management, Waste management, work scheduling and smart energy management. Internet of Things directs smart way for accessing of internet [19]. Users are able to communicate with their devices anywhere, anytime, any service through smart and intelligent technologies. IEEE has formed particular standards such as **802.11.15.4.** Internet of things makes life easier by enabling the people use their smart devices to take decisions anytime. It is possible through interoperability among various protocols. Large numbers of organizations based on various standards such as IEEE, IETF and ITU are working to create Internet of things for automatics home management, energy management and health services applications [10]. We emphasize on automatic health services provided with help of IoTs.

A. *Smart healthcare Through IoTs:-*

As we know that IoT is all about using internet in smarter way with heterogeneity. It means sensors networks respond to users request in better, accurate and fast way. IoT applications can play very vital role in healthcare monitoring system. IoT basically helps those patients who are not able to visit their hospital regularly or living in remote areas. The sensors network can be used to get information about vital parameters of body such as heart-beat, pulse-rate, body-temperature etc. from home location of people. This information then is transferred to server which then transferred to physician's display panel. So, sophisticated hardware sensors, microcontrollers and software such mobile App, ZigBee, Bluetooth and Wi-Fi play their prominent role for providing smart healthcare facilities using IoT.

B. Challenges to be faced using IoTs:-

1. **Scalability: -** IoT is spread in itself in very fast manner, so more hardware and software expansion is required day by day. It also needs automation of all devices in better way.
2. **Auto Organizing: -** IoT requires very less human intervention for configuring, managing and establishing connection. So, more smart applications are needed to implement for self-organizing systems.
3. **Huge Data Volume: -** as the things automatically happens, large amount of data are being generated. So, to manage, store, access and manipulate this huge amount of data, big data also needs to be used.
4. **Managing Heterogeneity: -** IoT consist of dissimilar types of devices that need to be communicated in smarter way. So, more efforts are required to manage heterogeneity.
5. **Automatic Discovery: -** Networks must be efficient so it should detect new devices automatically and correctly.
6. **Energy and Power efficiency:-** As wireless devices pass data in the form of electrical waves, signals. So much energy is required to transceiver the information. IoT needs to use energy efficient manner so that less radiations gets produced.

IV. PROPOSED SYSTEM

Our proposed system extends the functionality of existing system by adding two key features:-

a. Searching and connecting the patient to nearest hospital, physicians and health home centers while patient is far from home location through mobile application.
b. Use of NoSQL for storing, managing and fetching un-structured data locally as well as at cloud server.

So, now we will elaborate the above features one by one that adds robustness in our healthcare monitoring system.

A. Searching and Connecting Dynamically:-

As we know that, wearable devices attached to human body, respond with electric signals in case of monitoring cardiac health. ECG signals can be converted into proper values for determining any abnormality [11]. This data is fed to application installed in mobile Device through Bluetooth or ZigBee or any other effective technology. Now, mobile application will execute its methods or modules that are preferably programmed or designed using highly featured Mobile App tools and programming languages [12]. So, location monitoring system is also activated to search out the nearest points where aid can be provided to patient on the move [20]. The application will then connect to the application running in various nearby nursing homes and health care centers which are open to communicate with needy people. After the mobile app will manipulate the data and convert it into storable format. Generally, if we talk about vital parameters of body such as ECG, SCG and pulse rate etc., are depicted using graphical and pictorial form. So, this un-structured data handling is also an improvement presented in our system through Advanced data analytics such as NoSQL [7], will be discussed next. So, Auto Synch operation can also be executed by Mobile App time to time. In our system, battery operated devices get low load and performs very less data processing. The sensors pass the signals to app. The application consists of software module which checks if any irregularities occur and how much level of severity is here. This part of our work outlines three important features as:-

i) Battery operated devices need not to process any different manipulation for decision making. The App will convert the raw data into systematic form and store data.

ii) Patients will be connected to nearest physician's system automatically when applies in open mode.

iii) Mobile App will store patient data permanently and update it time to time. So, if patient forgets to carry wearable device, he can send data from App to nearest cloud service, if any emergence occurs [10, 13]. Prescription and help can be provided on the basis of past symptoms.

B. Efficient Management of data using NoSQL:-

There are lot of types of types of data exist today that are unfit to store using traditional SQL approach. NoSQL stands for not only SQL, provides rich facilities to store, update, manage, analyze un-structured data. Un-structured data means collection of video, audio clips, graphs, full fledge documents, streamed data to be to be handled on real time systems. So, we have introduced used NoSQL data storage technology for wireless sensor data. ECG [8] is depicted using graphical way. These types of graphical information can be easily transferred using NoSQL to cloud servers [14, 15]. We can also create objects for interacting with cloud service. Mobile App works like switching of devices from one location to another as hand-off is provided in Mobile Computing. NoSQL can be implemented using advanced data analysis tools such as Firebird, MongoDB etc. One of the features of NoSQL is that NoSQL does not need to pre-define the database schema for storing any record into database where as in traditional SQL system uses pre-defined schemes for data storing, thus lacks in flexibility. Dynamic modification and alteration in database schema is not possible in SQL.

V. IMPLEMENTATION

A step by step algorithmic form of our approach is defined below. Our system is divided into two phases.

PHASE- I:

1. A wearable device, usually put n the finger, will get data from patient.
2. These signals will be passed to sensors for generating values.
3. Values will be converted into digital signals and passed to Mobile App. Then Mobile App will handle the process.

PHASE-II:

1. Now Mobile App will store the data into structured form. App will also open to communicate with physicians.
2. App will display nearest health home for getting instant help in remote area. App will manage data locally for future communication also.
3. App provides interface between patient and health care systems in dynamic way.

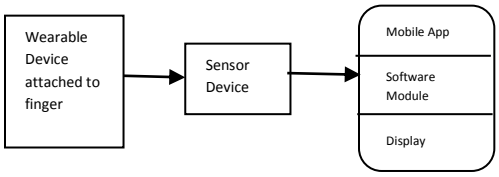

Fig2. PHASE-I

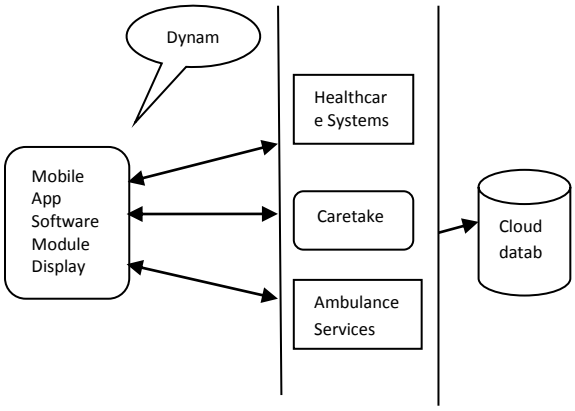

Fig3. PHASE-II

VI. CONCLUSION

Real time and mobile healthcare is biggest need of present system. Those who are suffering from heart diseases need instant action when a serious problem occurs. So, our system tries to meet requirements for Cardiac Healthcare monitoring system from remote location. The patient can face the shortness of breath, irregular heart beat and pulse rate. So, to save the life of patient, system must be capable to connect with nearest medical health care system regardless of their home location. The proposed system presents solution for this situation. People can use embedded system such as wearable devices to monitor their ECG, pulse rate, body temperature, blood pressure while they are on the move and can send to the nearest located healthcare center. Our system suggests using Distributed Mobile application along with modernized approach to store data both in on-line as well as offline mode. By this people can know about its past information any time. We have also performed a comparative analysis between two major standards as Bluetooth and ZigBee, used for adhoc wireless communication. Further, we discussed some compressions techniques of ECG and SCG to make better analysis patient's cardiac health.

VII. FUTURE WORK

Wireless sensor network is very broad area. Lot of further work has to done as future research. In our work, we have found that compatibility between various devices using dynamic connection management can create some chaos in heavily loaded applications. More research is required on interoperability between microcontrollers and software systems. Another area where further research can be done is combined study of SQL and NoSQL. Both SQL and NOSQL combine their functionality to make new scenario that is NewSQL. It enables to implement ACID [9, 20] properties provided by SQL and dynamic schema manipulation properties available in NoSQL. Scalability can be an issue due to massive amount of data generation round the clock, so it also needs attention of researchers.

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