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# Survival of ICU Patient Health Monitoring Using IoT

**Dr Julie, Dr Sai**
Prathyusha Engineering College,Thiruvallur

## Abstract

Internet of things serves as a catalyst for the healthcare and plays prominent role in wide range of healthcare applications. In the modern health care environment, the usage of IoT technologies brings convenience of physicians and patients, since they are applied to various medical areas such as real-time monitoring, patient information management, and healthcare management. The Body Sensor Network (BSN) technology is one of the core technology of IoT developments in healthcare system, where a patient can be monitored using a collection of lightweight wireless sensor nodes. Hence, this project proposes IoT based BSN for health care Monitoring and Management. The healthcare parameters such as EMG, BP etc., are sensed by using appropriate sensor and its values are continuously compared with the threshold limits. Whenever the sensed values exceed the threshold limits, the information about the patient's health condition is communicated through IoT. Depending on the criticality of the condition, the patient's health condition is communicated to the care takers of the patient. In this project Raspberry pi is used as a processor and IoT is used to communicate the various sensors output to the care takers. The processor picks up the sensor data and sends it to the network through IoT and hence provides real time monitoring of the healthcare parameters for caretakers like doctors, relatives, ICU etc. The data can be accessed anytime which alert the caretaker about variation in sensor output.

***Keywords:*** **Internet of Things; Body Sensor Networks; Healthcare Monitoring; Rasperrypi Processor.**

## 1. INTRODUCTION

In the modern health care environment, the usage of IoT technologies brings convenience of physicians and patients, since they are applied to various medical areas (such as real-time monitoring, patient information management, and healthcare management). The body sensor network (BSN) technology is one of the core technologies of IoT developments in healthcare system, where a patient can be monitored using a collection of tiny-powered and lightweight wireless sensor nodes. [1]

The rapid growth in physiological sensors, low-power integrated circuits, and wireless communication has enabled a new generation of wireless sensor networks, now used for purposes such as monitoring traffic, crops, infrastructure, and health. The body area network field is an interdisciplinary area which could allow inexpensive and continuous health monitoring with real-time updates of medical records through the Internet. A number of intelligent physiological sensors can be integrated into a wearable wireless body area network, which can be used for computerassisted rehabilitation or early detection of medical conditions. [1]

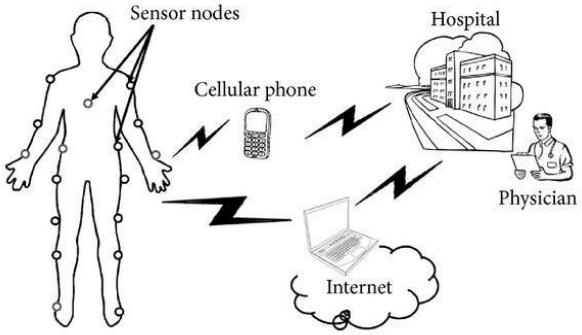


**Fig.1. Body Area Networks with IoT**

Fig.1. shows that, various sensors are placed on the patient's body and the sensors transmit the information to Cellular phone, hospital and physician through internet. Recent technological advances in sensors, low-power integrated circuits, and wireless communications have enabled the design of low-cost, miniature, light-weight, and intelligent physiological sensor nodes. These nodes, capable of sensing, processing, and communicating one or more vital signs, can

be seamlessly integrated into wireless personal or body networks (WPANs or WBANs) for health monitoring. These networks promise to revolutionize health care by allowing inexpensive, non-invasive, continuous, ambulatory health monitoring with almost real-time updates of medical records via the Internet. Though a number of ongoing research efforts are focusing on various technical, economic, and social issues, many technical hurdles still need to be resolved in order to have flexible, reliable, secure, and power-efficient WBANs suitable for medical applications. [12]

# II. LITERATURE SURVEY

Pros anta Gope and Tzonelih Hwang, describes about the recent advances in information and communication technologies and embedded systems have given rise to a new disruptive technology, the Internet of Things (IoT). IoT allows people and objects in the physical world as well as data and virtual environments to interact with each other so as to create smart environments, such as smart transport systems, smart cities, smart health, and so on. However, IoT raises some important questions and also introduces new challenges for the security of systems and processes and the privacy of individuals, such as their location and movements and so on. In this paper, at first, we propose a distributed IoT system architecture. Subsequently, we propose an anonymous authentication scheme, which can ensure some of the notable properties, such as sensor anonymity, sensor intractability, resistance to replay attacks, cloning attacks, and so on. It is argued that the proposed authentication scheme will be useful in many distributed IoT applications (such as radio-frequency identification-based IoT system, Biosensor-based IoT healthcare system, and so on), where the privacy of the sensor movement is greatly desirable. [1]

Aleksandra Milenković, Chris Otto, Emil Jovani describes about Wireless Sensor Networks for Personal Health Monitoring: Issues and an Implementation that technological advances in sensors, low-power integrated circuits, and wireless Communications have enabled the design of low-cost, miniature, lightweight, and intelligent physiological sensor nodes. These nodes, capable of sensing, processing, and communicating one or more vital signs, can be seamlessly integrated into wireless personal or body networks (WPANs or WBANs) for health monitoring. These networks promise to revolutionize health care by allowing inexpensive, non-invasive, continuous, ambulatory health monitoring with almost real-time updates of medical records via the Internet. Though a number of ongoing research efforts are focusing on various technical, economic, and social issues, many technical hurdles still need to be resolved in order to have flexible, reliable, secure, and power-efficient WBANs suitable for medical applications. This paper discusses implementation issues and describes the authors' prototype sensor network for health monitoring that utilizes off-the-shelf 802.15.4 compliant Network nodes and custom-built motion and heart activity sensors. The paper presents system architecture and hardware and software organization, as well as the authors' solutions for time synchronization, power management, and on-chip signal processing. [8]

Media Aminian and Hamid Reza Naji describes "A Hospital Healthcare Monitoring System Using Wireless Sensor Networks" In a hospital health care monitoring system it is necessary to constantly monitor the patient's physiological parameters. For example a pregnant woman parameters such as blood pressure (BP) and heart rate of the woman and heart rate and movements of fetal to control their health condition. This paper presents a monitoring system that has the capability to monitor physiological parameters from multiple patient bodies. In the proposed system, a coordinator node has attached on patient body to collect all the signals from the wireless sensors and sends them to the base station. The attached sensors on patient's body form a wireless body sensor network (WBSN) and they are able to sense the heart rate, blood pressure and so on. This system can detect the abnormal conditions, issue an alarm to the patient and send a SMS/E-mail to the physician. Also, the proposed system consists of several wireless relay nodes which are responsible for relaying the data sent by the coordinator node and forward them to the base station. The main advantage of this system in comparison to previous systems is to reduce the energy consumption to prolong the network lifetime, speed up and extend the communication coverage to increase the freedom for enhance patient quality of life. We have developed this system in multi-patient architecture for hospital healthcare and compared it with the other existing networks based on multi-hop relay node in terms of coverage, energy consumption and speed. [12]

# III. INTERNET OF THINGS

The term Internet of Things was coined by Peter T. Lewis in a 1985 speech given at a U.S. Federal Communications Commission (FCC) supported wireless session at the Congressional Black Caucus 15th Legislative Weekend Conference. In his speech he states that "The Internet of Things, or IoT", is the integration of people, processes and technology with connectable devices and sensors to enable remote monitoring, status, manipulation and evaluation of trends of such devices. The Internet of Things (IoT) is a system of interrelated computing devices, mechanical and digital machines, objects, animals or people that are provided with unique identifiers and the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction. Practical applications of IoT technology can be found in many industries today, including precision agriculture, building management, healthcare, energy and transportation. [13]

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# IV. SENSORS

A sensor is an object whose purpose is to detect events or changes in its environment and sends the information to the computer which then tells the actuator (output devices) to provide the corresponding output. A sensor is a device that converts real world data (Analog) into data that a computer can understand using ADC (Analog to Digital converter). [3]

Electromyography (EMG) is an electro diagnostic medicine technique for evaluating and recording the electrical activity produced by skeletal muscles. EMG is performed using an instrument called an electromyography to produce a record called an electromyogram. An electromyography detects the electric potential generated by muscle cells when these cells are electrically or neurologically activated. The signals can be analyzed to detect medical abnormalities, activation level, or recruitment order, or to analyze the biomechanics of human or animal movement. [1]

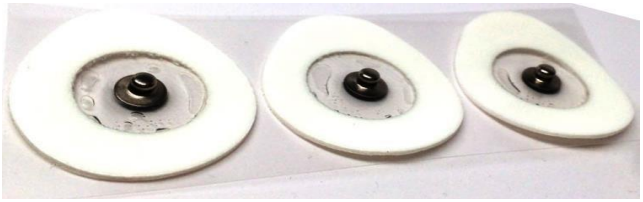

**Fig.2. EMG Sensor**

Blood pressure (BP) is the pressure of circulating blood on the walls of blood vessels. When used without further specification, blood pressure usually refers to the arterial pressure in the systemic circulation. Blood pressure is usually expressed in terms of the systolic (maximum during one heart beat) pressure over diastolic (minimum in between two heart beats) pressure and is measured in milli metres of mercury (mmHg). Normal resting systolic (diastolic) blood pressure in an adult is approximately 120 mmHg (80 mmHg), abbreviated 120/80 mmHg.

**Fig.3. BP Sensor**

# V. Existing Method

Recent wireless healthcare research and projects have aimed at monitoring the patients at various levels:

- Continuous
- In-ambulatory
- In-clinic
- Open Environment (Athletic health monitoring)

Code Blue-Several bio-sensors placed on the patient's body transmit data to their authorized devices. Any doctor/medical professional who requests for this medical info queries using their own personal device. These sensors sense the patient body and transmit it wirelessly to the end-user device (PDAs, laptops, and personal computer) for further

analysis. The basic idea of the Code Blue is straightforward, a doctor or medical professional issues a query for patient health data using their personal digital assistant (PDA).

Alarm-net-Patient health monitoring project based on heterogeneous networks, consists of body sensors and environment sensors. This was specifically designed for patient health monitoring in the assisted-living and home environment. Facilitates network and data security for physiological, environment and behavioral parameters about residents. It is susceptible to adversarial confidentiality attacks, which can leak resident's location

Median-Patient monitoring during disaster events, Comprises of multiple physiological monitors to collect health information (blood oxygenation, pulse rate etc). The author acknowledged the need for encryption but did not specify the scheme to ensure confidentiality. [1]

Healthcare monitoring enable automatic patient monitoring and provide potential quality of the healthcare without disturbing patient comfort. The paper focus on the reliability, cost effectiveness and power consumption of their prototypes, but although most of the healthcare paper address the requirement for security and privacy for sensitive data, only a few embed any security. Besides, none of the above papers addressed all the security requirements and their implication, which is greatly imperative for critical applications.

# VI. Patient Health Monitoring Using IoT

Health monitoring system using Raspberry pi microcontroller with Body Area Sensor Network (BASN) is proposed in this work. Blood pressure sensor, EMG sensor are used to develop this paper. These sensors are placed on human body that helps to monitor the health condition without disturbing the daily routine of the patients. The sensed health related parameters are communicated to physicians, patient's family member etc through server using long range wireless technology such as "interest of Things".

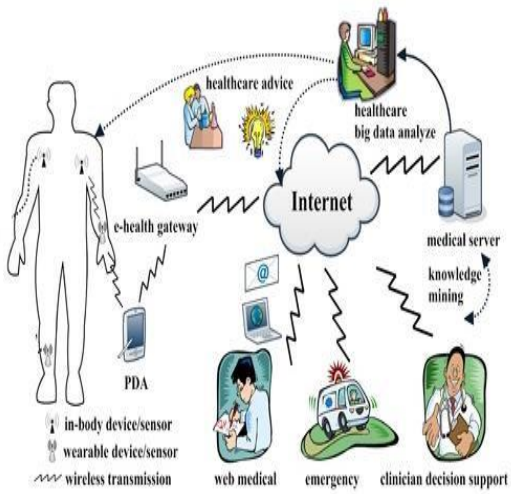


**Fig.4. Body Sensor Network with IoT**

The Fig.4. Illustrates the proposed work using Body sensor network with Internet of things. This paper uses blood pressure sensor which is used to measure the blood pressure of human body and EMG sensor which is used to measure the electrical activity of muscles at rest and during contraction. Threshold levels of these devices are programmed in the processor. The system is connected to internet connectivity for communication. When the sensors transmit the sensed values from the patient's body, the outputs are viewed on the system and alert messages are sent to patient's phone, family member, physician and hospital.

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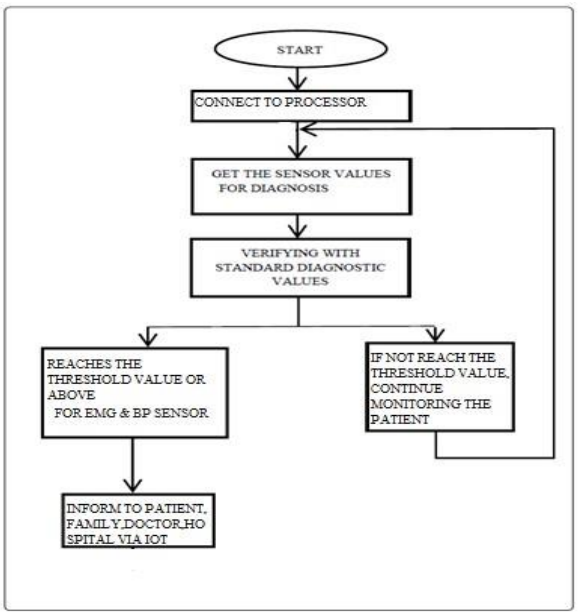


**Fig.5. Flow diagram for Health Monitoring**

The flow diagram of the process is shown in Fig. 5 When the sensed value reaches the threshold value or above of EMG and BP sensor, the information is passed to family members, doctors, etc. Otherwise the monitoring of the patient continues. This paper is developed using Raspberry Pi processor which is designed using python language. The app is android & web based which is connected to the internet thorough either Wi-Fi. It connects to the server which is connected to cloud server over the internet and lets the users to monitor threshold level. The alert is sent real time to the user app by a message.

# VII. SOFTWARE IMPLEMENTATION

Python Language is a widely used high-level, general-purpose, interpreted, dynamic programming language. Its design philosophy emphasizes code readability, and its syntax allows programmers to express concepts in fewer lines of code than possible in languages such as C++ or Java. The language provides constructs intended to enable writing clear programs on both a small and large scale.

Python supports multiple programming paradigms, including object-oriented, imperative and functional programming or procedural styles. It features a dynamic type system and automatic memory management and has a large and comprehensive standard library. Python interpreters are available for many operating systems, allowing Python code to run on a wide variety of systems.

# VIII. HARDWARE IMPLEMENTATION

Raspberry Pi3B is an ARM based credit card sized SBC (Single Board Computer) created by Raspberry Pi Foundation. Raspberry Pi runs Debian based GNU/Linux operating system Raspbian and ports of many other OS exist for this SBC. The Raspberry Pi 3 is the third generation Raspberry Pi. It replaced the Raspberry Pi 2 Model B in February 2016. Compared to the Raspberry Pi 2 it has:

- A 1.2GHz 64-bit quad-core ARMv8 CPU
- 802.11n Wireless LAN
- Bluetooth 4.1
- Bluetooth Low Energy (BLE)

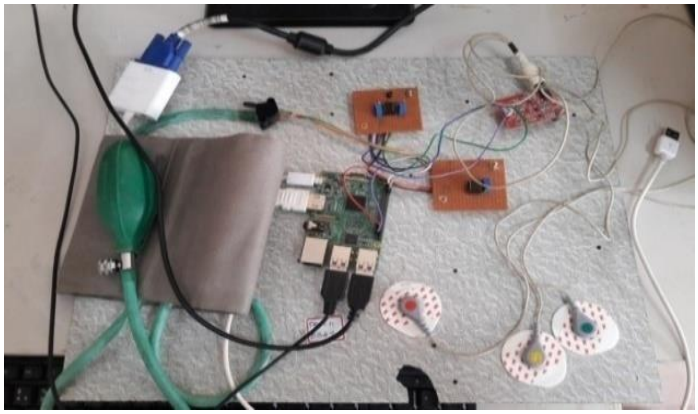

**Fig.6. Hardware Implementation using BSN with IoT**

Hardware implementations using BSN with IoT is shown in the Fig.6. The figure consists Raspberrypi processor, an EMG sensor, a BP sensor and an ADC which are connected to personal computer.

# IX. Hardware Results

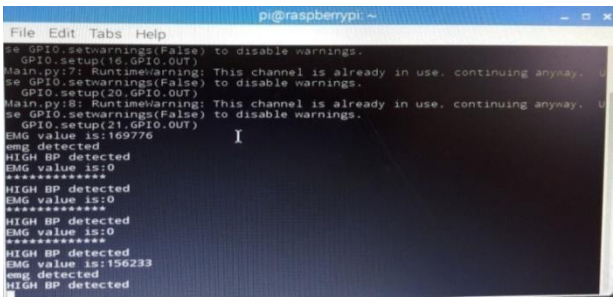


**Fig.7. Outcome of the Sensors (EMG, BP)**

The Fig.7 shows the outcome of the sensors on the system. The output consists of EMG values and BP detected messages of the patient.

# X. Conclusion and Future Work

Internet of Things has many applications in different areas. IoT has been already designed for Body Wireless Sensor Network (BWSN). It has been developed for health monitoring. This system presents a Remote health monitoring using IoT. There are some problems found in IoT and existing health monitoring. New technologies could help to minimize them by achieving the better quality as well as web based security concept. New technologies and methodologies which are already used to improve applications of IoT have been discussed in this paper. Raspberry Pi kit, Wi-Fi modules, blood pressure and EMG sensors are currently in used for IoT.

In future, this paper is to be designed with multiple sensors with sensor fusion technology with IoT and an alert message is given to Patient, Family member, Physician and Hospital. Further efforts are necessary to improve Quality of Service of wireless communication, reliability of sensor nodes, security, and standardization of interfaces and interoperability. In addition, further studies of different medical conditions in clinical and ambulatory settings are necessary to determine specific limitations and possible new applications of this technology.

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