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Smart Baby room with IoT

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Abstract

Parents nowadays often struggle to find time for their children, especially infants, in their hurried lifestyles. A newborn at home presents numerous complications for parents. They have to keep checking on the infant, which disrupts their routines and generates stress, making it difficult to concentrate on other tasks. Frequent visits to the baby's room may unintentionally transmit germs, endangering the infant's health. The lack of assistance from other family members further exacerbates the situation, leaving parents feeling overwhelmed. Frequent crying fits disrupt parents' sleep, impacting their well-being and productivity. To address these challenges, we offer a comprehensive solution that leverages modern technology to provide parents peace of mind and a safer environment for infants. The first step is implementing automatic cradle functions and cry detection. This system will recognize when the infant cries and start soothing cradle movements automatically, relieving parents of the need to react immediately. For added convenience and security, a smart door control system will be installed in the room, allowing parents to monitor and manage room access without frequent visits. Lastly, IoT-based temperature control will maintain an optimal room temperature, preventing the infant from becoming too hot or cold, thereby ensuring their comfort and health. By employing these strategies together, parents can better manage their time, reduce stress, and provide a more pleasant and healthy environment for their babies. Automation and smart controls will not only offer immediate relief but also improve the long-term well-being of both parents and children.

Keywords
Arduino mega - Used to create complex projects due to its structure
Arduino Uno - Used to create simple projects due to its structure
RFID – Identify Radio Frequency
DHT11 Sensor – Measure the temperature
Sound mic sensor – Detect the frequency of a area

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Thank you all for your invaluable support and contributions.

Declaration

We declare that the this project report or part of it was not a copy of a document done by any organization, university any other institute or a previous student project group at SLIIT and was not copied from the Internet or other sources.

Project Details

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Project ID	PEP_01

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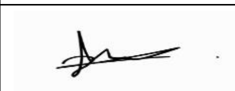
IT22092724	Dampage V.I.	
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List of Acronyms and Abbreviations

IoT -Internet of Things

RFID- Radio Frequency Identification

1. Introduction

The introduction of the Smart Baby Room with IoT project aims to provide a comprehensive overview of the document, detailing its purpose, conventions, intended audience, scope, and references. This section sets the stage for understanding the objectives, requirements, and functionalities of the project, emphasizing its significance in enhancing infant care through advanced IoT technologies.

1.1 Problem Statement

It can be difficult for parents and other caregivers to ensure the safety, comfort, and well-being of infants in today's hectic society. Conventional infant monitoring systems are mostly focused on auditory and visual monitoring, with limited functionality. For the health and safety of a child, these technologies are unable to provide real-time, full environmental management and monitoring.

Problem: Infants often cry due to discomfort, hunger, or other needs, and it is crucial to respond promptly to soothe them.

Problem: Maintaining an optimal temperature is crucial for an infant's comfort and health.

Problem: Unauthorized access to the baby’s room can compromise safety

Problem: Continuous monitoring and immediate feedback are necessary to ensure the infant’s environment is always optimal.

1.2 Product Scope

Through the integration of cutting-edge IoT devices and sensors, the Smart Baby Room with IoT project seeks to provide infants with an intelligent, secure environment. The system's automated reactions and real-time monitoring are intended to improve the safety and wellbeing of infants. The main objective is to give parents and other caregivers a complete solution that guarantees the best possible care and comfort for newborns while blending in seamlessly with contemporary smart home ecosystems.

Overall Scope

The overall scope of the Smart Baby Room with IoT encompasses the development, deployment, and maintenance of a system that integrates various IoT devices to monitor and control the infant's environment. This includes hardware components like sensors and actuators

In-Scope

1. Cry Detection and Cradle Automation
2. Door Control System
3. Temperature Regulation

Out-of-Scope

1. Non-IoT Based Monitoring Systems
2. Advanced Medical Monitoring
3. Non-Residential Applications
4. Custom Hardware Development
5. Long-Term Data Storage and Analysis
6. Direct Medical Interventions
7. Extensive User Training Programs

1.3 Project Report Structure

The Smart Baby Room with IoT project report provides a detailed overview of its development, implementation, evaluation, and future prospects, ensuring clarity and thoroughness throughout its journey.

Chapter 2 details the methodology for the Smart Baby Room system, including requirements analysis, design, implementation, and testing strategies, outlining stakeholder needs, technical specifications, and coding standards used during the development process.

Chapter 3 evaluates the Smart Baby Room IoT system's results, lessons learned, and potential future enhancements, comparing them to initial requirements and goals.

Chapter 4 concludes by outlining the project's key findings, achievements, and impacts, highlighting its significant contributions to infant care and IoT technology.

Chapter 5 provides a comprehensive list of all sources cited in the report, ensuring transparency and credibility.

Appendices A provide detailed diagrams of system architecture, component interactions, and data flows, to validate system functionality and performance.

Appendix B contains code snippets that highlight essential aspects of the system's implementation.

2. Methodology

2.1 Requirements and Analysis

This section analyzes the Smart Baby Room with IoT project's requirements, categorizing them into functional and non-functional aspects, and providing use case and activity diagrams for system operation and interaction.

Functional Requirements

F1: Cry Detection and Cradle Automation

Description: The system should detect an infant's cry using a voice sound detection mic sensor and activate cradle automation to soothe the baby.

F2: Door Control System

Description**:** The system should provide access control using an RFID module and RFID key tag token to automatically open the door.

F3: Temperature Regulation

Description: The system should regulate room temperature using a DHT11 temperature and humidity sensor to ensure infant comfort.

Non-functional Requirements

NFR1: Performance Requirements

Description: The system should achieve a minimum accuracy of 95% in identifying baby cries. Real-time monitoring of the baby's vital signs, movements, and environmental conditions such as humidity and temperature. The device must detect differences in room temperature and adjust it within 5 minutes.

NFR2: Safety Requirements

Description: Use of certified and insulated electrical components.
Regular inspection of wiring and connections to ensure safety.

NFR3: Security Requirements

Description: Authentication required for parents and caregivers to access the system.
Physical components like sensors, and microphones should be tamper resistant.
Use of tamper-evident seals where applicable to prevent unauthorized access to sensitive components.

2.2 Design

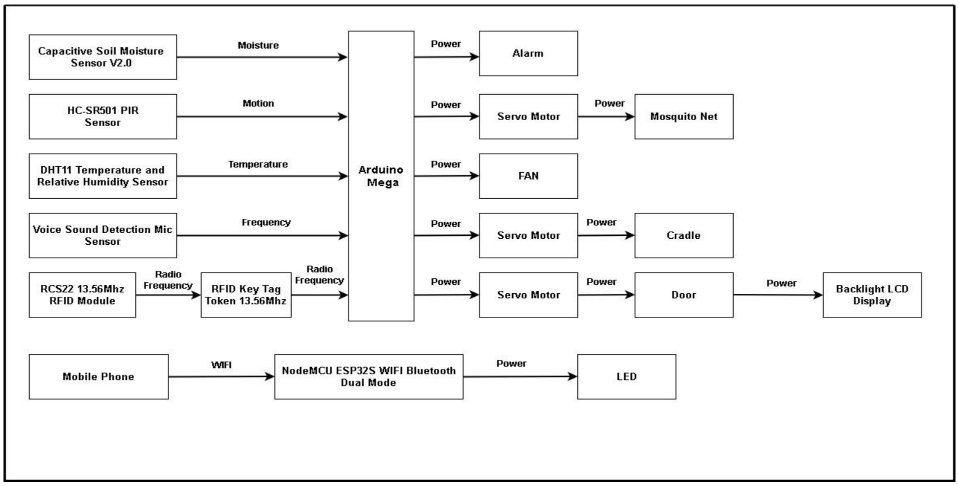

Figure 2.2.1 -High Level Architecture

2.3 Implementation

The main module structures for the Smart Baby Room with IoT project are created during the implementation phase in order to fulfill the functional criteria listed in the criteria and Analysis section. An extensive summary of the project's modules, development tools, implementation languages, and any unique algorithms is given in this section.

Cry Detection and Cradle Automation Module:

Description: This module integrates the voice sound detection mic sensor and the servo motor control to automate the cradle's swinging motion upon detecting an infant's cry.

Implementation: The module is implemented using Arduino IDE with C/C++ programming language. The sensor readings trigger the servo motor to swing the cradle, providing comfort to the baby.

Door Control System Module:

Description: This module allows authorized access to the room using an RFID module.

Implementation: Implemented using an Arduino microcontroller. The system uses an RFID module to read RFID key tags and a servo motor or solenoid lock to control the door mechanism.

Temperature Regulation Module:

Description: This module maintains optimal room temperature using data from the DHT11 temperature and humidity sensor.

Implementation: Implemented with integration of the DHT11 sensor readings. The system triggers the fan or heating system based on temperature variations, ensuring the baby's comfort.

Development Tools and Reusable Code

Arduino IDE: Used for programming the Arduino Mega for sensor integration and control.

Languages of Implementation

Programming microcontrollers (Arduino Mega) to control hardware elements and interface with sensors is done using C/C++.

code of Special Algorithms

- Sensor Data Processing Algorithms: Algorithms for real-time processing of sensor data, including filtering noise and interpreting sensor readings.
- Control Algorithms: Algorithms governing the interaction between sensors, actuators, and the IoT system to ensure timely and accurate response to environmental changes.

2.4 Testing

Table 2.1-Cry Detection Testing

Test Scenario ID	Cradle Automation-1	Test Case ID	CA-01
Test Case Description	Ensure cradle automation activates upon cry detection	Test Priority	High
Pre-Requisite	Cry detection system is activated, and cradle is stationary	Post-Requisite	Cradle stops rocking after a set duration

Test Execution Steps:

S.No	Action	Inputs	Expected Output	Actual Output	Test Result
01.	Trigger cry detection system	Recorded baby crying sound	Cradle starts rocking automatically	Cradle starts swing automatically	pass
02.	Play a recording of other sounds	Recorded other music	The system should not trigger	Cradle starts swing automatically	Fail
03.	Verify automatic stop function	Stop the noise	Cradle stops rocking after set duration or upon receiving stop command	Cradle stop automatically	pass

Table 2.2 - Temparature Regulation Testing

Test Scenario ID		Temperature Regulation-1		Test Case ID	TR-01
Test Case Description		Check if the temperature regulation system maintains the set temperature.		Test Priority	High
Pre-Requisite		Temperature regulation system is installed and operational.		Post-Requisite	NA
Test Execution Steps:					
S.No	Action	Inputs	Expected Output	Actual Output	Test Result
01.	Set desired room temperature on the system	Desired temperature value (e.g., 22°C)	Room is heated/cooled to reach the set temperature	The LED bulb is not bling	pass
02.	Introduce external heat source (e.g., heater) and observe system response	External heat source introduced for a set duration	System components feel the high temperature and give the output (e.g., LED blinging)	The LED bulb is bling	pass

Table 2.3 - Door Lock System Testing

Test Scenario ID		Door Control System-1		Test Case ID	DCS-01
Test Case Description		Verify that the door opens when a valid RFID tag is scanned.		Test Priority	High
Pre-Requisite		Door is initially closed. RFID Module and servo motor are functioning correctly.		Post-Requisite	Door remains open until it is manually closed or closed by another system command.
Test Execution Steps:					
S.No	Action	Inputs	Expected Output	Actual Output	Test Result
01.	Scan RFID tag	Valid RFID key tag token	Servo motor receives signal to open the door		pass

3. Conclusion

3.1 Assessment of the Project Results

The project has accomplished the main objective of largely automating baby care by successfully implementing several important capabilities.

Cradle Automation and Cry Detection: This functionality functions, however it has to be improved to enhance sound distinction.

Door Control System: This feature satisfies the established goals and is completely dependable and functional.

Temperature regulation: Currently partially automated, with the essential features in place but requiring additional integration for complete automation.
The overall effectiveness of the system shows that leveraging IoT to enhance baby care is feasible. To fully satisfy the initial requirements, some functionality must undergo more testing and development.

3.2 Lessons Learned

Importance of Specific Requirements: The effective implementation of a project depends on having clear and precise requirements. The cry detection requirements' ambiguities made it clear that comprehensive initial specifications were required.

Iterative Development: Using an iterative approach proved crucial for managing complex functionality as it allowed for gradual enhancements and tweaks depending on testing results.

Integration Difficulties: It was necessary to carefully plan and carry out the integration of multiple sensors and systems, highlighting the significance of a strong system architecture.

3.3 Future Work

Enhanced Cry Detection: Create and apply cutting-edge techniques to increase cry detection precision by differentiating between various noises.

Complete Temperature Regulation Integration: To provide all-encompassing environmental control, extend the temperature regulation module to manage the actual heating and cooling equipment.

Complete Smart Lighting System: To add even more automation and ease, complete the Smart Lighting System's testing and integration.

Development of Mobile Applications: To enable parents remote, real-time monitoring and control, develop an intuitive smartphone application.

Extend functionality: For a more complete smart baby room solution, include extra features like video surveillance, automatic feeding systems, and air quality monitoring.

The goal of the Smart Baby Room with IoT project was to improve baby care by using automation and intelligent monitoring. Temperature regulation, door control system, and cry detection and cradle automation were the main functional needs. Every module underwent development and testing to guarantee its dependability and functionality. Even if there was a lot of progress, there is still room for growth and improvement.

Achievement of Objectives

Cry Detection and Cradle Automation: Successfully implemented, but the system currently triggers automation for all loud noises, not exclusively baby cries. Further refinement is needed to distinguish between baby cries and other sounds.

Door Control System: Fully functional, reliably unlocking the door in response to authorized RFID tags and maintaining security by rejecting unauthorized tags.

Temperature Regulation: Partially achieved; the system turns on an LED bulb to indicate high temperatures but does not yet fully integrate fan or heating control. Further development is needed to ensure comprehensive temperature regulation.

Weaknesses and Limitations

Accuracy of Cry Detection: The present technology is unable to distinguish between different noises. By refining the sound classification algorithm to more accurately identify the distinctive features of a baby's cry, this constraint might be overcome.

Partial Temperature Regulation Implementation: Now, an LED is the sole way to indicate a high temperature. Integration with a heating system or fan is required for full performance.
Limited Smart Lighting System: Because primary functionality have been prioritized, the Smart Lighting System has not been fully tested or integrated.

4. References

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Appendix A: Design Diagrams

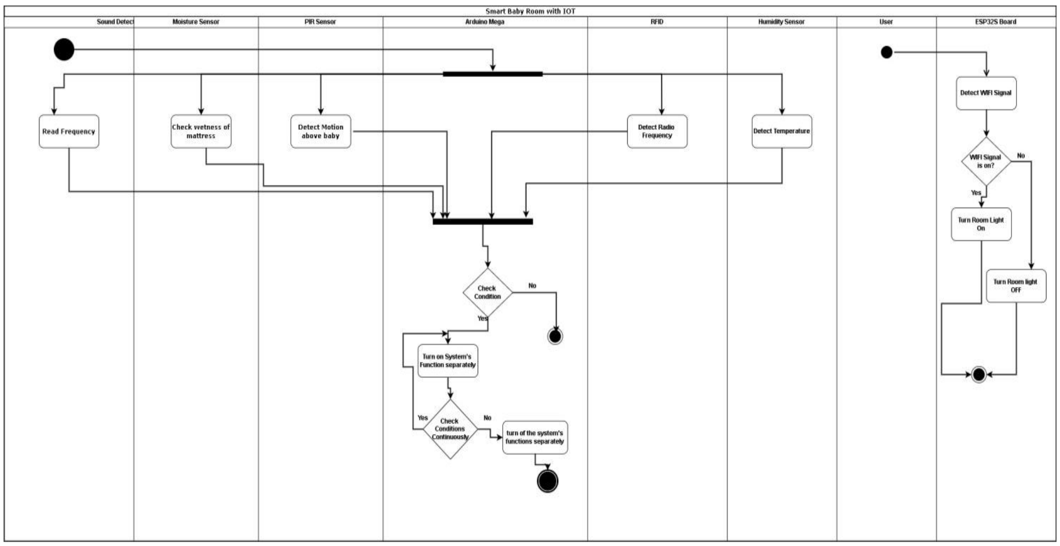

Figure 3.3.1 - Activity Diagram

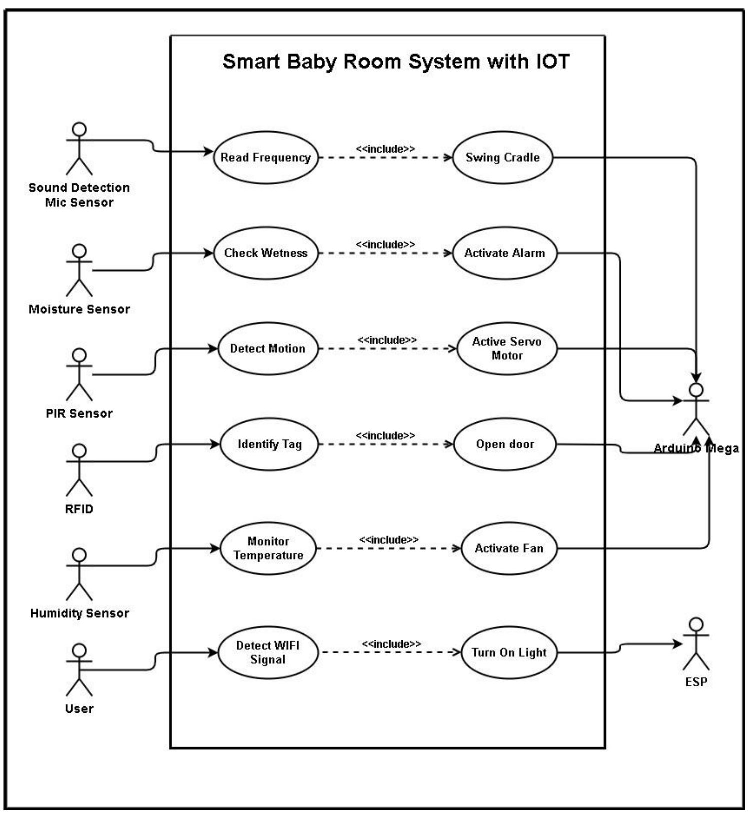

Figure 3.3.2 - User Case Diagram

Appendix B: Selected Code Listings

1.Cry detection, cradle automation and Temperature Regulation

```
#include <Servo.h>  // Include the Servo library
#include <DHT.h>    // Include the DHT library

#define SERVO_PIN 7   // Servo motor pin
#define SENSOR_PIN 6  // Sound sensor pin

#define DHTPIN 2       // Digital pin connected to the DHT sensor
#define LEDPIN 13      // Digital pin connected to the LED

#define DHTTYPE DHT11  // Type of DHT sensor

Servo myServo;
DHT dht(DHTPIN, DHTTYPE);

void setup() {
  Serial.begin(9600);  // Start serial communication
  pinMode(LEDPIN, OUTPUT); // Set LED pin as output
  pinMode(SENSOR_PIN, INPUT); // Set sound sensor pin as input
  myServo.attach(SERVO_PIN); // Attach servo to pin
  dht.begin(); // Initialize the DHT sensor
}

void loop() {
  // Read sound sensor
  int soundSensor = digitalRead(SENSOR_PIN);

  // Read temperature from DHT sensor
  float temperature = dht.readTemperature();

  // Control servo based on sound sensor
  if (soundSensor == HIGH) {
    for (int angle = 45; angle <= 120; angle++) {
      myServo.write(angle);
      delay(15);
    }
    for (int angle = 120; angle >= 45; angle--) {
      myServo.write(angle);
      delay(15);
    }
  } else {
    myServo.write(90); // Stop position
```

```
  }

  // Control LED based on temperature
  if (!isnan(temperature)) {
    Serial.print("Temperature: ");
    Serial.println(temperature);

    if (temperature > 40.0) { // Adjust threshold as needed
      digitalWrite(LEDPIN, HIGH); // Turn on LED
    } else {
      digitalWrite(LEDPIN, LOW); // Turn off LED
    }
  } else {
    Serial.println("DHT Error");
  }



  delay(2000); // Delay for stability
}
```

2.Smart Door Lock System

```
#include <Servo.h>
#include <LiquidCrystal_I2C.h>
#include <SPI.h>
#include <MFRC522.h>

#define SS_PIN 10
#define RST_PIN 9

String UID = "0C945049"; // Removed spaces from the UID string
byte lock = 0;

Servo servo;
LiquidCrystal_I2C lcd(0x27, 16, 2);
MFRC522 rfid(SS_PIN, RST_PIN);

void setup() {
  Serial.begin(9600);
  servo.attach(6);
  servo.write(60); // Initialize servo position
  lcd.init();
  lcd.backlight();
  SPI.begin();
  rfid.PCD_Init();
}

void loop() {
  lcd.setCursor(4, 0);
  lcd.print("Welcome!");
```

```
  lcd.setCursor(1, 1);
  lcd.print("Put your card");

  if (!rfid.PICC_IsNewCardPresent())
    return;
  if (!rfid.PICC_ReadCardSerial())
    return;

  lcd.clear();
  lcd.setCursor(0, 0);
  lcd.print("Scanning");

  Serial.print("NUID tag is: ");
  String ID = "";
  for (byte i = 0; i < rfid.uid.size; i++) {
    lcd.print(".");
    ID.concat(String(rfid.uid.uidByte[i] < 0x10 ? "0" : ""));
    ID.concat(String(rfid.uid.uidByte[i], HEX));
    delay(300);
  }
  ID.toUpperCase();

  Serial.println(ID); // Print scanned ID for debugging

  if (ID == UID && lock == 0) {
    servo.write(70);
    lcd.clear();
    lcd.setCursor(0, 0);
    lcd.print("Door is locked");
    delay(1500);
    lcd.clear();
    lock = 1;
  } else if (ID == UID && lock == 1) {
    servo.write(160);
    lcd.clear();
    lcd.setCursor(0, 0);
    lcd.print("Door is open");
    delay(1500);
    lcd.clear();
    lock = 0;
  } else {
    lcd.clear();
    lcd.setCursor(0, 0);
    lcd.print("Wrong card!");
    delay(1500);
    lcd.clear();
  }
}
```