Smart Traffic Signal Management for Emergency Vehicles with

Dynamic Prioritization Algorithm

### Problem Statement :

In urban areas, emergency vehicles such as ambulances, fire trucks, and police vehicles often encounter delays at traffic signals. Many systems exist to detect these vehicles and adjust traffic signals accordingly, allowing them to bypass the regular flow of traffic. However, when multiple emergency vehicles are detected at the same intersection, current systems fail to prioritize which vehicle should proceed first, causing inefficiencies in response times.

Moreover, while emergency vehicles can bypass traffic signals manually, this practice increases the risk of accidents and collisions, endangering both the emergency responders and civilians.

This project aims to develop an intelligent traffic management system that not only detects emergency vehicles but also uses a **dynamic prioritization algorithm** to decide which vehicle should be prioritized when multiple are detected. In addition, the system will reduce the need for emergency vehicles to manually bypass signals, thus minimizing the risk of crashes.

### Proposed Solution:

The proposed system will use advanced detection techniques to identify emergency vehicles and implement a **Prioritization Algorithm (PA)** that assigns priority levels based on:

1. The urgency and type of emergency.

2. Proximity of the vehicle to the intersection.

3. Real-time traffic conditions and potential impact on other critical routes.

By enhancing the traffic signal system with intelligent prioritization and reducing the reliance on manual signal bypassing, this solution aims to improve response times while reducing the risk of accidents involving emergency vehicles.

ALGORITHM :

### 1. \*\*Key Factors to Consider in Prioritization\*\*:

- \*\*Urgency of the Emergency\*\*: Different types of emergencies (e.g., ambulance for a critical patient vs. police vehicle) should have different priority levels.

- \*\*Proximity to the Intersection\*\*: How close each vehicle is to the traffic signal.

- \*\*Traffic Conditions\*\*: Real-time traffic congestion, traffic flow, and road conditions.

- \*\*Number of Lanes or Directions\*\*: Consider how many lanes each emergency vehicle must cross.

- \*\*ETA (**ETA** stands for **Estimated Time of Arrival**)to the Destination\*\*: Vehicles with tighter response times should have higher priority.

- \*\*Historical Data\*\*: Prioritize based on data from previous incidents (e.g., average time to handle similar emergencies).

### 2. \*\*Dynamic Prioritization Algorithm Outline\*\*:

#### \*\*Algorithm Name\*\*:

\*\*Dynamic Multi-Criteria Prioritization (DMCP)\*\*

#### \*\*Algorithm Approach\*\*:

The algorithm can follow a \*\*weighted scoring model\*\* or a more advanced \*\*reinforcement learning\*\* technique based on real-time inputs.

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### \*\*Step-by-Step Approach\*\*:

1. \*\*Input Gathering (Real-Time Data Collection)\*\*:

- Emergency vehicle location and type (e.g., ambulance, fire truck).

- Distance to the intersection.

- Traffic density near the intersection.

- The number of active emergency vehicles at the same intersection.

2. \*\*Priority Calculation\*\*:

Using a \*\*weighted scoring method\*\*, assign scores to each emergency vehicle based on these factors. You can create a formula like:

\*\*Priority Score = (w1 \* Urgency Level) + (w2 \* Proximity) + (w3 \* Traffic Conditions) + (w4 \* ETA)\*\*

Where `w1, w2, w3, w4` are the weights for each factor that can be adjusted based on the city’s priorities (e.g., giving more weight to urgency in medical emergencies). You can start with equal weights and adjust based on testing or historical data.

3. \*\*Decision-Making\*\*:

- Once the priority score is calculated for all emergency vehicles approaching an intersection, \*\*the vehicle with the highest score gets the right of way\*\*.

- If scores are close or identical, the system can further refine based on secondary factors (e.g., give priority to the vehicle that is closest).

4. \*\*Signal Adjustment\*\*:

- Once priority is assigned, the system adjusts traffic signals to allow the highest-priority vehicle to proceed.

- The traffic light for other lanes or directions remains red until the highest-priority vehicle passes.

5. \*\*Feedback Loop (for Optimization)\*\*:

- The system can store the results of each signal change (e.g., time taken for vehicle clearance, delay reduction) to continuously optimize the weight of each factor.

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### \*\*Advanced Techniques\*\*:

- \*\*Reinforcement Learning\*\*: If you want a more advanced method, consider using reinforcement learning (RL). RL can "learn" over time by testing various scenarios and understanding which signal prioritization leads to faster emergency vehicle clearance.

- \*\*Markov Decision Process (MDP)\*\* can be used to model the decision-making process of which vehicle to prioritize.

- \*\*Deep Q-Networks (DQN)\*\* can help predict the best signal change actions based on a set of inputs (real-time data).

- \*\*Fuzzy Logic\*\*: Since many of the factors you’re dealing with (urgency, traffic, distance) are not binary, fuzzy logic can handle the uncertainty better than traditional algorithms. You can design a fuzzy system where different input values (e.g., urgency level, distance) are mapped to fuzzy sets, and decision-making is handled through fuzzy rules.

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### Example of the Formula in Action:

Let’s assume:

- \*\*Ambulance\*\*: Urgency = 5, Proximity = 2 km, Traffic = 60% congestion, ETA = 8 minutes

- \*\*Fire Truck\*\*: Urgency = 3, Proximity = 1 km, Traffic = 40% congestion, ETA = 6 minutes

With equal weights (`w1 = w2 = w3 = w4 = 1`):

\*\*Ambulance Score\*\* = (5 \* 1) + (2 \* 1) + (60 \* 1) + (8 \* 1) = 75

\*\*Fire Truck Score\*\* = (3 \* 1) + (1 \* 1) + (40 \* 1) + (6 \* 1) = 50

The system would give priority to the \*\*ambulance\*\* because it has a higher score.