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INFANT INCUBATOR MONITORING BY IOT SYSTEM

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Master's Thesis

Supervisor

Prof. Dr. Hasan Hüseyin BALIK

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The thesis titled INFANT INCUBATOR MONITORING BY IOT SYSTEM prepared by HARITH MUTHANNA RAOOF and submitted on 16/12/2022 has been **accepted unanimously** for the degree of Master of Science in Electrical and Computer Engineering.

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I hereby declare that all information/data presented in this graduation project has been obtained in full accordance with academic rules and ethical conduct. I also declare all unoriginal materials and conclusions have been cited in the text and all references mentioned in the Reference List have been cited in the text, and vice versa as required by the abovementioned rules and conduct.

Harith Muthanna RAOOF

Signature

ABSTRACT

INFANT INCUBATOR MONITORING BY IOT SYSTEM

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When a newborn is being observed and cared for, a postnatal oscillator is a box-like containment that provides a regulated atmosphere. There would include a heater, a fan, a container for water, a control valve for oxygen, and reason of selecting for nursing home care inside the device, amongst other things. We will have to use internet of things (IOT to keep tabs on the vital signs of infants in this initiative. Because it's attached via Wi-Fi, it can be used with either a mobile phone or a device via an existing application. The system uses a DHT11 sensor to detect bodily characteristics including temperature and humidity, and an ESP32 NodeMCU Wi-Fi module with a heart rate sensor is used to measure the toddler's heart rate. Medical records may be updated in real time using Thingboard IOT apps, according to the findings.

Keywords: Internet Service Providers, TCP/IP, Internet of Things.

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ABBREVIATIONS

CIE	:	Commercial Internet Exchange
ISP	:	Internet Service Provider
LAN	:	Local Area Network
IoT	:	Internet of Things
NAPs	:	Network Access Points
NICU	:	Neonatal Intensive Care Unit
DARPA	:	Advanced Research Projects Agency
NSF	:	National Science Foundation
UIDs	:	Unified Identification

1. INTRODUCTION

1.1 INTRODUCTION

There has recently been a significant uptick in interest in and focus on the study of health monitoring systems. Infants in electronic incubators At the cutting edge of cutting-edge technology right now are sensor networks and records for keeping tabs on newborns. Babies may now be monitored from outside the hospital or doctor's office thanks to a technique called remote baby monitoring.

When creating a safe and comfortable space for newborns, temperature and humidity are two of the most crucial factors to keep an eye on [1]. Hyperthermia in neonates may lead to increased oxygen demand, dehydration, and apnea [2], for example, while hypothermia in newborns can cause a variety of problems. Additionally, when the temperature rises, the air's humidity rises as well. In order to create a healthy environment and keep the baby's core temperature steady at 37 degrees Celsius, the incubator's temperature and humidity levels must be carefully controlled around the clock.

That's why, for this project, we came up with a prototype that can keep tabs on infants' routines while also identifying and reporting on any of the aforementioned root reasons to parents. Because it's simple to use and accessible by any caretaker, this should help parents get a better night's rest. One of the cornerstones of the Fourth Industrial Revolution, or 4.0, is the Internet of Things, which will be used in the proposed project (IR4.0). In only a few seconds, the user may access the network and get the sensor data that was just measured.

As a result, we created a prototype that can track the motion of the phrase "Internet of Things" (IoT) has lately gained traction in the sphere of electronic communication. It's reached a new level of development and is considered a promising frontier. The Internet of Things is going to revolutionise a lot of things, it's going to alter the world. The number of Internet of Things (IoT) gadgets is projected to skyrocket in the next years. Over 12 billion Internet-connected gadgets exist now, but it is predicted that by 2020 there will be 26 times more linked objects than humans [3]. All sorts of everyday devices, from lamps and refrigerators to vending machines and automobiles, may now connect to the internet and exchange data with one another. With the help of hardware components, software, sensors, microcontrollers, and network connection, as seen in Figure 1.1, "Internet of Things" (IOT) devices are able to gather and share data. Each device has its own unique identity (UID), facilitating straightforward machine-to-machine (M2M) connection and hence facilitating reliable collection of real-time data. Data acquired from all around the globe is kept in the cloud. System performance will improve and intelligence will increase as a consequence.

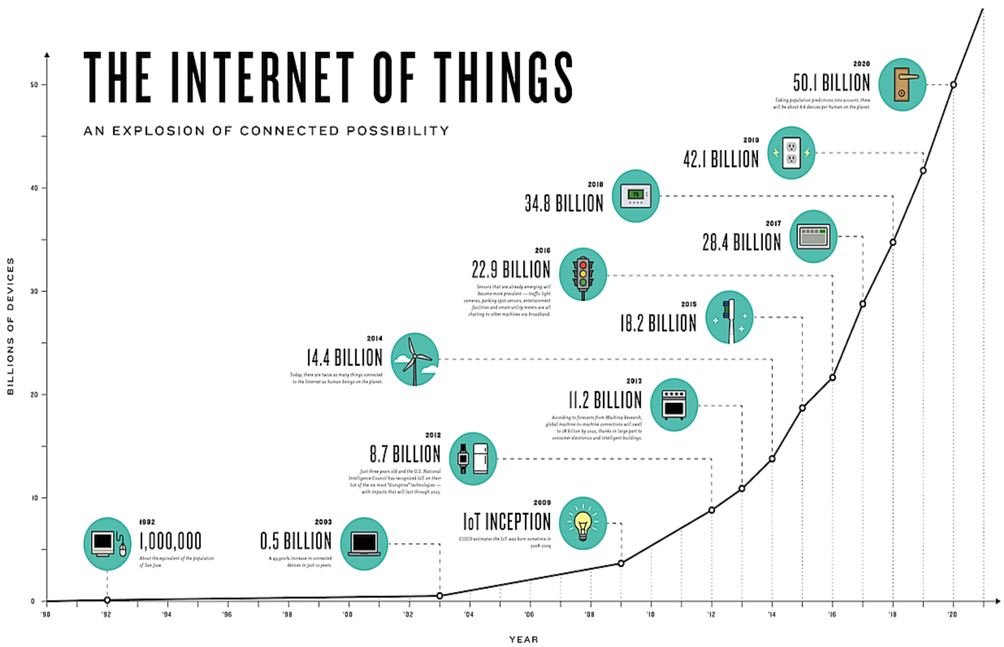

Figure 1.1. Increment of Devices Connected to Internet [1].

There are several types of incubators for preterm infants, but the most common is the neonatal incubator. A lack of effective incubator monitoring has recently resulted in the deaths of several preterm newborns. Designing an embedded device that monitors several factors, such as baby's heart rate and incubator temperature and humidity, is a focus of this project. So that correct steps may be made in advance, to maintain an incubator's atmosphere and protect the safety of an infant's life [4], IOT information is updated on an Android app or web page by medical staff. For this initiative to succeed, it must overcome these shortcomings and provide a safe and cost-effective way to monitor the incubator's operations. A preemie is a baby born before the mother has reached the gestational age of 37 weeks. Some of their vital organs cannot develop properly since they are born prematurely. Premature babies may have undeveloped digestive systems, lungs, immune systems, and even skin based on how early they were born[1]

1.2 PROBLEM STATEMENT

The primary goal of this research was to find a way to use IoT in our infant monitoring system to keep track of the room's temperature and humidity in real time, giving parents a better feeling of safety.

1.3 OBJECTIVES

The main objectives of this thesis are:

i- Remotely checking the incubator's temperature and humidity.

ii- To use Ardunio microcontroller with different sensors.

iii-To use open-source internet of things application.

iv-To developed system is connected to the internet via Wi-Fi.

1.4 THESIS OUTLINE

This dissertation is broken up into five sections, which are as follows:

Chapter1: Provided an introduction to VANETs before moving on to discuss the issue, goals, and scope. In Chapter 2, the theoretical section and associated work were presented. The research approach and the practical processes to acquire the findings were presented in chapter 3. The outcomes of the project were discussed in Chapter 4. Chapter Five: Wrap-Up and Looking Ahead.

2. LITERATURE REVIEW

2.1 INTONATION

It is in this chapter that the technological foundations and current state of the art are laid forth that make the work presented in this thesis possible. We start with an overview of the IoT, its recent architectural developments, and the IoT protocols we use in our analysis of the FIWARE platform's efficiency. To help the reader better understand the context of FIWARE for IoT, we present background information on cloud computing, performance studies, and the architecture of FIWARE. At last, we take a look at the research that surrounds FIWARE platform performance ratings in the Internet of Things.

2.1.1 Premature Infants

Babies born before the typical 36 or 37 weeks of gestation are considered premature. So many baby health problems may be traced back to the child's immaturity because of their physiological systems not being fully formed. Common issues include jaundice because of a developing liver, breathing difficulties because of undeveloped lungs, and low blood sugar, low oxygen levels, and even death because of an immature nervous system's reaction to cold stress.

Babies born too soon often die because their physiology isn't developed enough to compensate for the heat they lose. Evaporation, conduction, convection, and radiation are the four main types of heat loss. When temperatures drop, adults can shiver to generate heat, but premature newborns can't because they lack the muscular mass and the brown fat that makes up around 5% of their body weight. Due to their high surface area to volume ratio, they are very effective in losing heat (about 4 times the adult ratio).

They lose a lot of heat via evaporation, and they may die from a dangerous acid-base imbalance since their skin isn't fully developed yet. Body fluid is lost by evaporation after initially diffusing over the epidermis (general outer layer of skin). Evaporation from the skin's surface then helps to chill the baby.

The stratum corneum, the rough outer layer of the epidermis that protects the skin from external agents, is thinner and less developed in premature newborns, allowing excess water to seep out. To put it simply, a preemie loses a lot of heat via evaporation [5].

When a baby has one of the conditions listed in [6], it must be maintained in the Intensive Care Unit. Assuming the labour and delivery were very challenging and demanding careful supervision. When a baby is born too soon, or prematurely (i.e., within 7 weeks), it often has a low birth weight (less than 1000–2000 grammes) and is extremely little for its age. If it has a health problem like jaundice, dehydration, or infection, it may need to be hospitalised. If the woman has a serious illness, such as diabetes, or the infant has just had surgery, it may be best to wait until both have fully healed.

2.1.2 Thermal Protection in Newborn

The term "thermal protection of the infant" refers to the steps performed before, during, and after delivery to keep the baby's temperature between 36.5 and 37.5 degrees Celsius (97 and 99.5 degrees Fahrenheit) and to prevent the onset of hypothermia or hyperthermia. Having an atmosphere that is either too chilly or too warm may have devastating effects, therefore it's crucial to find that happy medium. This is the temperature range in which a newborn can keep his or her body at a normal, healthy level. In infants with a low birth weight or who are otherwise ill, the range is much less. A newborn's tolerance for extreme temperatures decreases in direct proportion to its size and the severity of its prematurity.

As a result, there isn't a magic temperature that's perfect for all newborns, regardless of their weight, gestational age, or health. A preterm newborn needs a warmer environment than what is ideal for a full-term baby, and a colder environment than what is ideal for a full-term baby. Newborns have less developed thermoregulatory systems and so have trouble maintaining a steady body temperature. It has a narrow temperature tolerance and hence cools down or warms up considerably more quickly. The danger increases with the size of the infant. As the infant gains weight, the environment is more stable thermally. The average temperature in the womb is around 100.4 degrees Fahrenheit (38 degrees Celsius).

Thermal protection of neonates is highly essential but not difficult since after delivery the wet baby finds itself in a considerably cooler environment and quickly begins losing heat. Whether the birth takes place at home or in a hospital, the same fundamentals apply. The initial few minutes after delivery are the most critical for preventing heat loss in a baby. There are four ways that a newborn infant might lose heat. Amniotic fluid evaporates, causing the infant to lose heat. However, the baby can lose heat in three other ways: through conduction (when placed on a cold surface like a table, weighing scale, or cold mattress); through convection (when exposed to cooler surrounding air); and through radiation (when the baby is near a cold wall or window but isn't touching it).

A newborn might become chilly in a room that is just 30 degrees Celsius (86 degrees Fahrenheit) because heat loss increases with air movement. The initial few minutes after delivery are critical for the cooling of a baby. Without adequate care, a newborn's body temperature may drop by as much as 8 degrees Celsius (17.2 degrees Fahrenheit) in the first few hours of life if they are not kept warm. Baby will have hypothermia (low body temperature) if heat loss is not stopped and allowed to continue. If a newborn is already tiny or unwell, and then exposed to hypothermia, it faces a much higher risk of complications and even death. If the infant is kept warm, however, it has a significantly greater chance of staying healthy or of surviving any preexisting conditions. Babies need to be kept warm, but it's essential to take precautions to prevent them from overheating. The aforementioned processes may also work in reverse to bring to hyperthermia, i.e. a higher than usual core body temperature. Hyperthermia is more rare than hypothermia, yet it's just as hazardous [7].

2.1.3 Premature Infants' Remote Monitoring Equipment Used To Keep Babies Warm

In this section, an Arduino microcontroller equipped with various sensors and an open-source internet of things (IoT) application are used to remotely monitor the incubator's air temperature and humidity levels. Using a wireless fidelity (Wi-Fi) connection, the system can be linked to a mobile app or a computer. An Arduino microcontroller, a DHT11/DHT22 sensor for monitoring environmental conditions inside the human body (including temperature and humidity), an LCD display, an ESP8266 Wi-Fi module, and a NodeMCU-v3 form the basis of the system's architecture. The outcomes have demonstrated that medical staff can receive up-to-date records in real time via Thing Speak IoT applications [8].

2.2 THE INTERNET OF THINGS (IOT)

ICT (Information and Communication Technology) defines the Internet of Things (IoT) as a dynamic global network infrastructure with self-configuring capabilities based on standard and inter operable communication protocols, where physical and virtual things have identities, physical attributes, and virtual personalities, use intelligent interfaces, and are seamlessly integrated into the information network. Embedded with electronics, software, sensors, actuators, and network connectivity, IoT enables physical devices, vehicles, buildings, and other items to collect and exchange data [7].

When asked to define the IoT in 2013, the Global Standards Initiative on Internet of Things (IoTGSI) did so by referring to it as "the backbone of the information society [8]. Embedded systems, wireless sensor networks, control systems, and automation systems are all part of the traditional realms that make up the IoT. That's why we can credit the revolutionary success of mobile and internet networks to the development of the internet of things [9, 10].

Not even a generation ago would have dreamed of a video call with loved ones. It's like a game for kids these days. The proliferation of internet access and the development of Wi-Fi-enabled gadgets are to thank for all of this. Smart phones are becoming more affordable as technology advances. With their built-in features and apps, smartphones can do just about anything. The current state of affairs can be summed up as an ever-expanding "Internet of Computers" (IoC). By the end of the decade, there will be an estimated 7.3 billion tablets, PCs, and Smartphones, and the world will be more deeply and intimately connected as a result, according to a study by Gartner. This interconnected system is expected to grow at an even faster rate, reaching 26 billion devices by 2023.

As a result, the Internet of Things has an enormous potential (IoT). The so-called "Internet of Things" is in the eye of a storm. Also, the centre of the storm is in one of five places. Topics such as sensors, local processing, networking models, data science, predictive technologies, machine learning, and security.

2.3 ECOSYSTEM FOR THE INTERNET OF THINGS

The Internet of Things has two key components. The first is a physical device or "thing" that you want to make smarter by connecting it to the internet. Additionally, an embedded system enables this connectivity. Complex systems such as many sensors and actuators as well as protocols and data management layers are required for the latter half of this process to work. Programmability, intelligence, and the ability to interact with people are the result of the interconnectedness between all of these.

2.4 IOT ECOSYSTEM COMPONENTS

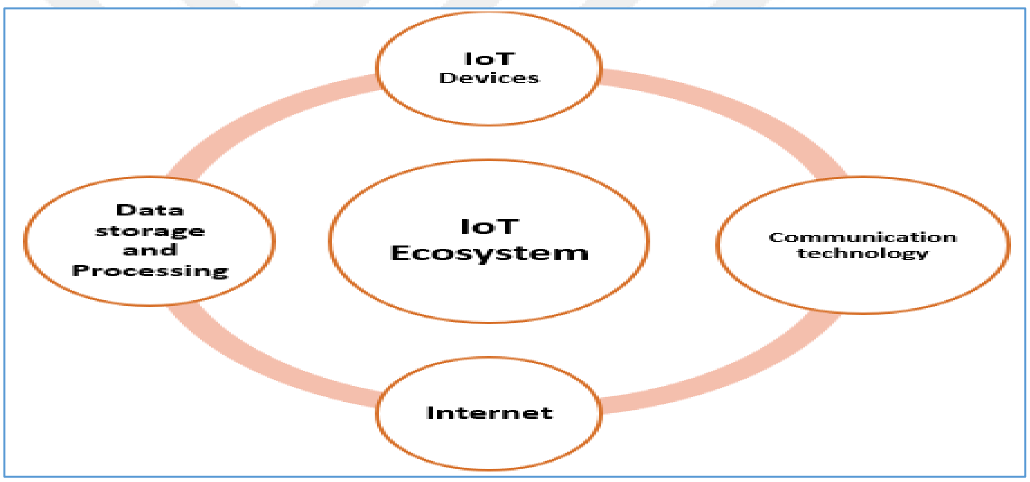

Figure 2.1: IOT Ecosystem Components.

The following are the building blocks of an internet of things ecosystem:

2.4.1 Detecting and Encasing Parts

This is the foundation of an Internet of Things (IoT) ecosystem, the core of the network. Sensors play a vital role in ensuring the integrity and accuracy of data in the Internet of Things (IOT). The most important parts of this layer are the tiny appliances (micro appliances) embedded inside an IoT device that either collect data or control a mechanism.

2.4.1.1 Sensors

The purpose of a sensor is to gather even the most minute information about its environment. In addition to their more common name, "sensors" go by the name "detectors" because of their ability to pick up on even the most subtle changes in their environments. Data may be gathered in real time or retrospectively using IoT devices. Depending on the kind of sensor it employs, this little piece of equipment can measure almost anything.

This might be due to smoke, movement, or even elevated blood pressure. However, even while current sensors can monitor a broad range of complexity, IoT devices may gather data from a number of sensors in order to perform a variety of functions. All sorts of sensors, including GPS, fingerprint readers, tilt and motion cameras, are included into our mobile devices. Thermostats and air conditioners that are "smart" can detect both the temperature and humidity in a space. Different applications necessitate different types of sensors, which may be found in a wide variety of devices and use cases.

Using sensors to activate automation based on certain conditions is essential. When using an automatic mode on a smart air conditioner, a user can program a preferred temperature range of 73 to 77 degrees Fahrenheit.

Air conditioning units will be instructed to run at specific temperatures as soon as a room temperature rises over 77 degrees. When the temperature in a room drops below 73.

Degrees, a signal is sent to the air conditioner to turn off. Today's sensors are small, clever, and inexpensive because to advances in technology! The type of sensors you use will be determined by the goal you're trying to attain. Motion, temperature, pressure, smoke, and other potential triggers can all be detected by this sensor. Other considerations include the sensor's accuracy, the dependability of its data and the Range at which it should operate. Resolution and intelligence also play a role in determining which sensors should be used.

Figure 2.2: Depicts the sensor's position in the IoT ecosystem.

2.5 ACTUATORS

Sensors and actuators are opposites. Sensors and actuators are two separate entities. To perform an action, they must first receive a signal. Actuators are equally important as sensors since they must be activated when sensors detect a change in the environment. Actuators can be used to regulate the temperature of a smart air conditioner or the flow of water in a smart faucet. Air conditioning or water flow may be shut off as soon as sensors detect a person's departure from a room, and actuators are automatically activated to do so. A variety of actuators are available, each with a specific vertical and usage application. To switch thing. on or off, they may be needed. However, they may also control valves and conduct movements like twisting or grabbing, which is extremely useful in industrial applications.

2.5.1 Connectivit

The Internet of Things (IOT) is a network of devices, sensors, clouds, and actuators, all of which must be interconnected in order to understand data and take action. To fully understand the IOT ecosystem, we must first understand connectivity.

2.5.1.1 Protocols

A transport medium is needed once sensors have gathered the data. To put it another way, sensors and the cloud need to be able to communicate with one another. It is only possible to transfer data in the online world if two devices are securely connected to each other using. IOT protocols. An unseen language enables physical items to speak with one another in the Internet of Things.

Power consumption, data transmission speed, range, bandwidth and overall efficiency all play a role in network selection. Bluetooth, Wi-Fi, ZigBee, LoRaWAN, DDS, MQTT, and cellular are some of the most prominent IOT wireless protocols and standards. They make it simple as well as safe to move and share data to the next IOT level for processing.

2.5.1.2 Gateway of Internet of Things

Gateways are used to route data from sensors to the cloud. Network protocols are translated by gateways to ensure that all devices in the network may communicate with one other. As a result of this, gateways serve as a critical communication point and are responsible for facilitating the efficient handling of data traffic. In addition, gateways provide safety by guarding against harmful intrusions and illegal access. Because it uses the most recent encryption techniques, it may be thought of as a safety net. Sensor data can be preprocessed by gateways before it is sent to the cloud. To put it another way, they reduce the amount of data that was previously'sensed'. Some intelligent IOT gateways are able to evaluate and average data before sending it to the cloud, so that only relevant information is sent.

2.5.2 The Internet of Things Cloud

Data must be processed once it has been gathered and sent to the cloud. The "clever stuff" happens on the cloud! An important part of the IOT ecosystem is connected via this high-performance facility. It's in charge of handling, storing, and making decisions about the data. It takes milliseconds to process enormous volumes of data, which is crucial for IOT, especially when it comes to matters of life and death like health and safety. There must be a component that can deal with massive volumes of data in order to accommodate the IOT model's timesensitive nature while still allowing real-time information to be provided and acted upon. Cloud computing can be useful in this situation. Because of their role in processing, controlling, and applying analytics to the data they acquire, IOT devices rely on these devices as their brains. It's possible to perform real-time data analysis using a combination of devices, protocols, gateways, and storage systems. Customers have easy access to information because of the cloud's vast processing, storage and networking resources as well as analytics capabilities.

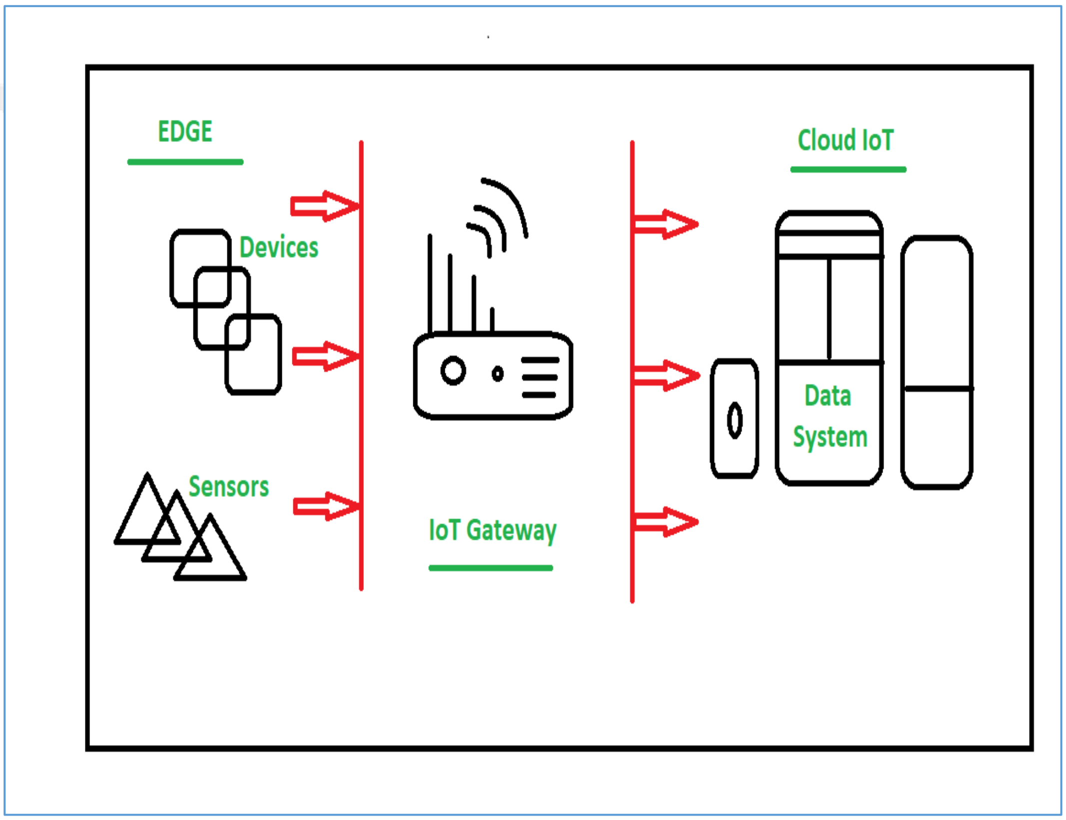

Figure 2.3: An IoT gateway's relationship to other elements in an IoT system.

While local processing using Edge or Fog computing is an alternative for IOT, the cloud may be selected as a high-performance facility that enables tremendous scalability and lower operational expenses, even if the cloud is not required. Using edge computing is preferable when substantial volumes of data processing and storage are needed on-site.

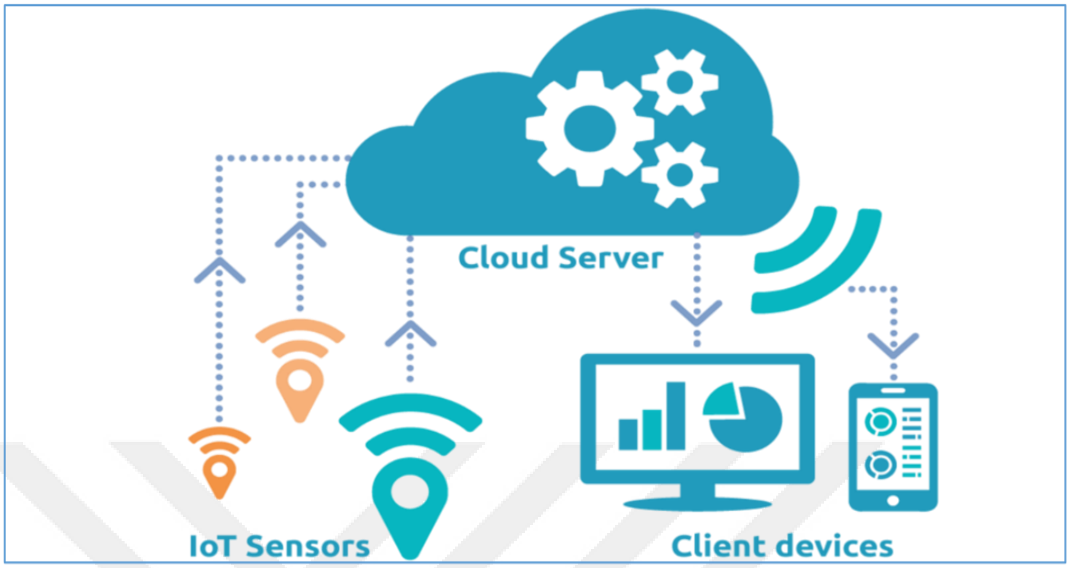

Figure 2.4: Internet of Things (IoT) cloud server.

2.5.3 Management of IOT Analytics and Data

Despite its diminutive size, the term "data" is loaded with great potential that may have a profound impact on any company's operations. To make sense of all the analog data, IOT Analytics is employed. Identifying critical performance indicators in an application where faults or abnormalities may be observed in real time, for example, can fall under this category. Once a problem is discovered, fast action must be taken to avoid any potentially harmful outcomes. Rather, analytics is the process of turning raw data into meaningful insights, which are then examined to help guide business decisions.

Multiple circumstances call for the usage of intelligent analytics. The primary responsibility of this position is to do situational analysis and then come to a conclusion. In the case of an automobile about to crash, this can be simple, such as determining if a room's temperature falls below an allowed range. It is possible to gain important business insights using data analytics. Predictive analysis may be performed using deep learning models.

The data may be used to draw a variety of insights for forecasting trends, making long-term plans, and making sound business decisions. To make sense of any data, analytics need substantial storage capacity and sophisticated processing. The cloud can be used to host tasks like these, depending on the architecture of the IOT.

2.5.4 User Interfaces and End-User Devices Are Included In This Category

The visible part of the IOT system that the user can readily access and manage is the user interface. Control and personalization options are available right here. The easier it is for a user to interact with this part of the IOT ecosystem, the more user-friendly it will be. The device itself can be used to interface with the system, or the user can use a smartphone, tablet, or laptop to do so remotely. "Things" may also be communicated with using smart home systems like Amazon Alexa or Google Home. An IOT device's visual appeal can help it stand out from the crowd in today's hyper-competitive marketplace. Some of the elements at play here include touch interfaces, color schemes, fonts, and even the user's voice. There must be a beautiful design, but the user experience must be user-friendly to eliminate inconveniences.

2.6 HEALTH CARE USES OF THE INTERNET OF THINGS

According to P&S Market Research, the healthcare Internet of Things (IOT) business will develop at a compound annual growth rate (CAGR) of 37.6 percent between 2015 and 2020. For sure, IOT has had a significant impact on healthcare over the past several years and will continue to do so for the foreseeable future. Here are the healthcare IOT applications everyone should be aware of:

2.6.1 Medical Devices for Monitoring Blood Sugar Levels Implanted

Sensors may be placed under the skin of diabetics to monitor their blood sugar levels at any time. When a patient's glucose levels fall below a certain threshold, the sensors in the devices will notify the patient through their mobile phone and store previous data for them as well. To better understand their risk of low blood glucose, patients will be able to assess not only their current risk, but also their future risk.

2.6.2 With Cancer Treatment and Activity Trackers

More than a patient's weight and age usually go into determining the best course of therapy for a cancer patient. Their way of living and degree of fitness also have a significant impact on the type of treatment they should get. A patient's movements, exhaustion levels, hunger, etc. are all tracked by activity trackers.

It will also help healthcare providers make modifications to the proposed treatment plan based on the data gathered from the tracker before and after treatment has begun.

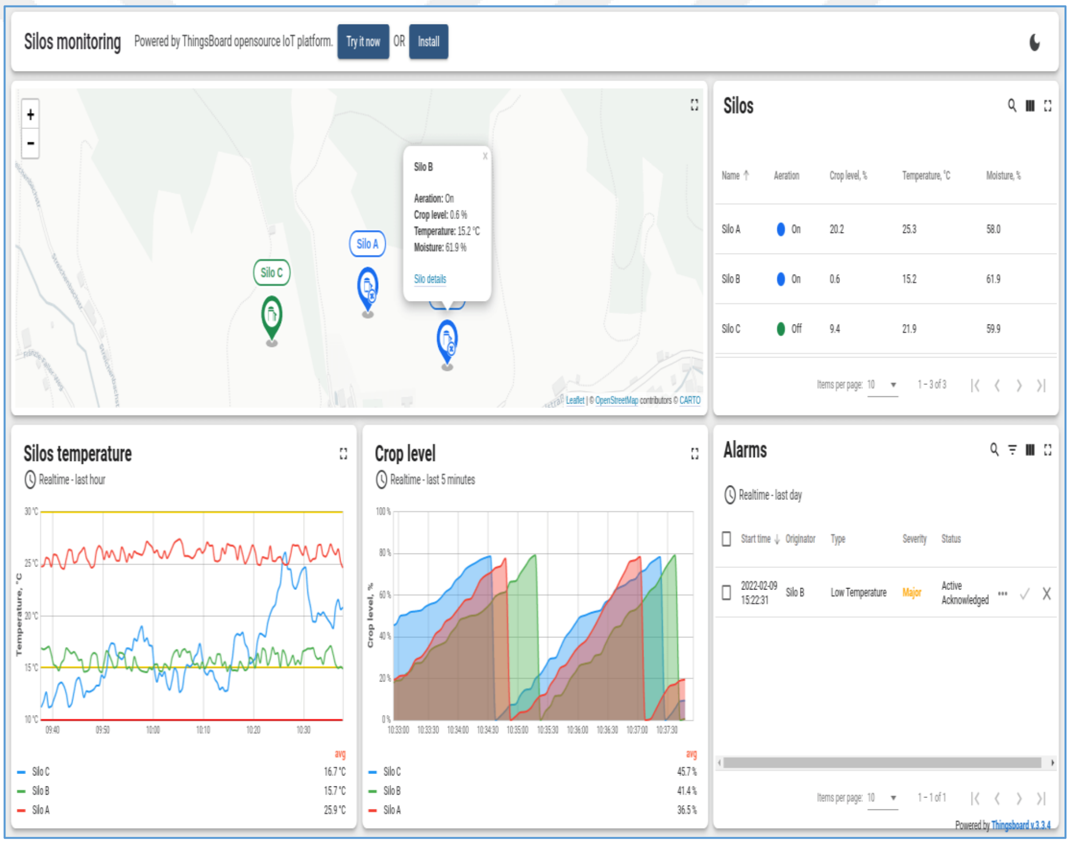

Figure 2.5: IoT platform's user interface.

2.6.3 Monitors for the Heart and Reporting

Patients with high blood pressure might have their heart rates monitored by devices they wear. During checks and examinations, healthcare practitioners will be able to get reporting of the patient's cardiac monitor data. Patients who are having arrhythmias, palpitations, strokes, or full-blown heart attacks might be alerted by the wearable devices to seek immediate medical attention. It may make the difference between life and if ambulances aren't sent quickly enough.

2.6.4 Medical Alert Devices

Those who want to In the case of an emergency, notify your loved ones. can do so by wearing jewelry-style devices. When a someone falls out of bed in the middle of the night and has a medical alert bracelet on, the individuals they choose to aid in the event of an emergency will be alerted on their cellphones.

2.6.5 Sensors That Can Be Absorbed Into the Body

Patients can now take sensors in the form of tablets and ingest them. They send information to the patient's mobile app that will help them keep track of their prescription doses once the sensors are eaten. Due to human error, most drugs are not taken as recommended. Patients can use this sensor to make sure they're taking the correct medications at the correct times and in the correct dosages. Irritable bowel syndrome and colon cancer can be diagnosed more accurately with the help of ingestible sensors.

2.6.6 Automated Medication Delivery Systems

Medication delivery systems that provide dosages continuously throughout the day can now be implanted in patients. Refill requests will be sent to patients through email. Missed doses can be communicated to doctors at routine appointments as well.

2.6.7 Sensors That Transmit Data Wirelessly

Blood samples, frozen pharmaceuticals, and other biological materials are being preserved at the appropriate temperature by wireless sensors in labs and hospital freezers.

2.6.8 Inhalers That Can Be Tracked

Patients' smartphones and tablets receive data from IOT inhalers, which tells them what they're doing or feeling that's triggering their asthma attacks. Those doctors can also use the information. They also remind patients when to use the inhalers that are linked to their smartphones.

2.6.9 Anti-Depression Wearable Devices

Manic depressive sufferers may now use an Apple Watch software to help them cope with their despair. The software keeps track of a patient's out-of-office episodes and keeps tabs on their cognitive and emotional functioning while they are not in the office.

2.6.10 Interconnected Eyeglasses

Patients with diabetes can now have their blood glucose levels monitored by wearing contact lenses with built-in sensors. In the near future, they will be able to help restore the eye's focus and improve eyesight.

2.6.11 Services for Locating Locations

Items such as wheelchairs, scales, defibrillators and other medical equipment may be tracked using IOT sensors and quickly identified by healthcare workers. Physical equipment is sometimes lost or difficult to locate, but with IOT, workers will always be aware of where everything is.

2.6.12 Remotely Observed

Healthcare providers may use Internet of Things (IOT) devices to keep tabs on patients who have just had surgery or are getting outpatient therapy. If a patient's condition becomes critical or if they need immediate medical attention, they will be made aware of this.

2.7 INTERNET OF THINGS (IOT)

Sensors/devices communicate with the cloud via some type of connection in an IOT system. An warning can be sent or sensors/devices automatically adjusted without the user's involvement after the data is in the cloud and software has processed it. However, if the user's involvement is required or if the user merely wishes to check in on the system, a user interface is available.

There are two ways in which the user's actions and modifications are transmitted: from the user interface back to cloud, and then back to sensors/devices to effect a change in the system.

2.8 PLATFORMS FOR CONNECTING THE INTERNET OF THINGS

The IOT technology (IOT) links things effectively to ensure seamless functioning and intuitiveness. An IOT portal helps sensors on a device to data networks. It provides a peek at the content with in backend program.

An IOT platform may be used to distribute programs, collect data remotely, encrypt connection, and administer sensors. An IOT network allows developers to build new mobile apps by managing the interconnection. It facilitates the collection of data from a variety of sources and the transformation of enterprises.

This gadget ensures that gadgets may communicate with one other transformation. There is an unbroken flow of communication between devices thanks to its role in interconnecting them.

Traditional business advantages, such as better asset utilization, are often included in IOT-enabled business objectives, as are new business prospects and revenue models, such as subscription-based services (versus owned assets). There are two sorts of IOT platforms: on-premises and cloud-based. On-premises IOT platforms are often installed on a company's own servers; cloud-based IOT platforms are typically hosted on a service provider's servers. Basic and complex IOT solutions and digital business activities may be supported by the IOT platform's Web-scale infrastructure capabilities.

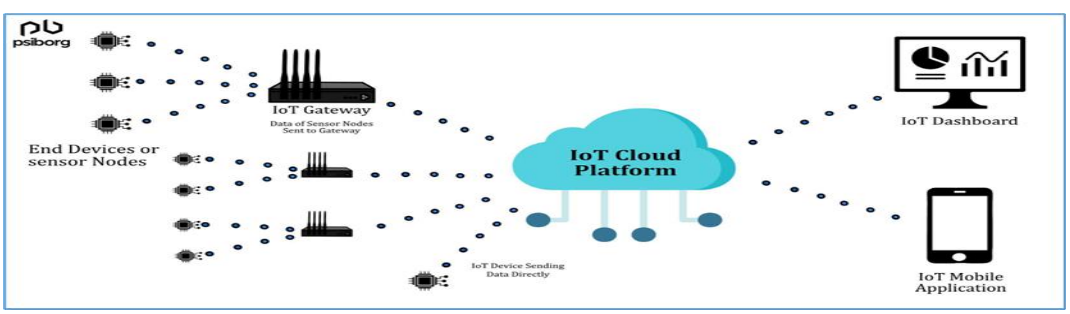

Figure 2.6: The Internet of Things (IoT) is in operation, with all of its sensor nodes and dashboards connected to a cloud platform.

2.9 IOT PLATFORM'S FUNCTION IN IOT SYSTEMS

i. The use of sensors and other hardware components is required.

ii. Adapt to a variety of hardware and software communication standards.

iii. Ensuring the safety of gadgets and the identity of their users requires.

iv. Compile and interpret the data that sensors and devices are generating.

Make use of all of the aforementioned in conjunction with existing business systems and online services.

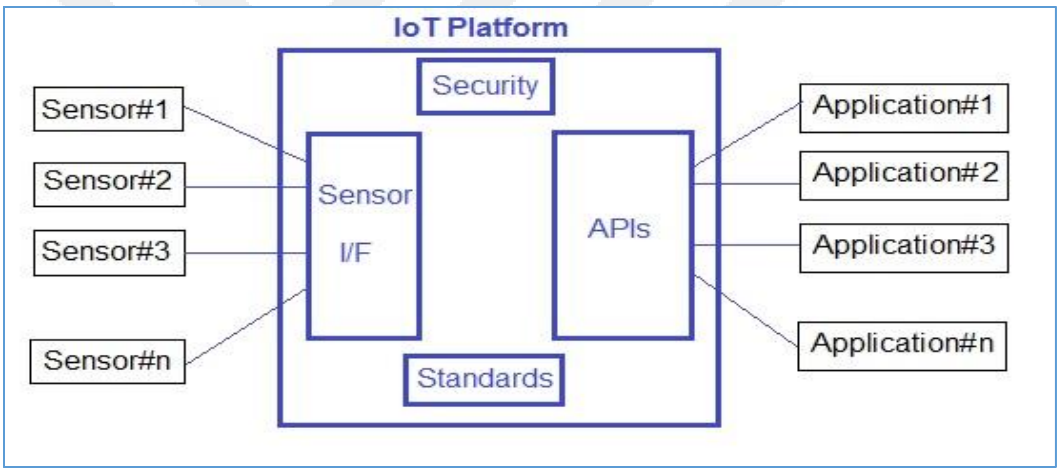

Figure 2.7: API-based IoT platform connectivity.

2.10 PREMATURE INFANTS

2.11 RELATED WORKS

In [6], the authors suggest a cloud-connected smart incubator system that collects data in real-time. Composed of an Arduino controller, several sensors, a wireless network, and a cloud-based data storage and processing system. In [7], the authors suggest a wireless smart sensor system for newborn incubators, complete with a variety of sensors, the ZigBee wireless protocol, and the IEEE 1451 communication interface, to enable remote monitoring of babies.

Using temperature sensors and an Arduino controller, a temperature control system for infant incubators is presented in [8].

If the incubator's temperature changes, the system will notify you immediately through the Internet of Things (IoT) web interface. In [9], a system based on contactless radar is presented for monitoring the baby patient's respiratory and cardiac rates. The antenna could only be made to cover the specific region that needed to be analysed. Multiple temperature sensors, a humidity measuring sensor, and an Arduino controller were utilised in a sophisticated monitoring and control system described in [10] to maintain an optimal temperature within the incubator and on the baby's body. In [11], a monitoring system for newborn incubators is presented, which includes remote temperature, humidity, and weight sensors linked to a centralised network that stores all of the medical records. The system uses a near-field communication interface to track physicians, patients' medication progress, and new information entered by doctors.

Most modern incubators have sensors on board that can track things like temperature and humidity [12-19].

When remote monitoring and control are needed, the ability to transmit these readings using these sensors is limited and may be expensive. With the development of communication technology and the advent of the internet, it is crucial to design and produce inexpensive incubators that can be remotely monitored and controlled.

We created a low-cost neonatal incubator that can be monitored remotely via the internet of things. ThingSpeak facilitates the development of sensor recording applications [20-24], whereas the IOT is a concept that continuously utilises the benefits of internet connection with the option of sharing data, remote controlling, and numerous other capabilities. This means that the Arduino IoT application may be used in conjunction with the ESP8266 wireless module to monitor the incubator's temperature and humidity as it fluctuates to ensure the safety of the newborn.

3. METHODOLOGY

3.1 INTRODUCTION

The purpose of this approach is to provide rapid methods of measuring several aspects of health. Various methods and components of the system are described in this section. In the first portion, we see a block schematic of the whole system. All the methods and components of the system are described here. Purpose: 3.1 Block Diagram**.**

The work of system that we proposed which depicted in Figure 1. The data is collected from the sensors (dht11 and max30100 sensors) and send the data to the microcontroller and after processing the data send to the IOT platform or the cloud when it is successfully connected to the network via Wi-Fi. Real-time monitoring of this IOT system is ensured by measuring and updating these values every second. The Internet of Things relies heavily on connectivity. Communication between IoT devices and other devices requires the use of a network. Internet of Things (IOT) devices are able to carry out their intended functions thanks to the transmission and reception of data. Then the user can monitor and show the result on its device.

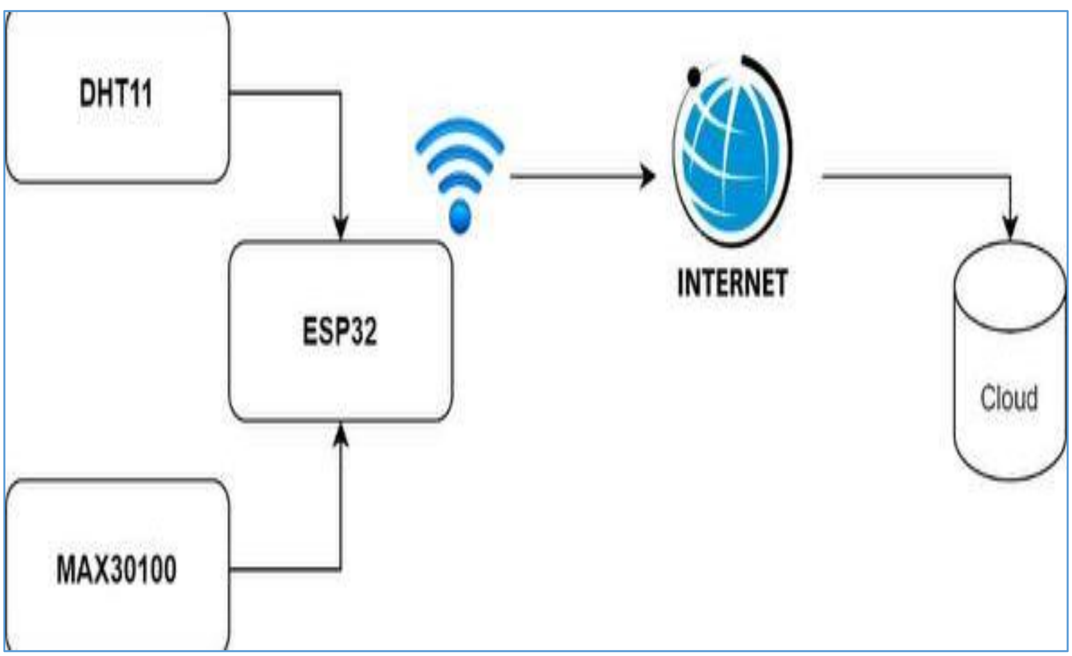

Figure 3.1: Proposed system's block diagram.

3.2 PROJECT MATERIALS

In this section of thesis, the hardware components that were used will be described briefly and their functions.

3.2.1 Maxim Pulsometer 30100 Max

The MAX30100 sensor monitors both pulse oximetry and heart rate. Pulse oximetry and heart rate data are detected using a low-noise analogue signal processor, together with two LEDs equipped with photodetectors and high-quality optics. The MAX30100 breakout board may run on 1.8V or 3.3V, and thanks to the board's software and low standby current, the power supply can be left connected at all times.

3.2.1.1 Application Examples of Max 30100 Pulse Sensor

i. Wearable Technology.

ii. Assistive Devices for Fitness.

iii. Medical Devices for Monitoring.

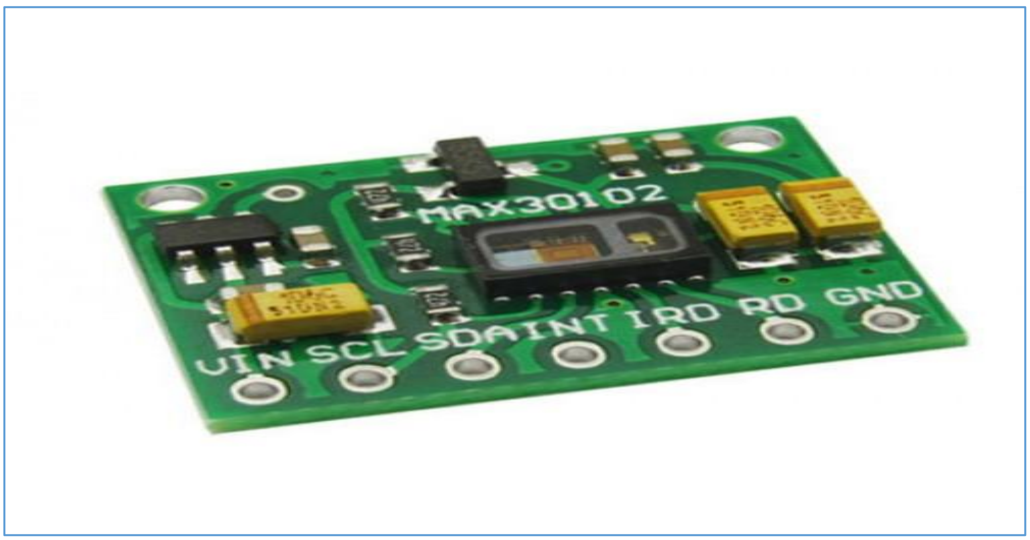

Figure 3.2: Max 30100 pulse sensor arrangement.

3.2.1.2 Principle of Measurement Max 30100

660 nm monochromatic red light and 940nm infrared light are the wavelengths of the light-emitting diodes used in the sensor. Oxygenated and deoxygenated hemoglobin absorb differently at these wavelengths, which is why these wavelengths were chosen. The emitted light is absorbed by oxygenated blood, and the remaining light is reflected by the finger and falls on a detector, the output of which is processed and read by a microcontroller. It communicates with the host microcontroller through an I2C digital interface. Because it has a red LED (with a wavelength of 650nm) and a far-infrared LED (with a wavelength of 650nm), the MAX30100 is equipped with ambient light cancellation, sixteen-bit ADC, and temporal filter (950nm). Your body's absorption of red and infrared light will be variable depending on your blood oxygen level. We can readily determine the oxygen content of your blood hemoglobin using this ratio.

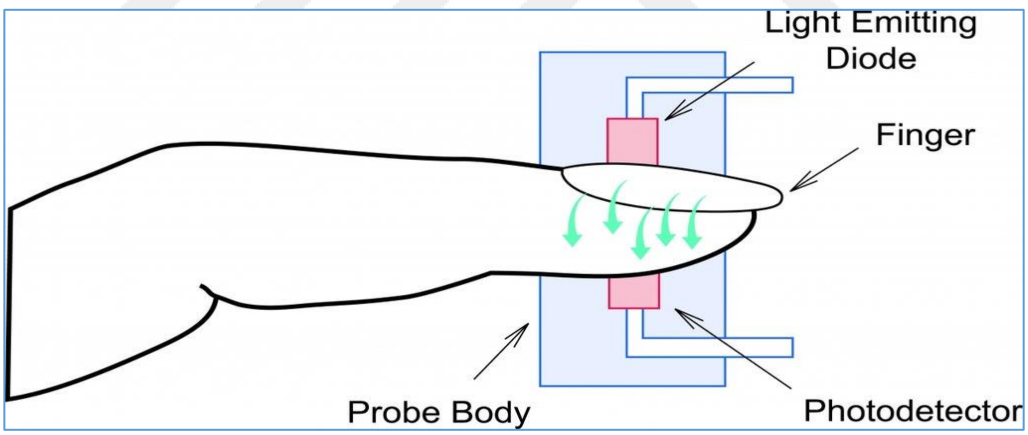

Figure 3.3: Illustrates the operating principle of the Max30100 pulse sensor.

3.2.1.3 Specification Details

The datasheet for this component contains additional information not included in these specs. The max30100 pulse sensor's technical parameters are shown in the table below.

Table 3.1 lists the sensor's technical parameters.

It's currently in the lead	during measurements ~ 600µA during standby mode ~0.7µA
A reliable source of electricity	3.3V to 5.5V
Wavelengths of IR LEDs	880nm
Infrared Red LED Spectrum	660nm
Range of Temperatures	-40˚C to +85˚C
Data	Serial data is used to provide temperature and humidity readings
Vcc	Input voltage range of 3,5 to 5.5 volts.
Ground	In the circuit, it's connected to the ground

Heart rate measurement and pulse oximetry are the two primary functions of the MAX30100 (measuring the oxygen level of the blood.

3.2.1.4 Measurement of Pulse Rate and Blood Pressure

HbO2 in arterial blood has a unique ability to absorb infrared light (IR). Redder blood (more hemoglobin) absorbs more IR light than white blood (lower hemoglobin). With each heartbeat, the amount of light reflected from the finger changes, resulting in a shifting waveform at the photo detector's output. Using a photo detector, you can rapidly receive a heartbeat (HR) pulse reading as you beam light and capture photodetector readings. Photoplethysmogram pulse detection heart rate sensor.

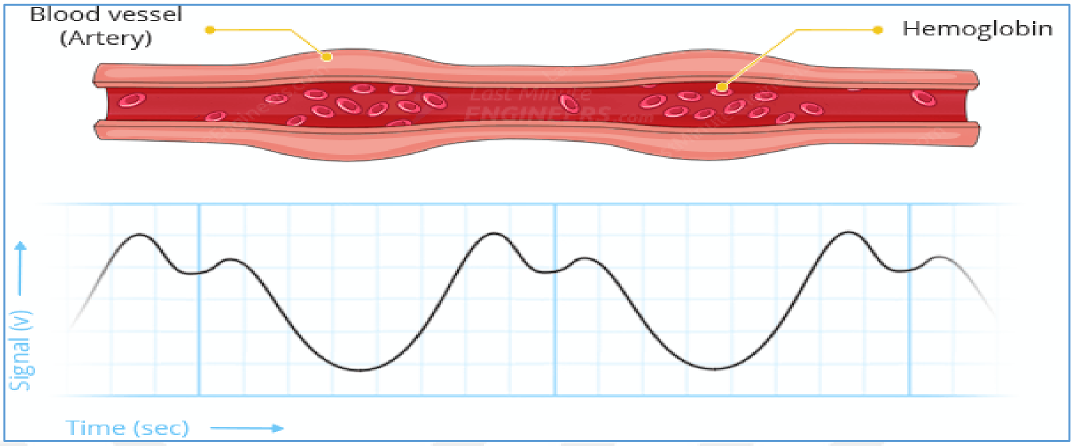

Figure 3.4: Hemoglobin detection signal trading.

3.2.1.5 Pulse Oximetry

Pulse oximetry assesses your oxygen saturation by observing how much RED and IR light is absorbed to calculate your blood oxygen levels. Below is a graph comparing the percentages of oxygenated (HbO2) and non-oxygenated (HbD) red blood cells (Hb). Blood that is low on oxygen (660nm) absorbs a greater amount of RED light (660nm) than blood that is high on oxygen (850nm) (880nm). By comparing the wavelengths of IR and RED light received by the photo detector, the oxygen saturation (SpO2) in the blood may be calculated.

Table 3.2 Parameter description of puls oximetry.

Data	Serial data is used to provide temperature and humidity readings
Vcc	Input voltage range of 3,5 to 5.5 volts.
Ground	In the circuit, it's connected to the ground

In order to determine your oxygen saturation level, pulse oximetry makes use of the fact that different amounts of red and infrared light are absorbed depending on the concentration of oxygen in your blood. In the graph below, we see the difference between oxygenated haemoglobin (HbO2) and its deoxygenated counterpart, HbD. (Hb). Blood that is low on oxygen (660nm) absorbs more red light (660nm) than blood that is high on oxygen (850nm) (880nm). The photo detector measures the amount of oxygen in the blood (SpO2) by comparing the wavelengths of light it receives from two different wavelengths, infrared (IR) and red (RED).

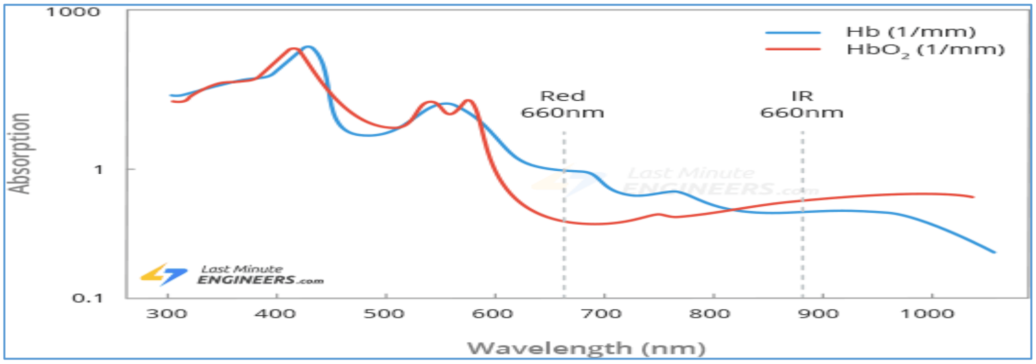

Figure 3.5: Relationship between absorbance and wavelength.

3.2.2 Temperature And Humidity Sensor Dht11, Version

The DHT11 detects both temperature and humidity and is a low-cost option for beginners. The relative humidity in the air is measured using a thermistor and a capacitive humidity sensor, and the reading is sent digitally through the data pin (no analogue input pins needed). Simple to use, however time is critical for data collection. Due to the fact that the sensor only refreshes itself once every two seconds, the readings you get while using our library may be up to two seconds out of date. The DHT11 is a common kind of temperature and humidity sensor that incorporates an NTC-based temperature sensor with an 8-bit microcontroller for serial data output.

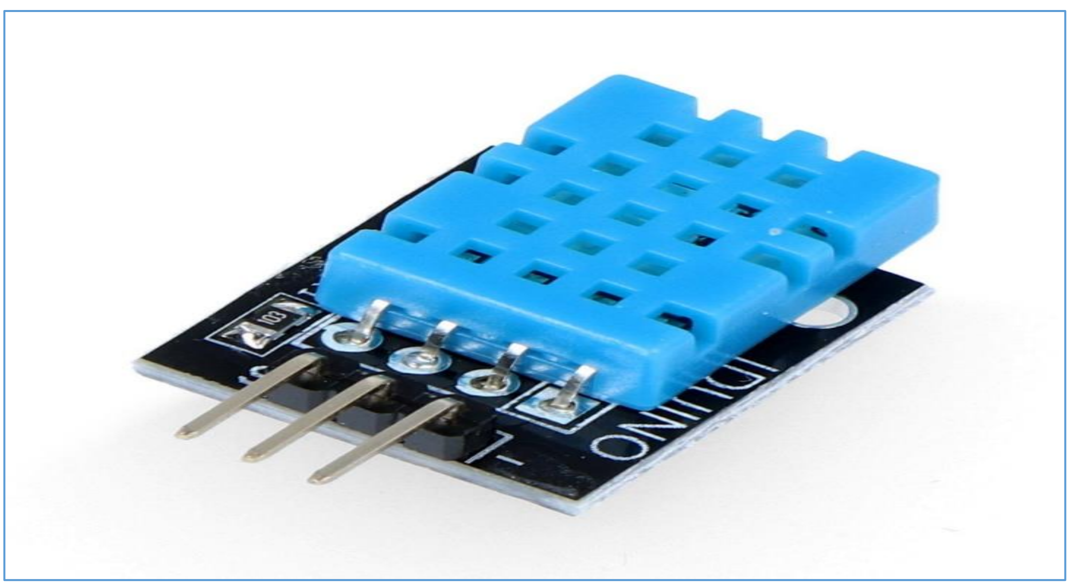

Figure 3.6: Temperature and Humidity Sensor DHT11.

3.2.2.1 DHT 11 Sensor Module Pin Configuration

3.2.3 Detailed Technical Information on the DHT11

i. 3.5 to 5.5V is the operating voltage range.

ii. (60uA) measured operating current (standby(0.3mA).

iii. Serial data is sent forth.

iv. From 0°C to a maximum temperature of 50°C.

v. percent relative humidity: 20% to 90%.

vi. Both the temperature and humidity have a 16-bit resolution.

vii. Accuracy: ±1°C and ±1%.

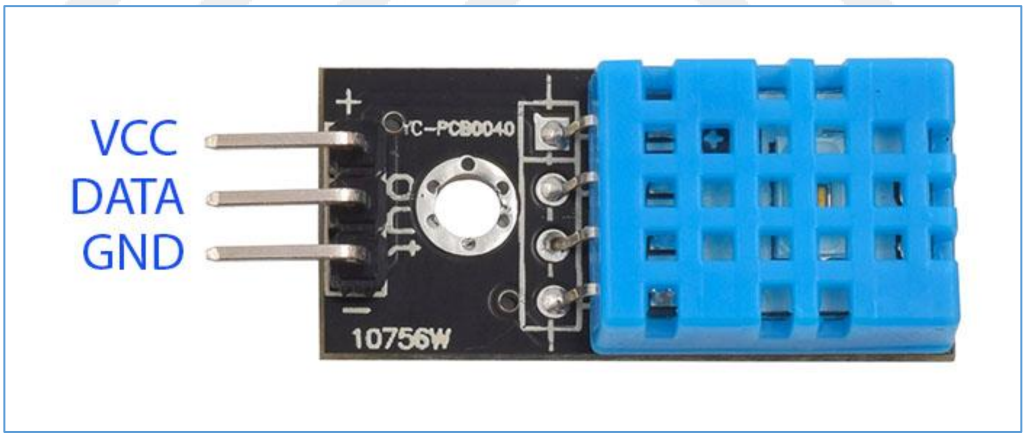

Figure 3.7: Sensor pinout for the DHT 11.

3.2.4 ESP32 MCU BOARD

SoC Signal generator by National Instruments, the makers of either the ESP8266 SoC, ESP32 offers in only one and dual-core versions of Tensilica's 32-bit Operating system LX6 Computer chip with incorporated WiFi and Wireless connectivity. There are both separate with dual versions of this processor available on the market. For example, when it comes to components like as Power Amplifier, Low Noise Receiver, Antenna Switching and Filtering and RF Contributing ideas, ESP32 and ESP8266 have many similarities. Due to its modest amount of external devices, ESP32-based technology is easy to build. In addition, the ESP32 is manufactured utilizing the 40 nm ultra-low-power technology from TSMC, which is vital to know. Therefore, creating battery-powered systems, such as textiles, sound equipment, baby monitors, smart watches, etc., with ESP32 ought to be a cinch.

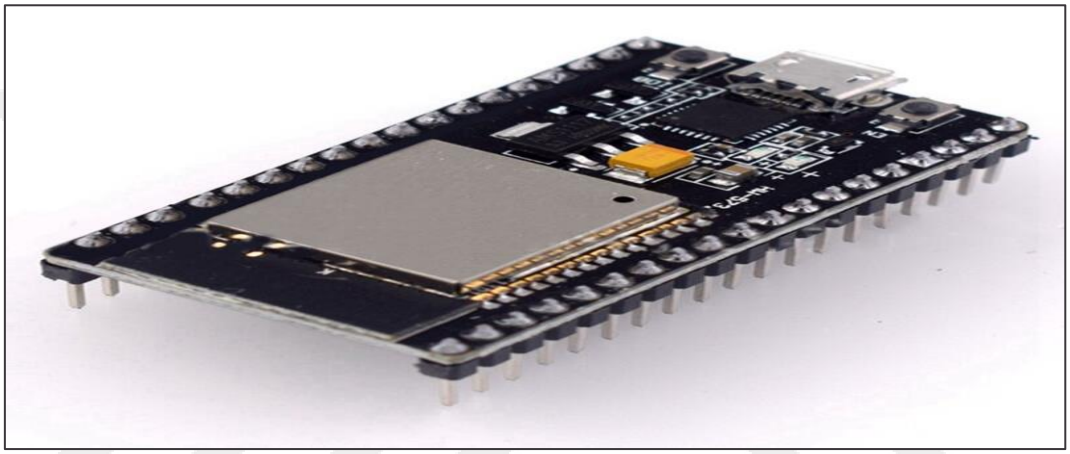

Figure 3.8: The No demcu Board For The ESP32.

3.2.4.1The Esp32's Specifications

Since ESP32 has many more functionalities than ESP8266, it would be impossible to include all of them in this introductory tutorial. Here I've compiled a list of some of ESP32's most salient features:

i. 32 -bit LX6 microprocessor with up to 240 MHz clock speed for single or dual core configurations.

ii. SRAM capacity is 520 KB, ROM capacity is 448 KB, and RTC SRAM capacity is 16 KB.

iii. Wi-Fi 802.11 b/g/n connection is supported, with a top speed of 150 Mbps.

iv. Support for both Bluetooth v4.2 and Bluetooth Low Energy standards.

v. A total of 34 programmable GPIOs are available.

vi. A 12-bit SAR ADC and two 8-bit DACs are available.

vii. Two I2Cs, two I2Ss, and three UARTs make up the serial connectivity.

viii. For the physical LAN communication, an Ethernet MAC is needed (requires external PHY).

ix. Memory cards can be used as either a host or a slave.

x. PWM for motors and LEDs with up to 16 channels.

xi. Flash Encryption and Secure Boot.

xii. AES, SHA-2, RSA, ECC, and RNG all benefit from hardware acceleration.

3.2.5 Programming In a Variety of Ways

If ESP32 can be programmed (written code) in several ways, it will be more user-friendly. As expected, the ESP32 can be programmed in a variety of languages. Programming environments that are regularly utilized include:

i. Arduino Software Development Environment (IDE).

ii. PlatformIO IDE (Integrated Development Environment) (VS Code).

iii. LUA.

iv. MicroPython.

v. Expressionism of the IDF (IOT Development Framework).

vi. JavaScript.

3.2.6 The Esp32 Devkit Is a Development Board for the Esp32

The ESP-WROOM-32 Module from Espressif Systems is one of numerous modules based on ESP32 that have been published by Espressif Systems. Assembled components consist of the embedded system processor (ESP32), the 40-MHz crystal oscillator, and the 4MB flash memory IC. I like the edge castellation on the PCB of the ESP-WROOM-32 Module. As a result, ESP-

WROOM-32 Module break-out boards are designed by third-party vendors. The ESP32 DevKit Board is an example of a board that may be used for this purpose. In addition to the primary module, it includes supplementary hardware for programming the ESP32 and connecting to the GPIO Pins, making it easier to get started.

3.2.7 Layout

In order to better understand what a typical ESP32 Development Board consists of, we'll take a look at the ESP32 DevKit Board, one of the most popular low-cost ESP Boards on the market. Marketed ESP32 Boards are various and varied, all using the ESP-WROOM-32 Module as its foundation. The features, layout, and pinout of each board are unique.

Pins are available on the board I'm using (15 pins on each side). It's possible to find 30 boards with 36 pins or even boards with less pins than that. To be safe, check all of the pins one more time before connecting anything or turning on the board.

3.2.8 The Board's Functional Pinout

There are a total of 38 interfaces on the ESP-WROOM-32s module, as illustrated in the following figure:

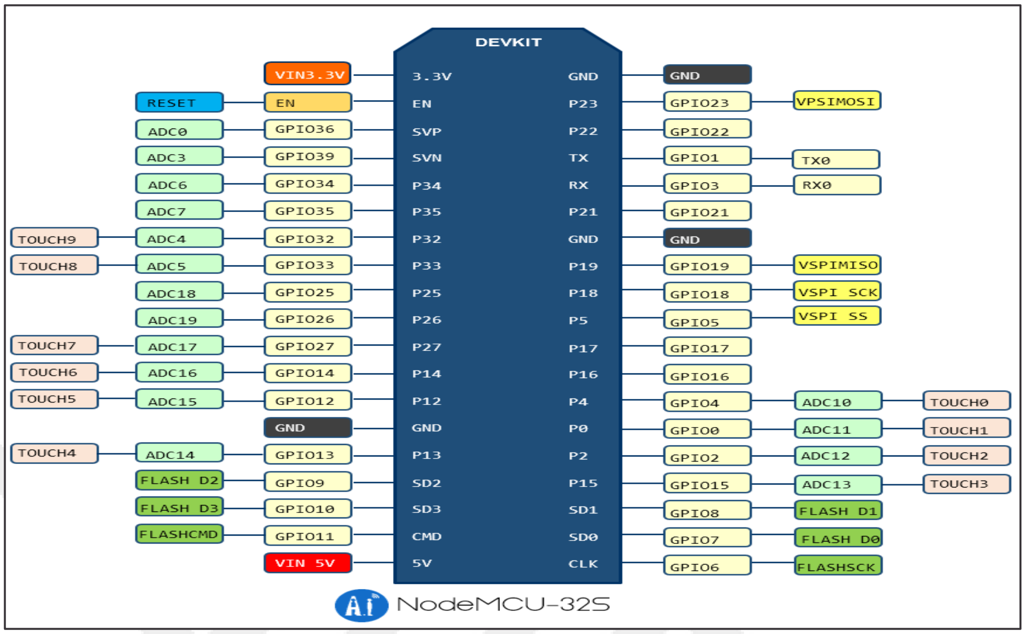

Figure 3.9: The pinout of the NodeMCU-32.

3.3 A TRANSFORMER RATED AT 5 VOLTS AND 3 AMPS

DC 5V, 3A/3000mA, 15W is the output of this transformer, which accepts AC 100–240V, 50/60Hz. No soldering is necessary to attach wires to it. Thus, the range of possible uses will be significantly widened. This 5V 3A transformer is capable of supplying any current in the range of 0.3 to 3.0 amps. ...such as 300mA, 800mA, 1A, 1.5A, 3A. If your gadget requires 2A of power, you will receive 2A of power. If a device requires more power than 3A, only 3A will be given, resulting in damage to the power supply.

Figure 3.10: A 5V/3 A Transformer.

3.4 IOT PLATFORM THINGSBOARD

IOT projects may be rapidly developed as well as managed and scaled with ThingsBoard's open source IOT platform. It is our mission to create an IOT cloud or on-premises server-side infrastructure solution that will enable your IOT applications.

3.4.1 Features

You can do the following using Things Board:

i- Define the relationships between devices, assets, and customers.

ii- Visualize data from devices and resources.

iii- Complex event processing can be used to analyze incoming data and trigger alerts.

iv- Remote procedure calls allow you to control your gadgets from afar (RPC).

v- Use REST API events, RPC requests, and other triggers to create workflows.

vi- Provide customers with device or asset telemetry and insights via dynamic and responsive dashboards.

vii- Customizable rule chains can be used to implement functionality tailored to specific use cases.

viii- Send data from a device to another system.

3.4.2 Architecture

The purpose of ThingsBoard is to:

i- Scaling: the platform that can be expanded horizontally and is developed using open-source technology.

ii- The cluster is fault-tolerant because there is no single point of failure.

iii- The number of devices that a single server node can support varies widely depending on the use case.

iv- When using a ThingsBoard cluster, you may connect an unlimited number of devices to it.

v- Widgets and rule engine nodes make it simple to add additional functionality.

3.5 DIAGRAM OF THE VOLT CIRCUIT

The ESP32, dht11sensor, and max30100sensor are all linked together in the following wiring diagram. These sensors are supplied with power and ground through the 3.3v pin of the esp32, and the SCL and SDA pins of the max30100 are linked to G20 and G22 (SDA SCL pins of the esp32) respectively.

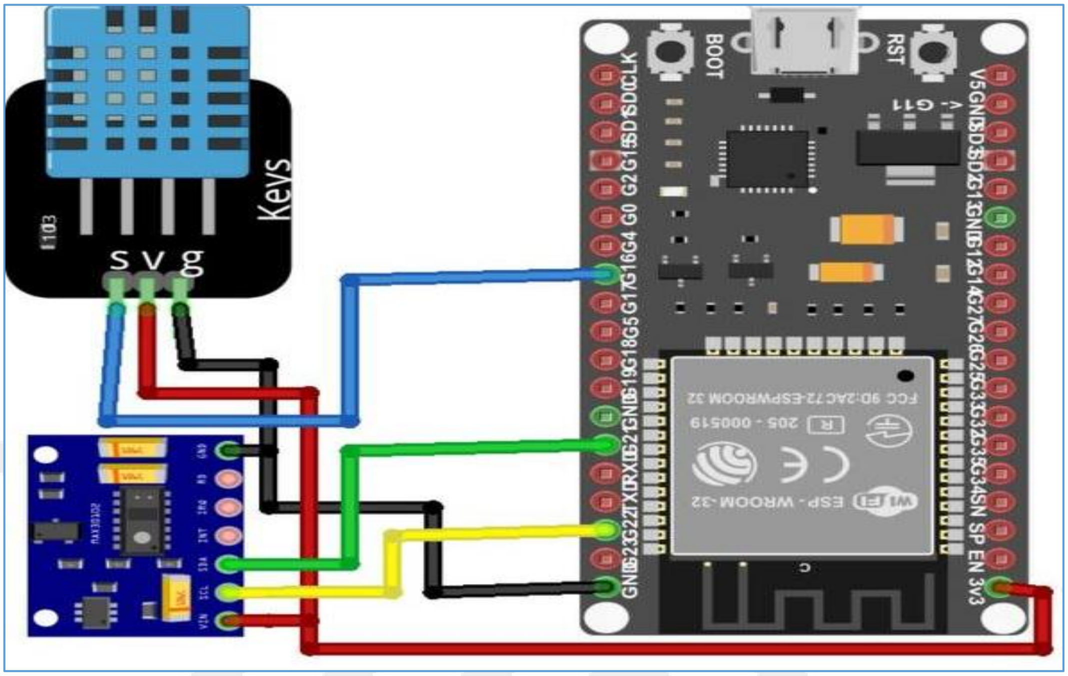

Figure 3.11: Proposed system circuit schematic.

3.6 IMPLEMENTATION OF CIRCUITS

The circuit implementation of the project is shown in the accompanying images, which show all of the components soldered on a PCB board.

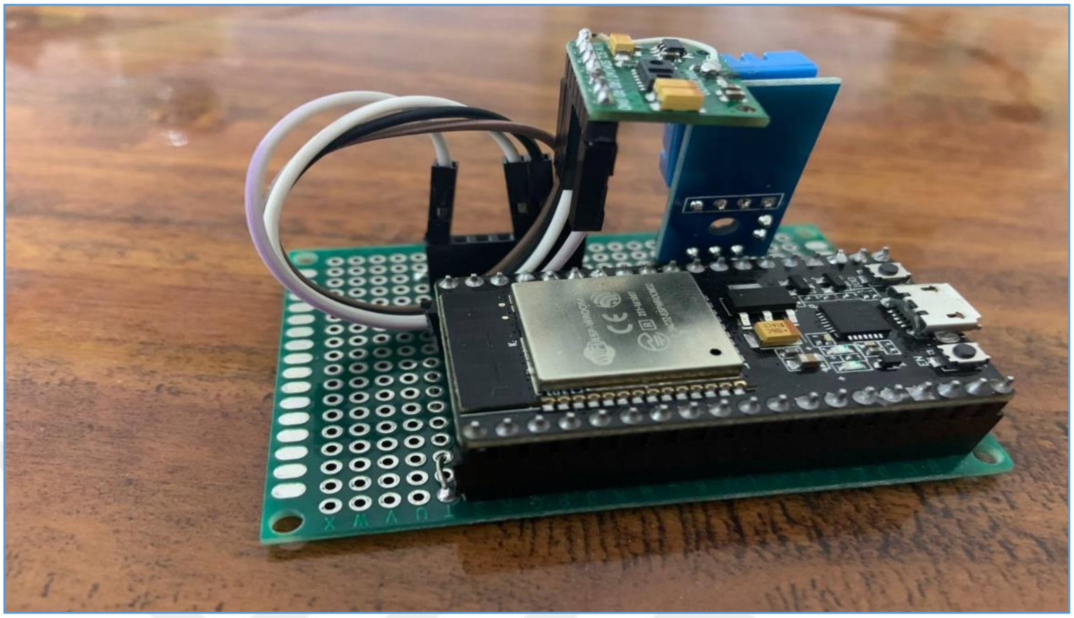

Figure 3.12: This circuit implementation is shown from the side.

The max30100 and dht11 sensors are powered by the esp32 board through a micro USB connection connected to the PC's USB port. The data from these sensors is uploaded to the thingsboard online IOT platform and updated in real time when a successful Wi-Fi connection is created.

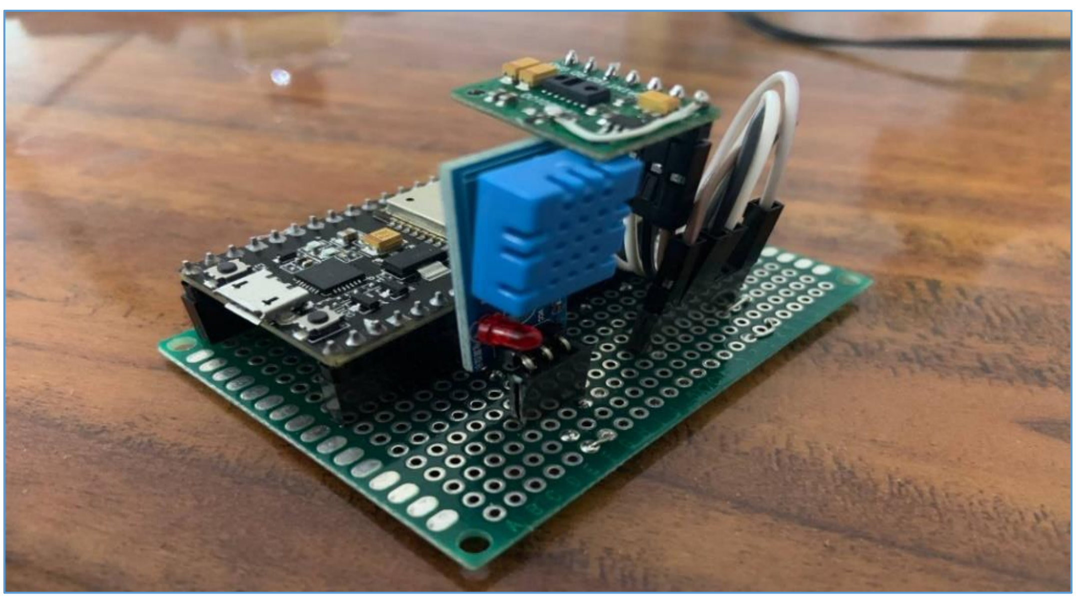

Figure 3.13: View from the side of the wire in the circuit.

3.7 THINGSBOARD DASHBOARD IMPLEMENTATION AT VERSION

Using the thingsboard platform's time series widget and heart rate, SPO2, temperature, and humidity graphs, we can receive the most up-to-date information on a baby's incubation phase health. Create and manage dashboards using ThingsBoard. There are several widgets that may be added to a dashboard. Data from a wide range of sources may be shown on dashboards. It's possible to allocate dashboards to certain individuals or departments inside a business.

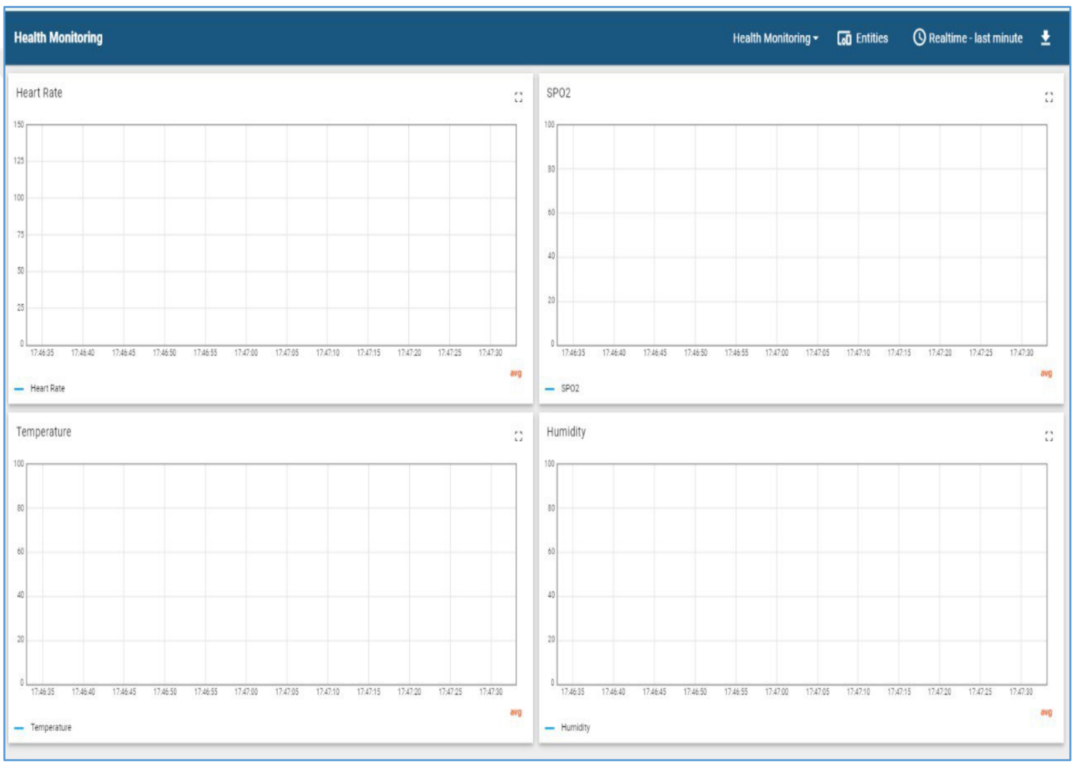

Figure 3.14: Thingsboard dashboard with four parameters.

4. RESULTS AND DISCUSSION

4.1 THE SUGGESTED SYSTEM'S OUTCOMES

Using the thing sboard online IOT platform, the system was able to operate and update in real-time mode..

Figure 4.1: Real-time metrics monitoring of the newborn.

4.2 THE HEARTBEAT RATE

We report here on experimental findings made possible by the finished device prototype. The Arduino receives readings from the cardiac pulse sensor. The data was processed by the microcontroller, and the LCD screen was used to show the results. Following transmission to the ESP8622 WiFi module, the data are sent to the thingspeak IoT platform over a reliable internet connection. Logging into your account on thingspeak.com will get you access to the heart rate data, which will be graphically represented for your viewing pleasure. The data may also be seen in a tabular format, along with a timestamp of its acquisition.

Remember that different people's resting heart rates result from a variety of circumstances, and that this variation is normal. The typical adult has a resting heart rate of 72 beats per minute. A child's heart rate between the ages of 7 and 16 is 70 to 140 beats per minute (bpm), whereas an adult's heart rate between the ages of 17 and 55 is 60 to 100 bpm. Heart rates of adults aged 60 and above also vary from around 65 to about 125 beats per minute while they're at rest. The size of a person, the amount of physical activity they engage in, etc. are also major contributors to their resting heart rate. The resting heart rate of an elderly man is seen in Figure 4.2a. The heart rate is65 and 125 beats per minute (bpm). The resting heart rate of an adult is shown in Figure 4.2b. The heart rate is obviously varying from 60 to 100 beats per minute. These plots prove that the suggested method is effective and trustworthy.

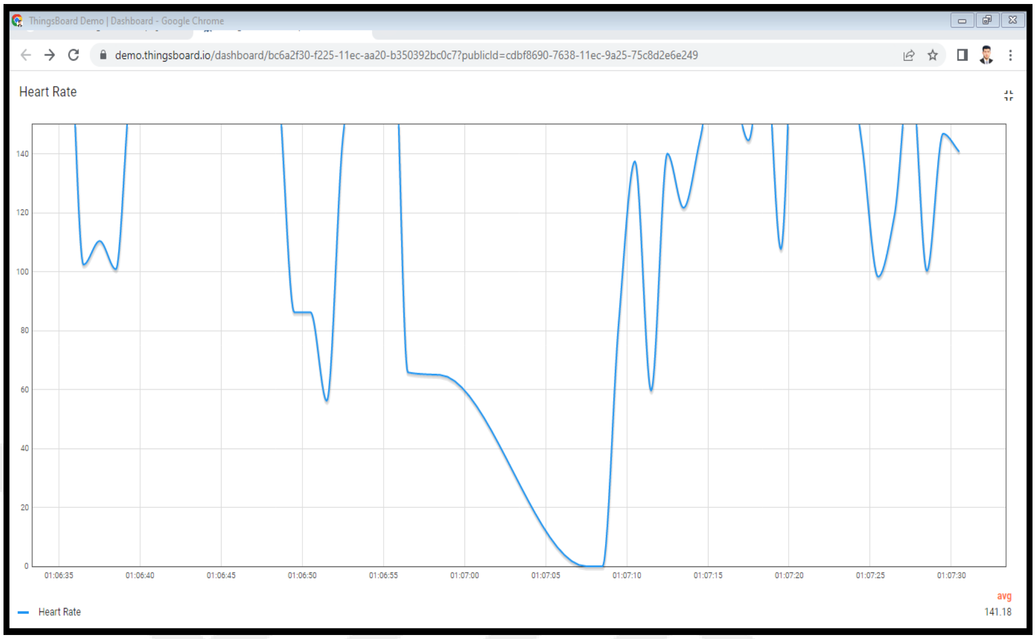

Figure 4.2: The heartbeat rate of man at rest state.

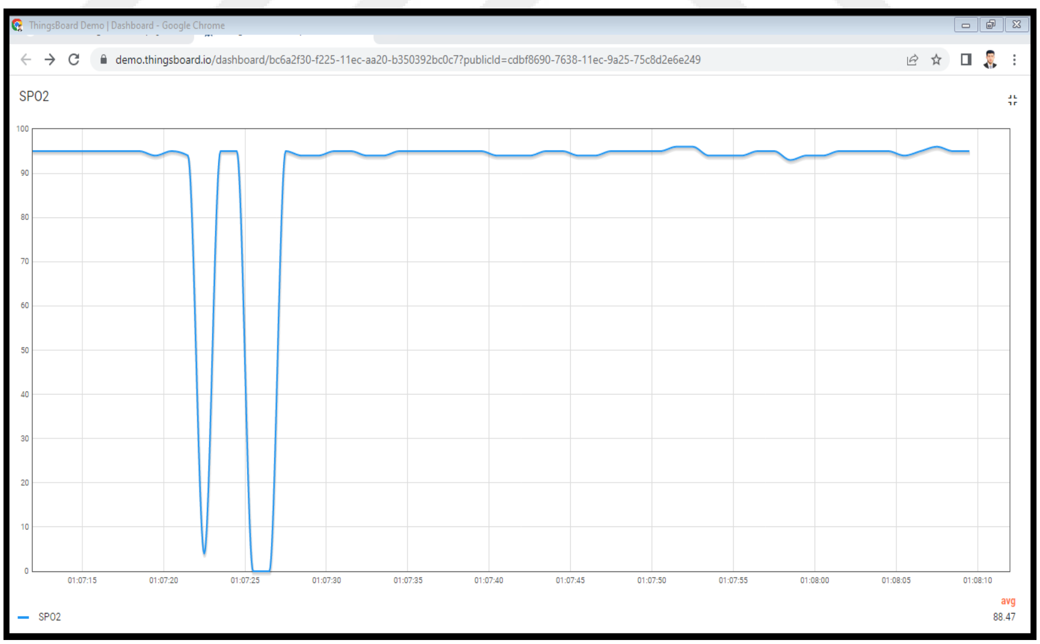

Figure 4.3: Heartbeat rate of an adult at rest state.

4.3 TEMPERATURE SENSOR

The LM35 series ar exactness computer circuit temperature sensors, whose output voltage is linearly proportional to the astronomer (Centigrade) temperature. The LM35 doesn't need any external activity or trimming to produce typical accuracies over a full fifty-five to 150C temperature vary. because it attracts solely 60mA for its offer, it's terribly low self-heating, but zero.1C in still air. The LM35 is rated to work over 20-degree temperature.

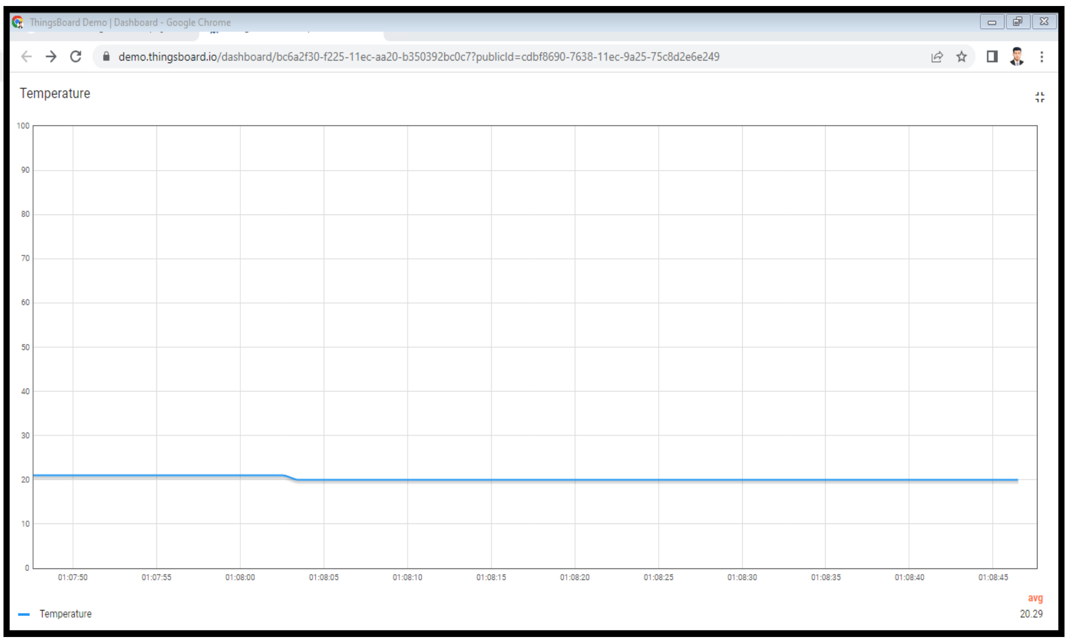

Figure 4.4: Temperature Sensor.

4.4 HUMIDITY SENSOR

One way to measure the amount of moisture in the air around you is using a device called a humidity sensor or detector. Wetness makes it hard to function well in daily life.

Figure 4.5: Humidity sensor.

4.5 DISCUSSION

This thesis details the hardware component of the Internet of Things-based Infant Equipment Monitoring System. The hardware component is comprised of a microprocessor, a data collection sub module, and a data transmission sub module. For this study, we used a MAX30100 sensor and a temperature-sensing ESP32 NodeMCU (with dht11). The ESP32 NodeMCU board acts as the information communication submodule, linked to the dht11sesnor Module and the max30100 sensor, which together communicate sensor data from the infant's body to a medical professional. The majority of this study's findings are unique approaches to use the ESP32 microcontroller board in the construction of a safe and effective baby hatchery.

5. CONCLUSIONS

Sensors are an important component of the Internet of Things (IOT). The Internet of Things (IOT) makes it possible to monitor and operate a wide variety of devices from a distance, as well as to integrate the real world directly into computer-based systems. As a consequence, productivity and accuracy are enhanced, as well as the economy’s bottom line. An easy-to-implement and short-ranged system will be the objective of the project. The ESP32 Wi-Fi Module is used to transmit sensor ratings to a specific IOT platform. The constant shifts in reading style are also evident at the same time. Having this system in place will allow you to catch problems before they get out of hand, thereby preventing them from becoming serious issues.

5.1 FUTURE WORK

Connecting more sensors to the internet that measure different health factors and would be helpful for patient monitoring may improve the future work of this thesis.

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