Website: www.aceiot.ur.ac.rw
Mail: aceiot@ur.ac.rw

College of Science and Technology

AFRICAN CENTER OF EXCELLENCE IN INTERNET OF THINGS

Research Thesis Title: IoT BASED SMART CRADLE FOR BABIES

A dissertation submitted in partial fulfillment of the requirements for the award of masters of Science degree in internet of things: wireless intelligent sensor network

Submitted By:

Name: Theodette UWIMBABAZI (Ref. No: 221003975)

December, 2022

UNIVERSITY of RWANDA

ACEIoT

Website: www.aceiot.ur.ac.rw
Mail: aceiot@ur.ac.rw

College of Science and Technology

AFRICAN CENTER OF EXCELLENCE IN INTERNET OF THINGS

Research Thesis Title: IoT BASED SMART CRADLE FOR BABIES

A dissertation submitted in partial fulfillment of the requirements for the award of masters of Science degree in internet of things: wireless intelligent sensor network

Submitted By

Theodette UWIMBABAZI (REF.NO: 221003975)

Supervised by:

Name of Main Supervisor: **Dr. Omar GATERA**
Name of Co - Supervisor : **Dr. Christine NIYIZAMYIYITIRA**

December, 2022

DECLARATION

I, **Theodette UWIMBABAZI** ,Masters 'student from African Centre of Excellence in internet of things (Ref. No:221003975), declare that the research thesis titled "**IOT Based Smart Cradle for Babies** " for the award of a Master's degree in Internet of Things- Wireless Intelligent Sensor Networking is my original work and has never been presented in any University or Institution for the same purpose.

Theodette UWIMBABAZI

Ref.No: 221003975

Signature:

Date :17th July 2023

Bonafide Certificate

This is to Certify that the submitted Research Thesis work report is a record of the original work done by **Theodette UWIMBABAZI (Ref. No: 221003975)**, MSc.IoT. WISENET student at the University of Rwanda /College of Science and Technology /African Center of Excellent in Internet of Things, The Academic year 2020-2023.

This work has been submitted under supervision of **Dr. Omar GATERA** and Dr. **Christine NIYIZAMYIYITIRA**

Main Supervisor: **Dr. Omar GATERA** Co – Supervisor : **Dr. Christine NIYIZAMYIYITIRA**

Date :17th July 2023 **Date :17th July 2023**

Signature: **Signature:**

The Head of Masters and Training

Dr. James Rwigema

Date :7th November 2023

Signature:

ACKNOWLEDGEMENT

First of all, I would like to thank God for all the blessings, guidance and protection during my studies. My deep gratitude and acknowledgements are also expressed to my supervisors, Dr. Omar GATERA and Dr. Christine NIYIZAMWIYITIRA for devoting their time to supervise and monitor this project. Their guidance, responsibilities, several meetings for feedback, and advice to me all helped to successfully complete this project. My sincere thanks are conveyed to my lovely husband for their love, spirit, devotion, and courage in providing me several types of assistance so that I could complete my studies.

Also, my sincerely appreciation goes to World Bank through the inter University Council for East Africa who are my sponsor, they have turned my Masters journey to the best part of my academic life.

Thank you to everyone who gave me their thoughts in order to assist me in achieving the thesis's goals. May God continue to bless them.

Abstract

In recent years, taking care of babies has gotten harder for working Women to monitor their babies all time. They hire a babysitter or leave their Child with grandparents. The proposed effort builds a smart Cradle for monitoring babies Health, in the baby monitoring system some parameters will be sensed with using different sensors such as heartbeat sensor, Dallas sensor, smoke sensor, sounds sensor, light sensor and GSM Module to sense data with Arduino Nano as Microcontroller. The sensed data is sent to the cloud using GSM Module. The cloud data is stored, processed, analyzed and then sends to the parents in case of irregulating sensed data system give an alert notification in real- time. There is a Camera for Visual baby monitoring, and Fan for regulating temperature.

There will be two temperature sensors used that are DHT11and Dallas, where DHT11 will check the ambient temperature especial inside of cradle and whole of room, Dallas senor will measure body .The proposed system prototype is fabricated and tested to prove its effectiveness in terms of cost and simplicity and to ensure safe operation to enable the baby – parenting anywhere and anytime through the Internet of Things. Finally, the baby Health monitoring system is proven to work effectively in monitoring the baby's situation and surrounding conditions according to the prototype. Smart Cradle will have two ways of charging such as Battery, and Electricity. The Smart Cradle is an IoT-based real-time monitoring solution with the best security.

Keywords: smart cradle, IoT, Baby monitoring system, voice assistant, cry detection. GSM Module.

List of Figures

List of tables

List of Acronyms and Symbols

GSM- Global System for Mobile Communications

GPS- Global Positioning System

IoT- Internet of Things

API-Application Programming Interface

IDE- Integrated Development Environment

LCD- Liquid Crystal Display

PDL - Program Design Language

SMS- Short Message Service

OLED: Organic Light-Emitting Diode

SCBM: Smart Cradle Baby monitoring

TABLE OF CONTENTS

CHAPTER 1: GENERAL INTRODUCTION

1.1 Overview and Background

We all know that IoT stands for "the Internet of things, “which is supposed to save time and make work easier and more accurate [1]. We will use the Internet of Things (IoT) to build a Smart Cradle system that will save parents time and be safe and secure for the baby. [2]So, getting work done on time and taking care of the baby are important. If both parents work or if the mother is a housewife, the Cradle system will give them the time they need to rest. [3]In the last three years, there has been a huge increase in number of single-parent families and a huge shift toward both parents working. Families with two working adults making more money, but taking care of a new baby are big and hard challenges. The internet of things could be used in this way to let parents work while still keeping a close eye on their babies. IoT is network of things that are connected to the internet. Parents who are busy at work or at home would benefit a lot from being able to use sensors and detectors to control important system functions such as playing a lullaby through the speakers; Streaming baby position inside of Smart Cradle and so on. The main goal of this study is to turn archaic Cradles into Smart ones that can monitor baby health. A review of the research shows that new technologies aren’t used to check on the Health of babies [4]Especially in Rwanda, where traditional methods are used instead [5].The traditional Cradle system has some problems, such as: they have to swing by hands, which can take time and be hard for mothers who have other things to do around the house. They are are hard to get around .In the research I‘ve seen the holes in the current system that affect baby health by 98percent [6] . For example, the babies cannot be comforted when it cries, even if it knows how the heart beat and not be able to know the position of baby inside of cradle .Now I will solve that problem 99percent of the way by making a smart cradle that can monitor some parameters like the baby's heartbeat, ambient temperature, body temperature, crying, play the baby's music, monitor smoke level. This proposed system would give parents a chance to relax and worry less about their baby’s wellbeing while they are away, since they would get updates on how the baby is doing. Another benefit is that alert messages will be sent out if the sensors pick up on any strange behaviour. We used IoT to build a baby monitoring system with multiple sensors into this smart Cradle.

Many of IoT devices are being develop in the IT Sector. There are some cradles also, which are built with integration of IoT, but still there are some less feature which could be threat to the health of the babies. As we have seen in Indian or any other industrializing nation that both the parent need to go to work and also look after the baby which increase workload on both the parent, it could also affect their professional life and their baby's life. Due to less featured cradle systems and parents busy schedule we are implementing modern day Cradle system.

1.2 Problem statement

Many parents these days go to work to earn a living for the family, so they don't take care of their children. The childcare worker do not take care of them , This challenge provide high risk of missing bay health as we understand on Radio and Television where some childcare workers kill the children or keep them at home alone where they can even die because of the lack of parental care. Now Mother always worries about the well-being of their babies [7].

They use traditional method to monitor their baby's health status, when there is anomaly in the health state of baby, there is no way to notify parents or childcare. In additional they do not have real time monitoring system to monitor baby health status. This shows that they need an established of strong Baby health monitoring system to monitor Baby health status such as Heartbeat, body temperature, ambient temperature, sound level and steaming baby position into Smart Cradle [8]. The system will help parents remotely monitor the health of their babies and send real time data using IoT.

1.3 Study objectives

1.3.1 General objective

The main objective of this project is to Design, develop and implement an **IoT based Smart Cradle** that can be able to monitor the health and safety of babies and send real time data using IoT.

1.3.2 Specific Objectives

To achieve our general objective, specific objectives that have to be achieved are as follows:

To design a system to monitor baby health

To review the existing literature on how baby health are monitored

To design an IoT system that will notify the parents about health status of their babies

To develop IoT baby health monitoring system using parameters like temperature, heartbeat, sound, light, smoke and stream the position of baby inside of Cradle.

1.4 Hypothesis

The hypotheses for the study were: 1) There are no existing architectures for integration of IoT into existing baby health monitoring systems.2) It is possible to use IoT technologies to develop a real –time baby health monitoring system.

1.5 Study Scope

The thesis was focused on monitoring the baby health by monitoring parameters such as Temperature, heartbeat, sound, light, smoke and Streaming baby position inside of cradle. Data was collected from baby. Within the implementation of a prototype, the solution will eliminate the gaps existing in the literature during the baby health monitoring.

1.6 Significance of the study

This system is going to develop a working environment in our country that helps parents who have a job to take care of their baby's health in real time wherever they are and do their work well and quietly. So they can be productive in the companies that work within because they have safe mind where they are able to monitor their babies in real – time.

1.7 Organization of the Study

The rest of the study is organized as follows:

Chapter 1: Presents introduction, which includes the background of the study, problem statement, general objective, specific objectives, hypothesis, scope, significance and organization of the study.

Chapter 2: Presents a review of related literature.

Chapter 3: Outlines the methodology applied in the study.

Chapter 4: Presents the data finding and analysis.

Chapter 5: Presents the system design.

Chapter 6: Presents the results and analysis and the proposed architecture and lastly conclusions and recommendations.

CHAPTER 2 LITERATURE REVIEW

This chapter consists of the presentation of previous works done on monitoring Baby Health, and it concludes by identifying the gaps of presented approaches. A review of relevant literature is conducted to generate a picture of how baby Health is monitored with using Smart Cradle.

2.1 IOT in Baby health monitoring

Nowadays many researchers are very interested with real time solutions, looking for ways to help different people, such as working parents to get better technology of monitoring their babies. [9] In this research paper authors states that system is designed monitor baby movement, bed-wet condition and body temperature. System was giving Three modules that was obviously good point. But there was absence of one important module of swinging Cradle automatically.

2.2 Babies health monitoring challenges

Traditional cradle is an infant bed which is generally contain many challenges such as:

They need to swing manual which can be time consuming and difficult for mother carrying other home duties. They have some safety related issues. Baby can get injure by falling out of hammock. They are not comfortable for babies [10].

2.3 Related Literature

Few studies have investigated the possibilities of automated baby cradle using different perspectives. A baby monitoring system has been proposed in [11], in which an enhanced noise cancelling system that monitors the baby and reduces sound pollution has been suggested. The main function of the system is to reduce the noise that might disturb the baby by playing relaxing songs. This system can also adjust the room's light intensity with the aid of a light sensor. However, our system has more advanced features, such as supporting real-time monitoring over the IoT network and vision monitoring using web camera.

Goyal and Kumar [12] introduced an E-baby Cradle that can swing automatically when it detects Crying and stops swinging when the crying stops. The speed for the swinging cradle can be

controlled based on the user's need. It has an alarm embedded in the system, which notifies the user when two conditions occurred. First, the alarm goes off when the mattress is wet, indicating that the mattress should be changed. Second, when the baby does not stop Crying for a certain time, the alarm alerts the parents to attend to their baby. However, it is only applicable when parents are near the cradle, because it only uses a buzzer alarm, the sound of which might frighten the baby. Parents cannot monitor their baby when they are away from home, for example when at work or when traveling to other places.

A similar automatic baby monitoring system was proposed in [13]. The authors developed a low-budget system that swings the cradle when the Crying sound is detected, and the Cradle stops when the baby stops crying. The built-in alarm goes off under either one of the following conditions: After a particular amount of time, the baby's sobbing hasn't stopped or the mattress is moist. To keep an eye on the child, a video camera is positioned above the cradle. However, the parents are unable to operate the system and can only receive SMS notifications. As a result, the suggested solution in the current study is more sophisticated because it makes use of an Internet of Things application to remotely monitor and control the created smart cradle in real time.

An Arduino- based resonant Cradle designed with infant crying recognition was proposed by [14]. A ball bearing design is adopted to reduce system damping and allows the cradle to swing freely even without electricity. Subsequently, an appropriate sensor is designed to detect the Swinging status or angle. The authors claimed that their system is energy saving and allows parents to record infant cries due to hunger or pain on an SD card stored in an SD module. However, such local control solution is inappropriate when parents are located slightly far from their babies, because it does not allow updating of the date in the IoT server or controlling the cradle remotely.

D.M.J.a.A.I.Jhun [15]Design a system for baby monitoring based on Raspberry pi and pi camera. The designed system can spot the motion and crying condition of the baby. They used condenser MIC to spot the crying condition and PIR motion sensor to spot the baby movement with the help of pi camera. The camera is turned on only when the condenser MIC detects sound and sends a signal to Raspberry Pi. However, the output of this system is only available on monitor display; thus, the parents can only view the data on a limited number of devices within a fixed area.

A baby condition monitoring system based on GSM network was proposed in [16]. The author's built a prototype that can measure infant's pulse rate, body temperature, movement and moisture

condition and send information through GSM network. It consists of Sensors, LCD Screen, GSM interface and buzzer, which are controlled by a PIC 18f4520 8-bit Microcontroller. The LCD module display the sensor readings and the GSM interface sends an SMS alert to the parent's mobile number. Although the system was proposed to monitor the baby's condition, appropriate control actions are required to make accurate readings, given that the baby could have crawled around and the sensors may have been detached. The System should be improved in terms of safety, cost effectiveness and user- friends.

Saadatan et al. [17]proposed a mobile- based system that updates parents about the infant's status. The System measures the temperature, motion and heart rate and then sends the data to a server to be analysed. The analysed data will then be sent to the parents and generate alert if any abnormality is found. In this modern area, parents are busy building their lifestyle, carrier etc.

As we know it has now become hard because parents have to take care of their children simultaneously, which paves a lot of work pressure and family pressure especially for women. Health of the child is affected and better care has also reduced. So, in order to handle such situation, we use temperature, Humidity, Ultra-sonic Sensor. The conditions of the external atmosphere help to detect increased body temperature, baby's voice while crying and their movements while they are continuously moving and also indicates the time for the diaper to be Changed. If there are any abnormal activities are observed in baby's atmosphere. An alert message is sent to the parents. In this system a video camera is attached and operated under the microcontroller's instruction and it records a video when the motion sensor detects any continuous movements. The recorded video is broadcasted in a display to the parents which helpsthem to monitor baby in live. And in addition, this system detects and displays the status of the infant and alert the respective guardian by collecting values from sensor like temperature sensor,

Ultrasonic sensor, and also the location value from raspberry pi. In this modern era, parents are busy building their lifestyle, carrier etc.

As we know it has now become hard because parents have to take care of their children simultaneously, which paves a lot of work pressure and family pressure especially for women. Health of the child is affected and better care has also reduced. So, in order to handle such situation, we use temperature, Humidity, ultra-sonic Sensor. The conditions of the external atmosphere help to detect increased body temperature, babies voice while crying and their

movements while they are continuously moving and also indicates the time for the diaper to be changed. If there are any abnormal activities are observed in baby's atmosphere. An alert message is sent to the parents. In this system a video camera is attached and operated under the microcontroller's instruction and it records a video when the motion sensor detects any continuous movements. The recorded video is broadcasted in a display to the parents which helps them to monitor baby in live. And in addition, this system detects and displays the status of the infant and alert the respective guardian by collecting values from sensor like temperature sensor, ultrasonic sensor, and also the location value from raspberry pi.

In this modern area, parents are busy building their lifestyle, carrier etc. As we know it has now become hard because parents have to take care of their children simultaneously, which paves a lot of work pressure and family pressure, especially for women. Health of the child is affected and better care has also reduced. So, in order to handle such situation, we use temperature, Humidity, ultra-sonic Sensor. The conditions of the external atmosphere help to detect increased body temperature, baby's voice while crying and their movements while

they are continuously moving and also indicates the time for the diaper to be changed. If there are any abnormal activities are observed in baby's atmosphere. An alert message is sent to the parents. In this system a video camera is attached

And operated under the microcontroller's instruction and it records a video when the motion sensor detects any continuous movements. The recorded video is broadcasted in a display to the parents which helps them to monitor baby in live. And in addition, this system detects and displays the status of the infant and alert the respective guardian by collecting values from sensor like temperature sensor, ultrasonic sensor, and also the location value from raspberry pi.

2.4. Status of the new Project

The current system is able for sensing some parameters such as Heartbeats, body temperature, ambient temperature, Smoke, Light, Noise, and GSM used to send notification to parents in case one of the listed parameters is not normal, there is also a camera to see the position of baby to make sure if the position of baby is comfortable. All sensed data will be displayed to the O LD after processed by microcontroller.

2.5 Summary

The above studies and most of others have contributed to improve health monitoring using IoT have restrictions as majority of them were carried out on population from developed notions and therefore They is time consuming, not easily to monitor baby health, more parents are disturbed in their jobs; they do not alert notification to parents and most lack the monitoring baby movement inside of Cradle.

CHAPTER 3 RESEARCH METHODOLOGY

3.1 Research Design and Tools

This chapter presents how research was conducted to achieve the stated objectives. A mixed research tools was used for better understanding the existing Baby Health Monitoring Systems and yield more complete evidence for integration of IoT in baby health monitoring in developing countries. Data was collected from working parent in Rwanda from different locations during the period of September October 2022.

Observation, interview, documentation analysis guides were used as the main tools for collecting data.

The selection of those tools was guided by nature of the data to be collected, time available as well as by the objectives of the study.

The Observation Method: During the observation, the research data findings were based on seeing the way of monitoring health of babies were the working parents locate in Rwanda.

Therefore, the research made indicates that:

The majority of working Parents utilize more time for their babies health monitoring.

Parent visit their babies physical to give them parental care.

The existing system that is currently in use indicates that there is still problem of monitoring health of babies for better providing them good Health by getting real time information about their health status anywhere at any time.

Due to those difficulties or challenges on monitoring health of babies, the new system will come up with the aim of improving the way of monitoring babies Health.

The study targeted on the working parents with babies aged between 3Months and

6Months who decide to let babies stay at home alone, this can cause high risk to the baby health. In this study we expected to collect data from biological sensors such as heart beat, body

temperature, and sound sensor and to stream baby position and then send notification to the parents.

3.2 Embedded System Design

In this section the embedded system level design is presented; First system architecture is outlined followed by the system design. The system components, system PDL flow chart and are presented.

3.2.1 System Architecture

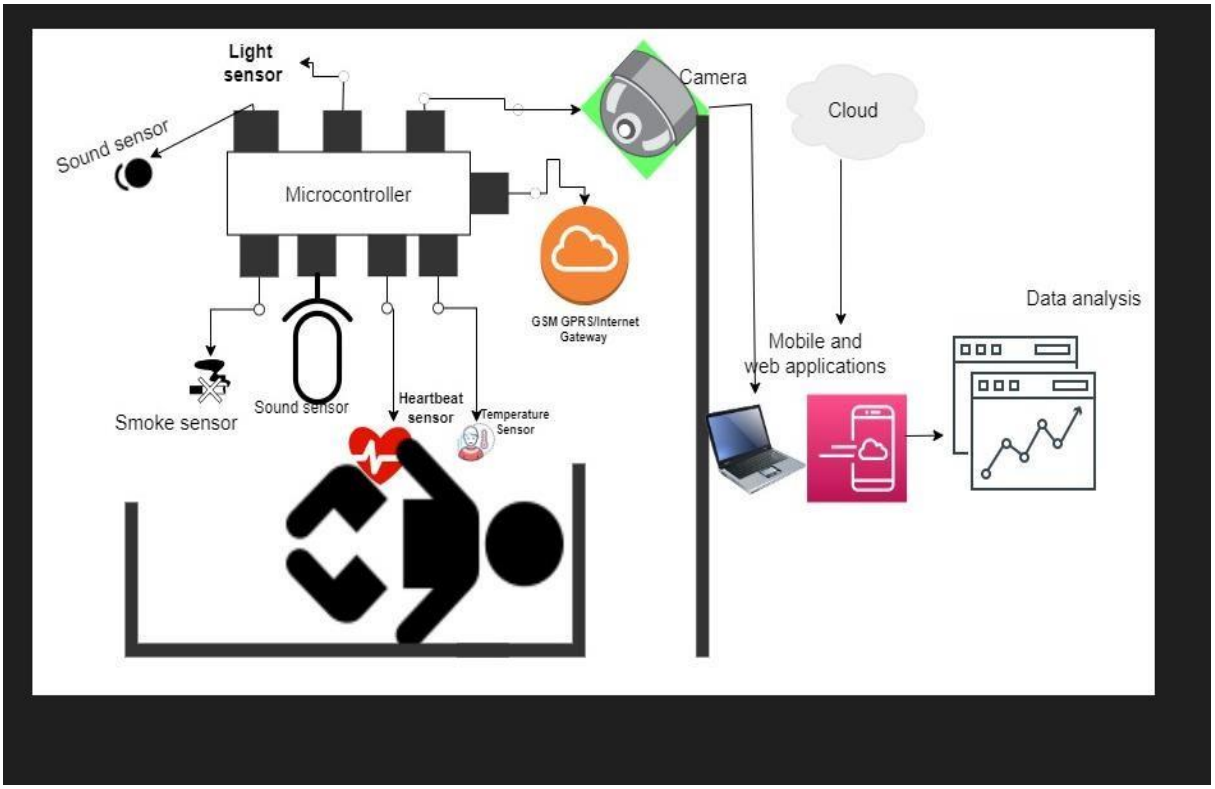


Figure 1: System architecture

Figure 1. Give the system architecture. The main components of the architecture include sensing unit, the microcontroller connect to GSM internet gateway, an open cloud server, a GSM module and user alert unit. The sensing unit is made by temperature sensor, Dallas sensor Light sensor, sound sensor, smoke, and the GPS module connected to the microcontroller. These sensors collect

data for the different parameters and Camera stream the position of baby inside of cradle. The GSM modem connects on the system then transfers the data to the cloud server for storage, analysis and processing. The processed data is sent to the parents and display on the OLED. The term cloud refers to a network or Internet. In other words, we can say that cloud is something, which is present at remote location. Cloud can provide services over public and private networks, i.e, WAN, LAN or VPN.

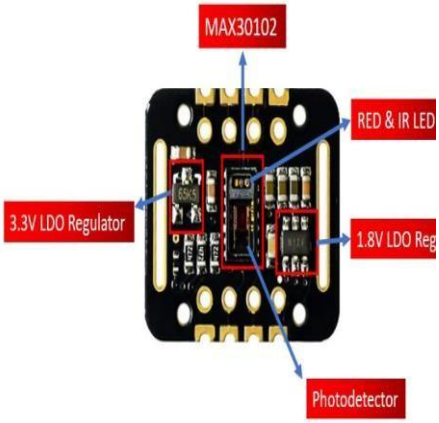
3.3 System Components

The system is made up of both hardware and software components. The components have been grouped in categories based on their functions.

3.3.1 The sensing Module

This is basically the data collection part of the system which is comprised of different sensors that take parameters from baby health's side and send to the cloud for storage, analysis and processing.

3.4. Hardware Components

Hardware	Description	View
Heart Beat Sensor	It is used to measure the heart rate i.e., how many times the heart beats (speed). Generally, body temperature is measured with a thermometer, and blood pressure is measured with Sphygmomanometer. Nowadays, heartbeat sensors are used in smart watches, smartphones. Heartbeat rate can be monitored in two ways. By checking the pulse	

	and by using a heartbeat sensor.	
DHT11 Sensor	DHT11 is a Humidity and Temperature Sensor, which generates calibrated digital output. DHT11 can be interface with any microcontroller like Arduino, Raspberry Pi, etc. and get instantaneous results. DHT11 is a low cost humidity and temperature sensor which provides high reliability and long term stability.	
Dallas Sensor	The Dallas sensor allows you to use DS18B20 and similar sensors. First, you need to define a Dallas sensor component. The Dallas sensor component (or "hub") is an internal model that defines which pins the DS18B20 sensors are connected to. This is because with these sensors you can actually connect multiple sensors to a singlepin and use them all at once.	

Smoke Sensor	A smoke sensor is **a device fitted to smoke alarms**. A smoke alarm is designed to detect the presence of smoke in a home to alert the occupants that a fire has broken out. A smoke alarm contains not only a smoke sensor but also a loud audible alarm (85 decibels on average) to alert people in the home.	
Light sensor	Light Sensors. The light sensor is **a passive device that converts the light energy into an electrical signal output**. Light sensors are more commonly known as Photoelectric Devices or Photo Sensors because they convert light energy (photons) into electronic signal (electrons).	
Sound sensor	**The sound sensor has a thin piece of material called a diaphragm that vibrates when hit by sound waves** (similar to how your eardrum vibrates when hearing sound). The vibration of the diaphragm is converted	

	by the sensor into an electrical signal that is sent to theLEGO brick, which knows that a sound has been heard.	
GSM Module	The GSM Module that will be used during the project is GSM with GPRS shield based on SIM900 from SIMCOM. The GSM once connected to the Arduino board will allow it to connect to the internet, sends and receive messages and can make calls using GSM library(jojo, 2020). GSM in this study will be used to send notification tothe Cassava processingIndustries managers, The stores owners and store keepers about the measuredconditions and the action to take	

OLED	OLEDs enable emissive displays - which means that each pixel is controlled individually and emits its own light (unlike LCDs in which the light comes from a backlighting unit). OLED displays feature great image quality - bright colors, fast motion and most importantly - very high contrast. Most notably, “real” blacks (that cannot be achieved in LCDs due to the backlighting). The simple OLED design also means that it is relatively easy to produce flexible and transparent displays.	
Camera **Fan**	If your ESP32-CAM AI-Thinker has no Wi-Fi connection or poor connection, it might have the external antenna enabled. If you connect an external antenna to the connector, it should work fine. Check if the jumper Ok resistor by the antenna connector for the desired antenna.	

	A fan is a power machine used to create a flow of air. A fan consists of a rotating arrangement of vanes or blades, generally made of wood, plastic or metal, which act on the air. The rotating assembly of blades and hub is known as an impeller or runner**.**	

Table 1: Hardware components

3.5 System Functionality

This part explains the flow both instruction and data in the system and how it functions. It also explained the data flow its function in the system. It presents the processes details of how can be implemented.

3.5.1 System flowchart diagram

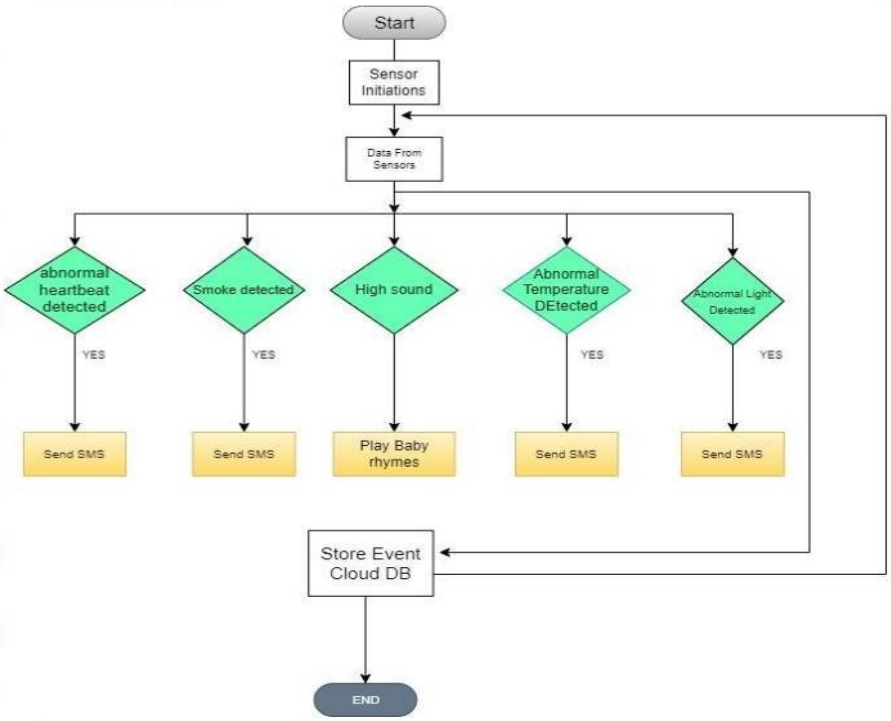


Figure 2:Flowchart

A flow chart is the way of displaying the data into the system and describes where the decision takes place. Is a graphical representation of a computer program in relation to its sequence of functions as distinct the data it processes.

CHAPTER 4 SYTEM ANALYSIS AND DESIGN

4.1. Introduction

This Section describe step by- step the system analysis and the results obtained. The system was designed and simulated in Easy Eda and working prototype was developed using the different hardware components with data being sent to the Thing speak cloud platform**.**

4.2. System Architecture

The architecture of a system is a high-level description of the complete system that identifies its fundamental parts and functions as well as the rules that each element must stand by in order to communicate and work together. The Internet of Things is firmly deep-rooted in embedded systems and other technologies like pervasive systems and sensor networks. The Internet of Things (IoT) is a system in which "things" are interconnected through a network (through Internet protocol) to cooperate and carry out activities while interacting with the physical and digital worlds [18]. The IoT based Smart Cradle for babies monitoring system was developed using the IoT architecture.

4.2.1. Block Diagram of the system

A block diagram is a graphical representation of a system, it provides a functional view of a system. It give us a better understand of a system’s functions and help create interconnections within it.Also is an essential method to develop and describe hardware or software systems as wellas well as represent their workflows and processes.

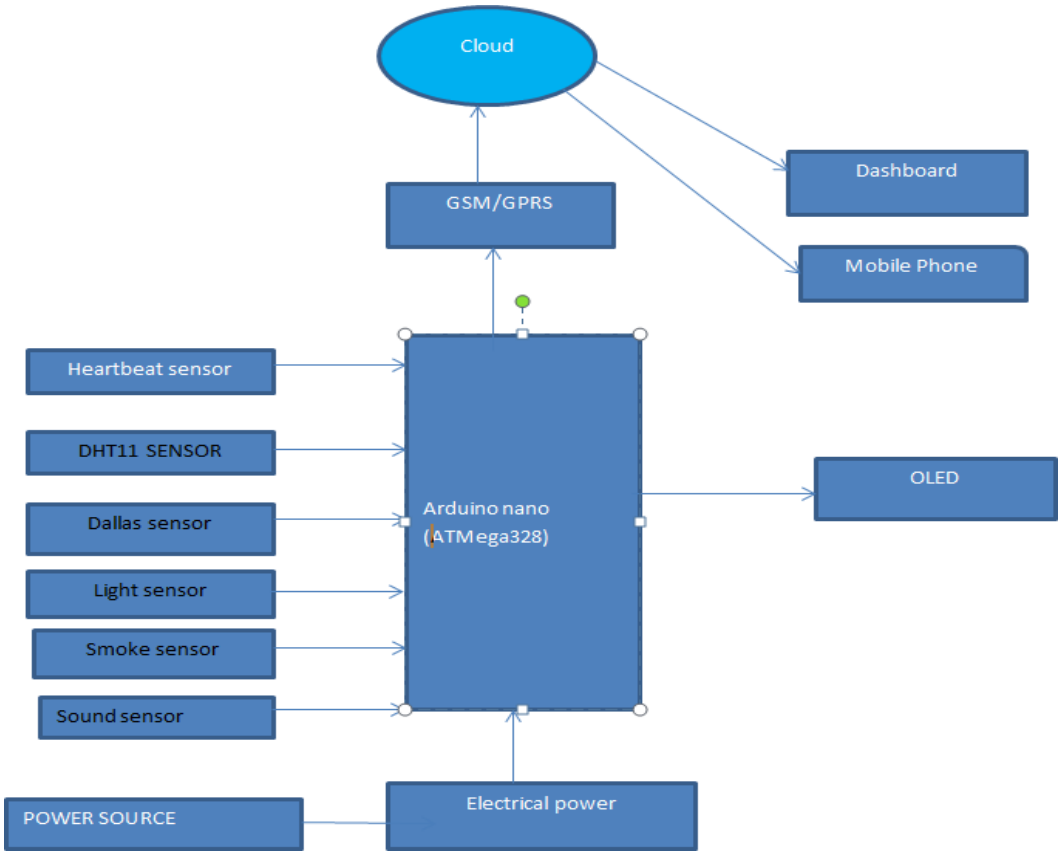


Figure 3:Block Diagram of the system

4.3. System components Design

System design is the process of defining building blocks and their integration, APIs and data models that all function together to create large-scale systems. It is important to keep in mind that each system is designed to meet certain predetermined functional and non –functional requirements.IoT –based Smart cradle for babies system is composed by four Units which are sensing unit, Control unit, Communication unit and Application unit.

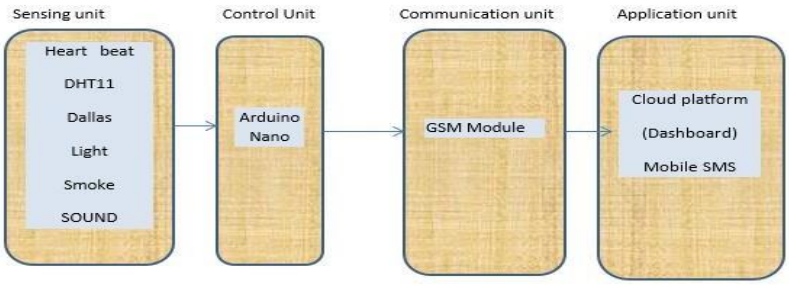


Figure 4: System design components diagram

4.4. Sensing unit

4.4.1. Sensing Unit

Sensors detect the change in the environment and responds to someone output on the other system. A sensor converts a physical phenomenon into a measurable analog voltage (or sometimes a digital signal) Converted into a human- readable display or transmitted for reading or further processing .A sensor is a device that measures physical input from its environment and converts into data that can be interpreted by either a human or a machine.

Heart beat sensor

Heart beat sensors are designed to give digital output heart beat when a finger is placed on it.When the heart beat detector start working, the light emitting detector (LED) blinks simultaneously for every heartbeat [19]. The output of this LED flash is in Digital form, Wich can be processed by the microcontroller to measure beats per minute (BPM) rate.

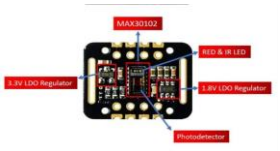


Figure 5:Heart beat sensor

Temperature sensor

This sensor is used in various applications such as measuring humidity and temperature values in heating, Ventilation and air conditioning systems.

Figure 6:Temperature sensor

C. Dallas sensor

The DS18B20 sensor is digital temperature sensor used to measure temperature in range of-55^{o}C to + 125^{0}C with 5% accurate. This temperature sensor supplies 9-bit to 12- bit readings as the range of output resolution [20]. It is programmable and digital temperature sensor where it changes 12-bit temperature to digital word within 750ms time and can be power driven from the data line. The communication of tis sensor can be done through a one wire bus protocol which uses one data line to communicate with an inner microprocessor.

Figure 7:Dallas sensor

D.smoke sensor

An optical smoke alarm contains a photoelectric sensor, which measures variations in a light signal emitted by an electroluminescent diode. Under normal conditions and if no smoke is present, the signal is continuous and normal.

Figure 8:Smoke sensor

e. Light sensor

Alight sensor is a photoelectric device that converts light energy (photons) detected to electrical energy (electrons).Seems simple? There is more to a light sensor than just its definition.

Figure 9:Light sensor

f. Sound Sensor

The sound sensor is one type of module used to notice the sound. Generally, this module is used to detect the intensity of sound. The applications of this module mainly include switch, security, as well as monitoring.

. 

Figure 10:Sound sensor

4.4.2. Wireless Communication

This unit describes the wireless communication part of the System. **The Collected data are sent to the Microcontroller** for further processing. In case the Values are over the thresh older values, for Smart Cradle for babies values measurements, the alert messages is displayed on OLED and sent to the mobile phone of the parents to let her /him to know the health status of babies as well as to the dashboard cloud platform for being analysed Via Arduino Nano .

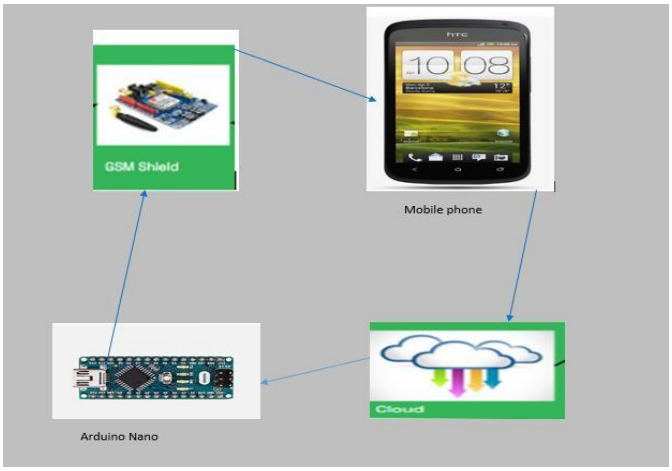


Figure 11:Wireless communication Block Diagram

The following tools are used in this project

1. Arduino Nano

Arduino Nano has a number5 of facilities for communicating with a computer, another Arduino or the microcontrollers. The ATmega328 provide UARTTL (5v) serial communication, which is available on digital pins 0(RX) and 1(TX).

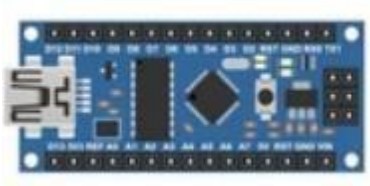


Figure 12:Arduino Nano the ATmega328

2. GSM

The GSM Module that will be used during the project is GSM with GPRS shield based on SIM900 from SIMCOM. The GSM once connected to the Arduino board will allow it to connect to the internet, sends and receive messages and can make calls using GSM library (jojo, 2020). GSM in this study will be used to send notification to the Cassava processing Industries managers, the stores owners and store keepers about the measured conditions and the action to take.

Figure 13:GSM Module

4.4.3. Application and Cloud Unit

Cloud platform

Cloud computing is Internet-based computing in which virtual shared servers offer clients pay-

per-use access to software, infrastructure, platforms, devices, and other resources. Through the

internet, users can access on-demand computing resources such as infrastructure, software, and storage. In this study, dashboard cloud platform is used as an IoT analytics platform service that permits the aggregation, visualization, and analysis of real-time data [21].

2. Integrated Development Environment Requirements (IDE)

For Windows, macOS, and Linux, the Arduino Integrated Development Environment (IDE) is a cross-platform program that uses C and C++ functions [22]. It is used to create and upload applications to boards that are compatible with Arduino as well as to other vendor development boards with the aid of third-party cores. Version 1.8 of Arduino was employed in this study [23].

3. Arduino C Programming

Instructions are sent into the Arduino C programming language compiler, which turns them into executable code for the microprocessor or microcontroller. Although it is an extra step, the software it produces is more effective than an interpreter [24]. While your program is executing, an interpreter converts your code into machine language, literally one line at a time [25].

CHAPTER 5 RESULTS AND ANALYSIS

5.1. Introduction

This chapter shows the results obtained in solving the problem of monitoring baby health and in real – time by receiving the notifications of SMS. Sensors are installed on the Cradle to communicate with the Microcontroller inorder to send sms to the parents in case of sensed parameter is not normal.

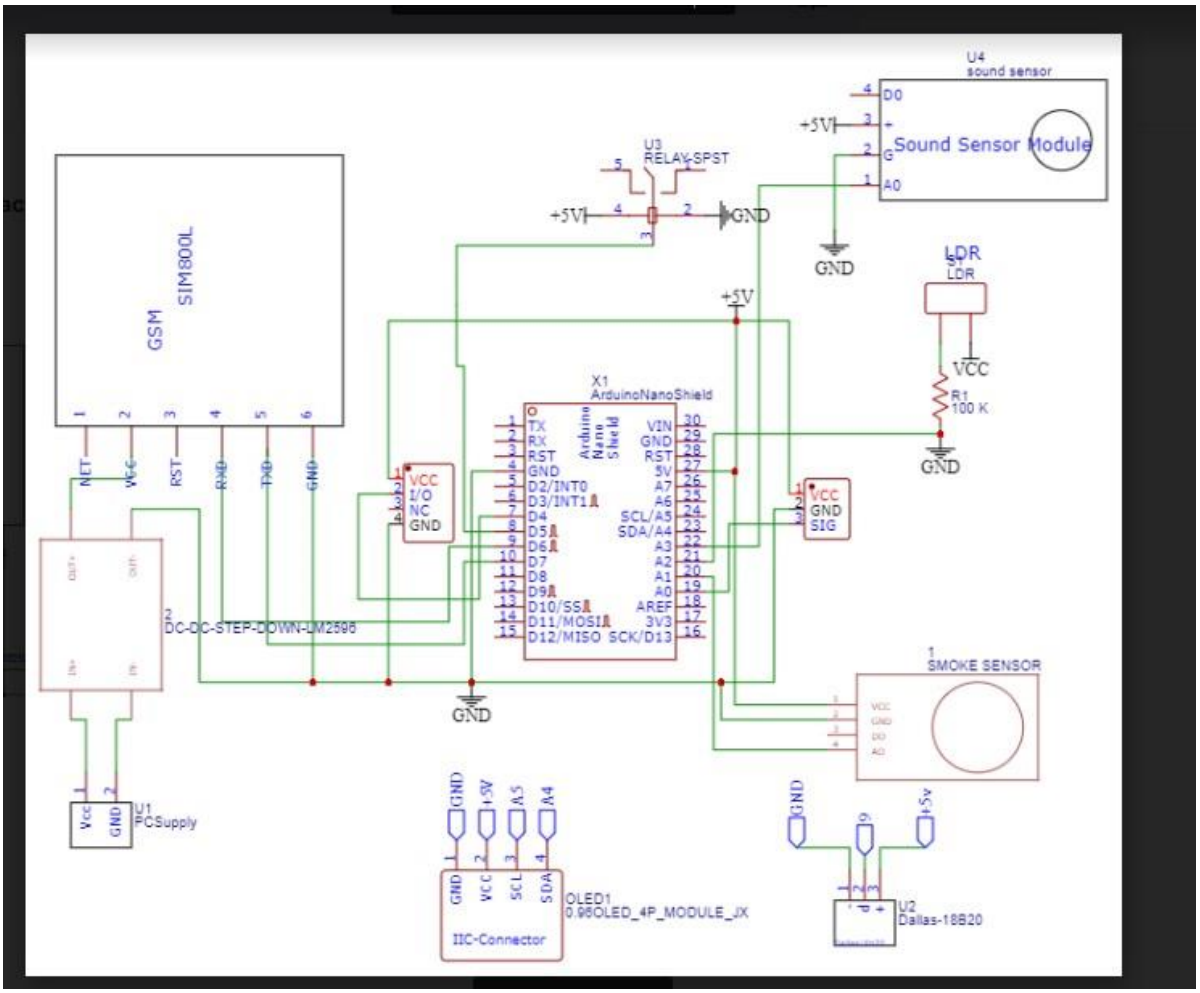


Figure 14:Circuit Diagram

This circuit diagram of the system shows how the electronic devices used are connected one to other to communicate and complete the task of monitoring baby health.

5.2 Cloud Platform dash board and Visualisation

After the system data was collected it was sent Via GSM Module SIM900A to thing speaks and send to the cloud, and then the following figures were obtained as outputs over time.

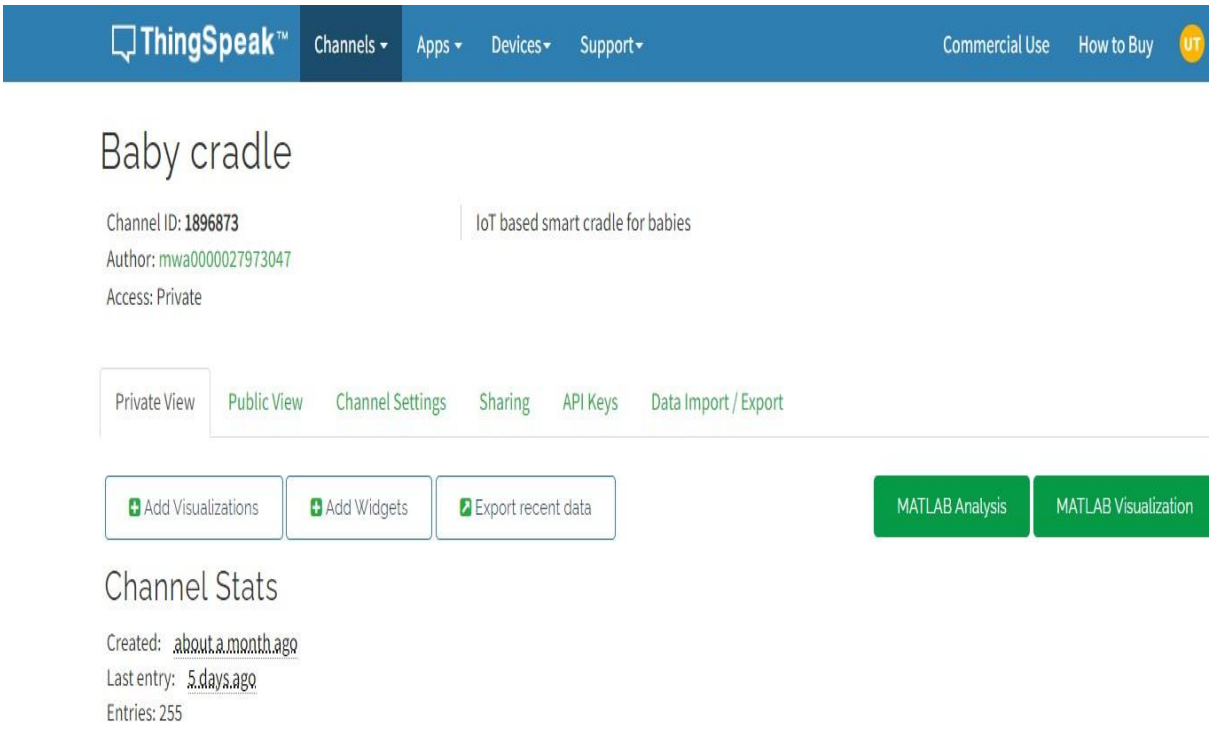


Figure 15:Baby monitoring system Dashboard

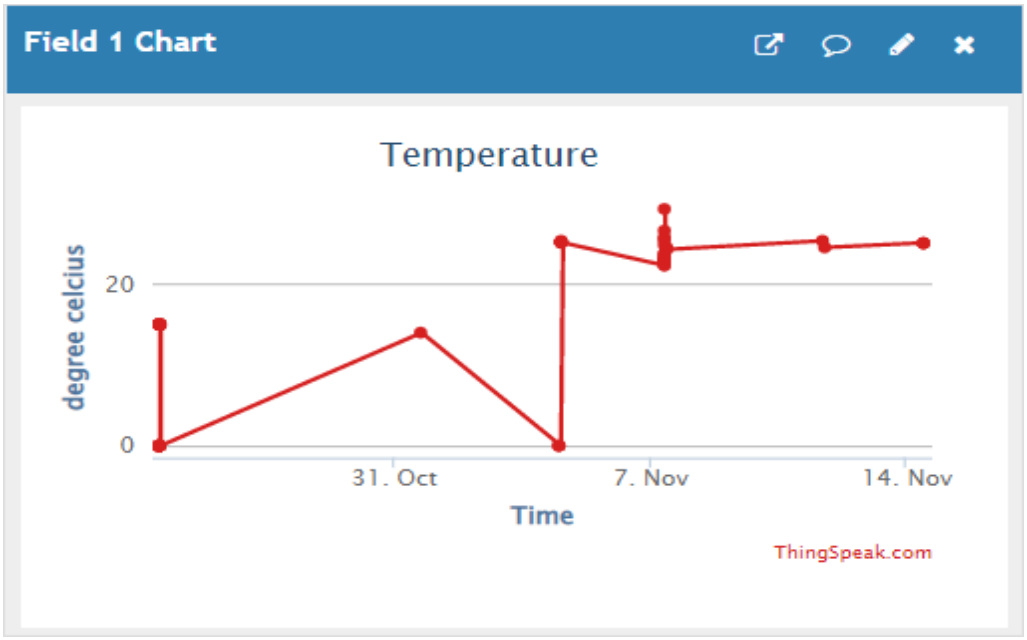


Figure 16:Graph of Temperature from Thing speak

Figure 8.Indicates the graph of data stored on the thing speak, to indicate the temperature value

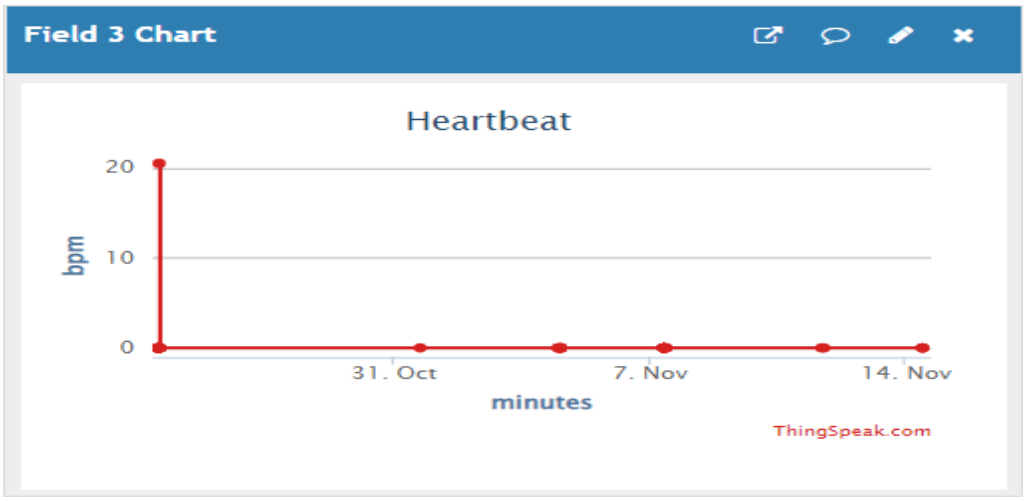


Figure 17:Graph of Heart beat from Thing speak

Figure 17 Indicates the graph of data stored on the thing speak, to indicate the Heart beat value

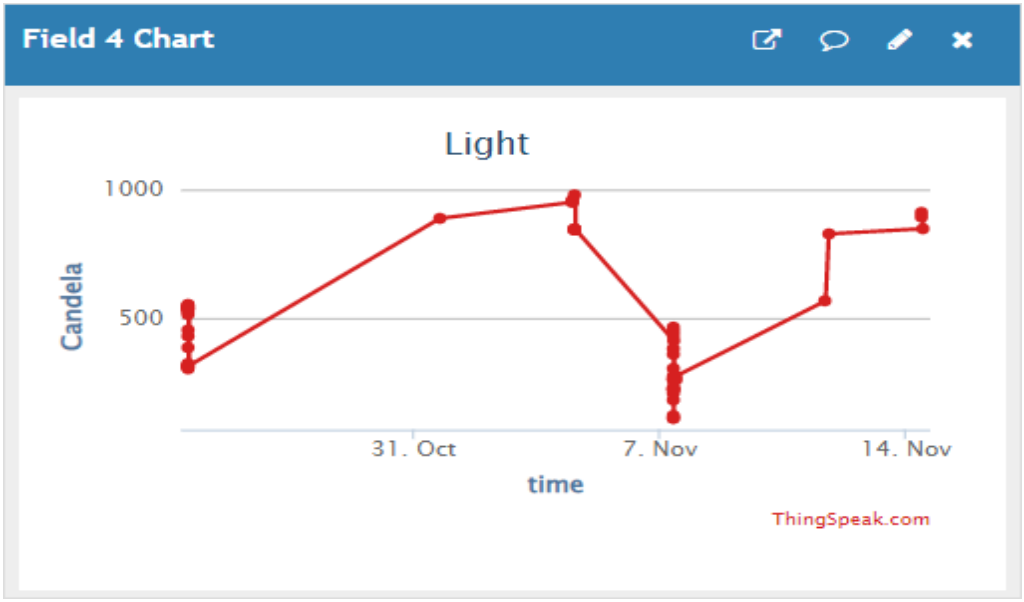


Figure 18:Light level stored on thing speak

Figure 18indicates the graph of data stored on the thing speak, to indicate light value

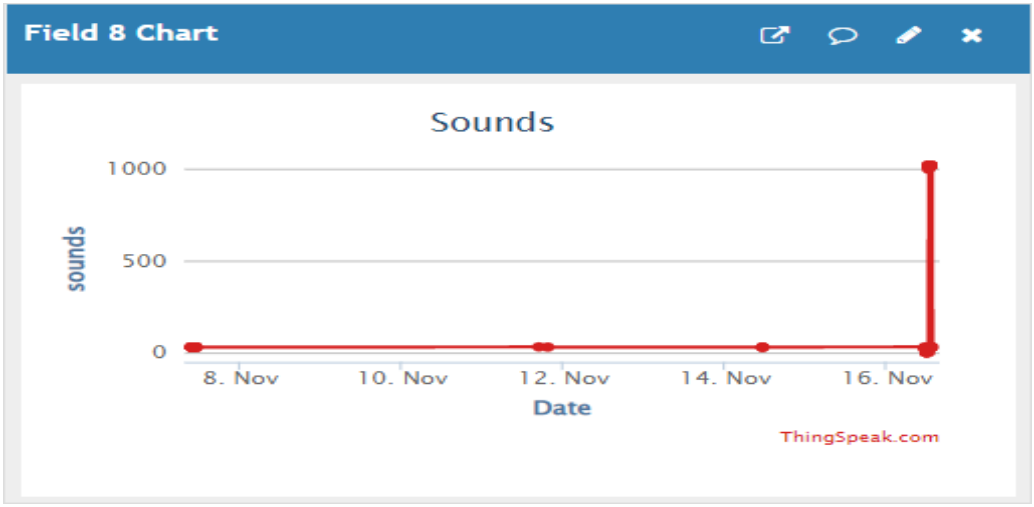


Figure 19:Sound stored on thing speak

Figure 19 Indicates the graph of data stored on the thing speak, to indicate Sound

5.3 prototype of the system

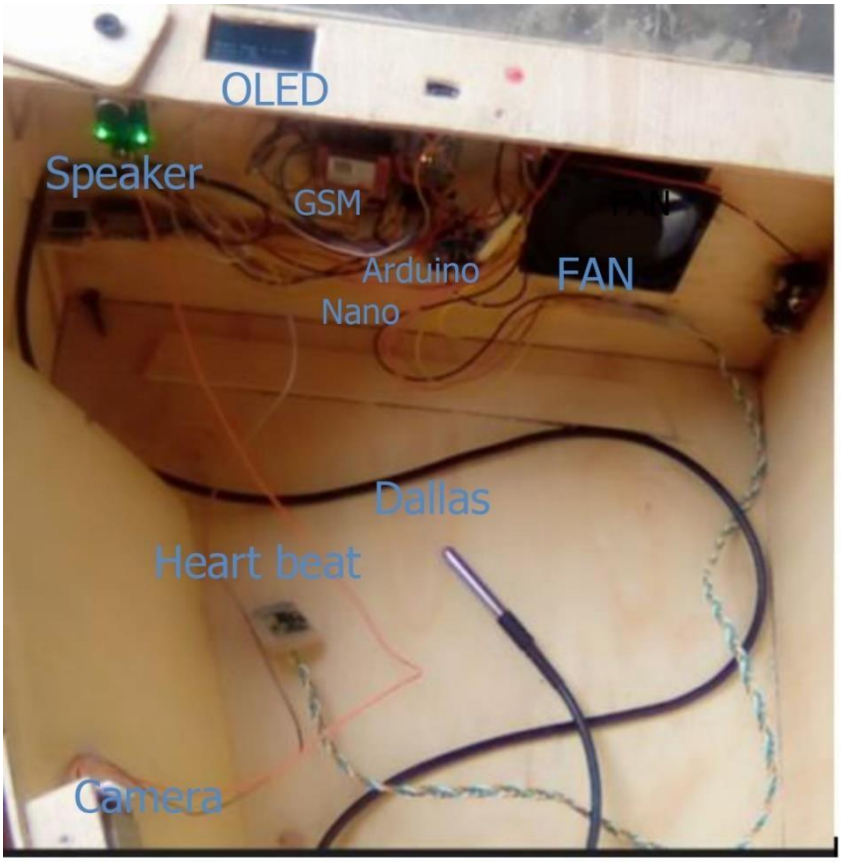


Figure 20:Prototype of the system

This figure shows the prototype of the whole system .The sensors are attached to the Cradle to monitor baby health, other sensors such as light sensor, smoke sensor, DHT11 appear at the backend of this smart cradle with microcontroller which has a job of processing sensed data and sent it to Thing speak with GSM module.

5.4. Final prototype of the system

Figure 21:Final product known as Smart Cradle.

Figure 21 indicate how Smart cradle will help the working parents to monitor baby health where Dallas sensor and heart beat sensor will be posed to baby to sense body temperature and heart beat then send notification to the parents.

5.5. Top view of the final prototype

Figure 22:Smart cradle with camera to monitor baby movement anywhere and anytime

Figure 22.The final prototype of the project. The frame design was simple to show the basic support for the baby. The sensors connected inside and camera modules are connected on the top of the cradle.

CHAPTER 6. CONCLUSION AND RECOMMENDATION.

AS we know in this current world of growing technology, how technologies help people in various ways. The smart Cradle system becomes the bridge between a child and parent in this busy world where parents work for hours and could not give total care to their child. All the sensor's data and alert messages like the baby's temperature, heartbeat, sound level, light level ,smoke level and movement of the baby is measured .This system assures them that their baby has basic support and is safe in the Cradle. Also this system is easy to use and efficient. It is less expensive and more secure with new features. This smart Cradle system will help parents to do their daily work and look after their baby. I recommend future work to create Mobile application for data Visualization.

REFFERENCES

[1] Prof.A.R.Patil, “Smart cradle an IOT Based management system.,” in *Smart city and Emerging Technology(ICSCET)*, 2018.

[2] P. A. e. .al, General Idea about Smart Cradle, Int .j.of innovative. science and Eng, Jan-Feb2014.

[3] S. p. T. w. R. R. Rachna palaskar, “An automated monitoring and swinging the baby cradle for Infant Care Int.J.of Advanced Research in computer and commun.,” Eng.,Dec 2015.

[4] J. A. a. B.J.Taylor, “International comparison of sudden unexpected death codes,” 2015.

[5] D. a. P. M.LEVY, “"Smart Cradle fo baby using FN-M16P Module"Perspct.commum.Embedded-Syst. Signal-Process.VOL,” 2019.

[6] M. a. S. W.A.Jabbar, Design and implementation of IoT- based aotomation system for smart Cradle.

[7] J-R.C.Chien, “"Design of Home care instrument based on embedded system" PRO.IEEE Int.conf.Ind,Technol.,” PP.1-6,April.2008.

[8] K. a. r. D.N.F.M.ISHAK, “Arduino based infant monitoring system,Proc,IOP Conf.Ser.Master.Sci.Eng.,Vol.226,no.1,” 2017.

[9] S. c. a. E.Saadatan, “LOW COST infant monitoring and communication system, pro.IEEE Colloq.Humanities SCI.Eng.,PP.503-508,Dec.2011”.

[10] M. a. R. A. D.N.F.M Ishak, “Arduino based Infant Monitoring systm Proc. IOP Conf. Ser. Master.Ser.Master.SCi.Eng.Vol.226,No.1,2017”.

[11] R.Krinamurty and J.Cecil, “A next GEneration IOT-Based collaborative framework for electronic assebly ,INT-J.Adv.Manuf,” 2018.

[12] G. A. R. M.Shama, “ADvanced conceptual diagnostics healthcare framework for diabetes and cardiovascular 209[2019]”.

[13] R. a. M. .. S.-M. m. o. t. m. P. I. C. E. I. M.S.Rachana.S.M.Nadig, “2018”.

[14] M. K. a. Y. S.-A. S.Brangui, “An enhanced noise cancelling system for a ccomprehensive monitoring and controling of baby environmrnts,” 2015.

[15] C.-K.-. Chiung, Baby cry recogonizer, 2017.

[16] S. a. M.R.Mhetre, “Intelligent baby monitoring System ITSI TRAS. Elect.Eng.,2,no.1,pp.11-16,2014”.

[17] C.-W. ,.-S. a. C.-J. C-T.Chao, “Arduino based resonant Cradle design with infant Cries recognition,” 2015.

[18] K. Kumar.R.S, “A Design Approach to smart Health monitoring Using Android Mobile device,” *INternational confernce on advanced communication control and computing Technologies.(ICACCCT),* 2014.

[19] R. K. a. J.Cecil, IoT -Based collaborative framework for electroninic assembly " INt . J.Adv.Manuf.TEchnol.,Vol.96, 2018.

[20] E. Y.E.OKTIAN, A Conceptual Architecture in Decentralizing Comuting Storage and Networking Aspect of IoT Infrastructure, Mar 2021.

[21] s. R.Palaskar, “Automatic and swining baby cradle for infant care,” in *International journal of advanced Research in computer b and communication engineering*, 2015.

[22] S. .. care", “Internet of things IoT:IoT in Health,” *International Conference of Trend in Scientfic Research and Development,,* Vols. Vol.3,no4, no. possibilities of automatic child Cradle, pp. 980-982, 2019.

[23] M. a. D.C.Mehetre, IoT Based cradle system with an android App for baby monitoring, 2017.

[24] E. Y.E.OKtian, “A conceptual Architecture in decentralising computing storage and networking,” 2021.

[25] N. S. etaL, Data Security in Cloud Computing Using Tree - Factor Authentication, 2020.

[26] “IOT based smart cradle system,” in *cradle*, jsidhuri P. Joshi , Madhuri P. Joshi , 2017, p. 78654.

[27] M. R.blea, Automatically rocking baby cradle, 1973.

[28] M. Goyal, Automatic E- baby cry, 2013.

[29] M. E. K. a. Y. S.-A. S. Brangui, “An enhanced noise,” pp. 404-409, 2015.

[30] Amol Srivastava, B. E. Yashaswini, Akshit Jagnani, , “Smart Cradle System for Child Monitoring Using,” *Engineering and Technology*, Vols. Volume-8 Issue-9, no. Issue-9, pp. 2278-3075, July 2019.

[31] G. Rajesh, R. Arun Lakshman, L. Hari Prasad And , “Baby Monitoring System Using Wireless Sensor Network,” *International Research Journal of Engineering and Technology (IRJET),* Vols. Volume: 05,, no. Issue: 03, pp. 2229-6948, September 2014.

[32] Mohamed Y. E. Simik; Abdeldime M.S Abdelgader; Feng Chi; , “Analysis on IoT Based Smart Cradle System with an,” March2019.

[33] A. Nawaz, Development of an Intelligent Cradle for Home and Hospital Use, 2015.

[34] D.F.M.Ishak.M.M.A, “Arduino Based infant monitoring system,” in *Proc.IEEE Colloq.Humanities Sci. Eng., PP.503-508.Dec,2011,* 2011.