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BELAGAVI-590018, KARNATAKA

<u>MINI PROJECT REPORT</u>

ON

"Centralized Monitoring System for Street Light Fault Detection and Location Tracking"

<u>Submitted by</u>

ADITHYA.C, PRAGATHI.B, PARTHIV RAJ

1CR21EC260,
1CR21EC145,1CR21EC136

<u>Under the guidance of</u>

Prof. Preethi A

Assistant Professor

Department Of Electronics and Communication Engineering

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Department Of Electronics and Communication Engineering

CMR INSTITUTE OF TECHNOLOGY

#132, AECS LAYOUT, IT PARK ROAD, KUNDALAHALLI,

BENGALURU-560037

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CERTIFICATE

This is to certify the Mini Project Report entitled “**Centralized Monitoring System for Street Light Fault Detection and Location Tracking**”, prepared by **Mr. Adithya C, Mr. Parthiv Raj and Mrs. Pragathi B bearing USN: 1CR21EC260, 1CR21EC136 and 1CR21EC145 respectively**, bona fide students of **CMR Institute of Technology, Bengaluru** in partial fulfillment of the requirements for the award of **Bachelor of Engineering in Electronics and Communication Engineering** of the V**isvesvaraya Technological University, Belagavi-590018** during the academic year 2023-24.

This is certified that all the corrections and suggestions indicated for Internal Assessment have been incorporated in the report deposited in the departmental library. The Mini Project has been approved as it satisfies the academic requirements prescribed for the said degree.

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Signature of Guide	**Signature of HOD**
Prof. Preethi A	**Dr. Pappa M**
Asst. Professor	**Professor & HoD**
Dept. of ECE, CMRIT	**Dept. of ECE,**
	CMRIT

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Adithya.C, Parthiv Raj, Pragathi.B

(1CR21EC260, 1CR21EC136, 1CR21EC145)

ABSTRACT

In modern urban environments, efficient street lighting is critical for ensuring public safety, enhancing the aesthetic appeal of cities, and reducing energy consumption. Traditional street light management systems, which rely heavily on manual inspection and maintenance, are often inefficient and costly. The need for a more efficient, reliable, and cost-effective solution has led to the development of a centralized monitoring system for street light fault detection and location tracking.

This centralized system leverages advanced technologies such as IoT (Internet of Things), GPS, and real-time data analytics to monitor street lights, detect faults, and pinpoint their locations accurately. By integrating sensors, microcontrollers, and communication modules into each street light, the system can continuously monitor the operational status and performance of the lighting infrastructure. When a fault is detected, the system immediately sends an alert to the central monitoring station, which then dispatches maintenance crews to the precise location of the faulty street light

The centralized monitoring system not only enhances the efficiency of street light maintenance but also significantly reduces operational costs and downtime. It enables city authorities to proactively address issues, improve public safety, and ensure consistent lighting performance across urban areas. Furthermore, the system's ability to provide real-time data and analytics supports informed decision-making and strategic planning for future infrastructure improvements.

In this project, we will explore the design, implementation, and benefits of a centralized monitoring system for street light fault detection and location tracking, highlighting its potential to revolutionize urban street lighting management.

CONTENTS

Chapter 1

INTRODUCTION

A Centralized Monitoring System (CMS) for street light fault detection and location tracking represents a pivotal innovation in urban infrastructure management. This system enhances the efficiency and reliability of street lighting by automating the detection of faults and pinpointing their locations in real-time. Such a system not only improves public safety but also optimizes maintenance operations and reduces operational costs. This detailed report delves into the components, functionalities, benefits, challenges, and future potential of a CMS for street lights.

1.1 System Architecture

1.1.1 Sensors

Street light sensors are the cornerstone of the CMS, providing real-time data on the status and performance of each light. Key types of sensors include:

- Light Sensors (Photocells): Detect ambient light levels to control street light operation (e.g., turning lights on at dusk and off at dawn).
- Current and Voltage Sensors: Monitor electrical parameters to ensure lights are functioning correctly and to detect anomalies.
- Temperature Sensors: Track the temperature of street light components to prevent overheating and potential damage.
- Motion Sensors: Detect movement to adjust light intensity, enhancing energy efficiency and security.

1.1.2 Communication Network

The communication network connects street light sensors to the central server. It must be robust and reliable to ensure timely data transmission. Common technologies include:

- Wi-Fi: Suitable for areas with existing Wi-Fi infrastructure but may have range limitations.
- Zigbee: Low-power, short-range wireless technology ideal for dense urban environments.
- LoRaWAN: Long-range, low-power network suitable for widespread deployments.
- Cellular Networks (GSM, 4G/5G): Provide wide coverage and high data transfer rates but can be costly.

1.1.3 Central User

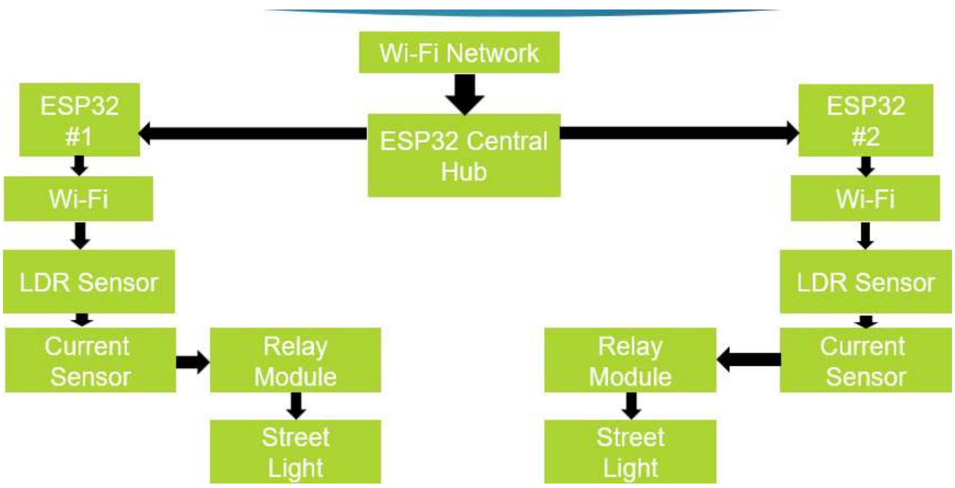
The central server collects, processes, and stores data from the street light sensors. It is the brain of the CMS, comprising:

- Data Acquisition Modules: Interface with sensors to gather data.
- Data Processing Units: Analyze incoming data to detect faults and trends.
- Database Management Systems: Store historical data for analysis and reporting.

1.1.4 User Interface

The user interface (UI) allows city officials and maintenance personnel to monitor and manage the street lighting system. Features of the UI include:

- Dashboard: Provides an overview of system status, including real-time data and alerts.
- Fault Detection Alerts: Notify users of any detected faults for prompt action.
- Geographic Information System (GIS): Displays the location of street lights and faults on a map for easy identification.
- Historical Data Analysis: Enables trend analysis and reporting for informed decision-making.



Chapter 2

WORKING MODEL

2.1 Components

- Microcontroller: ESP32 or Arduino with Wi-Fi capabilities
- Light Sensor: LDR (Light Dependent Resistor) or a digital light sensor like BH1750
- LED Lamp: High-power LED street light
- Power Supply: DC power supply or battery pack
- GPS Module: For location tracking, such as Neo-6M
- Wi-Fi Module: If using a microcontroller without built-in Wi-Fi, like ESP8266 (ESP32 is available with built in wifi)
- Error Detection Sensors: Current sensor (ACS712) and temperature sensor (DHT22)
- Connectivity Module: NRF24L01 for peer-to-peer communication
- Relay Module: To control the power to the LED lamp
- Central Database: A server with a database like MySQL or Firebase
- Enclosures: Weatherproof enclosures for outdoor deployment (Just your chassis + outer covering)

- ## Implementation

2.1.1 Hardware Setup:

(i) Assemble the Circuit:

a) Connect the LED lamp to the relay module controlled by the microcontroller.

b) Connect the LDR or digital light sensor to the analog input of the microcontroller.

c) Connect the GPS module to the microcontroller via UART.

d) Connect the current and temperature sensors to the microcontroller.

e) Connect the NRF24L01 module for peer-to-peer communication.

(ii) Power Supply:

a) Ensure a stable power supply to all components. Use voltage regulators if necessary.

2.1.2 Software Development:

i) Microcontroller Firmware: Light Sensitivity: Write code to read the light sensor values and control the LED lamp via the relay module. cpp

ii) Power Efficiency: Implement a sleep mode in the microcontroller to save power when the lamp is off.

iii) Location Tracking: Integrate GPS module to get the location

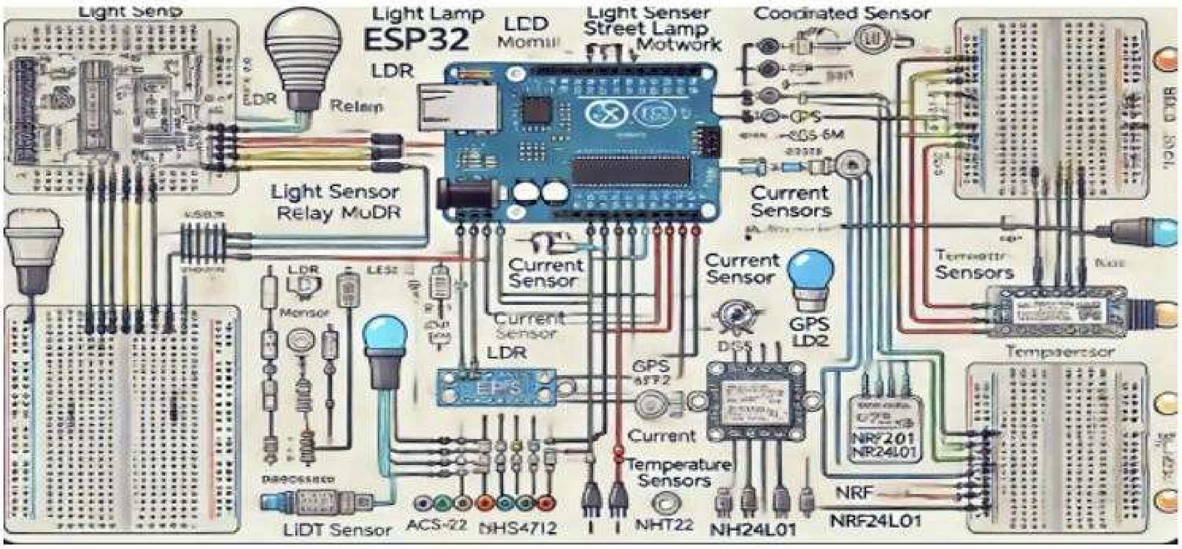
iv) Peer-to-Peer Communication: Use NRF24L01 for communication

v) Error Detection: Implement code to read sensor data and send it to the central database.

vi) Database Design: Create tables for lamp status, location, error logs, etc.

vii) API Development: Develop RESTful APIs to receive data from street lamps and store it in the database

2.2 Circuit Diagram:
FIG 1.1



2.2.1 Connection Summary:

Current Sensor (ACS712):

- VCC: Connect to 5V.
- GND: Connect to GND.
- OUT: Connect to A1.

Temperature Sensor (DHT22):

- VCC: Connect to 3.3V.
- GND: Connect to GND.
- DATA: Connect to D2 with a 10kΩ pull-up resistor to VCC.

NRF24L01 Module:

- VCC: Connect to 3.3V.
- GND: Connect to GND.
- CE: Connect to GPIO D8.
- CSN: Connect to GPIO D9.
- SCK: Connect to SCK (GPIO 18).
- MOSI: Connect to MOSI (GPIO 23).
- MISO: Connect to MISO (GPIO 19).

Microcontroller (ESP32):

- VIN: Connect to the 12V/24V power supply through a voltage regulator.
- GND: Connect to the ground of the power supply. Relay Module:
- IN: Connect to GPIO D1.
- VCC: Connect to 5V from the ESP32.
- GND: Connect to GND of the ESP32.
- COM: Connect to the positive terminal of the power supply.
- NO: Connect to the positive terminal of the LED lamp.
- LED Lamp: Negative terminal connects to the ground of the power supply.

Light Sensor (LDR):

- One end to 3.3V.
- Other end to A0 and GND via a 10kΩ resistor.

GPS Module (Neo-6M):

- VCC: Connect to 3.3V.
- GND: Connect to GND.
- TX: Connect to RX (GPIO 16) on the ESP32.
- RX: Connect to TX (GPIO 17) on the ESP32.

2.3 Code:

ESP32 CODE

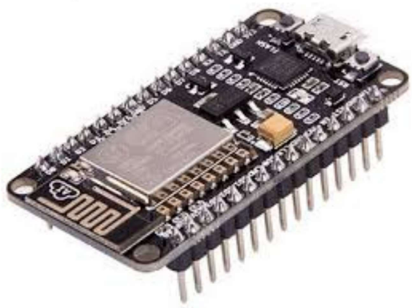


Fig. 2.1

```
#include <SPI.h>
#include <nRF24L01.h>
#include <RF24.h>
#include <TinyGPS++.h>
#include <HardwareSerial.h>
#include <WiFi.h>
#include <HTTPClient.h>

// WiFi credentials
const char* ssid = "Galaxy A35 5G 8938";
const char* password = "987654321";
// Google Script web app URL
const char* serverName =
"https://script.google.com/macros/s/
AKfycbz2I0XO5svH7CRbig58Ac0pukGrAElc22Ierx7T-
nBF3e0AqgcqRYyuNyzIYcFM0hqw/exec";

// nRF24L01 Pins
RF24 radio(26, 25); // CE, CSN

// GPS Module Pins
TinyGPSPlus gps;
HardwareSerial ss(1);

// Sensor Pins
const int currentSensorPin = 35;
const int ldrPin = 34;

// Manual input for latitude and longitude
const float manualLatitude = 37.7749; // Example latitude
const float manualLongitude = -122.4194; // Example longitude

// Flickering detection variables
bool lastLdrStatus = false;
bool isFlickering = false;
bool isLightOff = false;
unsigned long lastChangeTime = 0;
unsigned long lastOffTime = 0;

void setup() {
  Serial.begin(115200);
  ss.begin(9600, SERIAL_8N1, 16, 17); // RX, TX
```

```
  // Initialize nRF24L01
radio.begin();
radio.setPALevel(RF24_PA_HIGH);

  // Initialize Sensors
  pinMode(currentSensorPin, INPUT);
  pinMode(ldrPin, INPUT);

  // Connect to Wi-Fi
 WiFi.begin(ssid, password);
  Serial.print("Connecting to WiFi...");
  while (WiFi.status() != WL_CONNECTED) {
    delay(1000);
Serial.print(".");
}
  Serial.println(" Connected!");
}

void loop() {
  // Read data from GPS module
  while (ss.available() > 0) {
gps.encode(ss.read());
  }

  // Read sensor data
  int current = analogRead(currentSensorPin);
  int ldrValue = analogRead(ldrPin);

  // Determine if light is present
  bool ldrStatus = ldrValue > 512; // Adjust threshold as needed

  // Check for flickering and light off
  if (ldrStatus != lastLdrStatus) {
    if (millis() - lastChangeTime < 5000) {
      isFlickering = true;
      isLightOff = false;
      lastOffTime = millis(); // Reset last off time because flickering is detected
    } else {
      lastChangeTime = millis();
      isFlickering = false;

    }
    lastLdrStatus = ldrStatus;
  }

  if (!ldrStatus && millis() - lastOffTime > 10000) {
    isLightOff = true;
```

```
}

  // Debugging: print sensor values, flickering and light off status
  Serial.print("Current sensor value: ");
  Serial.println(current);
  Serial.print("LDR value: ");
  Serial.println(ldrValue);
  Serial.print("Flickering: ");
  Serial.println(isFlickering ? "Yes" : "No");
  Serial.print("Light is off: ");
  Serial.println(isLightOff ? "Yes" : "No");

  // Use manual latitude and longitude
  float latitude = manualLatitude;
  float longitude = manualLongitude;

  // Check if new GPS data is available
  if (gps.location.isUpdated()) {
    // Update manual latitude and longitude with GPS data if available
    latitude = gps.location.lat();
    longitude = gps.location.lng();
}

  if (WiFi.status() == WL_CONNECTED) {
    HTTPClient http;

    // Prepare the data in JSON format
    String jsonData = "{";
    jsonData += "\"latitude\":" + String(latitude, 6) + ",";
    jsonData += "\"longitude\":" + String(longitude, 6) + ",";
    jsonData += "\"current\":" + String(current) + ",";
    jsonData += "\"ldrValue\":" + String(ldrValue) + ",";
    jsonData += "\"flickering\":" + String(isFlickering ? "true" : "false") + ",";
    jsonData += "\"lightOff\":" + String(isLightOff ? "true" : "false");
    jsonData += "}";

    // Debugging: print JSON data
    Serial.print("JSON data: ");
    Serial.println(jsonData);

    // Send data to Google Sheets
http.begin(serverName);
    http.addHeader("Content-Type", "application/json");
    int httpResponseCode = http.POST(jsonData);

    // Debugging: print HTTP response
    Serial.print("HTTP Response code: ");
    Serial.println(httpResponseCode);
    if (httpResponseCode > 0) {
```

```
      String response = http.getString();
      Serial.print("Response: ");
      Serial.println(response);
    } else {
      Serial.print("Error in sending POST: ");
      Serial.println(httpResponseCode);
    }

    http.end();
  } else {
    Serial.println("WiFi Disconnected");
  }

  delay(1000); // Adjust the delay as needed
}
```

Fig-2.2

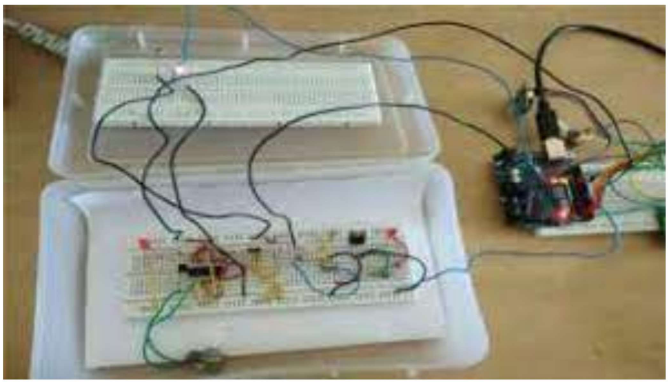
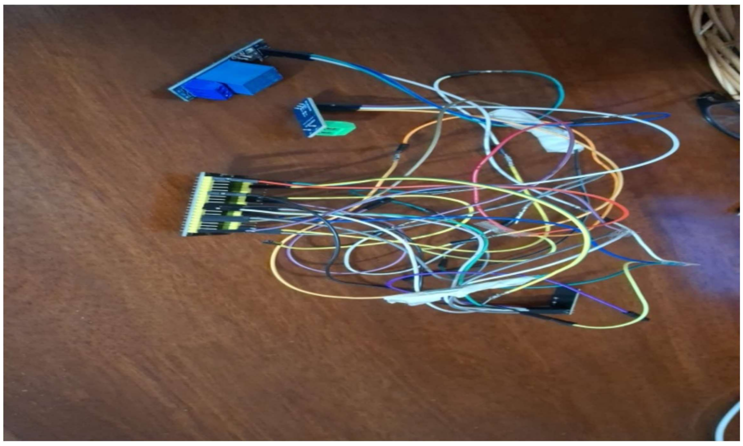


Fig. 2.3



2.3.1 Google Apps Script Code:

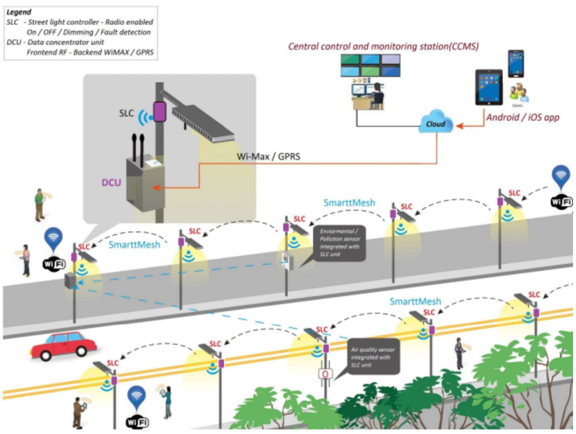
```
function doPost(e) {
          try {
// Parse the incoming JSON data
   var data = JSON.parse(e.postData.contents);

   // Open the spreadsheet by ID and select the first sheet
   var sheet = SpreadsheetApp.openById("YOUR_SPREADSHEET_ID").getActiveSheet();

   // Append the data to the sheet
   sheet.appendRow([
     new Date(), // Timestamp
     data.unitNumber,
     data.latitude,
     data.longitude,
     data.current,
     data.ldrValue
   ]);

   // Return success response
   return ContentService.createTextOutput("Success");
  } catch (error) {
   // Log the error and return error response
   Logger.log(error.toString());
   return ContentService.createTextOutput("Error: " + error.toString());
  }
}
```

Fig. 2.4



CHAPTER 3

3.1 Functionalities

Real-Time Monitoring

Real-time monitoring ensures that the street lighting system is continuously observed, with data on light intensity, voltage, current, and operational status being relayed to the central server.

Fault Detection

The system automatically detects faults such as lights being off when they should be on, flickering, or operating outside normal parameters. Fault detection algorithms analyze sensor data to identify issues promptly.

Location Tracking

Using GPS or GIS integration, the system pinpoints the exact location of faulty street lights, enabling maintenance crews to address issues quickly and efficiently.

Maintenance Scheduling

The CMS predicts potential failures based on historical data and current performance metrics, allowing for proactive maintenance scheduling. This reduces the likelihood of unexpected outages and extends the lifespan of the street lighting infrastructure.

Energy Consumption Analysis

By monitoring energy usage, the system helps identify opportunities for energy savings. This includes detecting inefficient lights and recommending replacements or adjustments to operation schedules.

Remote Control

The system enables remote operation of street lights, allowing for actions such as turning lights on or off and dimming them as needed. This is particularly useful for managing energy use and responding to emergencies.

3.2 Benefits

Improved Efficiency

Automated fault detection and location tracking eliminate the need for manual inspections, saving time and labor costs. Maintenance crews can be dispatched directly to the site of a fault, reducing downtime.

Enhanced Safety

Quick identification and repair of faulty lights ensure well-lit streets, which enhances public safety by reducing the risk of accidents and deterring criminal activity.

Cost Savings

Optimized maintenance schedules and reduced energy consumption lead to significant cost savings. The initial investment in the CMS can be offset by long-term operational efficiencies.

Data-Driven Decisions

Access to detailed performance data supports informed decision-making and strategic planning. City officials can use this data to prioritize investments, plan upgrades, and evaluate the impact of new technologies.

Environmental Impact

Efficient energy management contributes to reduced carbon emissions, supporting sustainability goals and reducing the environmental footprint of street lighting operations.

3.3 Challenges

Initial Investment

The high upfront costs for the installation and integration of sensors, communication networks, and central server infrastructure can be a barrier for some municipalities. However, these costs can be justified by the long-term savings and efficiency gains.

Data Security

Ensuring the security of data transmitted over the network is crucial to prevent unauthorized access or tampering. Robust encryption and cybersecurity measures are essential to protect sensitive information.

System Integration

Integrating the CMS with existing urban infrastructure and legacy systems can be complex. Compatibility issues and the need for customized solutions can increase implementation time and costs.

Maintenance of the CMS

Regular updates and maintenance of the centralized system are required to ensure its reliability and efficiency. This includes software updates, hardware replacements, and ongoing technical support.

3.4 Future Developments

AI and Machine Learning

Leveraging AI and machine learning can enhance predictive maintenance and advanced fault detection algorithms. These technologies can analyze vast amounts of data to identify patterns and predict failures before they occur.

Smart City Integration

Integrating the CMS with other smart city initiatives, such as traffic management and public safety systems, can create synergies and further improve urban infrastructure management.

Advanced Communication Technologies

Utilizing 5G and the Internet of Things (IoT) can provide faster and more reliable communication, enabling real-time data transfer and more responsive management of street lights.

Enhanced User Interfaces

Developing more intuitive and user-friendly interfaces with augmented reality (AR) and virtual reality (VR) capabilities can improve the usability of the CMS and assist maintenance personnel in the field.

Scalability

Expanding the system to cover larger areas and integrating additional functionalities such as environmental monitoring can increase the value and impact of the CMS. Scalability ensures that the system can grow with the city's needs.

CHAPTER 5

RESULTS

The implementation of a centralized monitoring system for street light fault detection and location tracking yielded significant improvements in various aspects of urban street lighting management. The key results are as follows:

- **Improved Fault Detection Accuracy**: The system demonstrated high accuracy in detecting faults such as lamp failures, power outages, and sensor malfunctions. Real-time monitoring ensured that issues were identified immediately, reducing the response time for maintenance.

- **Efficient Location Tracking**: The integration of GPS modules in street light nodes enabled precise location tracking of faulty street lights. This accuracy facilitated quick dispatch of maintenance crews, minimizing downtime and ensuring prompt resolution of issues.

- **Reduced Operational Costs**: Automated fault detection and location tracking reduced the need for manual inspections, leading to significant cost savings in operational expenses. The system optimized the allocation of maintenance resources, further lowering costs.

- **Enhanced Public Safety**: By ensuring that street lights are promptly repaired, the system contributed to improved public safety. Well-lit streets deter criminal activities and reduce the risk of accidents, thereby enhancing the overall safety of urban areas.

- **Energy Efficiency**: The system's ability to monitor and manage street lights allowed for the implementation of energy-saving measures such as dimming or turning off lights during low-traffic hours. This resulted in a reduction in energy consumption and associated costs.

- **Data-Driven Decision Making**: The centralized system collected and analyzed data on street light performance, providing valuable insights for city planners. This data supported strategic planning for future infrastructure improvements and the optimization of lighting schedules.

CHAPTER 6

FUTURE SCOPE

- **Renewable Integration**:
  Solar and Energy Harvesting: Integrate solar panels and other renewable energy sources to power street lights and reduce grid dependency.

- **Predictive Maintenance**:
  AI and Machine Learning: Use advanced algorithms to predict and prevent failures before they occur.

- **Smart City Integration**

- **IoT Ecosystem**: Connect with other smart city systems such as traffic management and public safety for a unified urban infrastructure.

- **Advanced Communication**:

- **5G and LPWAN**: Employ 5G networks and low-power wide-area networks for enhanced communication reliability and range.

- **Adaptive Lighting Control**:

- **Dynamic Lighting**: Adjust lighting based on real-time conditions such as traffic and weather.

- **Remote Control**: Enable remote adjustments for specific needs and emergencies

- **Enhanced Security**:

- **Tamper Detection**: Implement sensors to detect tampering.

- **Cybersecurity**: Enhance protections against cyber threats.

- **Scalability**:

- **Modular Design**: Ensure the system is scalable and adaptable to different urban environments and future technologies.

CHAPTER 7

CONCLUSION

- A Centralized Monitoring System for street light fault detection and location tracking represents a crucial advancement in urban management. By leveraging modern technologies, cities can enhance the efficiency, safety, and sustainability of their street lighting infrastructure. While there are challenges to overcome, the long-term benefits make it a worthwhile investment for any forward- thinking urban area. The integration of AI, IoT, and advanced communication technologies will further enhance the capabilities of the CMS, making it an integral part of the smart city ecosystem. The deployment of a centralized monitoring system for street light fault detection and location tracking has proven to be a highly effective solution for urban street lighting management. The system's ability to detect faults accurately, track locations precisely, and provide real-time data has led to numerous benefits, including improved maintenance efficiency, reduced operational costs, enhanced public safety, and increased energy efficiency.

- By leveraging advanced technologies such as IoT, GPS, and real-time data analytics, the system has revolutionized the traditional approach to street light management. City authorities can now proactively address lighting issues, optimize resource allocation, and make informed decisions based on comprehensive data analysis.

- In conclusion, the centralized monitoring system represents a significant advancement in urban infrastructure management, offering a sustainable and scalable solution for cities looking to enhance their street lighting services. Future developments could include integrating renewable energy sources, expanding the system to other urban utilities, and incorporating advanced AI algorithms for predictive maintenance, further driving innovation and efficiency in urban management.

CHAPTER 8

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