

REMOTE PATIENT MONITORING FOR SMART CARE USING IOT

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Abstract —Internet of Things (IoT) is gaining more attention from last few decades. Nowadays, people are moving towards the IoT based systems for living their life luxuriously. Adoption of IoT in the field of healthcare sector is noticeable. Real time monitoring of patient is possible in better way using this technique. Due to integration of IoT, the quality of services in healthcare field is surpasses. Most of the time due to improper monitoring of patient's body parameters causes hazardous effects on patient's health. In this paper, we discuss the IoT based remote monitoring of patient. The aim here is to get proper and timely treatment to the patient, when any of the health parameters crosses its set limits. The abnormal condition of patient is informed to his physician, care taker and family members by sending message about abnormal health parameter. So that patient can be treated well in time.

Keywords- Internet of Things, Wi-Fi, heart rate, remote patient monitoring, pulse oximetry, healthcare, remote monitoring, sensors, health parameter, temperature sensor, microcontroller, quality of service

I. INTRODUCTION

Internet of Things (IoT) plays an excellent role in the field of energy, healthcare, transportation, home automation, etc. Healthcare sector is facing problem of continuous monitoring from many years. The patients those need notable attention include disable people, patient with chronic diseases, elder people, etc. In ICU, after surgery patients are monitored until they become stable. But after shifting from ICU to the ward or after discharge from hospitals continuous monitoring is not taken place. This monitoring is many times essential for checking improvement in patients or for those patients who need special attention. It is not economic to admit the patient in hospital after recovery from disease or surgery.

This paper aims to provide solution in healthcare field for remote patient monitoring. The proposed remote healthcare monitoring system is designed and implemented using Internet of Things (IoT). This system is capable of monitoring health parameters of remotely located patient. The four health parameters which are monitored include body temperature, Heart rate, SPO₂ and fall detection of patient. Physician is able to monitor patient from his work place. Doctor or physician recommend special workout routine which helps in improving health condition of patient and get rid of diseases. Due to remote patient monitoring, quality of life of people can be improved to great extent. And physician can suggest medicines during the time of emergency even though patient and physician are away from each other. Also physician can suggest preventive actions for patient to be taken by the caretaker or relatives until admittance of patient in hospital for further treatment. Many times even after assigning care taker or nurse, continuous monitoring is not done efficiently. Many factors like inadequate training, poor ability of care taker or improper attention by of nurse or care taker.

II. LITERATURE SURVEY

While designing the new proposed system, a study of existing remote patient monitoring systems currently operational in the health care field around the world was carried out using publicly available information on the web. Various technical papers correlating to the study of Internet of Things for remote monitoring of patient were referenced to get an idea on the existing work being done in this field. Intelligent and advanced healthcare monitoring at remote places such as public sectors, homes, offices, etc. can be advantageous and economic in order to avoid or reduce hospitalized readmissions [1],[2],[3],[4],[5]. In order to obtain a broad overview of the practical implementation of these technologies, current technical papers on remote patient monitoring using IoT technology were also researched. Also due to rapid propagation of patient's health parameters, patient can be treated effectually and quickly [6],[7],[8],[9].

In almost all modern systems the use of IoT has become inherent to the monitoring of patient from remote location. It is observed that the use of Internet of things technology can cater improvement while treating patients [10],[11]. By using wearable sensors patient can move from one location to another anywhere on the Earth. Also the disabled person can also be assisted properly by his caregiver by alert system in case of emergency. While there are multiple options for creating a network, IoT appears to be the best bet on account of its wide range, high reliability and better security [12],[13].

- Necessity of Heart Rate Monitoring: -

Our heart rate is also called as pulse i.e. in a minute how many times our heart beats. Heart rate differs from person to person. When our body is at rest, our pulse is lower and higher, when we exercise. Usually 60-100 beats per minute is the normal resting heart rate. This heart is different for different age groups. Resting heart rates for children is higher than that of adults. Patients recovering from an injury or an illness, including a cardiac incident, real-time heart rate monitoring is valuable. This data can help ensure that your gradual return to full strength and endurance proceeds safely and steadily.

- Necessity of SpO2 Monitoring: -

Normal blood oxygen saturation level (SpO2) should be in between 94% to 99%, for a normal healthy person. The SPO2 level should be 90% or above, in case of patients with mild respiratory diseases. If this level falls below 90%, it is not acceptable for a long period of time then supplementary oxygen should be used. The pulse rate and the blood oxygen level are associated with each other to a certain degree. They are not strictly correlated with each other. For example, an infant, children between age 13 to 19(teenager), a youngster and an elderly person in good health conditions, all may have a blood oxygen level (SPO2) of 94 or higher but the pulse rate is different for the person from each age group. An infant can be 108 beats per minute while the other three people from different age group can have SPO2 level that average between 60 to 72 beats per minute.

When the factors like diet and exercise taken into consideration pulse rate changes in dramatically. A marathon runner is a good example of such dissimilarity in pulse rate. They can bring the pulse rate up to 35-40bpm low keeping blood oxygen level of 97% or more. As their heart works very less for circulating same amount of blood because of their great state of health as compared to other people. The normal values of blood oxygen are based on health condition of a person, oxygen percentage in the air, respiration rate, activities performed by person and other factors too. Lung capacity of transferring oxygen to blood can be affected due COPD, smoking habit, lung cancer, Asthma, Chemotherapy, etc. Due to this blood oxygen level brings down permanently. Person needs to consult with a doctor immediately if blood oxygen saturation level falls below 88%.

- Necessity of Body Temperature Monitoring: -

Human body temperature is an important parameter which needs to measure accurately. The balancing between production of heat and loss of heat is represented by body temperature. Human body is considered to be stable if heat produced is equal to heat lost. Body temperature of across the body is not evenly distributed. Varying amount of heat is produced by all metabolizing body cells. Core body temperature is obtained in the brain, thoracic cavities, in abdominal cavities. It can be affected by various intrinsic parameters and to less extent by external environmental parameters.

III. PROPOSED SYSTEM

In today's day to day social insurance framework, checking is done either via overseer/ medical caretaker for patients who stays in home during post operational days. Continuous observations may not be achieved by this system, if guardian/attendant is not in the premises, and it causes more significant harm as, on the grounds, within a part of seconds, anything can change in parameters of human body. So with this innovation created period where web administers the world gives a thought to add to another keen health awareness framework where time to time constant checking of the patient is accomplished. Generally patients those require continuous assistance have to call caregiver by using a buzzer or by voice. The buzzer is normally placed in same location inside the room or near the room of patient. But during the situations, when caregiver can't hear the voice of patient or may be caregiver went outside the house or in some situation when patient fallen out of the wheel chair and unable to beep the buzzer. For this reason, the immediate information of abnormal condition of patient should be informed or received by caregiver irrespective of location of patient or caregiver.

The IOT based healthcare system for remote patient monitoring provides such a feature of accessing patient health parameter monitoring status by patient's physician, caregiver and family members any time when they want to check .And also notifying them when parameters goes out of range i.e. abnormal condition of patient to provide immediate and appropriate treatment. By using remote monitoring of patient using IoT, patient or person from the rural areas can also be monitored because many a time sufficient medical facilities are not available in rural areas. The first requirement in remote patient health monitoring is parameters to be monitored, and sensors required to measure respective health parameters. Here in this project we are monitoring four health parameters namely temperature, heart rate blood oxygen saturation level and falling condition of a patient. For temperature measurement DS18B20 temperature sensor is used. Heart rate sensor is used for measuring heart beat rate. Blood oxygen saturation level is measured by using Pulse Oximeter (SPO2 sensor). Fall detection of patient is sensed by using ADXL 345 accelerometer sensor.

The patient monitoring system should be portable .For this reason we have designed health monitoring system placed on the band of patient which can be fixed on wrist during monitoring of health parameters. So that patient can wear it easily and also can move from one place to another. Person who needs assistance from physician or care giver can alert them by using buzzer which is present on our wearable device. Raw data from multiple patients can be collected continuously after every 1 minute with the help of monitoring system on the wearable band wore by them. Here in our project we are collecting the data after every 1 minute with the help of smart sensors connected by an inter-connected

network. Using this collected data medical experts can diagnosis in more efficient ways and give accurate treatment during critical condition of patient.

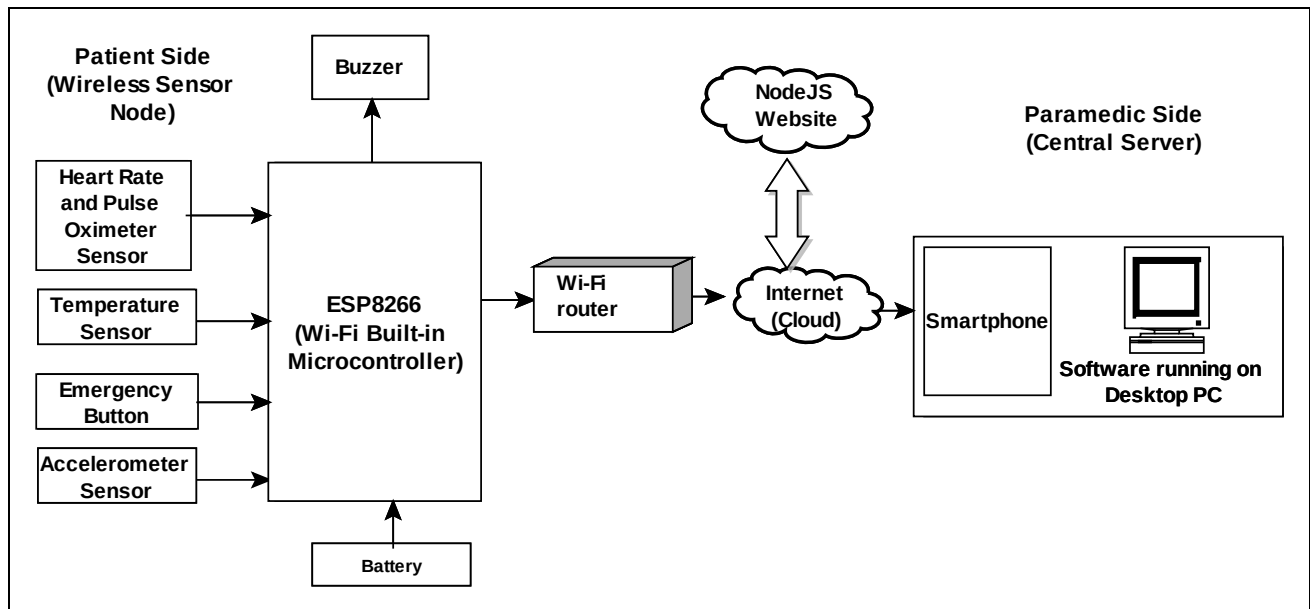


Figure 1. Block Diagram of Remote Patient Monitoring System for the Smart Care

This project proposes a Remote Patient Monitoring solution, powered by cloud service Internet of Things platform, empowers providers to transform the patient care relationship while mitigating the challenges impeding innovation and outcomes. The main idea of the designed system is to continuous monitoring of the patients over internet. The model consists of NodeMCU board based on ESP8266, Wi-Fi Built-in Microcontroller, Temperature sensor, Pulse Oximeter Sensor, Heart Rate Sensor, Accelerometer Sensor sand Li-Ion Battery. Because of our proposed solution of provision of personalized patient monitoring, it is possible to easily collect patient's data anytime from any location, and also enables better care team collaboration with a holistic, near real-time view of a given patient's health and activities. A remote patient monitoring system with improved outcomes and reduced cost of system are trying to achieve in this project. In this way, access to the healthcare system can be improved due to reduction in delivery cost of health monitoring.

The main idea of our designed system is to continuous recording and monitoring of the health parameters of patients over an internet. Our proposed solution is a sensor based patient monitoring system to measure heartbeat, amount of Oxygen in blood, body temperature of the patient, fall detection and emergency condition by using embedded network. The main idea of the proposed system is to provide better and efficient health services to the patients by implementing a networked information cloud so that the experts and doctors could make use of this data and provide a fast and an efficient solution. This will be a wearable device which constantly monitoring the health parameters using the sensors. For reading the body temperature DS18B20 is used. It provides $\pm 0.5^{\circ}\text{C}$ Accuracy from -10°C to $+85^{\circ}\text{C}$. The MAX30100 is an integrated pulse oximetry and heart rate monitor sensor solution. It can be doubly dangerous for a patient, experiencing a fall unobserved. If treatment is not obtained within a short time the obvious possibility of initial injury may be further aggravated by the possible consequences. ADXL345 is having feature of detecting "Free-fall sensing" if the device is falling. A push button is available so that the patient can raise an alarm if he/she is not feeling well and need immediate help. The whole system is powered by a Lithium-Ion Battery.

ESP8266 microcontroller is the main brain of this system. It collects all the sensor data and uploads it to a cloud server – PubNub. From there the data is sent to a website (made using NodeJS) where the data is stored for future use. A smartphone app is also provided so that the doctor, care taker, relatives or immediate well-wishers of the patient can check the health parameters from anywhere in the world. For each sensor there are limits which can be set by the doctor using mobile App. Also when limits are set, the data goes from the app to the website via PubNub and it is stored in the database. ESP8266 uploads the sensor data (Temperature, heart rate, SPO2, fall detected or not, battery level) after every minute (this can be changed). The data goes via PubNub to the app and the website (local host). This collected data from the sensors is stored into the database of website. The website also has a facility to enter the higher and lower limits for each sensor. If these limits are crossed, then the website sends a notification SMS to the registered contact numbers (immediate well-wishers of the patients). The mobile numbers of the immediate well-wishers can be entered via the website console after login. Using the programmable PubNub network, the ClickSend SMS block permits to send SMS to web enabled computers and mobile phones.

IV. RESULTS

3 different cases for patient's health parameters depending upon lower and upper ranges set for every sensor are as follows:

Case 1: When any of the single parameter exceeded its limit:

Case 1(a): When patient's free fall is detected:

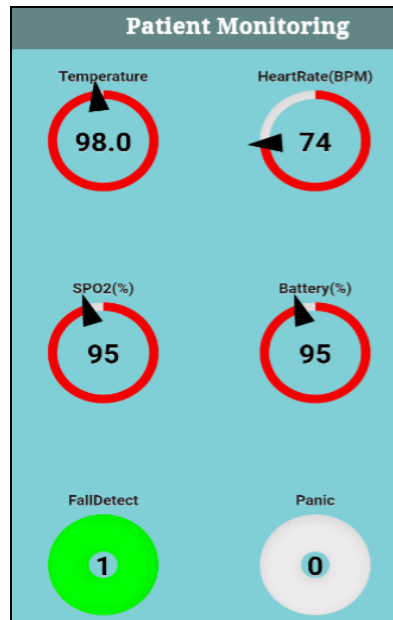


Figure 2. App Screenshot for free fall detection

```

C:\Windows\System32\cmd.exe - node server.js

E:\Node and DataBase Example\Testing_Patient>node server.js
Listening on port 8080
Subscribing..

Data from channel : esp_channel
Free Fall Detected
sending SMS to 8976389698

statusCode: 200
headers: { 'access-control-allow-credentials': 'true',
  'access-control-allow-headers': 'Content-Type, X-Auth-Token, Origin, Authorization',
  'access-control-allow-methods': 'POST, GET, OPTIONS, PUT, DELETE',
  'access-control-allow-origin': '*',
  'cache-control': 'no-cache, no-cache="set-cookie"',
  'content-type': 'text/html; charset=UTF-8',
  date: 'Sun, 09 Jul 2017 06:49:53 GMT',
  server: 'Apache/2.4.25 (Amazon) PHP/5.6.30',
  'set-cookie': [ 'AWSSELB=ADB93F691E8B6632005DF9824F3562ACCEB67F88E7B465B2F22D1801531BC80E0254C3A2266E30AA2' ],
  'x-powered-by': 'PHP/5.6.30',
  'content-length': '335',
  connection: 'Close' }
<?xml version="1.0" encoding="UTF-8"?>
<xml><messages recipientcount="1"><message><to>+918976389698</to><messageid>B758A8DD-7F95-490D-AC46-87F07B15
text><price>0.4911</price><currency_symbol>?</currency_symbol><currency_type>INR</currency_type></message></
Done
    
```

Figure 3. Server Window ScreenShot for free fall detection



Figure 4. SMS Screenshot to the Subscribed mobile number for free fall detection

Case 1(b): When 'Alert' button is pressed:

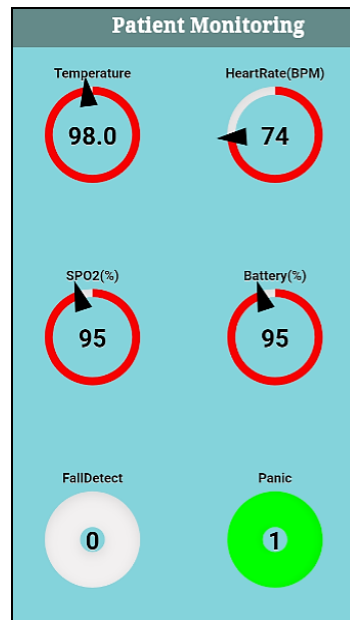


Figure 5. App screenshot for Panic Alert detection

```
Data from channel : esp_channel
Panic Alert!
sending SMS to 8976389698

statusCode: 200
headers: { 'access-control-allow-credentials': 'true',
'access-control-allow-headers': 'Content-Type, X-Auth-Token, Origin, Authorization',
'access-control-allow-methods': 'POST, GET, OPTIONS, PUT, DELETE',
'access-control-allow-origin': '*',
'cache-control': 'no-cache, no-cache="set-cookie"',
'content-type': 'text/html; charset=UTF-8',
date: 'Sun, 09 Jul 2017 06:51:39 GMT',
server: 'Apache/2.4.25 (Amazon) PHP/5.6.30',
'set-cookie': [ 'AWSELB=A0B93F691E8B6632005DF9824F3562ACCEB67F88EAD94A04ADCE78D64E67C48EDCE8AA
/' ],
'x-powered-by': 'PHP/5.6.30',
'content-length': '335',
connection: 'Close' }
<?xml version="1.0" encoding="UTF-8"?>
<xml><messages recipientcount="1"><message><to>+918976389698</to><messageid>3C13975A-09F7-4677-9C
text><price>0.4911</price><currency_symbol>?</currency_symbol><currency_type>INR</currency_type><
Done
```

Figure 6. Server Window ScreenShot for Panic Alert detection

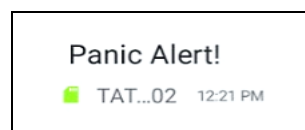


Figure 7. SMS ScreenShot to the Subscribed mobile number for Panic Alert detection

Case 1(c) : When Body Temperature Exceeded:

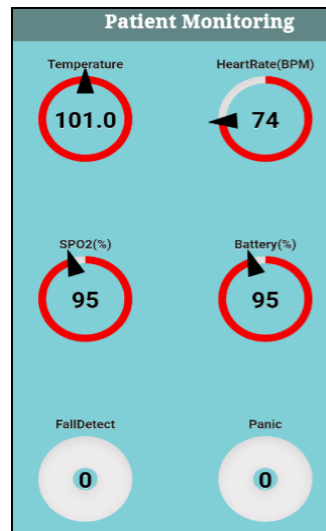


Figure 8. App screenshot for exceeded body temperature

```
Data from channel : esp_channel
Body Temperature Level Limits Exceeded!!!
sensordb DB connected!
Data Added:
{ temp: 101,
  hrate: 74,
  spo: 95,
  blevel: 95,
  sdate: '2017-07-9',
  stime: '12:24:27',
  _id: 5961d32307d63911dcfe8e3c }
sending SMS to 8976389698
```

Figure 9. Server Window ScreenShot for exceeded body temperature

```
Body Temperature Level
Limits Exceeded!!!
TAT...02 12:24 PM
```

Figure 10. SMS Screenshot to the Subscribed mobile number when body temperature exceeded its limit

Case 2: When two parameters exceeded beyond its limit:

When Heart rate and SPO₂ level crosses their sensor limits. Heart Rate (Min=62, max=80), SPO₂ (Min= 88, Max= 99):



Figure 11. App screenshot displaying exceeded limits of SPO2 and Heart Rate

```
Data from channel : esp_channel
HeartRate and SPO2 Level Limits Exceeded!!!
Body Temperature Level is Normal!
sensordb DB connected!
Data Added:
{ temp: 98,
  hrate: 99,
  spo: 80,
  blevel: 95,
  sdate: '2017-07-9',
  stime: '12:30:42',
  _id: 5961d49a07d63911dcfe8e3f }
sending SMS to 8976389698

sending SMS to 8976389698
```

Figure 12. Server Window screenshot displaying exceeded limits of SPO₂ and Heart Rate

```
HeartRate and SPO2 Level
Limits Limits Exceeded!!!
TAT...02 12:31 PM
```

Figure 13. SMS ScreenShot to the Subscribed mobile number when SPO₂ and Heart rate exceeded its limit

Case 3: When three parameters exceeded beyond its limit:

When Temperature, Heart rate and SPO₂ level crosses the sensor limits. Heart Rate (Min=62, max=80), SPO₂ (Min= 88, Max= 99):

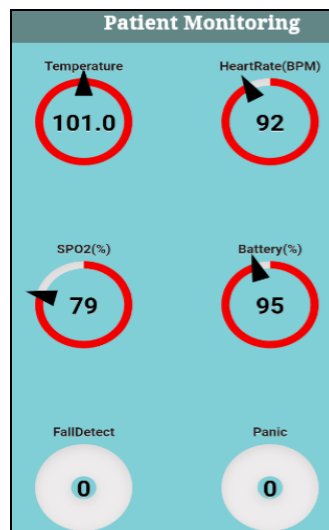


Figure 14. App ScreenShot when temperature, SPO₂ and Heart rate exceeded its limit

```
Data from channel : esp_channel
Body Temperature, HeartRate and SPO2 Level Limits Exceeded!!!
sensordb DB connected!
Data Added:
{ temp: 101,
  hrate: 92,
  spo: 79,
  blevel: 95,
  sdate: '2017-07-9',
  stime: '12:37:41',
  _id: 5961d63d07d63911dcfe8e41 }
sending SMS to 8976389698
```

Figure 15. Server Window Screenshot when temperature, SPO₂ and Heart rate exceeded its limit

```
Body Temperature,
HeartRate and SPO2 Level
Limits Exceeded!!!
TAT...02 12:37 PM
```

Figure 16. SMS ScreenShot when temperature, SPO₂ and Heart rate exceeded its limit

V. CONCLUSION

This paper proposes a system based on IoT for smart monitoring of patients from remote location. This aims to provide paramedic assistance to physician, family members and caretaker in order to provide the proper treatment to the patient well on time. Health parameters of a patient which includes body temperature, oxygen saturation level in the blood (SPO₂), heart rate and patient's fall detection are monitored and collected by proper sensor attached to the wearable wrist-band shaped health monitoring kit.

Using Wi-Fi, information collected by various sensors is transmitted to the cloud. A panic button is provided on this monitoring kit which when pressed sends the message of panic alert to the physician, caregiver, and family members of respective patient. We can therefore conclude that remote monitoring of patient is greatly enhanced by using IoT.

VI. REFERENCES

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