Emergency Vehicle Priority Routing

Enhancing response times and safety through intelligent traffic management.

Autonomous Traffic Light: Emergency Vehicles Take Control of Traffic Lights to Eliminate Traffic Jam Via Fog Computing

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INTRODUCTION

- The increasing demand for smart traffic systems has highlighted the need for low-latency, real-time solutions.
- Emergency vehicles require immediate access through intersections, which traditional cloud-based systems cannot guarantee due to network delays.
- Our system uses **Edge Computing**, where **On-Board Units (OBUs)** in emergency vehicles communicate directly with **Roadside Units (RSUs)**.
- This local decision-making ensures faster signal control without relying on cloud processing.
- The result is a responsive, decentralized routing system designed for emergency traffic management.

Problem Statement:

- **Traffic Jams**: Urban areas face significant traffic congestion and poorly managed transportation systems.

- **Emergency Vehicle Delays**: Emergency vehicles struggle to navigate congested roads, causing delays that can lead to critical consequences, such as death or severe injuries.

- **No System Control**: Emergency vehicles currently lack the ability to control traffic lights to clear their path, leading to them being "trapped in the jam".

- **Driver Non-Compliance**: Emergency drivers frequently encounter other drivers who fail to follow protocol, hindering their speed and response time and sometimes causing accidents.

Why it is an edge /fog problem ?

1. **Need for Real-Time Traffic Light Control**
2. **Decentralized, Distributed Processing**
3. **Scalability for Growing Urban IoT Systems**
4. **Security and Privacy of Vehicle Communications**
5. **Dynamic Rerouting & Congestion Updates**

🧠 Why Edge is Required

- Real-time Traffic Light Control: Emergency vehicles can instantly turn lights green
- Low Latency: By processing close to traffic lights, cloud delays are avoided.
- Distributed Architecture: By allowing local decision-making by each fog node, system resilience is increased.
- Dynamic Route Management: In real time, fog suggests alternate routes and sensors identify traffic jams.
- Security & Privacy: Access control and encrypted communication are guaranteed by edge nodes.
- Support for Regular Drivers: Drivers can check light status to avoid traffic and improve flow.

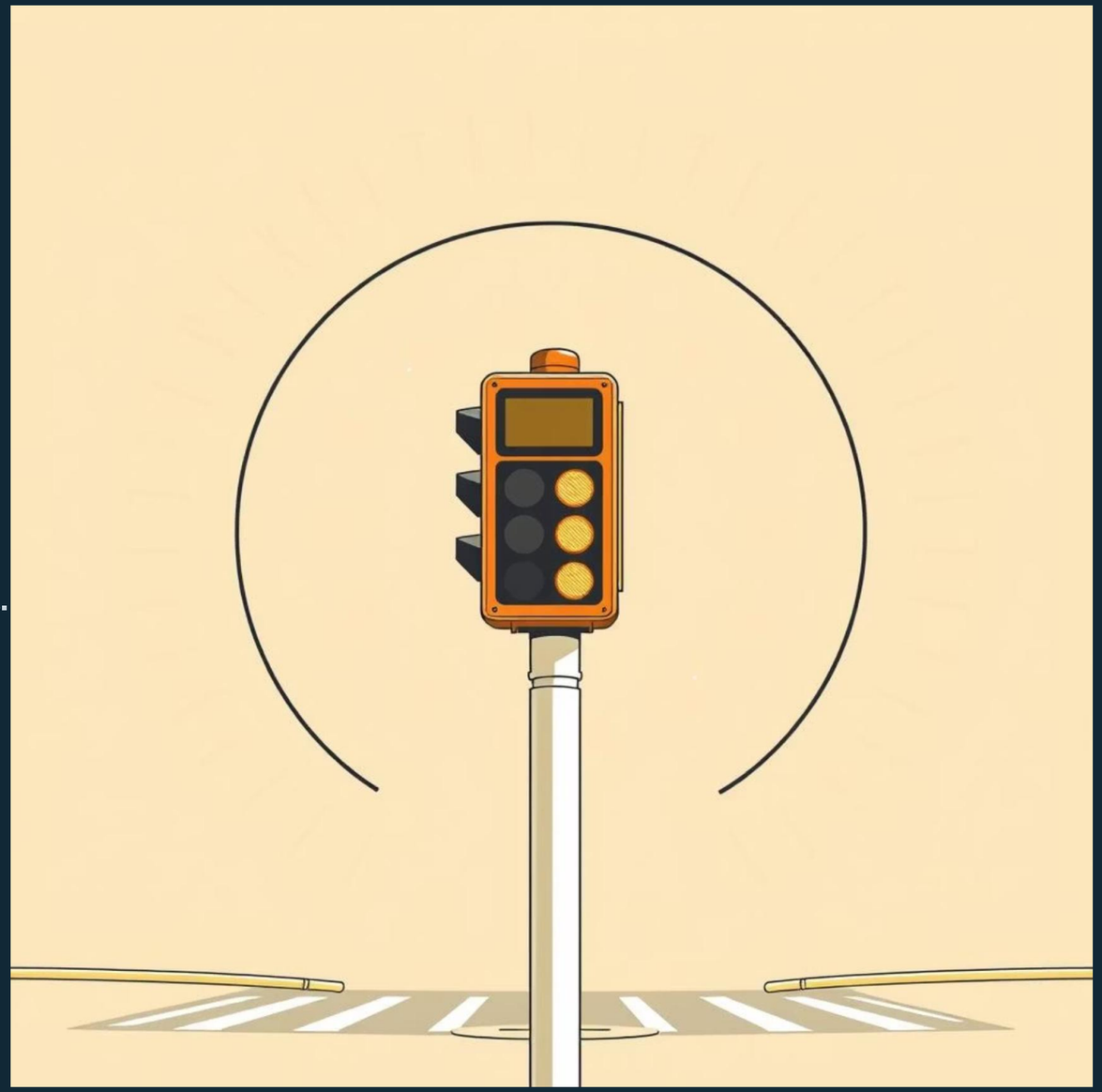
The Fog Layer: The Local Brain

Key Player:

- **RSU (Roadside Unit):** One per smart intersection,
- serving as a local micro-server.

Responsibilities:

- Receives signals from OBUs.
- Identifies emergency vehicle direction and optimal path.
- Executes rapid decision-making logic for traffic light control.
- Sends precise commands to traffic light controllers.



State of art of literature :

Approach	Strengths	Weakness
Acoustic / Siren Detectors	Low-cost, simple deployment	False positives from noise, short detection range
Camera-based Detection	Uses existing CCTV, vision-based tracking	Sensitive to weather, lighting, and occlusion
GPS–Cellular App Trigger	Easy rollout via mobile connectivity	Network latency, dependency on telecom coverage
DSRC OBU→RSU Preemption	Low-latency V2I, works offline, reliable	Requires infrastructure (RSUs), cost of setup
Fog-based RSU Orchestration	Real-time local decisions, fast response	More complex coordination logic, needs multiple RSUs

🎯 Plan of Action

- **Integrate IoT Sensors & Fog Nodes:**
  Connect traffic lights and road sensors to fog nodes for real-time data collection.

- **Develop Priority Algorithm:**
  Shortest path (Dijkstra) algorithm for emergency light control and routing.

- **Emergency Level Integration:**
  Add dispatcher/driver input to classify severity (High, Medium, Low) for prioritization.

- **Simulate in iFogSim2:**
  Evaluate traffic flow, latency, and vehicle waiting times with different congestion scenarios.

- **Test Multi-Ambulance Scenarios:**
  Handle conflict resolution when multiple emergency vehicles approach the same junction.

Fog Layer Superpowers: Speed and Autonomy

Super Fast Response

Decisions are made in near real-time, typically within milliseconds, critical for dynamic traffic adjustments.

Cloud Independence

No reliance on external cloud connectivity for critical path-clearing decisions, ensuring uninterrupted service.

Local Intelligence

Empowers localized data processing and autonomous decision-making for each intersection.

The Fog Layer significantly reduces network congestion and provides the resilience needed for mission-critical operations, even in areas with limited or unreliable cloud connectivity.

CONCLUSION:

- The proposed strategy improves the traffic light system and the driving experience, while also reducing accidents.
- The strategy is beneficial for emergency drivers as it gives them control over traffic lights during emergencies.
- This allows the emergency driver to clear the path from their starting point to the destination, which helps to eliminate traffic jams and prevent delays.
- Once the emergency mission is complete, the traffic lights return to their normal mode, which is controlled by the system without driver intervention.
- The system could be further enhanced in the future to prevent possible accidents by monitoring car speed, calculating the space between cars, and considering the status of traffic jams.

ADITHYA

Research and Analysis

DHARSHAN

System Design and Strategy Development

THAHSEEN

Technical Implementation and Pseudo Code

SANJAY

Data Collection and Reporting

Cloud Layer Superpowers: Insights and Scalability

Long-Term Storage

Securely archives vast amounts of operational data, enabling historical analysis and compliance.

Offline Analytics

Processes aggregated data to generate actionable insights into system efficiency and emergency response patterns.

AI Training Ready

Provides the necessary dataset for training machine learning models to further enhance predictive routing and traffic optimization.

The Cloud Layer is essential for continuous improvement, allowing for deep dives into system performance and future-proofing the solution with AI-driven capabilities.

Thank You & Next Steps

We believe this Emergency Vehicle Priority Routing System represents a significant leap forward in urban emergency response.

Key Takeaways:

- **Edge-to-Cloud Synergy:** Optimal performance through distributed intelligence.
- **Sub-second Latency:** Critical for saving lives and improving flow.
- **Scalable & Resilient:** Designed for current needs and future expansion.