Smart Traffic Management System

CS1005 – Internet of Things Laboratory

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CMP515 - Internet of Things

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Introduction

Problem Statement

Traffic congestion is a major issue in urban areas of India, where traditional traffic light systems often lead to inefficiencies, such as green lights for empty lanes while congested lanes wait. This results in wasted fuel, increased pollution, longer travel times, and safety risks due to impatient driving. Manual traffic management is inadequate for handling dynamic traffic patterns, especially in densely populated cities. This project aims to develop a smart IoT-based traffic management system that dynamically adjusts signals based on real-time vehicle detection to improve flow, reduce delays, and enhance safety.

Objective

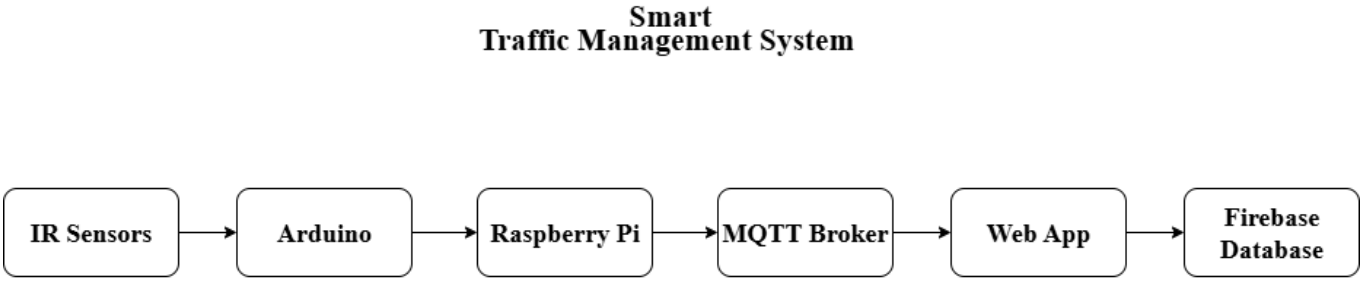
1. To create an IoT-based system that detects vehicle presence and density in real-time using sensors.
2. To dynamically control traffic lights based on traffic conditions, with options for smart automatic mode and manual remote override.
3. To log traffic data for analysis and optimization.
4. To ensure fault-tolerant operation with features like automatic reconnections and backup power.

Proposed Solution

The proposed IoT solution uses infrared (IR) sensors to detect vehicles at intersections, connected to microcontrollers that communicate via MQTT protocol. A central processor analyzes data to adjust traffic lights adaptively. A web dashboard enables remote monitoring and manual control for emergencies, with data logged to the cloud for future insights. This system addresses India's urban traffic challenges by reducing congestion and supporting emergency vehicles.

System Design

Block Diagram



Tools & Technologies

- Hardware: Raspberry Pi 4 (central processing and data handling), Arduino UNO (sensor data collection and MQTT publishing), IR sensors (vehicle detection), LEDs and resistors (simulating traffic lights), Battery (backup power).
- Software: Arduino IDE with C++ (for Arduino programming), Python (for Raspberry Pi scripting), MQTT protocol (device communication), React.js (web dashboard), Firebase (data logging and storage).

Implementation

IoT Component

The IoT system performs the following functions:

- IR sensors detect vehicle presence and density in lanes, calculating metrics like the number of active sensors per lane.
- Arduino UNO publishes sensor data via MQTT to Raspberry Pi 4, which subscribes and processes it.
- In Smart Mode, traffic lights adjust dynamically: prioritizing congested lanes, switching after set intervals and handling empty lanes efficiently.

- Manual Mode allows remote control via a web app for scenarios like ambulances or VIP vehicles.
- Logs lane activity with timestamps to Firebase for analysis.
- Includes fault tolerance: automatic Wi-Fi/MQTT reconnection and battery backup for uninterrupted operation.

AI Component

Currently, the system does not include an AI component for real-time operations. However, future integration of AI is planned for predictive traffic control using logged data.

Conclusion and Future Work

Summary: The project will implement an IoT-based smart traffic management system that reduces congestion by adapting signals to real-time conditions, with remote control and data logging features. It will demonstrate efficient use of sensors and cloud integration for improved urban mobility in India.

Future Enhancements: Integrate AI for predictive analytics to further optimize traffic without heavy sensor reliance. Enhance security for cloud data and expand to multi-lane intersections.