Smart Traffic Diversion System for Road Congestion Management

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EXECUTIVE SUMMARY

The IoT-Based Automated Traffic Control System aims to dynamically adjust traffic signals by detecting real-time traffic levels in each lane, prioritizing lanes with the highest congestion to efficiently clear traffic jams. Integrated with Blynk, the system allows traffic authorities to monitor and control signals remotely, ensuring effective traffic management even in case of hardware malfunctions. This approach has shown significant improvements in traffic flow management during testing, offering a promising solution to urban traffic congestion problems. The system's real-time adaptability reduces travel time and fuel consumption, contributing to lower emissions and improved air quality. Additionally, it enhances emergency response times by clearing traffic more effectively, including prioritizing lanes for ambulance passage.

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PROJECT OBJECTIVE

In India, traffic signals typically operate on fixed cycle times, regulating phases such as green, yellow, and red for all directions at an intersection. These predetermined timings often result in increased waiting times for vehicles, particularly when the traffic light remains green for empty roads, exacerbating congestion.

The objective of this project is to efficiently manage these congestions by implementing sensors that detect empty roads and dynamically adjust signal timings.

SCOPE

The scope of the Smart Traffic Diversion System project includes the design, development, and implementation of an intelligent traffic management solution aimed at improving traffic flow and reducing congestion through real-time data analysis and dynamic signal control. The following key areas define the scope of this project:

System Design and Architecture:

- Evaluate existing traffic signal infrastructure and determine necessary modifications or upgrades.
- Use of potentiometers for accurate vehicle detection at intersections.

Dynamic Signal Control:

- Adjustment of traffic signal timings based on real-time traffic and pedestrian data.

Emergency Vehicle Priority:

- Providing a facility for emergency vehicles to send "SOS" signals to preemptively alter traffic signals and clear their path.

Data Processing and Management:

- Utilize edge computing for low-latency processing of sensor data and real-time signal adjustments.

Communication Systems:

- Enable communication between emergency vehicles and traffic signals for enhanced coordination and safety.

METHODOLOGY

Analysis and Planning: During the Analysis and Planning phase, we identified existing issues with the current traffic control system and planned efficient solutions to overcome these challenges.

Modelling: In the Modelling phase, we translated our ideas into a practical model. Through iterative improvements, we refined the model to ensure feasibility.

Construction: The Construction phase involved building the fully functional model using components such as ESP32, potentiometers, and LEDs. The model was integrated with Blynk for mobile control.

Testing: Testing was conducted to evaluate the system's performance under various conditions.

Deployment: Finally, the Deployment phase involved implementing the system in real-world environments to assess its effectiveness in practical traffic management scenarios.

ARTIFACTS USED

The following artifacts were utilized throughout the project:

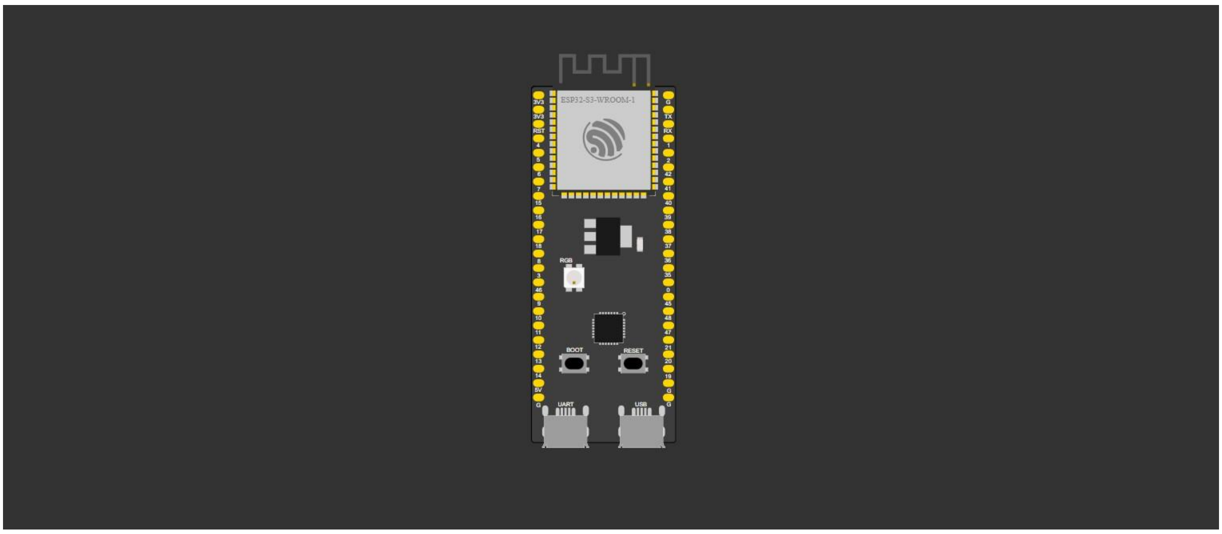
- **Traffic flow data:** Real-time traffic data is stimulated with the help potentiometers

- **Library:**
    1. Arduino library has been used for interfacing with the Blynk platform and sending/receiving data.
    2. TM1637 library is used for the seven-segment display

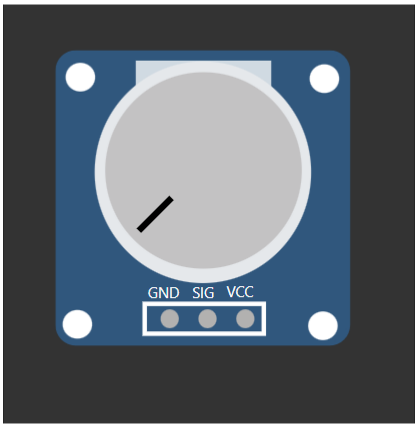
- **Wokwi online simulator tool:** Used for testing and debugging Arduino code.

- **Blynk IoT Platform**: Mobile App used by the emergency vehicle drivers to control the traffic lights.

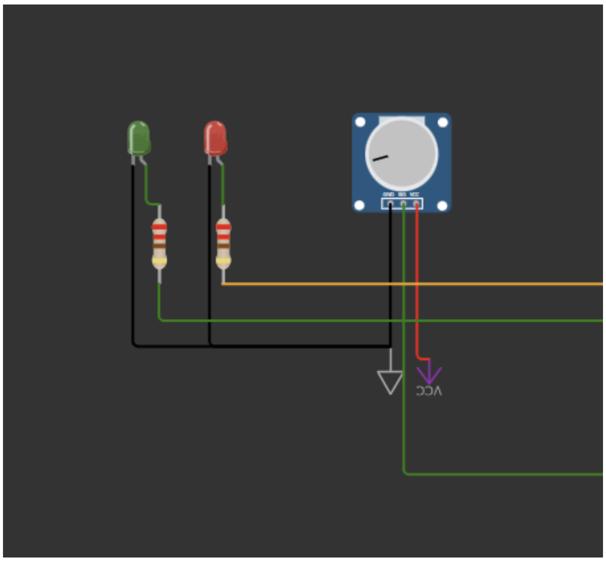
- **ESP32-S3:** A hardware platform with WIFI capabilities used in building the system.



- **Potentiometer:** Placed in all the lanes for detecting traffic vehicles.



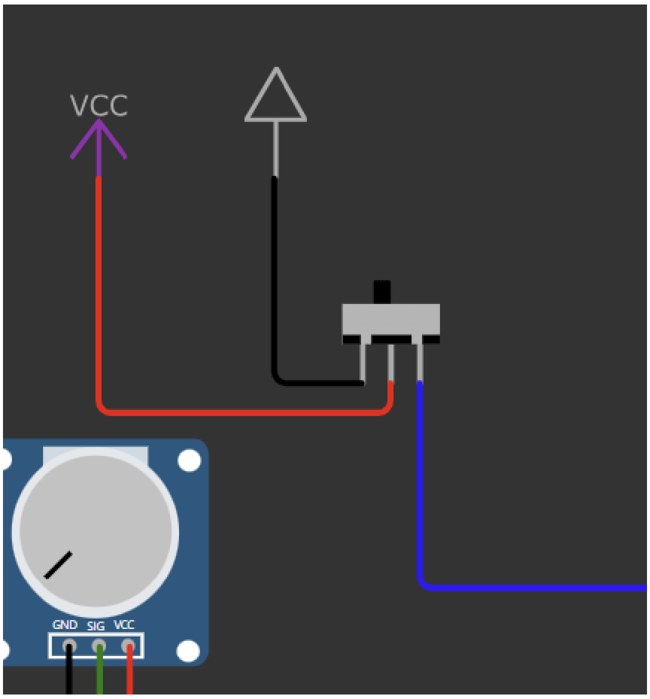
- **LED lights**: To represent traffic signals we have used red and green LED'S.



- **Slide switches**:

  1. The slide switches can be used by the operator to quickly turn a lane green in case of emergencies like ambulance arrival.

  2. These slide switches functionality can even be used by the ambulance driver through an app



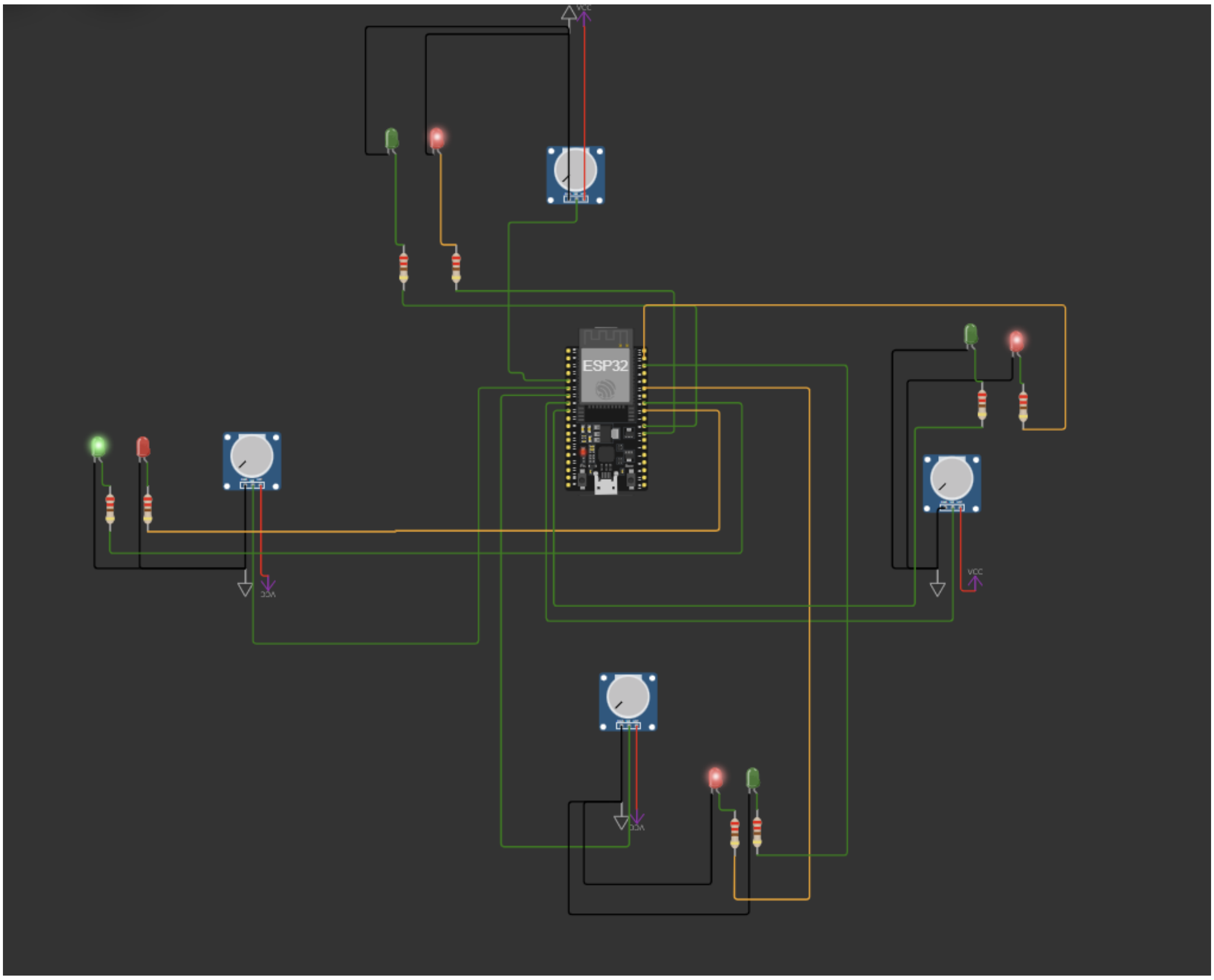
TECHNICAL COVERAGE

SIMULATION OF NORMAL TRAFFIC SIGNAL:

The first step in our automated traffic system is to simulate the current functionality of the traffic system.

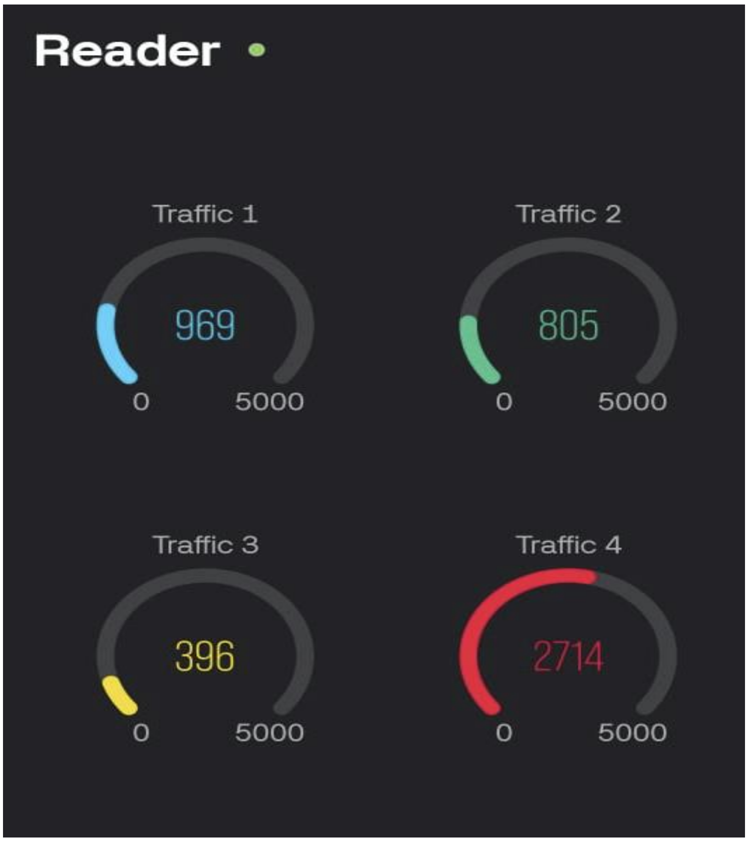
Each Traffic signal will have a timer displayed using the seven-segment display and two LEDs to indicate green and red signal

- Consider four lanes: lane 1, lane 2, lane 3 and lane 4.
- Each of these lanes has its own green time (example: 10 for all lanes).
- When lane 1 turns green the other three lanes turn red.
- The waiting time for lane two will be the green time of lane 1.
- The waiting time for lane three will be the green time for lane 1 + green time of lane 2.
- The waiting time for lane three will be the green time for lane 1 + green time of lane 2 + green time of lane 3.



In the above image there are three lanes each with the green time of 10 seconds.

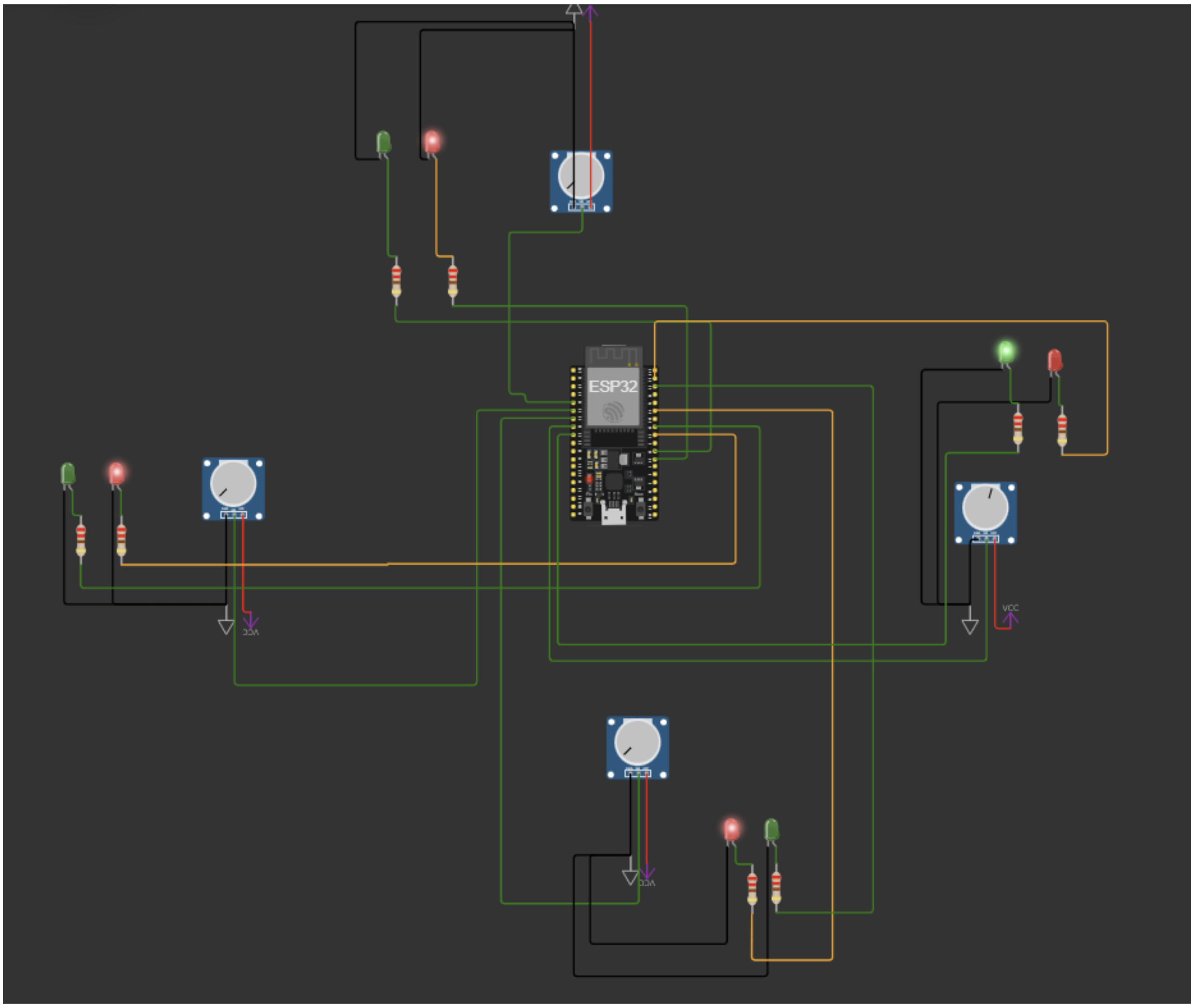
- The lane 2 is now green therefore the timer starts from its green time.
- The timer for lane 3 is green time of lane 2 = 20.
- The timer for lane 1 is green time of lane 2 + green time of lane 3 = 10 + 20 = 30



The potentiometer reading which acts as the traffic density can be measured from the above app used in phone.

SIMULATION OF DYNAMIC SIGNALS BASED ON VEHICLES IN A LANE:

Let’s say that lane 3 is now green with 9s however there are no vehicles detected by the potentiometers at lane 2 but there is a huge traffic at lane 3. Now lane 3 gets green signal and it continues in green till the traffic congestion gets released considerably. After that normal round robin method of traffic signal gets activated.



The above image shows the traffic clearing in lane 3 due to the high traffic congestion which is given as input in potentiometer. Thus, the other 3 lanes will have a red signal till the traffic density decreases considerably in that particular lane

RESULTS:

Here are the promising results of the IoT-Based Automated Traffic Control System project. Each result highlights a key benefit or feature, demonstrating the system's potential to revolutionize urban traffic management

1. **Efficiency**: Reduced traffic congestion through dynamic signal adjustments.

2. **Integration**: Seamless control and monitoring using the Blynk mobile application.

3. **Adaptability**: Real-time signal changes based on traffic levels.

4. **Environmental**: Lowered emissions and improved air quality.

5. **Savings**: Reduced travel time and fuel consumption.

6. **Reliability**: Effective management during hardware malfunctions.

7. **Innovation**: Modern solution to outdated fixed-cycle traffic signals.

8. **Testing**: Validated performance under various traffic conditions.

9. **Deployment**: Successful real-world implementation.

10. **Management**: Improved traffic flow management capabilities.

11. **Feasibility**: Practical and refined model through iterative improvements.

12. **Upgrades**: Necessary modifications to existing traffic signal infrastructure.

13. **Cost-Effectiveness**: Affordable solution using readily available components.

14. **User-Friendly:** Easy-to-use Blynk interface for traffic authorities.

15. **Sustainability:** Long-term reduction in urban congestion and environmental impact.

16. **Accessibility**: Improved access to traffic control for authorities via mobile interface.

17. **Convenience**: Streamlined traffic management processes.

18. **Impact:** Significant overall improvement in urban mobility and traffic management.

CHALLENGES AND RESOLUTIONS:

1. Technology integration:

Challenges:

Integrating new technology with the current traffic control systems can be difficult due to differences in technology and hardware. This brings a challenge of compatibility with the existing system.

Resolution:

Development of the system using a modular approach allows new technologies to integrate easily with existing infrastructure and enables future upgrades without complete overhauls.

2. Data Management

Challenges:
Handling large volumes of real-time data from sensors and cameras can be complex and resource-intensive.
Resolution:
Implement robust encryption protocols and secure data storage solutions to protect sensitive information and ensure compliance with data protection regulations.

3. Responsiveness

Challenges:
The system needs to process and respond to traffic data in real-time, which can be technically challenging. Ensuring the system can scale to accommodate varying traffic volumes and conditions without performance degradation is also a major challenge.
Resolution:
Use edge computing to process data locally at intersections, reducing latency and improving real-time responsiveness. Designing the system architecture to be scalable, allows it to handle increased data loads and traffic conditions efficiently.

4. Traffic Coordination

Challenges:
Adjusting traffic signals at one intersection can impact others nearby, requiring careful coordination. Diverting traffic from congested areas can create new congestion points elsewhere.
Resolution:
Establishing a centralized control center to monitor and manage traffic signals across multiple intersections, ensures coordinated adjustments.

5. Public Acceptance

Challenges:
Gaining public acceptance of the new system requires educating the public on its benefits and operation. Encouraging drivers and pedestrians to adapt to new traffic patterns and signal changes.
Resolution:
Conduct campaigns to inform the public about the system’s benefits and educate them on adapting to new traffic patterns. Engage with local communities and stakeholders to gather feedback and address concerns, fostering public support.

CONCLUSION:

The Smart Traffic Diversion System represents a significant advancement in traffic management by leveraging IoT technology to create a more adaptive and responsive network. By integrating real-time vehicle and emergency detection through sensors, this system addresses the inefficiencies of static traffic signals. It prioritizes high-traffic directions, minimizes congestion, and ensures swift passage for emergency vehicles through an "SOS" signal feature.

This innovative approach not only improves traffic flow and reduces waiting times but also promotes public safety and operational efficiency. The challenges of technology integration, data management, real-time responsiveness, and public acceptance are met with robust resolutions including modular design, edge computing, centralized traffic management, and comprehensive public awareness campaigns.

Ultimately, this project lays the groundwork for smarter, safer, and more efficient urban mobility solutions, paving the way for future enhancements and scalability across diverse urban environments. The successful implementation of this system promises to transform traffic management, reduce congestion, and significantly improve the quality of urban life.

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