REAL-TIME IOT ENABLED CLOUD BASED WEARABLE HEALTH MONITORING BAND

Ajeesh M[1], Geethu G I[2], Kavya Pramod M[3]
Department of Electrical and Electronics Engineering
[1,2,3] Student, PRS College of Engineering and Technology,Kerala,India

Abstract- *Health is one of the global challenge for humanity, the need for health care increases everyday. As the age profile of many societies continuous to increase, in addition to the increasing population of people effected by chronic diseases including diabetes, cardiovascular disease, obesity and so on, supporting health both mentally and physically is of increasing importance if independent living is to be maintained. Also, people working on hazardous areas face increased risk of health problems, and if they are at remote location, their identification, rescue and treatment is very difficult. Sensing, remote health monitoring & recognizing activities of daily living have been a promising solution. IOT is gaining a rapidly growing attention in many fields, especially in health care created many advancements in health monitoring field. Also the development of wearable sensors added the advancements to a higher level. The main contribution of this paper includes: firstly, this paper presents a reliable system,Real-time IoT enabled Cloud based Wearable hEalth monitoring Band (RICWEB) for real-time personal health monitoring. RICWEB implemented with body area sensor network and real-time health monitoring. Several wearable sensors have been embedded, including the heartbeat, body temperature, and the blood pressure sensors. Secondly, the majority of existing wearable health monitoring systems requisite a smart phone as data processing, visualization, and transmission gateway, which will indeed impact the normal daily use of the smart phone. While in RICWEB, as an alternative solution for quick view of the real-time data, a wearable OLED display is provided, so, the data gathered from the sensors are viewed on the OLED display and directly transmitted to the cloud.*

Keywords- Internet of things, Wearable, Cloud computing, Health monitoring, body area sensor network.

I. INTRODUCTION

Health is one of the global challenges for humanity. According to the constitutions of World Health Organization (WHO) the highest attainable standard of health is a fundamental right for an individual. Healthy individuals lead to secure their life time in come and hence to increase in gross domestic product and in tax revenues. Healthy individuals also reduce pressure on the already overwhelmed hospitals, clinics, and medical professionals and reduce work load on the public safety networks, charities, and governmental (or non-governmental) organizations. Also the Life expectancy has increased dramatically, especially in the more affluent nations, which is set to be celebrated and should be viewed as an opportunity for people to live longer and better. However, this requires substantial improvement in both the healthcare service and the living environment, as older people generally require more healthcare than their younger counterparts. Additionally, older people are more likely to suffer from chronic disease as part of the natural ageing process. In parallel to this demographic time bomb, the cost of healthcare provision is increasing rapidly in all thenations across the world.In many countries more than half of workers are employed in the informal sector with no special protection for seeking healthcare and lack of regulatory enforcement of occupational health and safety standards. Modernized healthcare system should provide better healthcare services to people at any time and from anywhere in an economic and patient friendly manner. Currently, the healthcare system is undergoing a cultural shift from a traditional approach to a modernized patient centered approach. In the traditional approach the healthcare professionals play the major role. They need to visit the patients for necessary diagnosis and advising. There are two basic problems associated with this approach. Firstly, the healthcare professionals must be on site of the patient all the time and secondly, the patient remains admitted in a hospital, wired to bedside biomedical instruments, for a period of time. In order to solve these two problems the patient oriented approach has been conceived. In this approach the patients are equipped with knowledge and information to play a more active role in disease diagnosis, and prevention. The key element of this second approach is a reliable and readily available health monitoring system (HMS).

Smartphone, supported with high-speed data services has revolutionized health care by playing the role of a powerful medical device for monitoring the patients' health. Heart disease and diabetics monitoring and controlling systems are very much common now. An estimated 95,000 health care applications are available today and over 200 million people have downloaded these applications to their smart phones.

In the meantime, several phenomena have been risen, such as ambient assisted living (AAL), ubiquitous healthcare, and IoT for healthcare. Such terms all differ with each other, while all are co-related. IoTemphasises the interconnection of all physical and digital items including sensors, smart devices, cyber sensors, and so much more, which allows the automatic and efficient data transmission and shared over the Internet. Hence, empowering the utility of IoT in healthcare, with interconnected medical sensors, especially wearable or implantable, is considered to be able to provide smart accurate and cost-effective personalized healthcare service.

The sensing layer is designated to observing the users' health condition both physically, mentally, and emotionally; thereby, a set of sensors can be embedded , for example, the wearable sensors such as ECG and blood pressure, to collect the biomedical parameters, the GPS sensor for positioning and localization, and RFID for identification. In addition, smart homes are often frequently applied for sensing the information of the users' immediate surroundings, such as the home conditions and the items used. Secondly, the network layer enables the efficient and secure data transmission to corresponding data process units.A number of shortrange communication protocols have been widely applied, such as ZigBee. More recently, several new techniques have been introduced, such as the 6LowPAN, NBIOT, and LoRa. And then, the third layer is the Data Processing module, which is responsible for retrieving valuable knowledge from the sensor data that obtained from the first layer. Learning-based approaches have been the most promising solution for data mining. Finally, based upon the conduction of the top three layers, intelligent services and applications can be delivered, such as disease diagnosis, behaviour recognition, and smart assistance.

In this paper we presented a framework of Real-time IoT enabled Cloud based Wearable hEalth monitoring Band (RICWEB). This paper is structured as follows: Section 2 illustrates the related research in IoT-enabled personal healthcare for assisted living. Section 3 demonstrates the design, methodology, and experiment results of the proposed RICWEB system. Section 4 outlines the discussion and future works, after which this paper is concluded in Section 5.

II. RELATED WORKS

Wearable, real-time, Wireless health monitoring system has drawn considerable attentions from the research community as well as industry during the last decade. And many of the applications have already been commercialized and available in the market. Existing works often focus on assisting people who experience difficulties in maintaining independent living, for example, elderly or people with certain chronic diseases, such as heart disease, diabetes, and Alzheimer's.

Windows Mobile based system for monitoring body parameters has been presented in [1]. The proposed system consists of a body sensor network that is used to measure and collect physiological data. Bluetooth has been used to transmit data from the sensor network to a mobile device. The reliability and robustness of the proposed system has been verified by the authors. The experimental results show that the proposed system is able to monitor the physiological data of patients under mobility condition.

A complete wireless body area network (WBAN) system has been designed in [2]. The proposed system uses medical bands to obtain physiological data from sensor nodes. The author has chosen medical bands in order to reduce the interference between the sensor device and other existing network devices. To increase the operating range multi-hopping technique has been used and a medical gateway wireless board has been used in this regard. This gateway has been used to connect the sensor nodes to a local area network or the Internet. By using Internet the healthcare professionals can access patients' physiological data from anywhere at any time.

A smart shirt has been designed in [3]. The shirt can measure electrocardiogram (ECG) and acceleration signals for continuous and real time health monitoring of a patient. The shirt mainly consists of sensors and conductive fabrics to get the body signal. The measured body signals are transmitted to a base station and server PC via IEEE 802.15.4 network. The wearable devices consume low power and they are small enough to fit into a shirt. To reduce the noise associated with the ECG signal an adaptive filtering method has also been proposed in this work.

Real time mobile health care system for monitoring the elderly patients from indoor or outdoor locations has been presented in [4]. A bio-signal sensor and a smart phone are the main components of the system. The data collected by the bio-signal sensor are transmitted to an intelligent server via GPRS/UMTS network. The system is able to monitor the mobility, location, and vital signs of the elderly patient from a remote location.

Breathing rate monitoring (BREMON) system has been proposed in [5]. The system allows paramedics to monitor the breathing activities of patients by using a smart phone. The system uses the smart phone based accelerometer to monitor the breathing activities of a patient. The acceleration data are then processed to calculate the number of breaths per minute (BPM).The data is then sent to the paramedics via a multi-hop network.

A system to monitor the blood pressure of a hypertensive patient using mobile technologies has been proposed in [6]. By using the system a doctor can carefully monitor the patient and can perform diagnosis. The system is implemented on the Java platform and it can reside in a small capacity device. The system is also able to communicate with a server via Internet. The server is used for storing and displaying patient data graphically.

Cloud computing has been incorporated in a healthcare system in [7]. The authors have proposed a cloud based intelligent healthcare monitoring system (CIHMS) for providing medical feedback to a patient through cloud. The proposed system can obtain adequate data related to patient's disease and deliver the data to a remote location by using cloud computing devices.

Although mobile devices are always considered a promising tool to monitor and manage patients' own health status, these devices have some inherent limitations in computation or data intensive tasks. A new hybrid mobile cloud computational solution has been proposed in [8] to overcome these limitations. The authors have introduced a mobile cloud based electrocardiograph monitoring system. The experimental results show that the proposed system can significantly enhance the conventional mobile based medical monitoring system in terms of diagnostic accuracy, execution efficiency, and energy efficiency.

Wireless electrocardiogram (ECG) monitoring system based on Bluetooth Low Energy (BLE) technology has been reported in [9]. The system consists of (i) a single-chip ECG signal acquisition module, (ii) a Bluetooth module, and (iii) a smartphone. The system is able to acquire ECG signals through two-lead electrocardiogram (ECG) sensor. The system is also able to transmit the ECG data via the Bluetooth wireless link to a smartphone for further processing and displaying the ECG signals. The results show that the proposed system can be operated for a long period of time due to low power BLE technology.

In order to monitor the breathing disease called Obstructive Sleep Apnea Syndrome (OSAS), occurs due to sleep disorder, has been introduced in [10]. This disease not only interrupts normal sleep pattern but also causes hypoxemia and hypercapnia. In this work a smartphone based wireless e-health system has been introduced for monitoring a patient with OASAS. The authors show that the proposed system is very energy efficient due to the use of Bluetooth.

Many health monitoring systems use wearable sensors that produce continuous data and generate many false alerts. Hence, these systems become unsuitable for use in clinical practice. To solve this problem some machine learning approaches have been proposed in [11]. In these approaches data generated by the wearable sensors are combined with clinical observations to provide early warning of serious physiological changes in the patients. The effectiveness of these approaches has been tested at Oxford University Hospital. The test results show that the proposed system can successfully combine data acquired from the wearable sensors. Combining these data with manual observations the clinical staff makes important decisions about the patients.

III. METHODOLOGY AND EXPERIMENTAL DESIGN

A. The design of the RICWEB system

This paper presents a framework of the Real-time IoT enabled Cloud based Wearable hEalth monitoring Band (RICWEB), which adopts a number of interconnected wearable sensors to observe the health condition of the subject. A set of biomedical signals can be obtained, including the blood pressure, the heartbeat, and the body temperature. Due to the limitedmemory and computing capacity of the sensor nodes, as well as to avoid the adoption of a smart phone as a processing unit, the sensor data collected from those wearable sensors will be transmitted to the cloud server directly. The general design of the RICWEB system is illustrated in Fig. 1. The RICWEB system contains three fundamental components which are the RICWEB body area network, the RICWEB cloud, and the RICWEB Users.

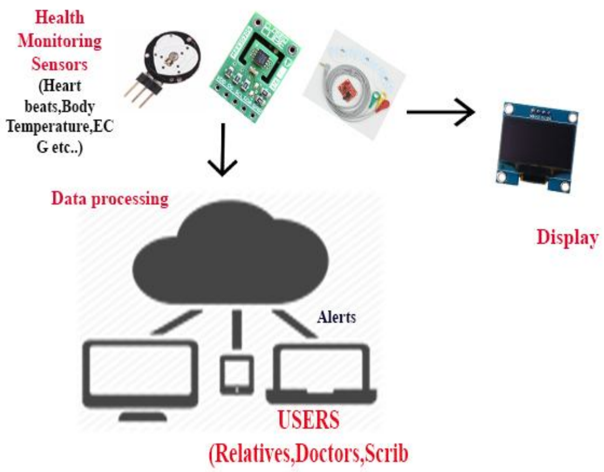

Figure 1

B. The RICWEB body area network

The body area network consists of three categories of sensing devices, which are the heartbeat sensors, body temperature sensors and the ECG sensors.

• The heartbeat sensor data indicates the regularity of the heartbeats, which can also reflect the myocardial activities. Such sensors have been commonly applies for monitoring patients with heart disease. The heartbeat sensor provides a simple way to study the heart’s function, it monitors the flow of blood. As the heart forces blood through the blood vessels, the amount of blood changes with time. The sensor shines a light lobe and measures the light that is transmitted. The clip can be used on a fingertip or on the web of skin between the thumb and index finger.

- The temperature sensor in the circuit will read the temperature from the surroundings and shown the temperature in Celsius (degrees). It is a low-voltage IC which uses approximately +5VDC of power.
- The ECG sensor is used to measure the electrical activity. It can be charted as an electrocardiogram or ECG and output as an analog reading. It is operated in 3.3V -5V DC power.

The majority of the existing wearable health monitoring systems utilize a smart phone as data processing, visualization, and transmission gateway. However, such monitoring systems often requisite the application to operate in a 24/7 basis, which has a dramatic impact on the normal daily use of the mobile phone. However, with RICWEB, data from body area network can be transmitted to the cloud via WiFi directly without the adoption of a smart phone. In the mean time, to facilitate users to quickly access the signals, a lightweight small-in-size wearable OLED can be embedded, to display the real-time heartbeat and body temperature data, as is demonstrated in Fig. 1. Once the RICWEB system is ON, the real-time data will be displayed. The RICWEB is developed based upon Arduino sensor platform integrated with the abovementioned sensor nodes. The implementation architectural block of the RICWEB system is presented in Fig. 3. In addition to the sensors that embedded in proposed system, several components are adopted as well. Firstly, a portable RFID reader is connected to the Arduino platform, which facilitates the identification of different users, thus a RFID tag should be amounted to each individual user. A lightweight OLED is included as an alternative option for the user to access the data as is depicted in Fig. 1. Furthermore, RICWEB is also empowered with a WiFi module, which enables the transmission of the data to the cloud and then allows the authorized users to access the real-time data from anywhere atanytime.

Resting Heart Rate for MEN

Age	18-25	26-35	36-45	46-55	56-65	65+
Athlete	49-55	49-54	50-56	50-57	51-56	50-55
Excellent	56-61	55-61	57-62	58-63	57-61	56-61
Good	62-65	62-65	63-66	64-67	62-67	62-65
Above Average	66-69	66-70	67-70	68-71	68-71	66-69
Average	70-73	71-74	71-75	72-76	72-75	70-73
Below Average	74-81	75-81	76-82	77-83	76-81	74-79
Poor	82+	82+	83+	84+	82+	80+

Figure 2

C. The RICWEB-Cloud

With the advancement of cloud computing technology, the RICWEB body area network data can be stored and processed effectively and efficiently on the cloud. A number of functionalities are implemented with the RICWEB Cloud:
• Data storage and processing. As is discussed in previous sections, a series of sensor signals can be gathered via the RICWEB body area network, including the blood pressure, heartbeat, and body temperature. Significant features can be retrieved to detect and identify potential heart disease; however, noise often existed during the data transmission, which will affect the diagnosis of the potential disease. Therefore, a data-filtering mechanism is adopted to avoid the invalid data. Moreover, the identification and accurate diagnoses of a potential disease often require a certain amount of historical data; therefore, a cloud database is established within the RICWEB-Cloud to store the sensor data from the RICWEB body area network for each individual user.

• Data visualization. A web-based data visualization scheme is implemented for authorized users to access the data.
• Disease identification and notification. A sudden heart attack often seriously threatens someone’s life, who suffers from cardiac diseases. RICWEB aims at protecting patients from such injury, and it is important that the patients’ health condition can be monitored and understand. Moreover, any suspicious and abnormal sensor reading can be identified and notifications can be sent to identified users, such as the family members and doctors.

Once the power supply is given, the temperature from the thermistor and heart rate from the pulse metre sensor are determined and displayed on the OLED display system provided. Same information is uploaded to the RICWEB-Cloud database server, and then displayed on the webpage in real time. A similar mechanism is also applied to the blood pressure sensor and data. Such information is fundamental for users to self-monitor their health condition, and for doctors to diagnose potential diseases. If any abnormal condition is detected, an alert will be generated to a certain stakeholder, which include a text message to the doctors and family members, and an alert is displayed on the OLED for the users themselves. Furthermore, long-term historical data can also be visualized on the cloud, as is illustrated in Fig. 7, which demonstrates the heartbeat and body temperature data for a period of a few weeks for a particular user. In addition, the similar approaches are also adopted for the blood pressure sensor data. Data mining module is the key component for diagnosis of heart disease. After extracting valuable features from the heartbeat and body temperature data, machine learning-based approaches are applied, such as SVM and neural network, to establish the decision models.

D. The RICWEB Users

The user component aims at providing a convenient interface for users to access the data. Authorized users can log in to the cloud server to visualized the data from the web. And for quick access the data is viewed on the OLED display provided.There are three categories of user groups within the RICWEB system, the person (or the monitored subjects), the doctors or nurses, and the family members or associated caregivers. All users must register with RICWEB via the GUI before accessing the data.

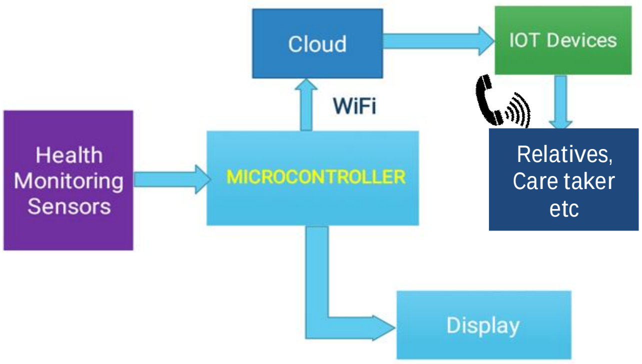

Figure 3

IV. DISCUSSION AND FUTURE WORK

IoT technology promises huge potential and benefits in the domain of personalized healthcare. The wireless body area network that consists of wearable sensing devices and communication modules have become the key enablers. Whereas patients' health condition can be remotely monitored in real time, emergencies can be identified accurately, and associated stakeholders such as doctors and family members can be informed when needed. Thereby, research in this area has been extensive, while challenges still exist, as discussed in the following section.

Biomedical signal monitoring often requires operating on a 24/7 basis; however, it is still uncomfortable and obtrusive for people to attach a number of sensors on some parts of the body round the clock and in the long term. On the other hand, sensors often with limited computing and storage capability, whilst they are generating massive amount of the data, not only significantly increase the memory and computational requirement, but also dramatically increase the complexity of the data analysis process. Hence, a more intelligent sensor datafiltering mechanism must be developed, in order to precisely retrieve the most valuable information. Moreover, battery life is one of the key issues with many sensing devices including the smart phone, especially with Bluetooth and WiFi connections. Therefore, a more sophisticated data transmission strategy can be an alternative solution, where the data transmission frequency can be minimized whilst maintaining or optimizing the overall performance of the system. Body area network as been the promising technique for personalized healthcare; therefore, more attention must be paid to the security, privacy, reliability, and robustness of the network. From a technical perspective, a Body area network must be more robust and tolerant when a node might fail due to the battery shortage or be damaged. The network must be ensure that the communications among other nodes would not be interrupted when some of the nodes fail.

IoT is gaining an increasing attention in recent years, which enables seamlessly integration of heterogeneous intelligent devices, such as sensors, smart phones, smart TVs, and many others. Wearable IoT is one of the branches of IoT, which emphasises the connection and communication of any wearable devices. In the meantime, healthcare has become one of the potential application of wearable IoT, which provides the infrastructure that facilitates medical data transmission and communication. It is expected not only to revolutionize the healthcare system, but also to reduce the healthcare cost. Few issues remain problematic, such as the development of a cost effective wearable IoT platform, ensuring the scalability, robustness, security, privacy, and so on. The data mining module must be further developed, which must be able to accurately discover the patterns of certain diseases from the historical data, and ideally predict the possible disease that may develop in a foreseeable future. Machine learning-based approaches can be adopted, for example, the support vector machine (SVM), the neural networks, and deep learning. Moreover, physical activity recognition is another key avenue to extend the WISE system, as the active level of an individual is also crucial to someone's health status. Hence, the recognition of such information is also fundamental for the detection, forecasting, and diagnosis of potential diseases. Several issues must be addressed in terms of real-time service delivery. Adaptive personalized and user-friendly services must be developed for both patients and their families, carers, and doctors.

V. POTENTIAL USE CASES FOR THE PROPOSED MODEL

The generic model we have proposed has a number of use cases. To provide context, this subsection discusses several of these use cases, which include aiding rehabilitation, assisting management of chronic conditions, monitoring changes in people with degenerative conditions, and monitoring critical health for the provision of emergency healthcare, health monitoring for workmen's in hazardous environment.

Our model could be used to develop a system capable of assisting with the management of chronic conditions such as hypertension. Blood pressure could be monitored at several locations on the body at set intervals throughout the day and communicated to the cloud via a wrist-worn central node. Again, a comprehensive record of the patient's blood pressure could be built and machine learning could be used to identify trends such as when the patient's blood pressure is highest. This information could also be used to determine optimal times for the patient to take any medication that they may require to manage their condition, and remind the patient of that using a buzzer or alarm on the central node.

Changes in people with progressive conditions such as Parkinson Disease could also be monitored using a system designed in accordance with our model. Symptoms of Parkinson Disease include slowed movement, tremors, gait problems, and balance problems. Using a series of wearable accelerometers, sensors could be developed to measure each of these parameters. Readings could be taken at set intervals every day and forwarded to the wrist-worn central node, which in turn forwards the data onto the cloud. As the data from the patient begins to grow, machine learning can be used to identify the rate at which symptoms are worsening for the patient. A doctor could also add records of which treatments are being used, and machine learning could be used to identify which treatments the patient's condition has responded the best.

In the case of people working on hazardous environment such as underground construction, tunnel workers, men working inside well, may face several health problems.This health band can be specially provided to those person working on hazardous condition,so their health condition and safety can be assured. critical health could be monitored using a system comprised of wearable sensors that monitor vital and other important signs, including pulse, respiratory rate, body temperature, and blood pressure. Measurements can be taken regularly, and if any of these parameters fall below the known healthy thresholds then the central node can forward the information to the cloud, which can be used to notify emergency services. Readings at the time of the emergency can be recorded in the person's health record in the cloud, and the doctor can append information regarding their diagnosis.

As more and more people suffer from emergency health conditions and have diagnoses added to their files, machine learning could begin to be used to make connections between symptoms and possible diagnoses. This information could then be provided to responding paramedics, ensuring that persons receive the most appropriate care for their condition.

VI. CONCLUSION

A need for real-time health and activity recognition with wearable sensors is a prerequisite for assistive paradigms. This paper presents a brief overview of existing health and behaviour-monitoring approaches based on wearable IoT technologies. Secondly, it illustrates a novel health monitoring system framework RICWEB, which enables the real-time monitoring of the patients, workman on hazardous environment, elderly users and allows the information to be accessed and stored in the cloud for further assessment. By using the system the healthcare professionals can monitor, diagnose, and advice their patients all the time. Our system is simple. The system is very power efficient. It is easy to use, fast, accurate, high efficiency, and safe (without any danger of electric shocks).

REFERENCES

[1] Global Challenges for Humanity available at http://www.millenniumproject. org/millennium/challenges.html
[2] A Right to Health available at http://www.who.int/mediacentre/factsheets
[3] FRANCIS S. COLLINS, "MOBILE TECHNOLOGY AND HEALTHCARE", AVAILABLE at http://www.nlm.nih.gov/medlineplus/magazine/issues/winter11

[4] How the Smartphone Can Revolutionize Healthcare available at http://www.mdtmag.com/

[5] mHealth App Developer Economics(2014) available athttp://mhealtheconomics.com/mhealthdeveloper-economics-report/

[6] Bourouis, A., Feham, M., and Bouchachia, A.(2011), " Ubiquitous Mobile Health Monitoring System for Elderly (UMHMSE)", International Journal of Computer Science and Information Technology, Vol.2, No. 3, June, pp. 74-82

[7] Lee, Y.D. and Chung, W.Y. (2009) "Wireless Sensor Network Based Wearable Smart Shirt for Ubiquitous Health and Activity Monitoring", Sensors and Actuators B: Chameical, Vol. 140, No. 2,July, pp. 390-395

[8] Orlando R. E. P., Caldeira, M. L. P. Lei S., and Rodrigues, J.P.C (2014), "An Efficient and Low Cost Windows Mobile BSN Monitoring SystemBased on TinyOS", Journal of Telecommunication Systems, Vol. 54, No. 1, pp. 1-9

[9] Yuce, M. R.(2010)" Implementation of wireless body area networks for healthcare systems", Sensor and Actuators A:Physical, Vol. 162, No. 1, July, pp. 116-129

[10] Lei Clifton, David A. Clifton, Marco A. F. Pimentel, Peter J. Watkinson, and Lionel Tarassenko (2014)," Predictive Monitoring of Mobile Patients by Combining Clinical Observations with Data From Wearable Sensors", IEEE Journal of Biomedical and Health Informatics, Vol. 18, No. 3, May ,pp. 722-730

[11] Parane, K.A., Patil, N.C. ;Poojara, S.R. ; Kamble, T.S(2014) "Cloud based Intelligent Healthcare Monitoring System", In the proceedings of International Conference on Issues and Challenges inIntelligent Computing Techniques (ICICT), February 7-8, Ghaziabad, Indian, pp. 697-701