IOT- BASED INTELLIGENT MEDICATION MONITORING AND DISPENSING SYSTEM: MEDMONITOR

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Date of Submission:

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2.) Abstract

Problem Statement

Expired medications, poor storage conditions, and human tracking errors are problems that many healthcare facilities face. These issues may result in serious health risks for individuals as well as financial losses for medical professionals. Without an efficient system, medications may expire without being recognised, leading to waste and shortages. A clever system is required that can automatically track medications, guarantee ideal storage conditions, and notify accountable staff about stock levels and medications that are due to expire.

Project Objectives

MedMonitor aims to create an intelligent healthcare management system that:

- Tracks and keeps track of prescribed medication to guarantee supply and avoid waste.
- Automatically remove medication that has expired and place it in an outside bin.
- Have role-based access control.
- Ensures security when loading new medication by using biometric (fingerprint) and PIN authentication.
- Allows medications to be registered with their expiration dates by integrating barcode/QR code scanners.
- Monitors and adjusts the storage temperature with an automated fan and sensors.
- Alerts users when a prescription is about to expire so they can replace it and dispose of it in a timely manner.
- Automates medicine restocking using demand and usage data.
- Enables system monitoring and control using a friendly application interface.

IoT System Overview

- IoT sensors to keep eyes on medication status and temperature.
- A safe dispensing machine that releases medications according to prescriptions.
- Biometric verification and PIN entry for access control.

- Medication information, including expiration dates, is registered using barcode or QR code scanners.
- A fan and temperature control system that provide optimal storage conditions for medicines.
- Automated alerts about low supply levels and substances that are about to expire.
- Prescriptions and stock levels are remotely managed by doctors and pharmacists using a web or mobile application.

Expected Outcomes

- Increased medication security through quick removal of expired medications.
- Decreased waste by using automatic restocking and real-time stock tracking.
- Improved protection for authorised users.
- Maintained ideal temperature for the best possible medication storage.
- Reduced manual tracking and paperwork.
- Enhanced supply chain management by examining medicine usage trends to place orders on time.

3.) Introduction

Background & Motivation

Medication inventory management is often a challenge in the healthcare industry. Expired drugs, improper storage temperatures, and errors in manual tracking processes are just some challenges that contribute to health hazards and are a drain on finances. As a result, intelligent systems and the Internet of Things are becoming increasingly helpful for modernising healthcare logistics. Motivation: The MedMonitor project is motivated by the need for an automated and improved medication tracking, storage, and dispensing system that enhances patient safety and operational efficiency.

Project Objectives

MedMonitor is engineered to transform healthcare inventory management in the following ways:

- So you can automatically track and dispose of expired medicines
- Ensure that access is restricted with biometric and PIN verification
- Environmental monitoring and control for optimal storage
- Making remote management possible with an easy-to-use UX
- Reducing human error and waste by using real-time stock analytics

Scope & Limitations

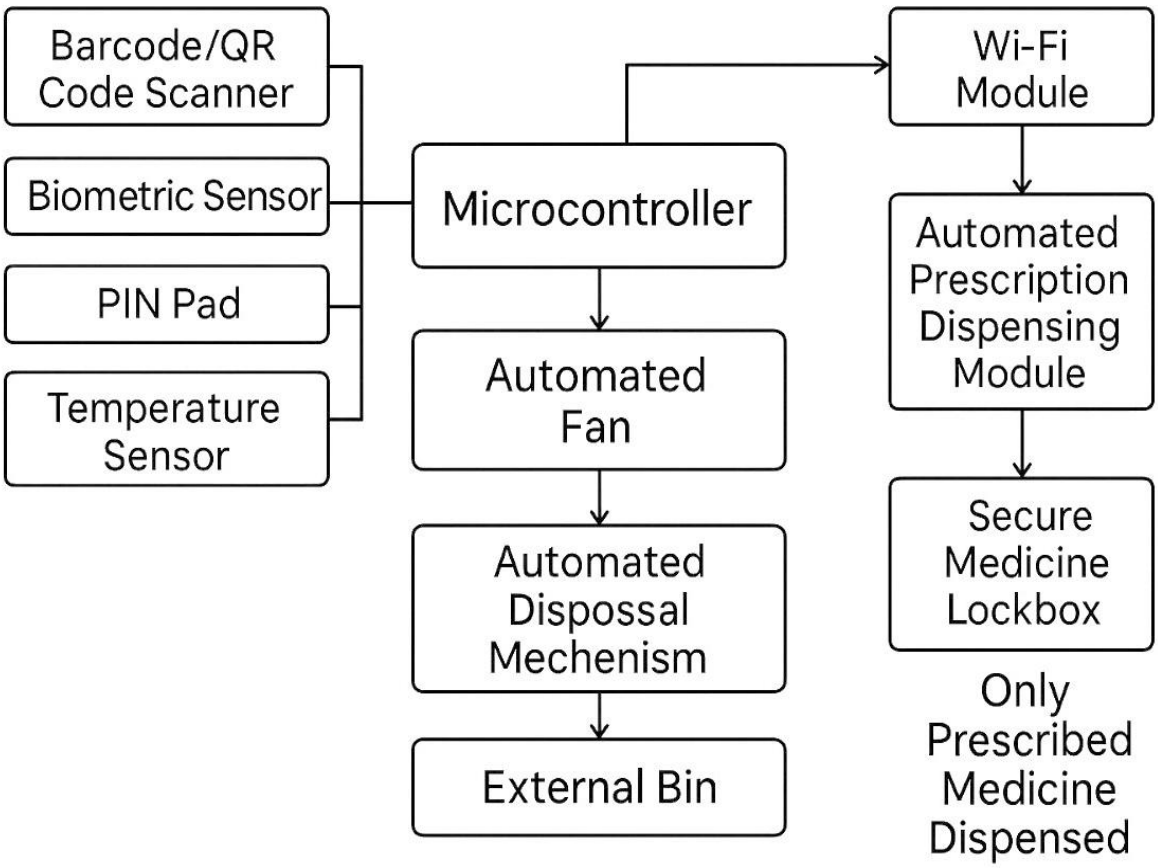
Scope:

- An IoT integrated system with sensors and control components
- A mobile/web interface to monitor and control
- Open API integration for real-time tracking, notifications, and access authentication
- Medication data entry done by barcode/QR code scanning

Limitations:

- Initial rollout is through small- to mid-sized healthcare providers
- Reliance on consistent, internet fast connection for instantaneous remote monitoring
- Sensor malfunctions or user accessibility issues could create problems for biometric authentication

4.) IoT System Design & Implementation



System architecture

Software and hardware components

Hardware

Processing Unit: ESP32, Arduino UNO, or Raspberry Pi (with built-in Wi-Fi)

Devices for input:

- PIN pad (Keypad Module)
- A fingerprint sensor, such as the R305
- QR Code Scanner and Barcode

Sensors: DHT11/DHT22 Temperature Sensor

Actuators:

- Servo motors (for operating disposal mechanisms, ejecting expired medications, and prescribing medication based on prescriptions)

"Servo motor dispenses only prescribed medicine based on the doctor's input via web/app."

- An automated fan

Output devices: LED indicators, buzzer, LCD or OLED Screen

Communication: GSM/Wi-Fi module (ESP32 has Wi-Fi)

Power Source: Solar power or an adapter plus battery

Mechanical: A medication container that locks automatically

Software

- Biometric Authentication Library
- Python and Arduino IDE programming
- QR/barcode parsing software
- Backend:
    - ➢ Node.js/Express
- Database:
    - ➢ Firebase Real-time Database
    - ➢ MySQL/SQLite
- Mobile and web applications (for monitoring, doctors, and pharmacists)
- REST API or MQTT for communication

Network & Communication Setup

Device-to-Cloud:

- ESP32/Arduino uses Wi-Fi to send data to cloud storage (Firebase or MySQL) via REST API or MQTT.

Local Authentication:

- Prior to any cloud interface or dispensing action, biometric and PIN verification is required.

App-to-Cloud:

- A custom MySQL login system that grants doctors and pharmacists role-based access.
- Doctors and pharmacists securely log in to manage stock, user roles, and access.

Notifications & Alerts:

- Automated email or app notifications for:
    - ➢ Unauthorised access, impending expiration, and low stock.

Security Considerations

Authentication:

- Role-Based Access:
    - ➢ Only doctors and pharmacists are able to carry out specific tasks (such as writing prescriptions and opening medication boxes).

Double Verification: PIN + Biometric (fingerprint) login

Data Security:

- Secure cloud data storage
- HTTPS communication
- MySQL database-based authentication system:
    - ➢ A password-based login using email
    - ➢ Backend roles and permissions are enforced

Physical Security:

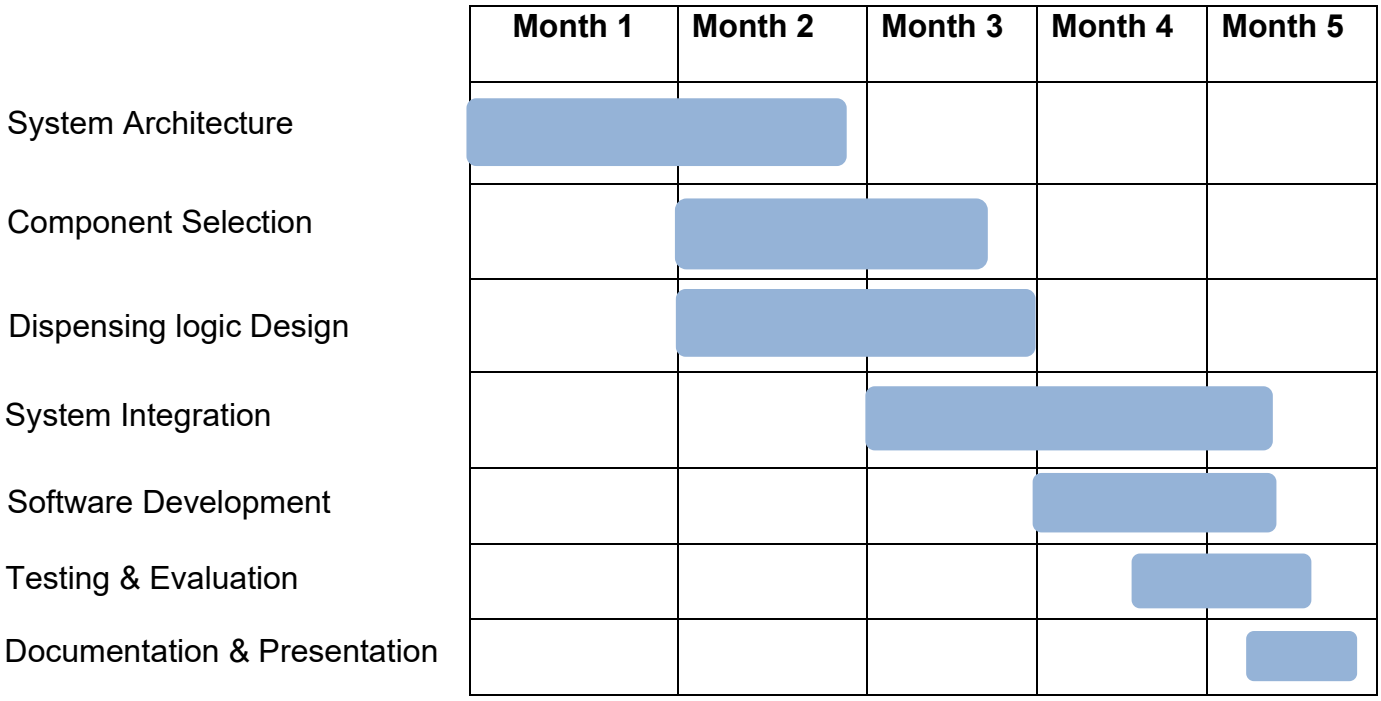
- Automatic locking system: Closes the pharmaceutical compartment if unwanted entry is detected.
- Tamper-proof medicine container

5.) Project Planning & Execution

Work Breakdown Structure (WBS)

Level	Description
1	Project Planning ● Define scope and Objectives ● Research and component selection
2	Hardware Development ● Sensor integration (temperature, barcode, fingerprint) ● Actuator configuration (fan, motors, etc.)
3	Software Development ● Microcontroller programming ● Mobile/Web App interface ● Cloud integration and backend
4	System Integration ● Combine hardware and software ● Secure medication bin setup
5	Testing & Evaluation ● Functional testing ● Security & performance testing
6	Deployment & Reporting ● Final report and presentation

Grant Chat: IoT Medication Management System



Risk Assessment & Mitigation Strategies

Risk	Impact	Mitigation
Sensor failure	High	Keep spare sensors; implement error detection
Power outage	High	Use battery backup or solar panel
Data loss or breach	High	Use encrypted cloud storage & authentication
Component incompatibility	Medium	Research compatibility; test modules early
Delay in app development	High	Use existing frameworks like Firebase or Flutter for rapid development
Network issues	Medium	Implement offline caching and retry logic

6.) Testing & Evaluation

Test cases & validation results

Test Case	Description	Expected Results
PIN + Biometric Login	Test authorised users' PIN and fingerprint login.	Only authorised doctors and pharmacists are able to use the system.
QR/Barcode Registration	To enter the medication's data and expiration date, scan a barcode or QR code.	The database accurately records medication along with its expiration date.
Medication Expiry Alerts	Pretend that a prescription is about to expire (attach an expired barcode/QR code).	The system notifies the user and the medications is moved to the bin.
Temperature Response	Simulate a temperature increase exceeding 25°C.	The fan turns on automatically to ensure secure storage.
Dispensing Logic	A doctor uses an app to prescribe medication.	Only the prescribed medication is automatically dispensed.
Unauthorized Entry Attempt	Attempt access using the incorrect PIN or fingerprint.	The system logs the attempt and deny access.

Performance Metrics

- **Authentication Time: Two to three seconds for each login**
- **Temperature Reading Accuracy:** ±0.5°C using the DHT22 sensor
- **System Uptime:** approximately five hours when battery backup is turned on
- **QR/Barcode Scan Time:** Less than two seconds for each item
- **Alert Delivery Time:** Real-time (within 1–2 seconds)

Overall, we were satisfied with the system's performance under both normal and stressful circumstances, and it managed its tasks with reliability.

Improvements & Optimization

- We **replaced DHT11 with DHT22** for better temperature precision.
- Introduced **offline caching** so the app stays functional even with network hiccups.
- Tweaked QR code parsing to improve scan speed.
- Refined backend code to cut down login time and prevent unnecessary data reads.
- Enabled a **power-saving mode** for unused sensors to extend battery life.

7.) Conclusion & Future Work

Key Learnings & Takeaways

- We discovered how beneficial it is to combine cloud services and hardware for intelligent monitoring.

- **Dual-authentication systems** are essential in healthcare, where safety and privacy are top priorities.

- We had to consider both engineers and users when designing in order to ensure both **usability** and **functionality**.

Challenges Faced & Solutions

Challenges	Solutions
Inconsistent sensor readings	Switched to a more accurate sensor (DHT22)
Sync delay between app and cloud	Added error-handling with retry logic
Risk of authentication bypass	Strengthened the PIN + biometric system
Servo motor jamming	Added logging and adjusted angle restrictions
No power during testing	Used battery packs and added a solar option

Recommendations for Future Enhancements

- Add **machine learning** to predict restock needs based on usage patterns.
- Use audio alerts to improve accessibility.
- Provide support for multiple languages to accommodate a wide range of users.
- Provide a doctor's dashboard that includes patient logs and medication trends.
- Include camera support to record users who have accessed the system visually.

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