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Minor Project Report

on

Design and Prototyping of Wireless Sensor Tags

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SCHOOL OF ELECTRONICS AND COMMUNICATION ENGINEERING

CERTIFICATE

This is to certify that project entitled **"Design and Prototyping of Wireless Sensor Tags"** is a bonafide work carried out by the student team of **"Sonal Kumar (01FE17BEC187), G K Praful (01FE17BEC052)"**. The project report has been approved as it satisfies the requirements with respect to the minor project work prescribed by the university curriculum for BE (V semester) in School of Electronics and Communication Engineering of KLE technological University for the academic year 2019-2020.

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ABSTRACT

Wireless Sensor Technology is an efficient tool for precise monitoring and automatic control of any particular quantity. When many sensors need to be deployed, a Sensor Tag plays a decisive role. The project aims at building a non-invasive, wireless data monitoring, portable sensor tag. The designed Sensor Tag can monitor many physical or environmental situations. It uses RF technology for communication that has the long-range for data transmission.

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Chapter 1

Introduction

A Sensor Tag Network is a wireless network which comprises of several distributed devices such as a sensor to monitor environmental conditions, like pollutants, humidity, motion, temperature, vibration, sound, pressure at different places. Hence, a Sensor Tag Network can be formed by combining these devices, or nodes with a gateway. These nodes communicate wirelessly to a gateway through which the data is sent to another platform i.e, cloud where you can collect, process, analyze the data and notify the user about the same. The wireless sensor is scalable, networked. It is software programmable, smart, reliable, also capable of fast data acquisition and accurate for a long period . They are cost-effective and easy to install with zero maintenance [1].

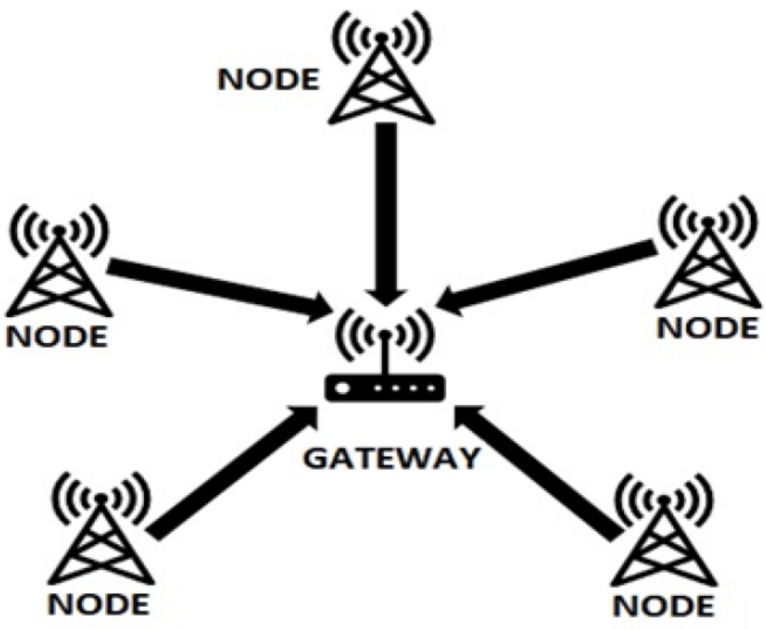


Figure 1.1: Star topology

Figure 1.1 depicts one of the most habitual networking frameworks in which each node is connected to a central network device like the hub, switch, and gateway. Each sensor node is powered by a battery, a tiny micro-controller and uses RF technology to communicate the data to the gateway. Hence tiny sized sensor nodes are to be designed which are easily attachable at any place with some disturbances to surroundings. Hence this pliability helps in reducing the cost, also the efforts in deploying and maintenance and also makes sensor tag network a competitive viewpoint for data collection compared to wired ones. The collected data is sensed, processed, transmitted and then it moves to sleep mode for a while until it generates the next sensing processing transmitting cycle or interrupt. Hence, energy consumption can be reduced by letting the sensor nodes turn to a dormant state. When the next sequence is generated, the micro-controller is wakened up to an active state, and the same process repeats.

Military appeals originally inspired the evolution of Sensor Tag Networks such as battlefield surveillance. Sensor Tag networks are being used sufficiently since then. However, sensor tag networks are now mainly used in many entreaties such as traffic control, environmental monitoring, home automation, and healthcare applications.

1.1 Motivation

Physical intimidations which lead to infrastructure failure and menace usually can't be envisaged. Considering the scenario of warehouses and industries, if there is any leakage of water or fire in the building, there will be a huge loss for the property and human beings. If all the inmates of that place are alerted to the menace quickly then there will be less probability of risk and less vandalization to the property. Sensor nodes are employed for different applications, extending from lifestyle and health to an automotive, modish building, predictive perpetuation, and RFID tags. Currently, these have bounded lifetimes and use a consequential amount of power. This motivated us to come up with a design that addresses the problem mentioned above and further uses the same concept for military surveillance, smart sensors to detect and control manufacturing prerequisites, sensor networks to monitor habitat or weather, biosensors for health applications and smart sensor domain for home automation electronics.

1.2 Objectives

The objectives for the proposed design are as follows:

- Non-Invasive sensing.
- Portable.
- Wireless data monitoring with IoT technology.
- User friendly mobile application.
- Scalability to a large scale of establishment i.e., employment.
- Effective hazard control.
- Ease of use.

1.3 Literature survey

Keeping the challenges in sensor network research areas such as signal processing methods, technologies in networking and distributed algorithms in the mind, the Defense Advanced Research Projects Agency i.e., DARPA organized Distributed Sensor Nets Workshop in the year 1978. Some other programs followed this such as Distributed Sensor Networks i.e., DSN and Sensor Information Technology i.e., SensIT program which provided new potentiality to sensor networks such as dynamic querying and tasking, reprogramming, networking, and multitasking. Hence wireless sensor networks have become the driving for the military.

The California University, Los Angeles with coordination of Rockwell Science Centre put forwarded the concept of WINS i.e., Wireless Integrated Network Sensors in the year 1996 which comprised Wireless Integrated Micro-sensor with low power. This highly smart sensing system was based on interface circuits, CMOS chip, wireless radio, digital signal processing circuits, integrating multiple sensors and single-chip micro-controller.

In the year of 1999, the University of California had come up with a new design of small sensor nodes which were called motes in the Smart Dust project. Hence this project was a milestone for showing the complete sensor system as tiny devices with the size of grains.[4]

In the year of 2000, Berkeley Wireless Research Center focused on the production of low power sensor devices in the PicoRadio project. The power used by the devices was so low that the devices could easily power themselves from easily available sources such as solar or vibrational energy.

Later on, the MicroAMPS project (micro-Adaptive Multi-domain Power-aware Sensors) was carried by MIT, which focused on hardware and software components with low power for sensor nodes. It included the use of micro-controller capable of restructuring data processing algorithms for lowering power requirements at the software level and also dynamic voltage scaling[2].

1.4 Problem statement

To develop an IoT framework based on a wireless control system that monitors physical or environmental situations with no physical interference using the LORA device and notify the user.

1.5 Application in the societal context

Sensor Tag technology has been the milestone in military applications which has its greater influence on the detection of submarines, battlefield surveillance. It also has its huge application in stockpile surveillance of weapons where micro-sensors attached to the weapons.

As the designed sensor node is cost-effective, it has potential applications for civilian purposes. Some of them are as follows:
1) Environmental monitoring:
We can use sensor tag networks in environmental monitoring for forest surveillance, animal tracking, flood detection, weather forecasting, etc.

2) Health monitoring:
We can embed sensor tag networks into hospital buildings for monitoring and tracking the patients' records. We can design special sensors to monitor Blood pressure, ECG, Body temperature, etc.
3) Traffic control
We can also use Sensor Tag networks for vehicle traffic detection and control for some time. At crossroads, we can bury sensor nodes to detect the population of vehicles and control the traffic lights.
4) Security
Sensor Tag networks cannot successfully deployed if security, privacy issues, and dependability are not addressed adequately. Sensor Tags are vulnerable and thus attractive because of the limited prices they provide intrusion detection, privacy protection, etc.

1.6 Project Planning and bill of materials

The following process was followed for the project:
1.Research on existing solutions
2.Design phase
3.Simulation
4.Implementation
5.PCB soldering and casing the module
6.Testing
7.Documentation

Table 1.1: Bill of materials

Components	Specification	Quantity	Price
ATMEGA328p	Microcontroller(node)	1	150/-
ESP32	Microcontroller(gateway)	1	500/-
HDC2080EVM	Temperature and Humidity sensor	1	4300/-
RFM98	LORA Module 868MHZ	2	2000/-
Battery	18650 3.7V 1000mAh cellLi-Ion	1	170/-
Jumper wires	MM ,MF, FF		100/-
PCB			60/-
Total		Rs	7280/-

1.7 Organization of the report

Chapter 2 : System Design
In chapter 2, the design of Sensor Tags is explained. The architecture, functional block diagrams are explained.

Chapter 3 : Implementation Details:
In chapter 3, the implementation of Sensor Tags is explained. Specifications, algorithm and flow charts are explained.

Chapter 4 : Optimization:

In chapter 4, optimization of Sensor Tags in terms of cost and size is explained.

Chapter 2

System design

System design involves the explanation of the architecture or the outline of the project's hands-on tools, the data used, the interfaces being done, and overall the specifications of both hardware and the software. We have divided the system design into 2 different peripherals, namely:
1) Hardware system design.
2) Software system design.

1) Hardware system design:

The hardware system comprises sensor nodes and a gateway. The sensor node has ATMEGA328p with an RFM98 transmitter and a dedicated sensor. Gateway has ESP32 with RFM98 receiver and a Wi-Fi module.

2) Software system design:

The software system consists of sensing the events or hazards and sending the sensed data to the gateway through LORA. The gateway publishes it to the cloud and notifies the user through the AWS platform.

2.1 Architecture

Figure 2.1 shows the system architecture of the Sensor Tags where it is composed of three main components: Sensor node, Gateway, and a web server. Sensor nodes are placed at the places where monitoring is needed and comprise several hardware components that include an embedded processor, a transceiver and one or more sensors and a power source. The Gateway receives the data from the transmitter and publishes it to the cloud. The cloud stores the information of the sensor nodes and notifies the user. The end users are notified through the mail and push notifications.

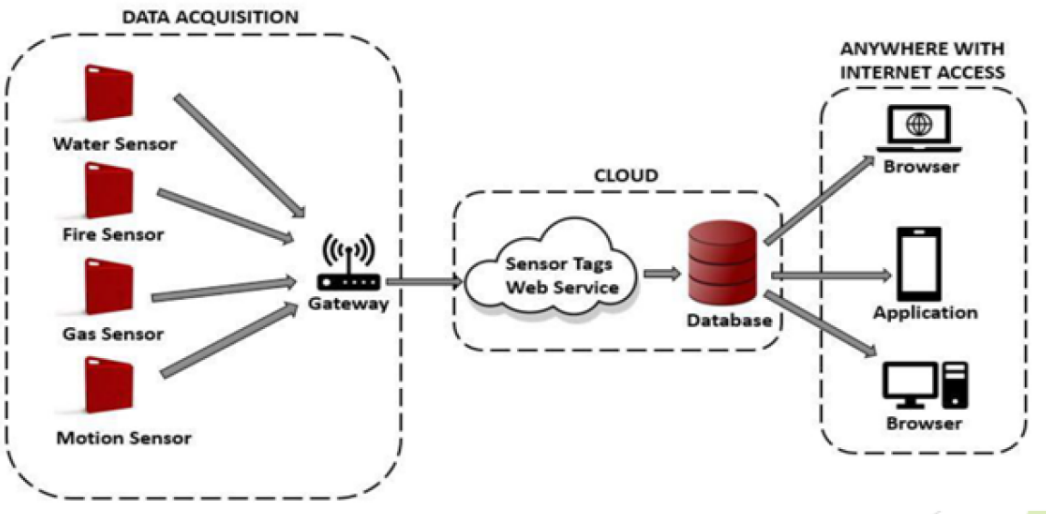


Figure 2.1: Architecture of Wireless Sensor Tags

2.2 Functional block diagram

Figure 2.2 depicts a block diagram of a sensor node that comprises a sensor that senses the physical events if generated. It then sends the data of the sensed event through an atmega328p controller embedded with RFM98 which acts as a transmitter. The sensor node is powered through a battery.

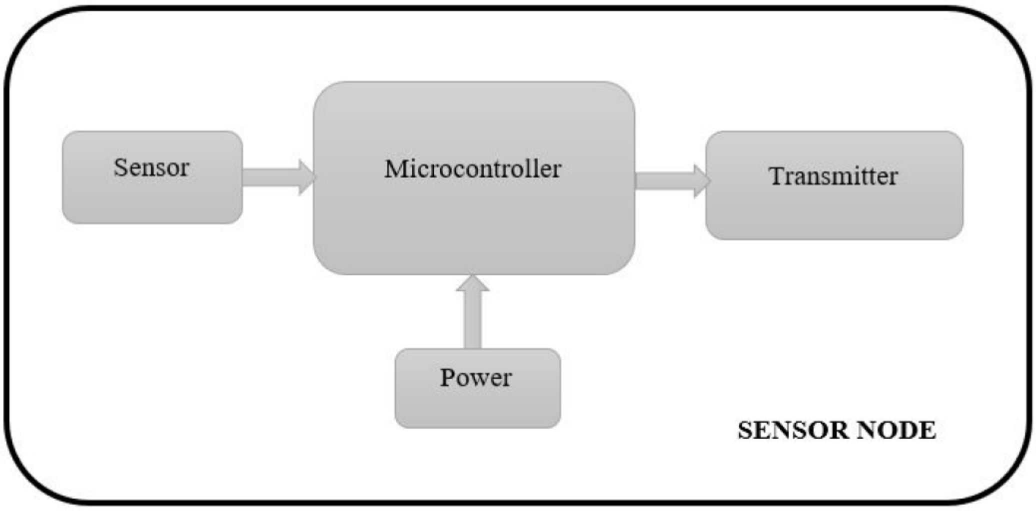


Figure 2.2: Block diagram of Sensor Node

Figure 2.3 depicts a block diagram of gateway which has ESP32 controller with RFM98 that receives the data sent through the transmitter. The receiver sends the data to the WiFi module that is ESP32 which publishes that data to the AWS cloud.

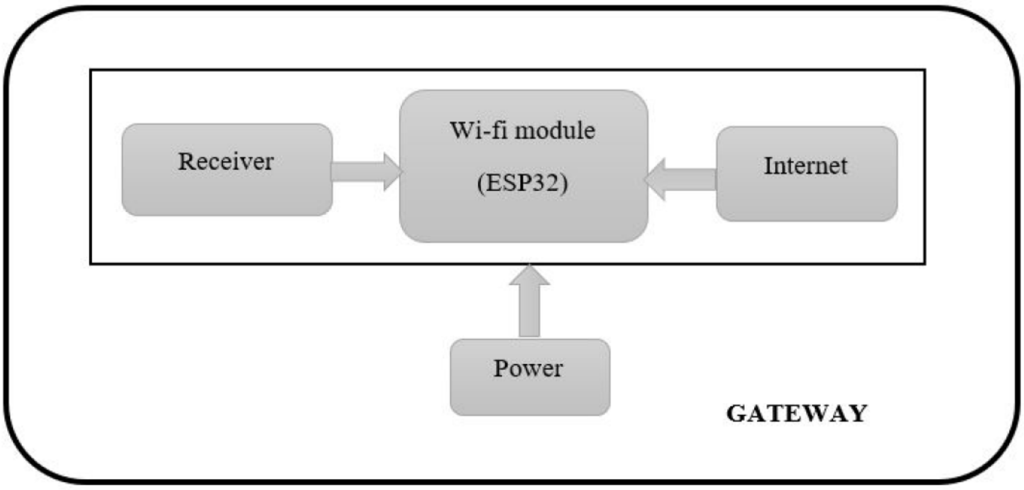


Figure 2.3: Block diagram of Gateway

2.3 Morphological chart

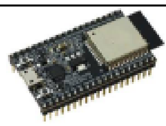
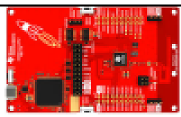
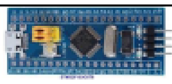
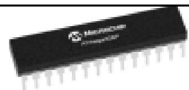
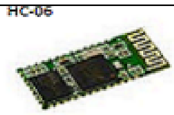
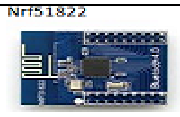
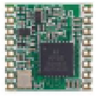
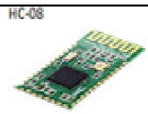
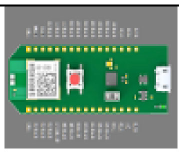
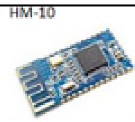
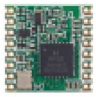
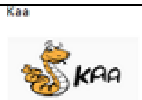
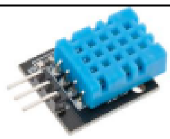
Functions/Means	Option 1	Option 2	Option 3	Option 4
Controller	 ESP32	 CC2640	 STM32	 ATMEGA328p
Wi-Fi module				
Transmitter				 RFM98
Reveiver				 RFM98
Storage and analysis				
Temperature and Humidity Sensor	 HDC2080	 DHT11		

Figure 2.4: Morphological Chart

A morphological chart is a visual way to capture the product functionality and explore alternative means and combinations of achieving that function. In the above chart, the necessary products used in the project are highlighted.

- Controller: ATMEGA328p.
- Wi-Fi Module: ESP32.
- Sensor Node: ATMEGA328p.
- Gateway: ESP32.
- Storage and Analysis: Amazon Web Services.
- Sensors: HDC2080.

Chapter 3

Implementation

3.1 Specifications and system architecture

The proposed system architecture consist of several components such as ATMEGA328p and ESP32 with RFM98 and sensors. The cloud database comprises Amazon Web Services like DynamoDB, AWS Lambda, and other services. The hardware section is divided into two parts:
(1) Sensor Node. (2) Gateway.
Sensor Node consists of RF module and a controller. Gateway consists of RF and a Wi-Fi module

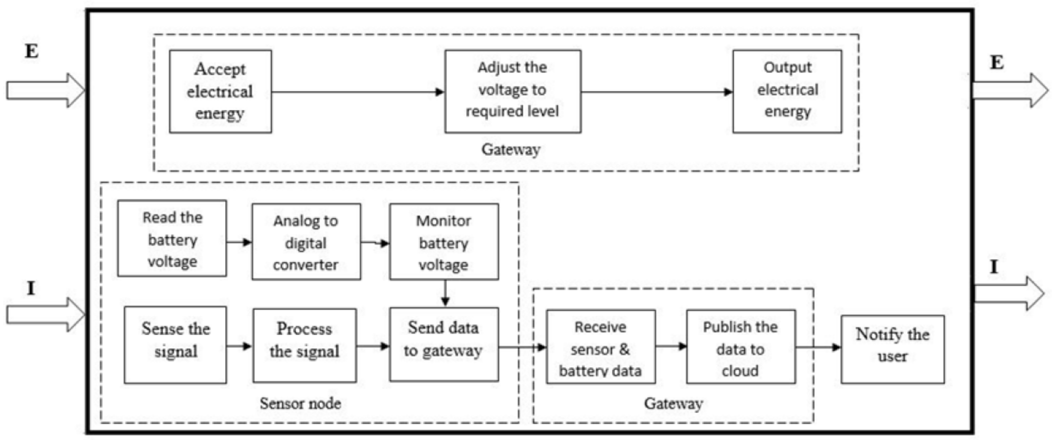


Figure 3.1: Whitebox of proposed solution

Figure 3.1 depicts the white box of the proposed solution where 'E' represents Energy information and 'I' represents Information from sensors. The system adjusts the input voltage to the required level and collects the information and sends it to the gateway. And then the gateway publishes the information to the cloud and notifies the user.

3.2 Algorithm

Step 1: START
Step 2: The sensor nodes keep a track of the physical events occurring in the surrounding with the help of prescribed sensors.
Step 3: If there occurs any physical anomaly, the information of the event occurred is sent to the gateway.
Step 4: The gateway receives the data.
Step 5: Gateway sends the data to the cloud.
Step 6: If the attempt to publish the data to the cloud fails, it tries to reconnect
Step 7: If the attempt is succeeded, the data is published to the cloud, and the user is notified of the event that occurred.
Step 8: STOP

3.3 Flowchart

Figure 3.2 refers to the flowchart of the algorithm explained above. The several events occurring in the surroundings are sensed using the sensors like humidity and temperature Sensor. Whenever the anomalies occur, the sensor node senses the event and the particular data is sent to the gateway which is at some distance from the sensor nodes. Then the gateway tries to connect to the cloud. If the connection is established, then the user is notified about the event through push notifications and mail. If the connection is failed at that moment, the data at the gateway is queued and whenever the connection is re-established, the event is notified.

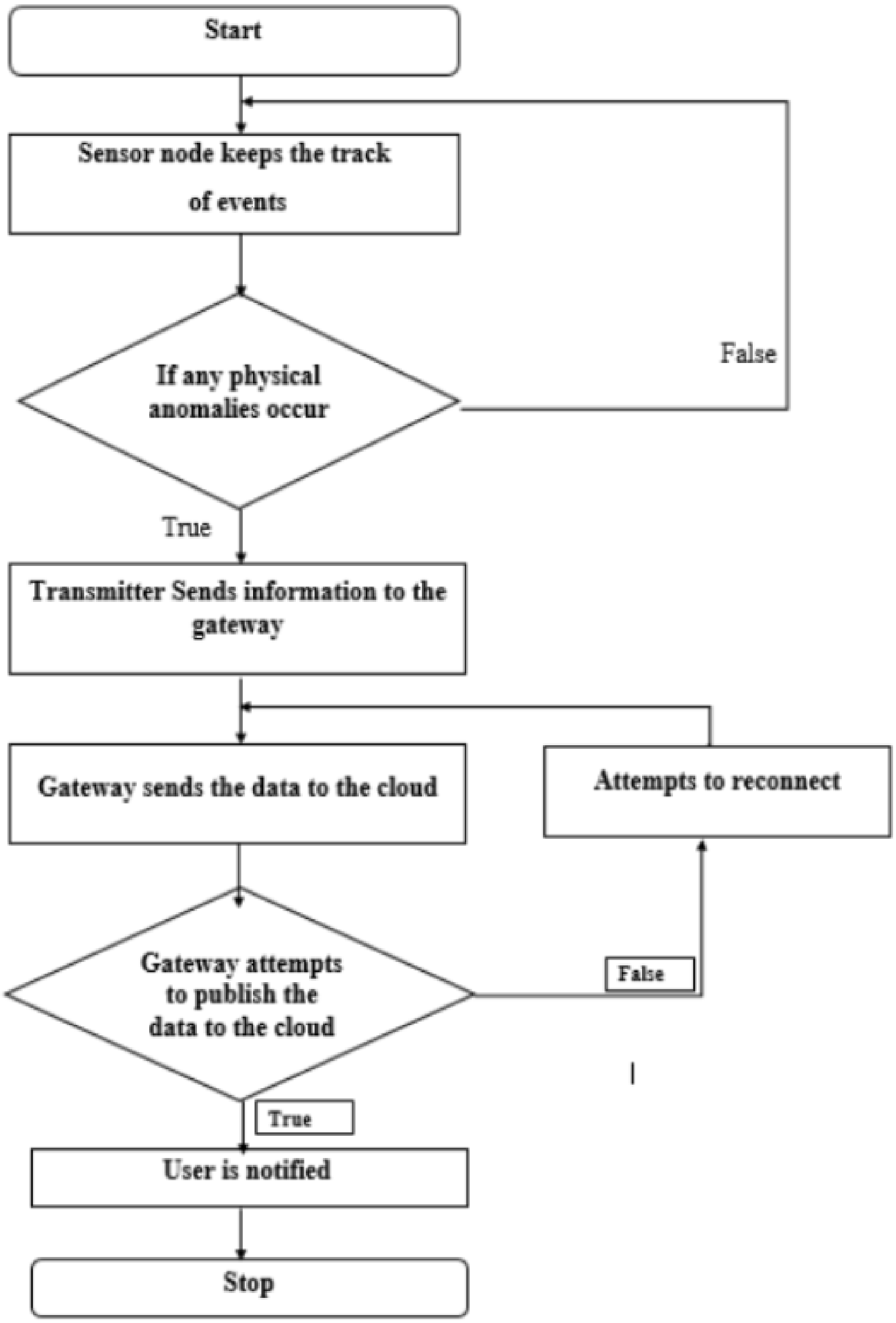


Figure 3.2: Flowchart of proposed architecture

Chapter 4

Optimization

4.1 Introduction to optimization

In an initially proposed architecture and proof-of-concept i.e., POC, pro mini boards along with HM10 module were used at sensor nodes which were not so fast and short-range. Now we use the rfm98 module for communication which has a range of over 100 meters. We will keep the atmega328p in the deep sleep mode most of the times which will consume less than 10 micro-amperes of currents during sleep. Before extending the previous work, the maximum distance achieved between the Transmitter and Reciever was less. Now we can get maximum distance achieved is approximately 100 meters.

The sensor nodes detects the interrupt and notifies the user about the same and remains idle most of the time. Hence we use external interrupts that detect the interrupts only when raised and goes to sleep for the rest of the time. It can detect the interrupt even when the processor is in the sleep mode. Watchdog timer interrupt is used to put the processor into the sleep mode and wake it up periodically to update the status of the battery.

4.2 Types of Optimization

- Global declaration
- Modular approach.
- Dead code Elimination
- Consolidate Repeated Code
- Power Optimization

4.3 Selection and justification of optimization method

Power Optimizatin - The node will go to deep sleep mode when it has to send the data and will awake once there is the external called or after a given time cycle. The sensor and transmitter will be powered by the internal pins in the controller now the sensor and the transmitter will awake only when the controller will be in active mode and will go to sleep when the controller will be in the sleep mode.

Chapter 5

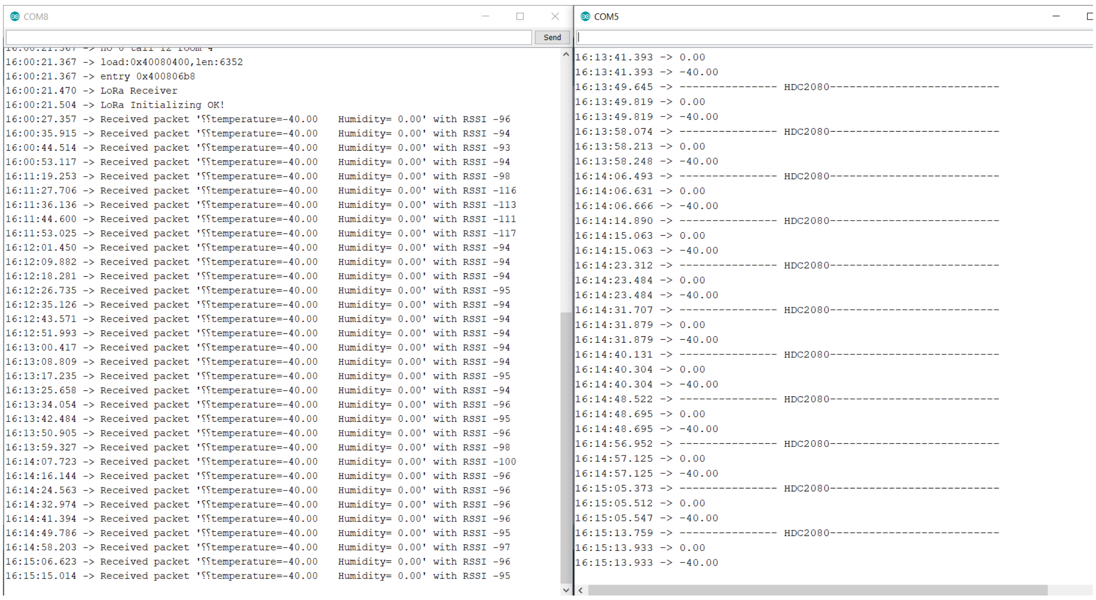
Results and Discussions

5.1 Result Analysis

Let us consider first sensor node for the analysis.

The vale of the sensor can be get through the uart and later can be uploaded to the aws.

The below figure shows how the output will occur through the the uart in the monitor screen which can further be used for uploading to the cloud.



5.2 Discussion on optimization

We have used dead code elimination and modular approach in our codes for optimizing our codes. Dead code elimination reduces the size and memory of the code and hence reduces the time taken for the implementation of the code.
By using the Modular approach of coding the code becomes accessed through the single shot, will allow easy debugging, we can reuse the function as many times we need, and

will be easy to maintain.
Power optimization has been introduced to reduce the power consumption by the module and make the module run for more time.

Chapter 6

Conclusions and future scope

6.1 Conclusion

We conclude that using the method of wireless sensor networks we can detect the hazardous things and notify the user about the event occurred. The usage of RF module further reduces the power consumption of the system and increasing the life of the sensor node. The Low-cost PCB is designed considering the peripherals needed for the system and hence size of the sensor node. It is smart, reliable, capable of fast data acquisition and accurate for a long period. It costs less easy to install with zero maintenance and does not disturb the ambiance. Hence the specifications are met according to the objectives.

6.2 Future scope

Presently there is onle one sensor node is connected to the gateway. In the future, the number of sensor nodes can be increased. The data can be further sent directly through the push notification or the application. In future power consumption and cost can be reduced.

Bibliography

[1] http://wirelesstag.net/

[2] https://www.instructables.com/id/make-iBeacon/

[3] https://ladvien.com/robots/advancedish-hm-10/

[4] https://www.google.com/url?sa=t&source=web&rct=j&url=http://www.blueluminance.com/HM-10-as-iBeacon.pdf&ved=2ahUKEwjJ286ozq3fAhWIP48KHTleAvwQFjAAegQIAhAB&usg=AOvVaw2io-CexoG_FIITE4bR_EeD

[5] Design challanges in wireless fire security sensor nodes. *International Journal of Embedded systems and Applications(IJESA)* Vol.5, No.2, June 2015 .