ISSN(Online): 2320-9801
ISSN (Print): 2320-9798

International Journal of Innovative Research in Computer and Communication Engineering

(An ISO 3297: 2007 Certified Organization)

Website: www.ijircce.com

Vol. 5, Issue 9, September 2017

Active RFID and MQTT based Child Health Monitoring system

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ABSTRACT: With the rapid burgeon in the field of portable technology and the advent of path breaking medical devices, the field of healthcare has made revolutionary improvements that have lead to ease of diagnosis and treatment for patients and of health monitoring for doctors. However, the issue of infants and new-borns getting mis-diagnosed or left un-monitored or even getting mis-identified in certain extreme circumstances, shortly after birth, has remained unsolved for long. This paper proposes a method of employing modern technology involving Internet of Things (IoT) modules based on MQTT protocol to collect and assess valuable data with minimal overhead- to remotely monitor infant health and uniquely identify each new-born in the hospital inventory. Monitoring of certain fundamental vitals such as heart rate, temperature, precipitation and perspiration levels of the infant, additionally identifying and tracking the child to instantly alert the concerned pediatrician as well as the parent, in case of any abnormality with an automated notification system, has been proposed and prototyped, which makes child health monitoring easier and more efficient for doctors.

KEYWORDS: Internet of things in healthcare; child health monitoring; RFID based medical monitoring; infant health devices.

I. INTRODUCTION

Infant health has been a long drawn concern for parents and has remained one of the major points under critical focus in hospitals, but has unfortunately never been automated or made easy to handle for medical practitioners.

In this paper we have proposed a system which would substantially lighten a parent's woes for prudent baby monitoring as well as- help doctors work more efficiently with their patients in the pediatric ward. The proposed model constantly monitors vitals which are fundamental to the well-being of any infant, such as heart rate, sweat levels and temperature, additionally enabling unique identification of each baby with the help of an RFID tag and sensors which sound an alert in case the baby falls off the crib or bed.

The parameters if normal will get updated over the cloud to an end device which is the MQTT box and any abnormality will be notified instantly to the doctor concerned. Constant monitoring will increase the probability of early detection of any adverse conditions potentially saving more lives. In addition, the sensor data can be viewed on an LCD monitor (liquid crystal display) display attached to the crib every time the RFID tag (radio frequency identification) of the child is swiped by the doctor.
Thus the proposed module plays a dual role of constant updation of all the vitals being monitored, which helps the doctor understand the infant's health-status quo, during a regular check-up when he simply swipes the RFID tag; and additionally alerts the doctors concerned in case any abnormalities are observed in the parameters monitored. The

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presence of the RFID which uniquely identifies the child helps avoid mis-identification of a child or mis-diagnosis and combats the issue of baby-swapping that may occur in certain cases, due to negligence of the hospital staff.

The content of this paper has been organized as follows: The second section is descriptive of the present practices available to monitor child health and the new advancements proposed by the system, the third and fourth sections discuss in detail, the architecture and system framework employed, the fifth section clearly delineates the algorithm used- in distinct steps and the final observations after multiple test runs, has been sampled in section six, which is followed by the possible future scope of this paper and the conclusions drawn from it.

II. BACKGROUND

At present, new born infants are constantly monitored by the hospital care takers. The infant'svitals are recorded by doctors or nurses on papers and is corroborated by manually examining the infant's records along with their respective mothers. The hospital staff solicits the security and well-being of the infants by physically being available and present at the neonatal department taking shifts or when needed.
However, constantly monitoring the ward and keeping it amply staffed by experienced doctors and nurses, may lead to an inefficiency on the part of the hospital and also increase pressure on the part of pediatricians, who may have to attend several other patients apart from the new born. Additionally, maintaining manual records may be susceptible to human errors, while taking record of the medical status of the child.
Inducing a timely check on the baby's vitals and notifying the medical personnel in case of abnormal and potentially harmful situations will substantially increase the protection for infants, and accuracy of medical diagnosis, simultaneously minimizing the pressure on manual labor as it does not demand the constant presence of the hospital staff near each child, thereby,boosting safety and reducing man power.

III. SYSTEM FRAMEWORK

In this paper, a prototype of an healthcare system for hospitals has been designed and illustrated. The concept is to continuously collect vitals of infants and keep them under continuous monitoring without the help of individuals .This system will be installed in cribs where babies can be monitored and the body vitals can be viewed on the LCD (liquid crystal display) by the doctors during their routine check-up and even monitored over the air from another end device, typically a computer or tablet (with the aid of the MQTT box) using the concept of IoT (Internet of things) . The principle of workingof the child health monitoring system is as shown in Fig.(1).

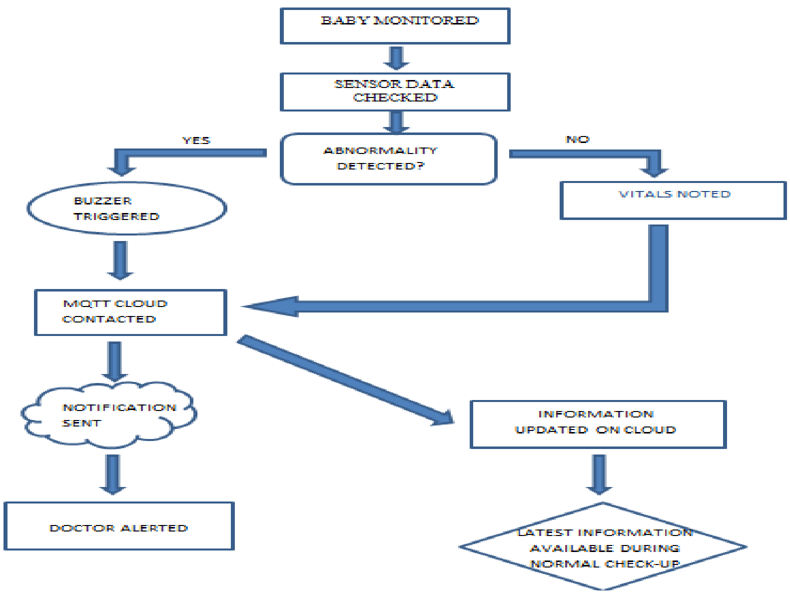

Fig (1) System Framework

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IV. SYSTEM ARCHITECTURE

The architecture of the child health monitoring system consists of both hardware and software. Block diagram is as shown in Fig.(2) and consists of the modules discussed in detail below.

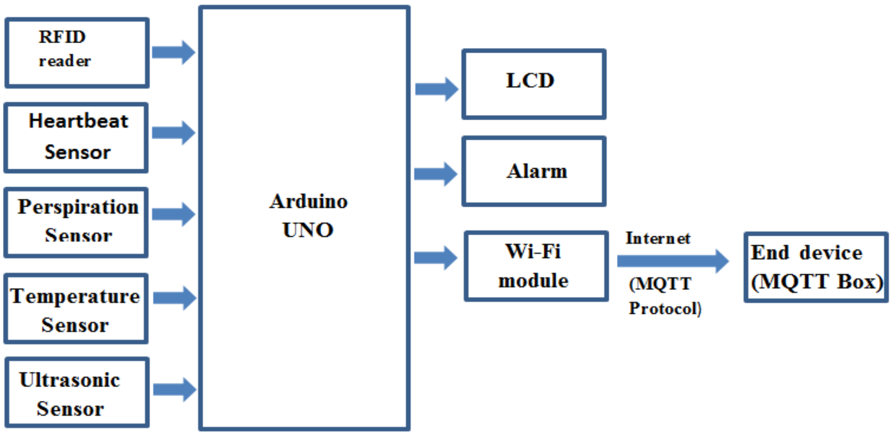

Fig (2) Hardware and software modules

The architecture of our proposed system consists of four major parts.

1. Sensor nodes- sensors for collecting the vital signals from infant.
2. Computing system, which processes the signals into interpretable data.
3. Display and alert unit-to display readings on an LCD monitor or to alert the concerned authority in case of any abnormality using buzzers.
4. Cloud computing or wireless transmission and presenting the received-over the air for remote monitoring and notification.

Hardware architecture:

1. Sensor node

The following are the sensors that have been implemented in this system and constitute the sensor node.

A. RFID:

The RFID (Radio frequency identification) works using active RFIDs. They operate at a low frequency range of 125–134.2 kHz and 140–148.5 kHz universally. The tags contain electronically stored information specific to the child in the respective crib. The active tag has a local power source of 12V AC supplied from the power supply unit in Fig.6. Active tags can be read from 100 feet or more away, the detector used in the prototype has been configured such that it detects tags less than one meter(>1m) of range.

B. Heartbeat sensor

The Heart beat sensor is designed to give digital voltage output of heat beat whenever a finger is placed on it. When the infant's finger is placed on the detector, the on-board LED flashes each time a heartbeat is detected. This output data can be connected to any device using necessary algorithms. Power requirement is a 5V DC supply.

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C. Temperature and Perspiration sensor

DHT11 is a composite, digital output temperature and humidity sensor. The DHT11 is a highly reliable sensor with an extensive lifetime. It is equipped with high temperature accuracy at 25°C ±2C and a response time: 1 / e (63%) 10S and humidity accuracy: At 25°C ±5% RH and with a Response time: 1 / e (63%) of 25°C6s. This sensor has also been calibrated to serve our purpose. Power requirement is a 5V DC supply.

Equation for display: Analog value of temperature to millivolts = Measured millivolts * 4.88

To view results in centigrade from millivolts:[(analog voltage in mV) - 500] / 10Eq (1)

Subtract the analog value of precipitation from 1023 to get the actual value of precipitation.Eq (2)

D. Ultrasonic sensor

HC-SR04 ultrasonic sensor module contains transmitter, receiver and a control circuit. The obstacle- detection range varies from (2cm-400cm).Trigger pulse generated from the Arduino board is given as the input and the received echo pulse is converted into a realizable distance value. Power requirement is a 5V DC supply.

2. Processing unit:

The Arduino Uno board is a microcontroller development board designed over an ATmega328 microcontroller with a 16 MHz resonator. It has 14 digital I/O(input/output) pins in which 6 Analog pins that can be used as PWM input and outputs. It is a fully accessible open-source project with software that is very flexible for customization and can be extended. The board can also supply a 5V and 3V3 voltage for powering up smaller components attached to it independently.

3. Display and alert unit:

The 16×2 LCD display is a basic component commonly used in all prototypes where display of information is required. The 16×2 display can print two lines of characters with 16 characters accommodated in each line. Each character is printed in a 5×7 pixel matrix. The display has two configurable registers, i.e., command register and a data register. The display unit also allows Contrast adjustment through a variable resistor inbuilt in it. The register select 'RS' is used to switch between registers:
RS=0 indicates command register.
RS=1 indicates data register.
A piezo electric buzzer is used for the sound alert, the piezo electric buzzer beeps whenever the vitals reach a user defined critical value or fluctuate out of the defined safety range. Both the buzzer and the display require a 5V DC supply to function.

4. Wireless transmission:

Internet protocol suite is employed to link numerous devices universally. Transmission of data over long distances require systems which makes use of WiFi and prefer an extremely light weight protocol called MQTT protocol over the conventional HTTP protocol. The MQTT protocol is most suited in this system which employs local monitoring over the cloud.

MQTT (MQ Telemetry Transport):

MQTT is a machine to machine connectivity protocol used for IoT applications. It works on publisher-subscriber model and is a light weight protocol (takes very less overhead) . It is hence highly effective in connecting of devices in remote locations making it essentially beneficial for constrained devices and unpredictable networks with low bandwidth or/and high latency, thereby making it more reliable and apt for use in hospitals and homes for real time monitoring.

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MQTT client- Clients are devices that have a running MQTT library and connected to a MQTT broker over a network. The clients are categorized into

- Publisher- A client who is transmitting a data .
- Subscriber – A client or a number of clients attempting to receive data

MQTT broker-A device that sends data to all its subscribed clients, it receives and filters the data. The main function of a broker is to authenticate and authorize all its clients

V. PROPOSED ALGORITHM

Step 1: RFID is swiped.
Step 2: Details of child retrieved using the RFID identification number.
Step 3: Display the details of the child on the LCD screen-on swipe.
Step 4: Analog value of Temperature is read from the Arduino board.
Step 5: Display the value of temperature using equation (1)
Step 6: Read the analog value of Precipitation from the Arduino board using the function.
Step 7: Display the value of precipitation computed using equation (2).
Step 8: Read the digital value of heart beat from the Arduinoboard using the function.
Step 9: Find the rate by finding the difference between the time1 and time 2.
Step 10: Find the rate of a single pulse.
Step 11: The final heart beat rate is found by using the formula 60000/rate of a single pulse.
Step 12: Display the heart beat rate.
Step 13: If the value of

- Temperature is more than 38 or less than 30 (OR)
- If the value of precipitation is more than 300 (OR)
- If the heart beat rate is more than 80 or less than 60
  - ⇨ the buzzer gets switched on and notification sent
  - ⇨ elsebuzzer remains off and vitals updated on MQTT cloud.

Step 14: Go to step 1.
Step 15: End.

VI. RESULTS

Results were tabulated after runs on the hardware unit, with the code burnt on the software arduino UNO version 1.6.1. The trials observed were recorded for cases where the temperature and heart rate were within normal range as well as out of range. It was observed that the system had a high success rate and the alert was provided promptly. The notification was sent without delay and there was no visible time lag or latency observed in the set module. The observations have been tabulated in fig(3). The lower limit for perspiration is not valid for check as there is no indicative medical use or diagnostic use of low sweat levels. The last column describes the response of the ultrasonic sensors fitted at the edge of the crib. In case the child moves to the edge of the bed and the path of transmission of the sensor is cut off due to the presence of an obstacle, the buzzer sounds an alert.

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PARAMETER	NORMAL	HIGH	LOW	BUZZER	ACCURACY
TEMPERATURE	32			OFF	100
		38.3		ON	100
			29.8	ON	100
SWEAT LEVEL	200			OFF	100
		302		ON	100
			NA	NA	NA
HEART RATE	72			OFF	100
		86		ON	100
			59	ON	100
BABY ON EDGE OF CRIB/ FALLS	NA	NA	NA	ON	100

Fig (3) Observed values and buzzer response

The set up in working and the hardware module in complete form is as shown below:

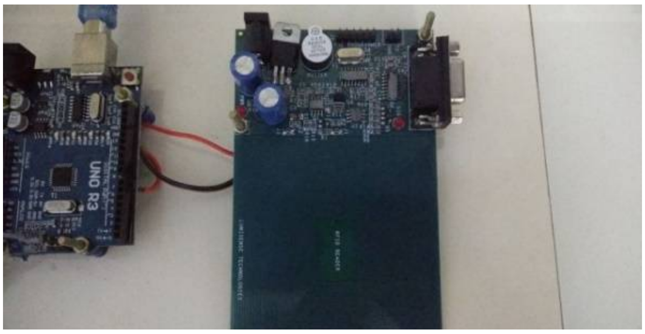

Fig (4) Arduino UNO R3 with circuitry- Top view

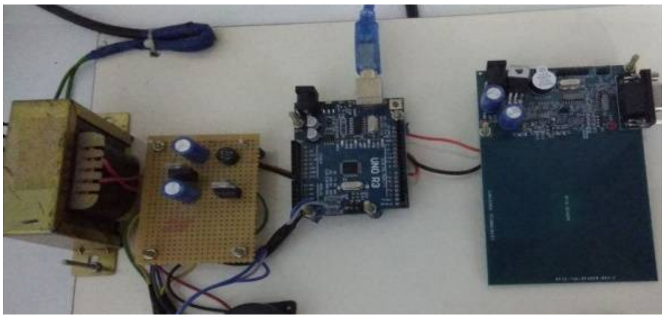

Fig (5) System hardware set up with sensor nodes-Top view

VII. CONCLUSION AND FUTURE WORK

The proposed system works efficiently in monitoring the vitals of a child and sending alert messages or notifications to the parents and the concerned pediatrician, with a high level of accuracy. The MQTT cloud which follows the MQTT protocol has minimal overhead and is the most advanced remote monitoring protocol that can be employed to a localized monitoring unit, such as a hospital or home. The module can further be extended to add a local server to track

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the history of the readings on a daily basis, and keep this information updated on the cloud, so as to analyze and generate conclusions on prolonged periods of monitoring. This analysis can be generated on the MQTT box in the form of graphs that indicate the mean-health or in the form of a normed plot, for doctors to gather a history of the baby's health. The system can also be extended effectively to monitor critically ill patients, the aged and elderly, as well as terminally ill patients who need extensive, prudent care.

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BIOGRAPHY

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