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# Smart Cradle with IoT-Based Baby Monitoring System

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**ABSTRACT:** This project is centered on the concept of creating a Smart Cradle System utilizing IoT that will allow parents to watch their children even while they are away from home and detect every activity of the baby from any location on the globe. It's a smart, inventive, and safe cradle system for efficiently nurturing a newborn. This approach takes into account all of the little aspects necessary for the care and safety of the baby in the cradle. The Internet of Things (IoT) (Modules like Raspberry Pi, Humidity & Temperature sensing), Cry Detecting Mechanism, Swing mechanism, Camera Interface, and other technologies/methodologies are used in the creation of smartness and innovation. User-Friendly Android Application & Cloud Computing (Data Storage) (for User Controls). Different Sensors/Modules are attached to the Cradle in order to monitor each and every action of Baby: Humidity & Temperature Sensing Module for detecting Wetness of the Bed, A Camera on top of the Cradle for snapshots, and Cry Detection Circuit to analyze Cry Patterns. Cradle will start swinging automatically when the crying of a baby is detected using a cry detection mechanism. There are two modes available in the swing mechanism one is auto mode and the other is manual mode. All of the data collected from the sensors/modules will be saved in Google's Firebase server and examined on a regular basis.

**KEYWORDS:** IoT, Baby monitoring, Cry detection, Swing mechanism, Sound classification, and Humidity & temperature Sensor, Android application, cloud computing.

## I. INTRODUCTION

As we are very well familiar with the obstacles confronted by Parents to support their newborn child and particularly in case if both the Guardians are working. To donate 24 hours of time in such cases is another inconceivable. In this way, we thought to develop something interesting that can help Guardians to have a continuous surveillance/watch on the Baby/Infant and can notify almost the same. As a result, we devised a plan to develop a Smart Cradle System based on IoT that can assist Guardians in monitoring their children even when they are away from home and can detect each activity of the infant from any location on the globe. It is an inventive, smart & protective Cradle System to nurture a newborn child in an efficient way. This approach takes into account all of the little aspects necessary for the care and safety of the baby in the cradle. The use of technologies/methodologies such as Internet of Things (IoT) (Modules like Raspberry Pi, Humidity & Temperature sensing, and IR sensor), Swing Automation, Cry Detecting Mechanism, Camera Interface, Cloud Computing (Data Storage), and User-Friendly Android Mobile Application contribute to the design of smartness and innovation (for User Controls). Different Sensors/Modules are attached to the Cradle in order to detect each and every activity of the Baby: Humidity & Temperature Sensing Module for detection of Wetness of the bed, swinging mechanism, a camera on top of the cradle collects photographs, and a Cry Detection mechanism for Crying Patterns (if required based on the range of frequency). All data collected from sensors/modules will be saved in the cloud (Google Firebase) and simply evaluated at regular intervals easily. If any abnormal behavior is identified (anything strange OR baby screaming OR moisture due to Baby Urine) in the Android Mobile Application that has been developed, an instant mobile notice will be created. It contains UI features, including the ability to regulate the cradle's swinging mechanism (can be turned on, turned off). The death of a child under the age of one year is known as Sudden Infant Death Syndrome (SIDS). It frequently occurs during sleep with no warning symptoms, making it

difficult to recognize and anticipate. As a result, our suggested monitoring system would be a useful tool for anticipating the beginning of SIDS.

## II. EXISTING SYSTEM

Some nannies were hired to look after the child. There are also some newborn health care centers that charge money to monitor or soothe the infant. As time goes on, there has been a lot of fraud uncovered in these types of centers, and we are becoming more aware of it thanks to newspapers and television networks. Some cradles are also developed, however they often just contain one or two characteristics. They were having problems taking care of the infant or interrupting the infant's sleep because of those one or two qualities.

In another study [1], a microcontroller-based project, a novel approach to an autonomous monitoring system for newborn care was presented. The authors created a low-cost baby monitoring system that detects sound when a baby cries and is connected to a swinging cradle that swings automatically whenever the system detects a sound and does not stop swinging until the baby stops screaming. A camera is also attached on the cradle's top to provide video footage of the baby's surroundings. Prof. Kranti Dive and Prof. Gitanjali Kulkarni recently presented a paper [2] on the creation of an embedded system for monitoring newborns. It is made up of a door sensor, an LDR-based light sensor, and a speech detection module for monitoring newborns. The sensors' output is shown through LEDs, and an alarm is coupled to the system to provide an alert.

The Internet of Things (IoT) is a term used to describe a network of items that are linked to the internet. It enables devices to send sensor data via the Internet without the need for human involvement [3], [4]. Because it is such a large category, the Internet of Things comprises a wide range of devices and is rapidly expanding. According to an estimate, roughly 26.66 billion IoT devices will be active in 2019, with 75 billion IoT devices available and wirelessly linked to the Internet by 2025 [5], [3] [6]. Millions of wearable sensors are commonly employed in healthcare applications among these linked devices [7].

Dainget al.[8] utilized an Arduino Uno with an ATmega328 processor to handle data from sensors (SN-PULSE pulse rate sensor and SN-model HMD humidity sensor) in an incubator with an LCD display to indicate the humidity within the incubator. The Arduino analyzed the sensor data and delivered it to the PC for ongoing monitoring. A Baby Monitoring System [9] is a system or tool that may aid parents in remotely monitoring their children, as well as provide security and comfort to the parents. suggested a project to design and build a Smart Baby Cradle that includes a microcontroller, a camera, a mobile toy, a stepper motor, a microphone, and a speaker. With the use of a mobile device application, the suggested study was able to assist young parents in taking care of their newborns. Savita P. Patil and Manisha R. Mhetre has introduced another GSM-based infant monitoring system [10]. Using the GSM network, this device can monitor a baby's body temperature, wetness, pulse rate, and movement and relay the information to the parents. This system, on the other hand, is controlled by a microcontroller, whereas the Raspberry Pi is utilized to operate the system provided in this paper.

## III. DESIGN AND FABRICATION OF SMART CRADLE

### Research Methodology

By completing a comprehensive literature study on research relevant to infant monitoring systems, flaws in existing systems were uncovered. Then we showed you a smart cradle that blends the Internet of Things idea with a baby monitoring system. The selection of material for the smart cradle was then completed. All of the hardware and materials utilized in the construction of this baby-friendly system were carefully chosen. The most important thing is to keep the infant safe. The system design, selecting the GUI of applications, and the prototype phase follow the modeling phase. The cradle design and the control system design are the two phases of the system design. For the infant monitoring system, a cradle prototype was created. The sorts of electronic components used in the control system design were identified and acquired for use in the system. Then, according to how the system was proposed, coding was done. Following the modeling phase, the planned infant monitoring system was improved and refined through a series of testing in order to obtain the desired result. The technology was then mounted on the cradle prototype for testing before the smart cradle was completed. When testing failed to owe to code mistakes or other issues, the testing step was repeated until the cradle produced the desired result and met the study objectives.

### Component Selection

The information of the components required for the infant cradle was chosen to guarantee that they could be placed correctly. We also looked at the various infant cradles. To acquire some traction, a baby monitoring system was introduced to the market. The construction of the infant cradle is shown. During this time, The hardware and software components were employed in this phase. The study was chosen.

The following were among the hardware components:

- Raspberry Pi 3.
- DHT11 Digital Temperature and Humidity Sensor.
- USB MIC.
- Pi Camera module.
- LEDs.
- IR Sensor.
- Serv motor.
- 5 V ADP.
- Memory card.
- Connecting wires.
- LED light.
- Baby cradle.

The following are some of the software components:

- Raspbian OS.
- Python IDLE – v 3.4.
- Android Studio – v 3.0.1.

Following the component selection procedure, we developed and built the infant cradle, into which the IoT-BBMS was later placed.

### Baby Cradle Fabrication

The materials were assembled throughout the production process by merging parts and components to create the completed product. The fabrication idea has always included the assembling process. Shop drawings were used to start the production process, which included exact measurements. The fabrication step was then finished, followed by the installation of the final project. Glue, screw, and nut were used to assemble the infant cradle, which held all of the parts together, including the legs and electrical components. To ensure strength and longevity, every item has to be glued together. The fence panel of the infant cradle is made up so that it prevents falls while yet allowing the infant to see out from the cradle. Furthermore, as compared to other prior designs, the infant cradle has a traditional style.

## IV. SYSTEM DEVELOPMENT FOR IOT-BBMS

### Design of monitoring system

The cradle is meant to attach to the servomotor. When the user turns on the switch or when the sound sensor detects the baby's cry, it swings. Following the circuit testing process, the control circuit components are fitted into the associated electrical box. Before transferring the components to the solder circuit panel, the components are put on the breadboard to confirm that the system functions properly. The cradle is attached to the shaft of the servomotor, allowing it to swing whenever the infant cry is detected or prompted by the user. The camera is mounted on the outside of the cradle to keep an eye on the infant. Our system uses wireless technology to monitor the baby's vital signals, such as body temperature and moisture. We're also working to expand the range of information that may be transmitted via the internet in order to allow remote access. The camera module allows for the presentation of visual feeds of the baby's position and keeping an eye on their movements in a limited region. This method eliminates the shortcomings of present methods, which are clunky, inefficient, and costly.

### IOT-BBMS Implementation

Because the Internet has certain constraints that would cause the system's connection to fail, the Raspberry Pi's connection is coded to connect to a specific Wi-Fi network with the specified password contained in the coding in the practical execution of the planned system. The method is then retested utilizing the data hotspot on the programmer's mobile phone. The connection was established successfully, and there was no time delay when sending and retrieving data to and from the Firebase server. Drilling a hole in the side of the electrical box to allow the DHT11 temperature



and humidity sensor to fit in the hole was used to detect the ambient temperature. As a result, the DHT11 sensor may be exposed to ambient temperature before being measured and uploaded to the Firebase server.

A rotating mechanism is utilized to swing the cradle, and a servomotor is utilized to move the cradle to and fro. When the motor turns, this mechanism swings the infant cradle by elevating it to one side and then to the other. While the servomotor turns to 180 degrees, it causes the cradle to swing by lifting roughly 20 degrees on one side and lowering on the other. All of this happens when the system recognizes the sound of a baby crying, or it may be done manually with the use of an application by the user. The code sequence must be reorganized in accordance with the overall architecture of the infant monitoring system, i.e., which sensor runs first and which sensor follows when it is activated. The data collected from the sensors (sound, temperature, and humidity) is sent to the Firebase server and utilized to control the linked actuators (swinging motor and the musical toys).

As an add-on feature for the designed smart cradle, a real-time camera is employed for visual monitoring of the baby's status. The camera view quality may be viewed in high definition (HD).

### Enhancement and optimization of the design

This phase is critical for optimizing system performance and detecting errors. The problem from the previous phases was discovered and remedied in this step. This process was repeated until the project was completed successfully. During the previous phase, an LED was utilized as a substitute for the read output, such as during the motor and buzzer while waiting for the actual product to arrive. Following the refinement and optimization, the final configuration of the system was accomplished, with the temperature and humidity sensor, IR sensor, camera module, and USB mic linked to the Raspberry Pi board and computer system.

### System architecture

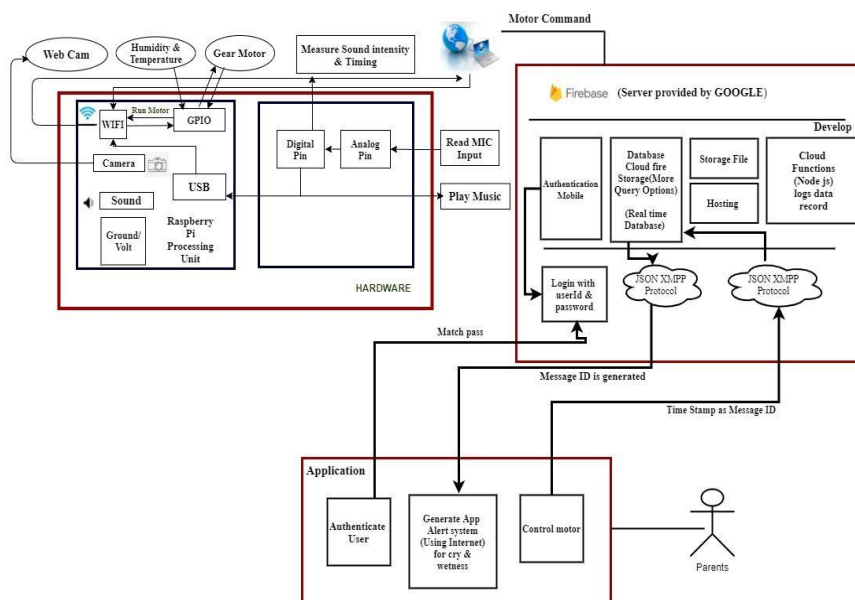


Fig 1. The architecture of system.

The complete system architecture of the developed IoT-BBMS is shown in the diagram above. For speed and convenience of data uploading, we used the Firebase server. Users may connect to the Internet using their smart devices, such as PCs, laptops, and smartphones, via Wi-Fi or mobile data connections. Users may undertake wireless remote monitoring of the baby's conditions by getting data from the sensors and actuators attached to the Raspberry Pi through the internet.

The system design comprises of a baby cradle that, in response to sound sensor input, swings automatically utilizing a motor. The normal data stored in the Firebase server cloud, such as ambient temperature and remote switches, may be seen by the parents through the Internet using the Firebase server, whilst abnormal circumstances are communicated to the parents via a triggering alert to take immediate action. To engage the infant, the parents may use an external web

camera to check the baby's condition and use the Firebase. A USB MIC is utilized to detect the baby's crying and supply the necessary data for classification of sound.

In the suggested system, a temperature and humidity sensor, DHT11, is employed to monitor the baby's surrounding temperature and moisture. A signal is transmitted to the firebase when the USB MIC detects a sound from the infant. The system activates a relay linked to a Servomotor, which is then linked to the cradle for swinging. The temperature and humidity sensor detects the room temperature, stores the measurements in the server, and simultaneously uploads the data to the Firebase server. An indication is delivered to the application if the temperature in the room exceeds a specified threshold. In this method, an external Pi camera is utilized to allow the parent to watch the baby's status in real-time. For data storage and transmission, the Firebase server is utilized. A setpoint is present for the values provided by the sensor, and if any of the setpoints are crossed, the system reacts to the situation and sends an alert to the application with a snapshot.

#### **Mechanism of system architecture**

All of the sensors and modules are linked to the cradle, and the data they collect is saved on Google's Firebase server, which the user may access through the application. The user may then verify the status of the infant using the camera; if the infant is inside the cradle, the condition is met or not. The system will next check if the baby is crying using our inbuilt microphone, and if the infant is identified weeping using the cry detection mechanism, the swing mechanism will be activated, along with a photograph and an alert on the app.

The wireless camera application also allows the user to see the baby's current status in real-time. The user may manually operate the device through the Internet with this baby monitoring system.

#### **V.RESULTS AND VALIDATION**

The findings, discussion, and validation of IoT-BBMS are detailed in this part. Prior to the deployment of the smart cradle's control system, several manufacturing procedures were completed. The data collected by the used sensors, such as the sound sensor, temperature, and humidity, is uploaded to the Internet and accessible through the firebase server and mobile app. A mobile application that works with phones that run on the Android operating system. "Baby Phone" is the name of the application, which may be synced with the Firebase server. We chose this program for constructing our dashboard after considerable tweaking and testing because of its simplicity and user-friendliness in terms of appearance and usage. The Login page for user authentication is shown in the screenshots below.

When sound is detected by the embedded mic and identified by the cry detection module, the smart cradle may swing automatically. A notice is delivered to the user via the mobile application to inform them that the baby monitoring system has detected crying. Toggling the switch in the mobile application allows the user to manually regulate the cradle's swing. An external wireless camera is used to provide real-time visual monitoring. The GUI also displays the ON/OFF toggle switches, which allow the user to control the Servomotor by sending a command to the relays.

To imitate a baby, the prototype was tested with the aid of a baby doll. The system was then put to the test to see if it could perform as expected. Furthermore, the prototype's functioning was tested using a mobile phone by accessing an Internet-sourced baby wailing sound. As a simulation of a real infant crying situation, a cell phone was placed near the mic. Due to the loop process in the programming codes, sound detection has a slight delay.

When the cradle began to swing, the user was alerted, signaling that the infant was crying at the time. The prototype was also tested with the upload of data from the system to the firebase server taking longer than expected. The process of uploading and retrieving data to and fro the server took around 3 seconds. Several testing methods were carried out, and in certain cases, no time delay was detected. However, some of the testing findings revealed a little time delay. The probability of time delay after numerous testing and fabrication procedures was determined by the strength of the linked network.

#### **VI.CONCLUSION**

To monitor a baby's essential factors, such as crying condition, humidity, and ambient temperature, a smart cradle with a baby monitoring system through IoT has been devised and constructed. During the enhancing phases, changes were made to ensure that the study outputs met the goals. A cell phone with a baby crying ringtone was put in the cradle and used to test the final prototype. The cradle began swinging when the phone rang for a few seconds because the system assumed the infant was sobbing owing to the detected sound. A notice was sent to the user's phone to indicate that the infant was crying. The wireless camera was used to perform real-time visual monitoring. The user may observe the infant via the camera mobile application. The user interface of our system has to be upgraded in order to overcome the



restrictions of both the Firebase server webpage and the mobile application. To add further monitoring and controlling features depending on our system needs, we will design our own web-based and Android-based dashboards for laptops, PCs, and smartphones. When parents are connected to the same network as the wireless camera, they can only see the part where the camera is positioned. The camera may record the baby's activity using a TransFlash card, although this is not considered real-time monitoring. As a result, the wireless camera may be converted to an IP camera in the future for network viewing through IP hosting. The specified IP address for the IP camera may be typed into the network browser by the parents to watch the baby's status in real-time. In addition, further work may be done to improve this system. To ensure the safety of the infant and minimize the weight of the infant cradle, a lighter and safer material, such as soft plastic, can be utilized to replace the wood materials.

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