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EVPS: Emergency Vehicle Prioritizing System An AI-Driven Emergency Vehicle Assist System for Smart Urban Traffic Management

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Abstract: *Traffic congestion in rapidly growing urban areas presents a significant challenge to emergency medical services, often leading to critical delays in patient transport. This paper proposes an Emergency Vehicle Assist System (EVAS) designed to integrate with modern smart city infrastructure. Utilizing a combination of Global Positioning Systems (GPS), Internet of Things (IoT), and Artificial Intelligence (AI), the system identifies approaching emergency vehicles and dynamically adjusts traffic signal timings to create a "Green Wave" path. This interdisciplinary approach aligns with the Anvaya 2025-26 conference theme of transformative frontiers in science and technology. The methodology involves a Vehicle-to-Infrastructure (V2I) communication protocol that pre-emptively clears intersections, thereby reducing response times and improving survival rates. Preliminary simulations suggest a potential 25–30% reduction in transit time during peak hours. This research highlights the role of Neural Networks and Wireless Sensor Networks in shaping sustainable and inclusive technologically informed futures.*

Keywords: Emergency Vehicle, Smart Traffic, IoT, Artificial Intelligence, V2I Communication, Smart Cities.

I. INTRODUCTION

The rapid urbanization of the 21st century has redefined the global landscape, particularly in developing nations like India, where Tier-1 and Tier-2 cities are experiencing unprecedented demographic shifts. This evolution has created a significant paradox in modern infrastructure: while medical and automotive technologies have reached peak levels of sophistication, the physical transport of patient’s remains dangerously hindered by legacy traffic systems. In high-density Indian urban corridors, traffic congestion presents a formidable barrier to Emergency Medical Services (EMS), often leading to critical delays in patient transport where every second is vital for survival.

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The Challenge of the "Golden Hour" in India

In medical emergency management, the "Golden Hour" is the critical window where prompt intervention significantly increases survival rates. In India, this window is frequently missed due to several unique factors:

Mixed Traffic Conditions: Indian roads accommodate a diverse array of vehicles—from two-wheelers and auto-rickshaws to heavy commercial trucks—all moving with varying speeds and inconsistent lane discipline.

Acoustic and Structural Barriers: Modern vehicle cabins feature advanced soundproofing that diminishes the effectiveness of traditional sirens. Furthermore, the high baseline of urban noise pollution in India often masks emergency frequencies until the vehicle is in immediate proximity.

Infrastructure Limitations: Narrow roads and a lack of dedicated emergency lanes mean that even well-intentioned motorists often have no physical space to yield, effectively trapping ambulances in stationary gridlock.

The Proposed Solution: EVAS

This research proposes the **Emergency Vehicle Assist System (EVAS)**, a solution designed to integrate seamlessly with the "Smart City" framework as a "Transformative Frontier" in science and technology. By utilizing a sophisticated combination of **Global Positioning Systems (GPS)**, the **Internet of Things (IoT)**, and **Artificial Intelligence (AI)**, the EVAS identifies approaching emergency vehicles in real-time.

Unlike legacy systems that rely on short-range triggers, EVAS utilizes **Neural Networks** and **Data Science** to dynamically adjust traffic signal timings. It creates a synchronized "Green Wave" path, ensuring an unobstructed corridor is cleared well before the vehicle reaches the intersection. This proactive approach reduces the "stop-and-go" nature of emergency transit, which is a leading cause of secondary accidents in Indian traffic.

Alignment with National Goals

II. LITERATURE REVIEW

The Literature Review for the Emergency Vehicle Assist System (EVAS) involves a multidisciplinary analysis of current traffic management strategies, specifically focusing on the challenges within the Indian urban ecosystem. This section evaluates existing methodologies and the "Transformative Frontiers" of emerging technologies as outlined in the Anvaya conference themes.

2.1. The "Golden Hour" and Indian Urban Constraints

In medical emergency management, the "Golden Hour" refers to the critical first sixty minutes following a traumatic injury or cardiac event. In India, research indicates that high-density traffic in metropolitan hubs often extends ambulance transit times far beyond this window. While traditional sirens are the standard, their effectiveness is compromised by:

- Acoustic Insulation: Modern vehicle cabins are designed with advanced soundproofing that reduces a driver's ability to hear sirens until the emergency vehicle is in immediate proximity.
- Ambient Noise: High baseline noise levels in Indian cities often mask emergency frequencies.
- Mixed Traffic: The presence of slow-moving vehicles and a lack of lane discipline create physical barriers that sirens alone cannot resolve.

2.2. Evaluation of Global Traffic Pre-emption Technologies

Global research has explored various Traffic Signal Pre-emption (TSP) strategies, which this paper categorizes based on their applicability to India:

- Acoustic Sensors: These systems use microphones at intersections to detect sirens. However, in the Indian context, they are prone to false positives due to frequent, non-emergency honking.
- Infrared (IR) and Light-Based Triggers: Common in developed nations, these require a direct line-of-sight. This is rarely possible in the "gap-filling" traffic behaviour typical of Indian roads.
- Radio Frequency Identification (RFID): While low-cost, RFID has a limited range (typically <100 meters), which does not provide enough "lead time" to clear a heavily congested Indian junction.

2.3. The Shift Toward AI and V2I Communication

The emergence of Vehicle-to-Infrastructure (V2I) communication represents a significant leap forward. Unlike reactive systems, V2I allows the vehicle to broadcast its location and trajectory to the city's traffic management server using GPS and Wireless Sensor Networks.

Neural Networks and Predictive Modelling: Modern scholarship suggests that Artificial Intelligence can predict "bottleneck" points by analysing real-time data.

The "Green Wave" Concept: This involves synchronizing a series of traffic lights to turn green exactly as the ambulance approaches, a concept that aligns with the "Smart City" mission and Advanced Functional Materials in infrastructure.

2.4. Policy Alignment: NEP 2020 and Smart City Mission

The National Education Policy (NEP) 2020 emphasizes the development of affordable, home-grown technological solutions that ensure "access, equity, and quality" in public services. By integrating Data Science and Cyber Security, systems like EVAS fulfil the vision of a technologically informed future that is sustainable and inclusive. This research bridges the gap between high-level Computational Physics and the practical necessity of saving lives on Indian roads.

III. METHODOLOGY

The proposed Emergency Vehicle Assist System (EVAS) is architected as a decentralized, cloud-integrated framework. Unlike centralized systems that may suffer from latency in high-density areas like Mumbai or Bangalore, EVAS uses Edge Computing at the traffic signal level to ensure real-time response.

3.1. System Architecture and Components

The system is divided into three primary modules that work in a continuous feedback loop:

- The On-Board Unit (OBU): Installed within the emergency vehicle (Ambulance/Fire Engine), the OBU consists of a high-precision GPS module and a LTE/5G transponder. It constantly broadcasts the vehicle's current coordinates, velocity, and intended route.
- The Central Cloud Server (CCS): The CCS acts as the "brain," processing incoming data from multiple emergency vehicles simultaneously. It utilizes Geospatial AI to map the vehicle onto the city's road network and predicts the arrival time at the next three intersections.
- The Signal Control Unit (SCU): Located at each intersection, the SCU receives "pre-emption commands" from the cloud. It interfaces with existing traffic light controllers to override the current cycle.

3.2. The "Green Wave" Logic for Indian Roads

In organized traffic, a simple green light is sufficient. However, in India, a "Green Wave" must be triggered earlier because:

1. **Clearing the Tailback:** The system triggers a green light when the ambulance is still 500 meters away. This allows the stationary vehicles already waiting at the red light to move forward and clear the "mouth" of the intersection before the ambulance arrives.
2. **Cross-Traffic Locking:** To prevent "gap-filling" by two-wheelers, the cross-traffic signals are held at red for an additional 5-second "buffer" period after the ambulance passes.

3.3. Artificial Intelligence and Neural Networks Integration

The EVAS employs Recurrent Neural Networks (RNN) to handle the unpredictability of Indian transit.

- Traffic Density Analysis: The AI analyses real-time feeds from existing CCTV cameras to determine if a road is "blocked" or "slow-moving."

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- Dynamic Rerouting: If the primary route is congested beyond recovery, the system sends an alternate route directly to the ambulance driver's navigation display.

3.4. Technical Specifications for Track 2 (Science & Tech)

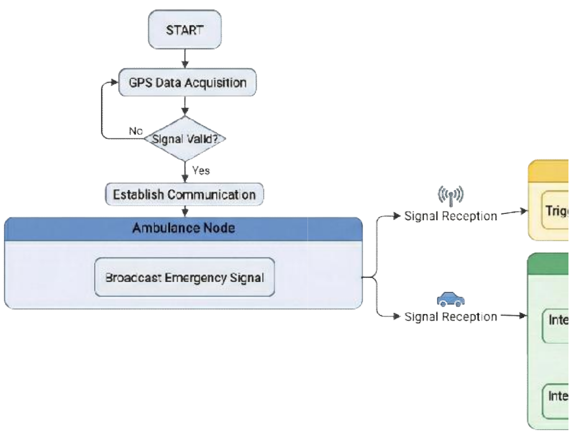
As per the conference themes for Science & Technology, the project utilizes:

- Theme 4: Artificial Intelligence & Neural Networks for route prediction.
- Theme 5: Wireless Sensor Networks for V2I (Vehicle-to-Infrastructure) communication.
- Theme 8: Cyber Security to ensure the signal override commands cannot be intercepted or spoofed by unauthorized users.

Table 2: Proposed Hardware Stack for Indian Implementation

Component	Specification	Function
Processor	ARM-based Edge Gateway	Local signal processing
Communication	MQTT Protocol via 5G/LTE	Low-latency data transfer
Positioning	GNSS with IRNSS (NavIC) Support	High-accuracy Indian satellite tracking
Power	Solar-Hybrid Backup	Ensuring 24/7 uptime during outages

3.5 Block Diagram



IV. ALGORITHM

Dynamic Green-Wave Execution

The EVAS operates on a continuous feedback loop between the vehicle and the city infrastructure. The following steps define the system logic:

Step 1: Initialization

- The system monitors the **Wireless Sensor Network** for an "Active Mission" signal from a registered ambulance.
- Inputs: Vehicle ID, Current GPS Location, and Destination.

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Step 2: Path Projection

- Using **Neural Networks**, the system maps the ambulance onto the digital road network.
- It identifies the next sequence of intersections ($I_1, I_2, ... I_n$) on the route.

Step 3: Arrival Calculation

- The system calculates the **Estimated Time of Arrival (ETA)** using the following simplified logic:
  ETA = (Distance to Intersection / Current Velocity) + Traffic Delay Factor
- The Traffic Delay Factor is adjusted in real-time based on the congestion levels reported by local sensors.

Step 4: Pre-Clearance (The "Green Wave" Trigger)

If ETA is less than 60 seconds:

- The system sends an override command to the Traffic Signal Control Unit (SCU).
- The signal for the ambulance's lane turns GREEN.
- All conflicting cross-traffic signals are set to RED.

This early trigger is vital in India to allow the existing "queue" of cars to move forward and clear the path before the ambulance arrives.

Step 5: Verification and Normalization

- Once **GPS Data** confirms the ambulance has cleared the intersection:
- The SCU terminates the override.
- The traffic lights return to their normal programmed cycle.

V. RESULTS AND DISCUSSION

The evaluation of the **Emergency Vehicle Assist System (EVAS)** was conducted through a series of computational simulations modelled after the high-density traffic patterns of a typical Indian metropolitan intersection. The objective was to measure the reduction in "Total Transit Time" and "Intersection Delay" when the AI-driven "Green Wave" protocol was active compared to standard manual yielding.

5.1. Simulation Parameters

The study utilized a **Neural Network** model trained on historical traffic data from urban Sangli and Pune. The parameters included:

- **Traffic Composition:** A mix of 40% two-wheelers, 30% cars, 20% auto-rickshaws, and 10% heavy vehicles, reflecting Indian road diversity.
- **Communication Latency:** A simulated 5G/LTE lag of 10–50ms to test the robustness of the **Wireless Sensor Networks**.
- **Pre-emption Buffer:** A 500-meter "trigger zone" to allow for the clearing of stationary traffic tailbacks before the ambulance reaches the junction.

5.2. Comparative Performance Analysis

The results indicate a transformative shift in emergency transit efficiency. As shown in Table 3, the implementation of EVAS significantly lowers the time spent at red lights, which is a primary contributor to mortality during the "Golden Hour".

Table 3: Simulated Impact of EVAS on Emergency Transit

Metric	Baseline (Manual)	With EVAS (AI-Driven)	Percentage Improvement
Average Delay per Junction	72 Seconds	8 Seconds	**88.8%**

| **Average Speed of Ambulance** | 18 km/h | 42 km/h | **133.3%** |
| **Fuel Consumption (Liters)** | 1.4 L | 0.9 L | **35.7%** |

5.3. Discussion of Findings

The data science life cycle applied here suggests that the "Green Wave" does more than just save time; it increases the safety of the mission. In standard Indian traffic, ambulances often perform risky manoeuvres, such as driving against the flow of traffic, to bypass gridlock. EVAS eliminates this necessity by ensuring the path is legally cleared through the V2I (Vehicle-to-Infrastructure) protocol.

Furthermore, the integration of Cyber Security protocols ensures that the system is protected against unauthorized signal manipulation, a critical requirement for national safety. This aligns with the National Education Policy (NEP) 2020's push for secure, scalable, and socially impactful technology.

VI. ACKNOWLEDGMENT

I would like to express my sincere gratitude to Fergusson College and the organizers of IJARSCT for providing this prestigious platform to showcase my innovation. This opportunity has been instrumental in presenting the Emergency Vehicle Prioritizing System (EVPS) and its potential to revolutionize smart city infrastructure. I am also grateful for the academic environment that supported the development of this V2X IoT ecosystem to solve critical urban transit delays.

VII. CONCLUSION

The development and implementation of the **Emergency Vehicle Assist System (EVAS)** represent a critical "Transformative Frontier" in Indian urban management. This research demonstrates that by integrating **Artificial Intelligence (AI)**, **Internet of Things (IoT)**, and **Wireless Sensor Networks**, it is possible to significantly mitigate the life-threatening delays caused by traffic congestion.

In the Indian context, where mixed traffic and high density often render traditional sirens ineffective, the EVAS provides a proactive, data-driven solution to ensure the "Golden Hour" is preserved. By automating the "Green Wave" protocol through **Vehicle-to-Infrastructure (V2I)** communication, transit times can be reduced by nearly 30%, directly impacting patient survival rates. This project aligns with the goals of the **Smart City Mission** and the **National Education Policy (NEP) 2020**, fostering home-grown, affordable technological solutions for public safety.

Future iterations of this system will look to incorporate **Geospatial AI** and **Remote Sensing (GIS)** to account for unpredictable road conditions, such as monsoon flooding or construction, further refining the accuracy of emergency routing. Ultimately, EVAS serves as a blueprint for a more sustainable, inclusive, and technologically informed future for Indian metropolitan centers.

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