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IoT Driven Healthcare System for Remote Monitoring of Patients

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ABSTRACT

Improving the efficiency of healthcare system is one of the most challenging goals for today's society. The Internet of Things (IoT) is re-designing modern health care in which objects are sensed and controlled remotely. Patient's physiological information is managed and recorded for long time using wearable sensors. This system is expected to reduce costs, increase the quality of life, and enrich the user's experience. According to World Health Organization standard, 60% population of India is affected by chronic and cardiovascular diseases. This system reduces the headache of patient to visit to doctor every time he/she needs to check ECG and temperature and pulse oxygen in blood. Doctors and hospitals could make use of real-time data collected on the cloud platform to provide fast and efficient solution.

Keywords: *IoT, cloud, healthcare, wearable sensors.*

I. INTRODUCTION

The Internet of Things (IoT), a new technology connects physical objects with the help of internet. The IoT has d-ifferent applications in smart cities, healthcare, logistics, and industrial control. Remote monitoring of patient's physiological parameters is major application of IoT in healthcare sector. The use of wearable devices provides greater flexibility for the elder people to monitor their health at home with less hospital related infections [1]. According to WHO, many people die due to chronic and cardiovascular diseases [6]. IoT provides immediate access to doctors and hospitals by measuring and processing vital signs of patients.This helps in reducing the mortal rate caused due to heart failures and strokes. Biomedical sensors measure the human body's heartbeat, blood pressure, pulse and ECG. In this study, we use the Intel Edison as an IoT device to process patient's vital parameters. Intel Edison development platform is very useful to design IoT and wearable computing products. It has 20 digital inputs, 6 analog inputs, 1 UART and 1 I2C. It has in built Wi-Fi and bluetooth. This IoT platform provides device to cloud communication. Cloud is a foundation tool to collect, store and process the data. [5].The electrical activity of the heart is measured in the waveform using ECG sensor [2]. Pulse sensor is optical heart rate sensor which amplifies the signal and cancels the noise. The Intel architecture provides benefits such as reduced hospital stays, lower cost, and improved self-management of health conditions, timely, affordable and easy access to care anywhere and anytime when it is needed. The existing in office care is very costly. New emerging systems are more efficient for management of chronic diseases of aging populations.

II. Related Work

IoT based healthcare applications will have large impact on global economy by 2025. There are different applications of IoT in healthcare such as Glucose level sensing which measures blood sugar level using non-invasive techniques. Body temperature sensors are responsible for temperature recordings and transmission. Oxygen level monitoring measures oxygen percentage in blood using noninvasive method. Home monitoring is a method that can help health systems work more closely with physicians and patients.It is estimated that many elder persons are suffering from chronic illnesses and may benefit from a telemedicine solutions. The existing remote monitoring solutions have higher cost and complexity. A newer advanced solution reduces the cost compared to traditional delivery models. Every year around 17.3 million people die due to cardiovascular diseases and it will increase by 2030[12].

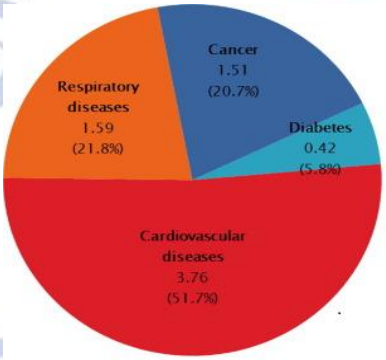


Fig 1: Healthcare Statistics [12]

Many monitoring devices that display the patient's physiological data are present in the operating rooms. But there are instances where the doctor is not available in case of an emergency; also the data cannot be shared remotely with other specialized doctors and the family members. The existing solutions are of large size, very expensive and needs lot of wires. Several communication protocols that are used between gateway and cloud include HTTP, CoAP, MQTT, and XMPP. HTTP is not perfect for IoT because it is not offering predictable latency and it depends on polling to detect state changes. Comparison among these protocols is shown in the following table.

Table I: Comparison of Different IoT Protocols

MQTT	CoAP	XMPP
Based on OASIS Standard	Based on CoRE IETF Group	Based on Internet official protocol standards
One to one, many to one, one to many Communication	One to one Communication	One to one or multiuserCommunication
Lightweight Publish-subscribe model	Client-Server Model	Client-Server Model
M2M, memory constrained devices	M2M applications, smart energy and building automation	VOIP, Gaming, IoT applications

III. PROPOSED SYSTEM

Figure 2 shows proposed IoT driven healthcare which collects the information related to patient's body temperature, pulse and ECG.

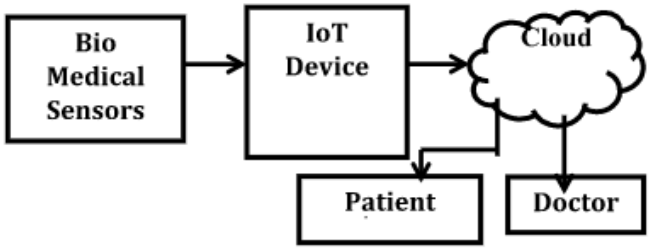


Fig 2: Block Diagram

A. Bio-Medical Sensors: Proposed solution uses following bio-medical sensors. The vital parameters include temperature, pulse and ECG

These wearable sensors are easy to wear on patient's body without disturbing his/her daily routine. The data from sensors is wirelessly transmitted to IoT device.

- Temperature Sensor:This sensor measures the body temperature. Body temperature recognizes characteristic changes in body that are caused due to many diseases.
- Pulse Sensor: A pulse sensor is used when a patient's oxygenation is unstable. A situation includes emergency and intensive care, operation recovery. Sensor determines the need for oxygen supplement.

  ECGSensor**:** The ECG sensor measures the muscular and electrical functions of the heart. By analyzing the exact waveform pattern, we can identify electrolyte imbalances, rhythm, disturbances and conduction abnormalities.

B. IoT Device: IoT device includes development boards such as microcontrollers from different vendors. It is used as a processing subsystem. The task is performed by the controller along with data processing and controlling the subsystem of other components in the sensor node. Sensor to IoT

device communication is done using short range RF protocols like ZigBee, Z-wave, Bluetooth, BLE, and Wi-Fi and gateway to cloud communicates using protocols like HTTP, MQTT, CoAP, and XMPP.

C. Cloud: Cloud is a network or internet which is present at remote location. It provides services over network on public networks or on private networks. There are different applications running on the cloud such as e-mail, customer relationship management. Cloud computing manipulates, configures and access the application online. Cloud has unlimited storage capacity.

IV. IMPLEMENTATION

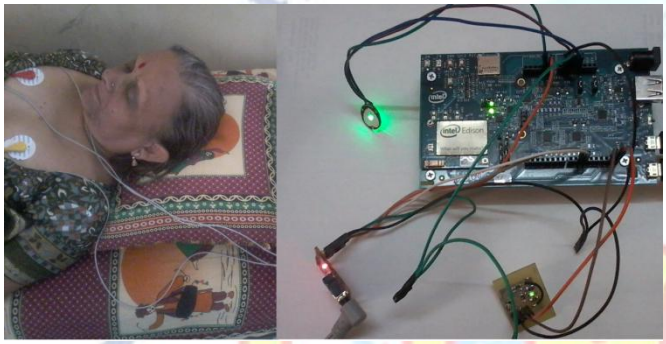


Fig 3: Healthcare System

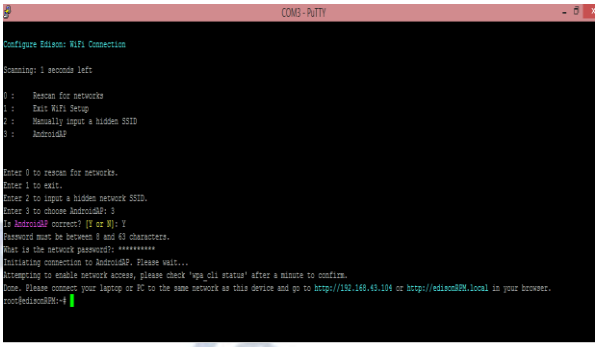
Figure 3 shows implemented healthcare system. Hardware assembly consists of Intel Edison board, AD8232 ECG Sensor, TMP112 Temperature Sensor, SEN 11574 Pulse
Sensor. AD 8232 has RA, LA, and RL electrodes connected to patient. ECG and Pulse has Analog outputs A0 and A1 respectively, whereas TMP 112 has digital output that can be read using I2C.

Algorithm

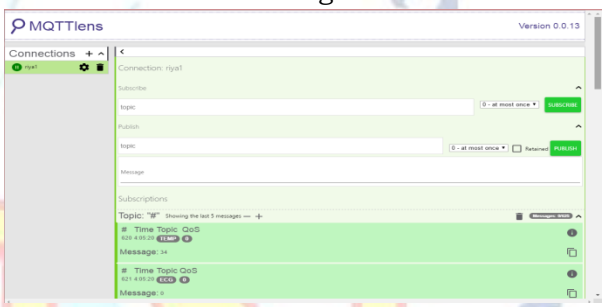
1. Start
2. Establish serial communication using PuTTY terminal emulator.
3. Configure Wi-Fi using command configure_edison –wifi
4. After successful connection establishment read the data from sensors connected to the board.
5. Establish connection with MQTT Broker using Network's SSID and Password.
6. If connection fails go to step 5.
7. If connection to MQTT Broker is successful then publish sensor data to MQTT Broker.
8. Add new connection to MQTT Lens.
9. Subscribe to any of the Published Topic.
10. Create new MQTT Load Test to view ECG, Pulse Temperature Data and Graph.

V. RESULT

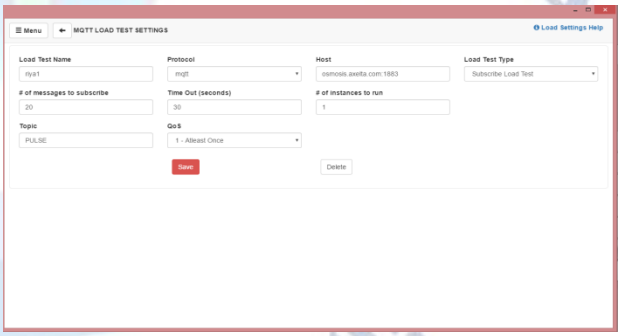
1. Edison Board connected to Wi-Fi using command configure_edison –wifi.



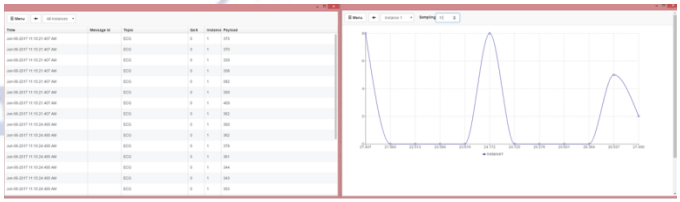
2. Subscribe to any of the Published topic using MQTTLens. MQTTLens is simple MQTT tool for the Web Browser of Google Chrome.



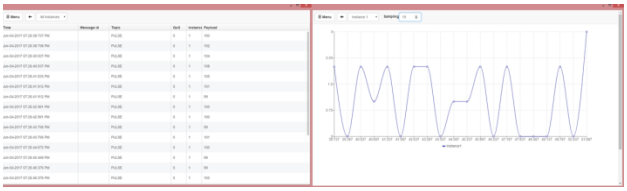
3. Create MQTT Load Test using MQTTBox to view ECG, Pulse graph and Temperature Data. MQTTBox is a cross platform application available on Chrome, Linux, MAC, Web and Windows to develop and load test.



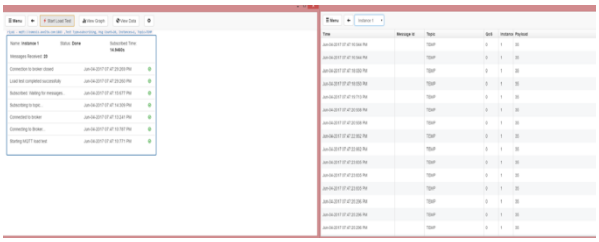
4. ECG Data and Graph



5. Pulse Data and Graph



6. Temperature Data



VI. CONCLUSION

It is impossible for the huge population of elders to follow the traditional health care. This IoT based system not only provides an accurate diagnosis of the users condition, but rather a solution that detects and prevents health episodes by carefully following, capturing, and describing the health trends recorded from physiological and contextual sensors. Use of Intel Edison provides multi-tasking capability and low power consumption. This system is useful for doctors who are overwhelmed with patient load and also beneficial for rural patients who have less access to health care facilities.

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