A Wearable Remote Patient Monitoring System using Raspberry Pi

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***Abstract*—In India everyday many humans are affected because the patient are not timely and properly and also for real time conventional parameters are not efficiently work on different situations, frequently check-up for patient condition also not possible. To overcome these kind of situations, our system is beneficial. Our system is designed to be used in Home or hospital for measuring and monitoring various parameter like ECG, Body temperature and Blood pressure. By using new technology Internet of Things (IOT) makes all objects interconnected and it has been recognized as the next technical revolution. The results can be recorded using Raspberry Pi displayed on a HMI interface display. Also the results can be sent to server using IOT and text message using GSM module. Relatives or Doctors can login to a website and view those results.**

***Keywords*—Raspberry Pi, Sensors, GSM Module, Internet of Things(IOT)**

I. INTRODUCTION

In today's life, health problems are occur more than last 25-30 years ago because of modernization, industrialization. Suddenly, changes in environment are directly effect to health condition. So, more health related problems are occurring day by day, require to daily checkup health condition. Researchers design health monitoring system by considering the health condition of patients. Therefore, make device as portable which can handle by any one person and also have ability to provide more flexibility. Normally occur health related problems are Temperature, Heart related problems, stomach problem and so on.

Researchers design health monitoring system using different hardware platform provide integration of different biomedical sensor on single system on-chip such as temperature sensor, heart rate sensor and so on. This technique gives more flexibility, reliability and portability for user. Here temperature sensor use for measuring body temperature, heart rate sensor use to measure heart rate of patient body. So, integration of different biomedical sensors is depending upon researchers design which meets to their needs. Different health monitoring systems are designed with different specification.

Wireless wearable ECG, Blood Pressure and Temperature monitoring system embedded in an IoT platform that integrates heterogeneous nodes and applications, has a long battery life, and provides a high-quality ECG signal. The system allows monitoring multiple patients on a relatively large indoor area (home, building, nursing home, etc.). Another remarkable feature of our system is a very low marginal cost per added sensor, since our architecture enables a single low-cost gateway to manage multiple sensors. Our work will focus on monitoring additional health related parameters using a broader combination of transducers, sensors, and correlation techniques, and on improving system reliability and robustness to patient movement and connectivity losses.

II. LITERATURE SURVEY

Modre-Osprian [1] monitors blood pressure level using Keep in Touch (KIT) and closed loop healthcare services. In KIT method, KIT is connected to the JAVA based mobile phone with the help of near field communication. It works on magnetic, inductive coupling and then the distance is short. After touching the KIT, the data is send to mobile phone. In closed loop services, the data is getting from mobile phone, then the data is send to the secure website. Using this website anybody can monitor patient's blood pressure level.

Junaid Mohammed [2] monitors patient's ECG wave anywhere in the world using IOIO- OTG Microcontroller. Android application is created for ECG Monitoring. IOIO-OTG microcontroller is connected to android phone using USB cable (or) Bluetooth dongle. After collecting data, the wave is send to android application. Monitor and store ECG waves in that android based application.

Mohammed S. Jasses [3] focused on body temperature monitoring using Raspberry pi board in cloud based system. In that paper, Raspberry pi is monitor body temperature and then these parameters are transfer by wireless sensor networks (WSN). Then these data's are added to the cloud based websites. Using this website monitor body temperature.

Hasmah Mansor [4] monitors body temperature using LM35 temperature sensor. The LM35 temperature sensor is connected to the Arduino Uno board. After that creating a website in SQL database format. Arduino Uno board is connected to that website. Then sensor output is send to the website. Using this website anybody can monitor body temperature in login process Mathan Kumar [6] discussed about monitors ECG, Respiration rate, heart rate and body temperature. These sensors are connected to PIC16F887A microcontroller. After collecting data from sensors, the data is

upload to the website manually. For monitoring purpose created an android application and webpage for monitoring health status.

Nithin P. Jain [8] monitors temperature, blood pressure, heart rate of patient's. Microcontroller AT Mega 32 is used for connecting these sensors. GSM module is connected to this microcontroller. After collecting data, if the value is low SMS is send to the doctor.

Soumya Roy [9] monitors ECG waves of patient's. AT Mega 16L microcontroller is used for monitoring ECG waves. ZigBee module is used for transferring ECG waves. ZigBee module is sends data to nearest connected system for ZigBee.

Rajeev Piyare [10] implement controlling and monitoring home appliances using android based smart phone. Arduino Uno board is connected to home appliances (light, fan, etc.). Creating an android application for this smart home. Arduino Uno board and android app is connected by internet. Using this android app controlling and monitoring home appliances anywhere in the world.

Karandeep Malhi [7] monitors body temperature, heart rate using C8051F020 microcontroller. Wearable sensors are used to collect data and then send to micro controller. ZigBee module is connected to this microcontroller and then that module is transfer data to the nearest receiver.

Subhas Chandra Mukhopadhyay [11] an increase in world population along with a significant aging portion is forcing rapid rises in healthcare costs. The healthcare system is going through a transformation in which continuous monitoring of inhabitants is possible even without hospitalization. The advancement of sensing technologies, embedded systems, wireless communication technologies, Nano technologies, and miniaturization makes it possible to develop smart systems to monitor activities of human beings continuously. Wearable sensors detect abnormal and/or unforeseen situations by monitoring physiological parameters along with other symptoms. Therefore, necessary help can be provided in times of dire need. This paper reviews the latest reported systems on activity monitoring of humans based on wearable sensors and issues to be addressed to tackle the challenges.

Shanzhi Chen [12] Internet of Things (IoT), which will create a huge network of billions or trillions of "Things" communicating with one another, are facing many technical and application challenges. This paper introduces the status of IoT development in China, including policies, R&D plans, applications, and standardization. With China's perspective, this paper depicts such challenges on technologies, applications, and standardization, and also proposes an open and general IoT architecture consisting of three platforms to meet the architecture challenge. Finally, this paper discusses the opportunity and prospect of IoT.

John A. Stankovic [13] many technical communities are vigorously pursuing research topics that contribute to the Internet of Things (IoT). Nowadays, as sensing, actuation, communication, and control become even more sophisticated and ubiquitous, there is a significant overlap in these communities, sometimes from slightly different perspectives. More cooperation between communities is encouraged. To provide a basis for discussing open research problems in IoT, a vision for how IoT could change the world in the distant future is first presented. Then, eight key research topics are enumerated and research problems within these topics are discussed.

Andrea Zanella [14] The Internet of Things (IoT) shall be able to incorporate transparently and seamlessly a large number of different and heterogeneous end systems, while providing open access to selected subsets of data for the development of a plethora of digital services. Building a general architecture for the IoT is hence a very complex task, mainly because of the extremely large variety of devices, link layer technologies, and services that may be involved in such a system. In this paper, we focus specifically to an urban IoT system that, while still being quite a broad category, are characterized by their specific application domain. Urban IoTs, in fact, are designed to support the Smart City vision, which aims at exploiting the most advanced communication technologies to support added-value services for the administration of the city and for the citizens. This paper hence provides a comprehensive survey of the enabling technologies, protocols, and architecture for an urban IoT. Furthermore, the paper will present and discuss the technical solutions and best-practice guidelines adopted in the Padova Smart City project, a proof-of-concept deployment of an IoT island in the city of Padova, Italy, performed in collaboration with the city municipality.

P.Karthick [15] The main focus of the paper is to implement a prototype model for the real time patient monitoring system. The proposed is used to measure the physical parameters like body temperature, heartbeat, ECG, blood sugar, and oxygen level monitoring with the help of biosensors. Conventionally there are number of techniques available for the ICU patient's health monitoring system with wired communication technology. In the novel system the patient health is continuously monitored and the acquired data is transmitted to an ARM server using zigbee wireless sensor networks. Embedded processor supports for analyzing the input from the patient and the results of all the parameters are stored in the database. If any abnormality felt by the patient automatic alarm sound will arrive and the message will send to the doctor mobile automatically by using GSM module. The implementation of the system is achieved by the advanced processor and simulation results are obtained by Keil c software.

III. METHODOLOGY

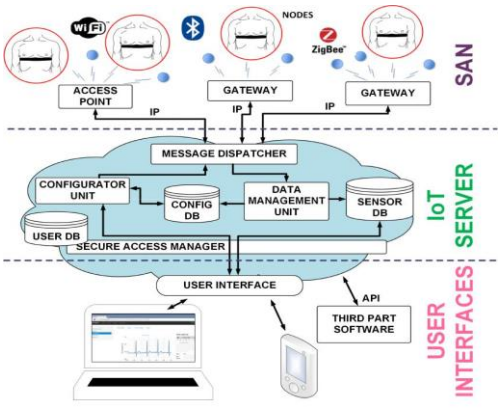


Fig 1: Overview of ECG & Blood Pressure Monitoring system using Raspberry Pi

In this paper we have ECG & Blood Pressure reading results are monitored. These sensors signals send to the Raspberry Pi via amplifier circuit and signal conditioning unit (scu), because the signals levels are low (gain), so amplifier circuit is used to gain up the signal and transmit the signals to the Raspberry Pi. Raspberry pi is a linux based operating system works as a small pc processor system. Here patients ECG & Blood Pressure is measured using respective sensors and it can be monitored in the monitor screen of computer using Raspberry Pi as well as monitoring through anywhere in the world using internet source.
Raspberry Pi is programmed for the particular project need that via USB dongle (or) Ethernet for patient's health monitoring through internet. It sends all the current health data of the particular patient to the web database. Anybody can access the web and can see the health of patients.

Sensor and actuator nodes (SANs). Lightweight wearable ECG sensors and other ambient sensors collect data and send them in real time via a wireless protocol (ZigBee, Bluetooth, WiFi) to a gateway connected to the home ADSL router (Fig. 1).

Both the gateway and the message dispatcher are transparent at the logical communication level between sensors and IoT server. The architecture has been developed with the aim of enabling the integration of sensor networks based on different networks protocols (WiFi, ZigBee, Bluetooth…) The only component aware of the local sensor network protocol is the gateway, which runs a firmware that can manage the corresponding protocol. The gateway encapsulates the packets of the sensors in a universal format which preserves all the information present in the native format. Hence sensors send messages in their native format to the IoT server, where the data management unit extracts information and enters it in a "universal" format into the sensor database. When sensors need to be configured or interrogated, the configurator unit prepares a command according to the target sensor protocol.

The IoT server converts the raw payload from heterogeneous nodes into a "universal" format, containing object identifier, object type, measurement unit, data field, geographical position, and timestamp. Then, it makes the data available to applications and users. In this way, data visualization and processing is separated from measurement and data collection, and does not need to take into account the communication protocol of the originating source. In addition, the IoT server receives data from users in order to configure and manage the SANs.

The main components of the IoT server are illustrated in the cloud of Fig. 1, since they can be part of a distributed information system. The *message dispatcher* manages the bidirectional communication with the sensor networks, using no information on the network protocol or on the type of application. The *data management unit* is a collection of software modules interpreting data from sensors and storing them in a universal format in the *sensor database*. The *configurator unit* receives inputs from users or applications and translates them into protocol-specific commands to the SANs, consulting the *configuration database.* Finally, the *secure access manager* provides access to stored information and SAN configuration only to authorized users and applications, according to information contained in the user *database.*.

User interfaces. The entire system is configurable and controllable through an intuitive web interface from any computer, smart phone or tablet connected to the internet. In the IoT server, health data can be combined with other data, merged, processed by users and/or authorized clinicians.

A. System Architecture

The interconnection between different components is explained using the architecture of system. Architecture diagram is shown in figure 2. The patients connect the sensors to their body and the other end of the sensors is connected to Raspberry Pi. The data acquired by sensors is stored in the Raspberry pi B+. The data values are shown on HMI interfaced display and at the same time if the values exceed the normal range, the alarm triggers. The values stored are sent to server with the help of IOT. All the values are stored on the server and the most recent value is displayed on webpage and send Text message using GSM Module. The doctor along with their login credentials can login and see the patient data. Doctors can see all previous records of a patient and suggest medicines and changes in prescription. Also patients are given unique user id and password to view their records.

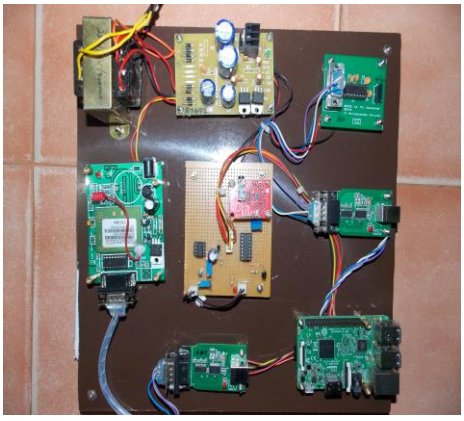


Fig. 2. Architecture diagram

The design of the system is divided into two parts: Hardware components and software components.

B. Hardware components

1) *Temperature sensor (LM35):*It is a sensor used to measure temperature. The LM35 series are precision integrated-circuit temperature sensors, whose output voltage is

linearly proportional to the Celsius (Centigrade) temperature. It measures temperature more accurately than thermistors. It is sealed and does not undergo oxidation. It does not require output voltage to be amplified.

Fig. 3. Temperature sensor (LM 35)

2) *ECG sensor:* ECG electrode sticks to chest to pick up ECG signals. Then wires are connected to AD8232. This sensor is a cost-effective board used to measure the electrical activity of the heart. ECGs can be extremely noisy, the AD8232 Single Lead Heart Rate Monitor acts as an op amp to help obtain a clear signal from the PR and QT Intervals easily.

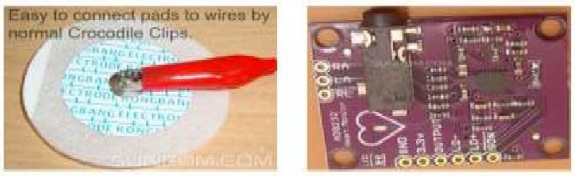


Fig. 4. ECG sensor

3) *Raspberry Pi*: The Raspberry Pi is a low cost, credit-card sized computer that plugs into a computer monitor or TV, and uses a standard keyboard and mouse. The Raspberry Pi 3 Model B+ has dual core ARM11 processor with 1GB SDRAM and powers through Micro USB socket of 5V. Sensors are connected to the Raspberry Pi 3 Model B+. Raspberry Pi sends the information to servers through GSM module.

Fig. 5. Raspberry Pi

3)*GSM module:* It requires a SIM (Subscriber Identity Module) card just like mobile phones to activate communication with the network. The use of GSM to send health information to webpage. This gives patient the ability to leave the hospital but still he has to stay in some known places to ensure the ability to reach him in emergency cases. Even with this solution the patient can't move freely and be far from his home.

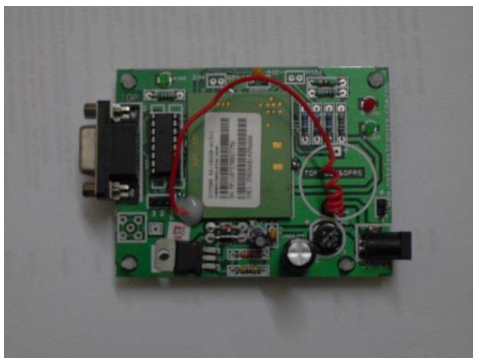


Fig. 6 GSM SIM300 Module

C. SOFTWARE COMPONENTS

1) *Server* - The data send by Raspberry pi is stored on a server. The detailed information of patients and doctor is registered through website on stored on server. The website can be accessible from anywhere.

IV. RESULT

Problem definition of our underlying system which is basically useful for doctor's for monitoring patient's health parameter virtually and gets the accurate result.

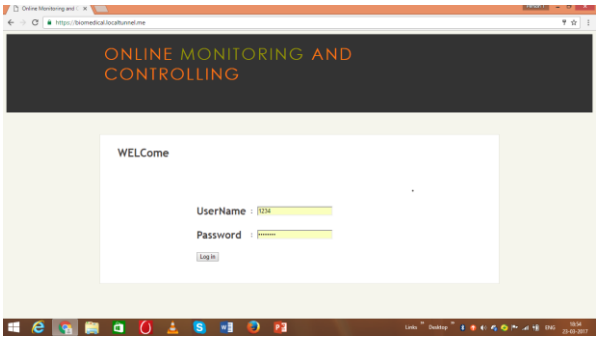
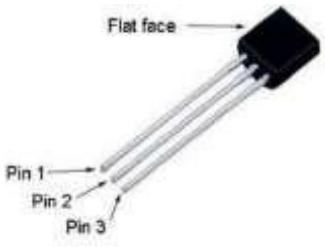


Fig. 7 Webpage of system

Fig.7 Shows that the webpage login for the end user who knows to the result of concern patient report. Also through this system real time parameter values can be measured so this system is beneficial for homes as well as in clinic also. Through this system, the doctor can able to calculate temperature, ECG, blood pressure values efficiently and store data on raspberry pi temporarily. The values are in form of - Temperature we are getting Celsius, Blood pressure, ECG in percentage shown on display as well as on website.



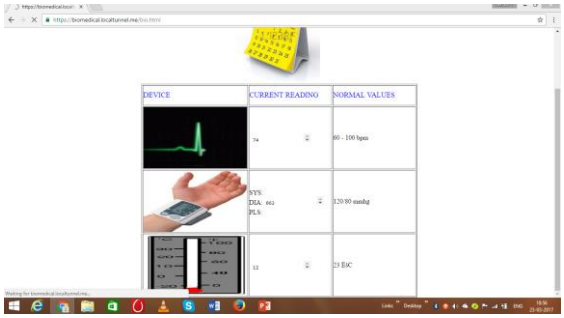


Fig. 8 Result Window of Our system

If the current value increase above the normal value means send the message to patient relatives to alert them. So we can help patient when they need doctor's help.

V. CONCLUSION AND FUTURE SCOPE

As health care services are important part of our society, automating these services lessen the burden on humans and eases the measuring process. Also the transparency of this system helps patients to trust it. When threshold value is reached, the alarm system that consists of buzzer and LED alerts the doctors and he can act more quickly. The objective of developing monitoring systems is to reduce health care costs by reducing physician office visits, hospitalizations, and diagnostic testing procedure.

The IOT technology helps the server to update the patient data on website. Many further improvements can be made in our system to make it better and easily adaptable such as adding more advanced sensors.

The biometric information of the patient which is stored and published online & transmit to cellular can be given to scientists and researchers of medical fields to analyze the value and find patterns or for other research work. To simplify the hardware and reduce wiring we can have used wireless sensors.

Instead of medical application we can use our system in industrial and agricultural application by using sensors like humidity sensors, fertility check sensors, etc. Future work will focus on monitoring additional health-related parameters using a broader combination of transducers, sensors, and correlation techniques, and on improving system reliability and robustness to patient movement and connectivity losses.

REFERENCE

[1] A. Dohr, R. Modre-Osprian, M. Drobics, D. Hayn, G.Schreier, "The Internet of Things for Ambient Assisted Living", Seventh International Conference on Information Technology, pp 804-809,2010.

[2] Junaid Mohammed, Abhinav Thakral, Adrian Filip Ocneanu, Colin Jones, Chung-Horng Lung, Andy Adler," Internet of Things: Remote Patient Monitoring Using Web Services and Cloud Computing", 2014 IEEE International Conference on Internet of Things (iThings 2014), Green Computing and Communications (GreenCom2014), and Cyber-Physical- pp 256-263,2014

[3] Mohammad S. Jassas, Abdullah A. Qasem, Qusay H. Mahmoud," A Smart System Connecting e-Health Sensors and the Cloud A Smart System Connecting e-Health Sensors and the Cloud" Proceeding of the IEEE 28th Canadian Conference on Electrical and Computer Engineering Halifax, Canada, pp 712-716,May 3-6, 2015.

[4] Hasmah Mansor, Muhammad Helmy Abdul Shukor, Siti Sarah Meskam, Nur Quraisyia Aqilah Mohd Rusli, Nasiha Sakinah Zamery," Body Temperature Measurement for Remote Health Monitoring System" IEEE International Conference on Smart Instrumentation, Measurement and Applications (ICSIMA)26-27 November 2013.

[5] R.S.H. Istepanian , S. Hu, N. Y. Philip, and A. Sungoor," The Potential of Internet of m-health Things "m-IoT" for Non-Invasive Glucose level Sensing", 33rd Annual International Conference of the IEEE EMBS Boston, Massachusetts USA, pp 5264-5266,August 30 - September 3, 2011.

[6] [6] K.Mathan Kumar, R.S.Venkatesan," A Design Approach to Smart Health Monitoring Using Android Mobile Devices" IEEE International Conference on Advanced Communication Control and Computing Technologies (ICACCCT), pp 1740-1744,2014.

[7] Karandeep Malhi, Subhas Chandra Mukhopadhyay, Fellow, IEEE, Julia Schnepper, Mathias Haefke, and Hartmut Ewald," A Zigbee-Based Wearable Physiological Parameters Monitoring System" IEEE Sensors Journal, Vol. 12, NO. 3, pp 423-430,March 2012.

[8] Nitin P. Jain Preeti N. Jain Trupti P. Agarkar," An Embedded, GSM based, Multi parameter, Real time Patient Monitoring System and Control –An Implementation for ICU Patients" IEEE World Congress on Information and Communication Technologies, pp 987 –992,2012

[9] Soumya Roy, Rajarshi Gupta," Short range centralized cardiac health monitoring system based on ZigBee communication", IEEE Global Humanitarian Technology Conference - South Asia Satellite (GHTC-SAS) Trivandrum, pp 177-182,September 26-27, 2014.

[10] Rajeev Piyare, " Internet of Things: Ubiquitous Home Control and Monitoring System using Android based Smart Phone", International Journal of Internet of Things, 2(1): 5-11,2013.

[11] Subhas Chandra Mukhopadhyay," Wearable Sensors for Human ActivityMonitoring: A Review", IEEE Sensors Journal, Vol. 15, No. 3, pp 1321-1330, March 2015.

[12] Shanzhi Chen, HuiXu, Dake Liu, Bo Hu, and Hucheng Wang, " A Vision of IoT: Applications, Challenges, and Opportunities With China Perspective", IEEE Internet Of Things Journal, Vol. 1, No. 4, pp 349-359,August 2014.

[13] John A. Stankovic," Research Directions for the Internet of Things", IEEE Internet Of Things Journal, Vol. 1, No. 1, pp 3 – 9,February 2014.

[14] Andrea Zanella, Nicola Bui, Angelo Castellani, Lorenzo Vangelista, and Michele Zorzi, " Internet of Things for Smart Cities", IEEE Internet Of Things Journal, Vol. 1, No. 1, pp 22-32,February 2014.

[15] P.Karthick , C.Sureshkumar , P.Arunprasad, S.Pusparaj, M.Jagadeeshraja, N.Suthanthira Vanitha," Embedded Based Real-time Patient Monitoring System", International Journal of VLSI and Embedded Systems-IJVES, Vol 05, Article 02231; March 2014.