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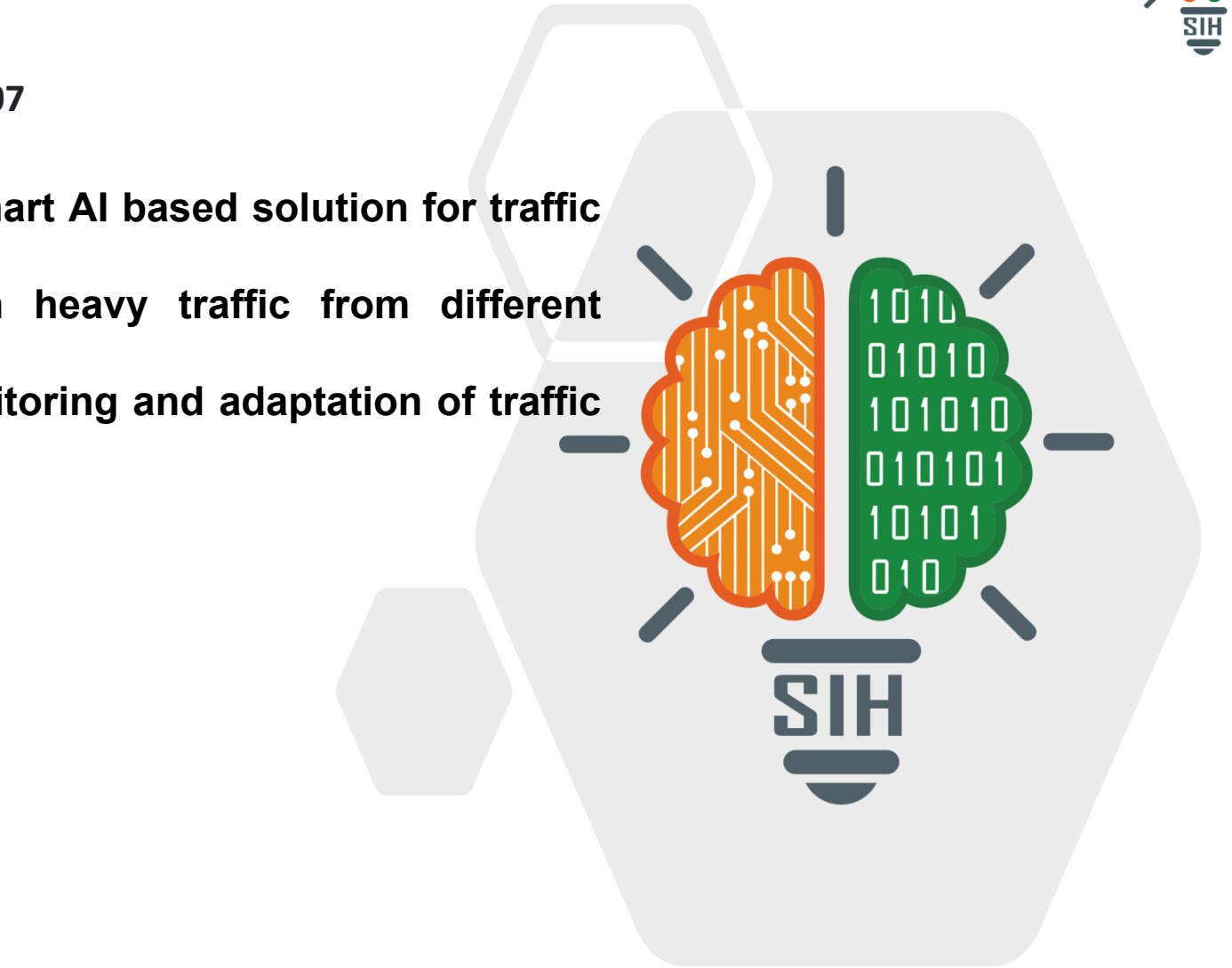
- **Problem Statement ID – SIH1607**
- **Problem Statement Title- A smart AI based solution for traffic management on routes with heavy traffic from different directions, with real-time monitoring and adaptation of traffic light timings.**
- **Theme- Smart Automation**
- **PS Category- Software**
- **Team ID- 26118**
- **Team Name- InnoMinds007**



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Distributed Edge Enhanced AI Traffic Flow Optimizer With Low Latency

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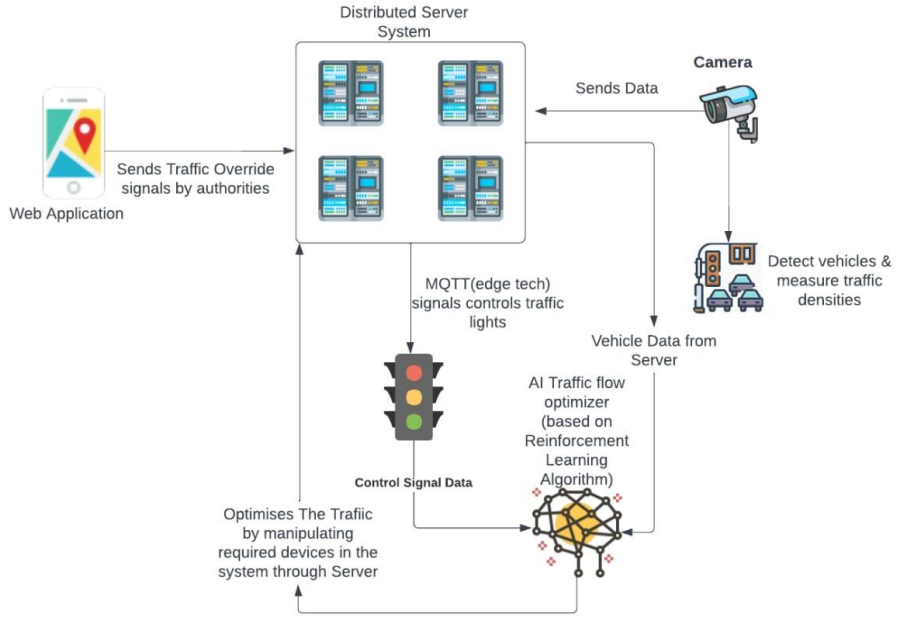
Proposed AI Solution

- **AI for Traffic Flow :**
  AI reduces wait times and minimizes congestion dynamically
- **Edge Technology :**
  Machines make real-time decisions without central systems.
- **Emergency Vehicle Detection :**
  An AI detects ambulances via camera. Server uses MQTT through AWS IoT. Video feed processed through AWS Video Kinesis.
- **Clustered Signals :**
  Signals within 350 meters operate as a synchronized cluster.
- **Distributed Server System :**
  Multiple servers manage clusters, not one centralized server.
- **Resynchronization After Disruption :**
  AI resyncs traffic lights after emergency disruptions.
- **Police Manual Control:**
  Police can use the app to manually control the traffic lights.
- **Public Alerts :**
  App gives real-time roadblocks and traffic updates.

How It Addresses the Problem

1.Optimized Traffic Flow : Reduces congestion, waiting times.
2.Emergency Response : Quick detection ensure ambulance priority.
3.Synchronized Signals : Clustering prevents traffic bottlenecks.
4.Rapid Resynchronization : AI quickly restores normal traffic flow.
5.Manual Control : Police manage lights during emergencies.
6.Public Notifications : Real-time updates guide drivers.



Unique Value Proposition :

- ✓ **Edge Technology Decision Making :** Local systems decide without relying on a central server.
- ✓ **Finding position of emergency vehicles using Radio Frequency:** Detect ambulance signals to determine position using Radio Frequency.
- ✓ **Distributed Server Architecture :** A cluster of servers oversees multiple signal clusters so reduced latency.
- ✓ **Cloud Integration :** Traffic data analyzed in real-time for continuous improvement.
- ✓ **Mobile App for Police :** Police can control the traffic during critical events.
- ✓ **Real-Time Public Alerts :** Drivers receive updates to avoid blocked routes.

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TECHNICAL APPROACH

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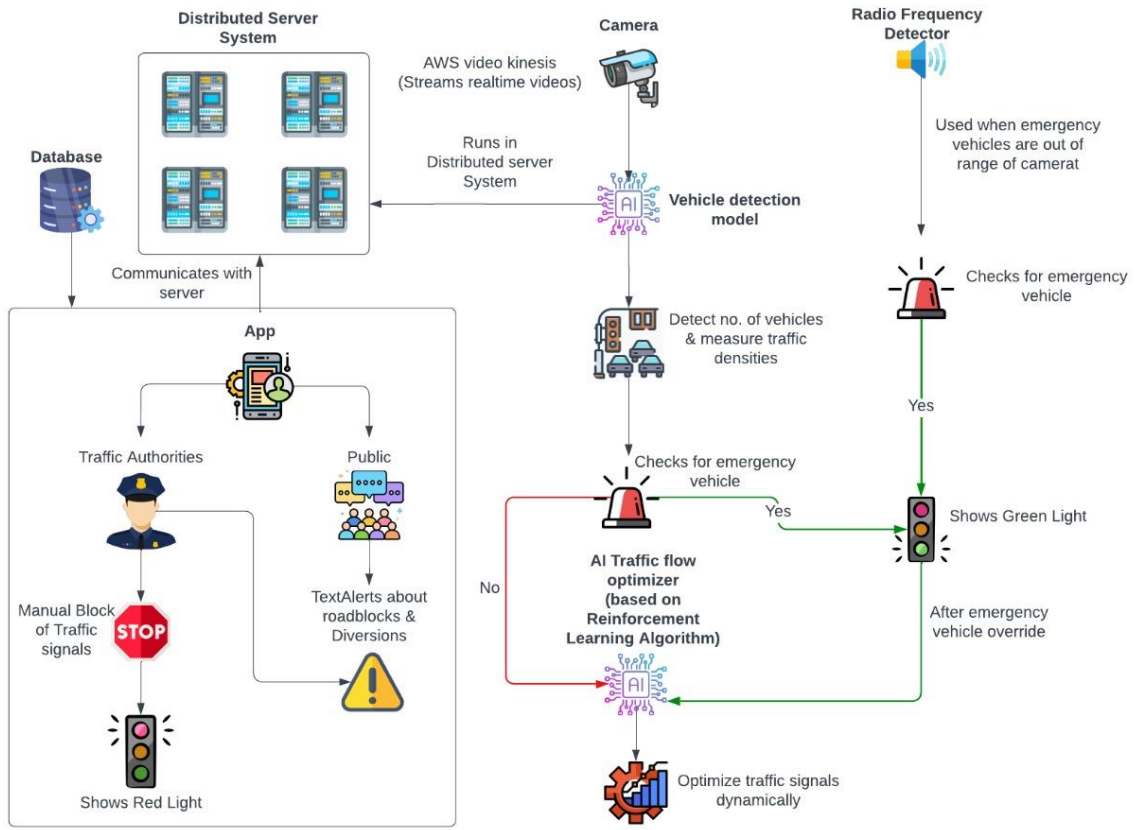
Tech Stack

- **Jetson (Server):**
  - Runs AI Vehicle detection and AI traffic flow optimizers models.
- **Vehicle Detection AI Model:**
  - Detects vehicles and measures traffic density.
- **AI Traffic flow Optimizer:**
  - Reinforcement Learning algorithms and deep learning is used to develop it.
  - Optimizes traffic flow to reduce waiting time and resynchronizes signals
- **React & MUI:**
  - Builds a responsive, user-friendly front-end for traffic control.
- **Firebase:**
  - Securely stores user data in database.
- **AWS IoT Core:**
  - Facilitates MQTT communication between server, traffic lights, and mobile devices.
- **AWS Kinesis Video Streams:**
  - Streams live video data to the server in real time.
- **AWS Load Balancer:**
  - Provides backup servers for seamless operation.
- **ESP32:**
  - Controls traffic lights based on AI-driven decisions.
- **Radio Frequency Detector**:
  - It detect sirens of emergency vehicles which is installed at traffic light intersections.



Revenue Streams:
SaaS product for both public and authorities

Prototype Video - Click Here

Web Application - Click Here

Credential :-
Username – sih
Password - 123

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FEASIBILITY AND VIABILITY

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Feasibility of the Idea

- **Edge Technology:** Initial cost for devices like NVIDIA Jetson is high, but long-term operational costs are low due to decentralized processing.
- **Google Maps API:** A cost-effective solution for real-time traffic data (density, roadblocks, diversions), reducing the need for expensive custom sensor infrastructure.
- **Reinforcement Learning (RL) for Traffic Control:** High initial resource demands for model training, but once deployed, it becomes highly efficient and adaptive, reducing ongoing costs.
- **Distributed Server System:** Reduces the load on a central server, improving system reliability and scalability, which lowers long-term maintenance and upgrade costs.
- **AWS Cloud Infrastructure:** Its scalable, pay-as-you-go model makes it cost-effective and feasible for large-scale implementations.

Potential Challenges and Risks

- **Latency:** Video Processing by the AI models may take some time.
- **Model Performance:** Customization is required to adapt AI models to local traffic patterns.
- **Camera:** If an ambulance is outside the camera's view, the system won't detect it, risking delays in giving priority to emergency vehicles.
- **Network Reliability:** Potential disruptions in cloud services or network connectivity could affect real-time decision-making and communication between devices.
- **Initial Training Time:** Reinforcement learning models require extensive data and training time before they can function effectively.

Strategies for Overcoming Challenges

- **Reduced Latency:** Fine-tuned AI models are deployed on edge devices like Jetson and ESP32 to minimize processing delays and improve response time.
- **Model Optimization :** Reinforcement learning AI continuously adapts to changing traffic patterns by training on real-time data, improving accuracy and performance.
- **Radio Frequency Detectors:** Radio frequency-based detectors are used to detect ambulance signals and determine the ambulance's position when it's outside the camera range.
- **Network Redundancy:** Implement backup systems, like AWS Load Balancer and distributed servers, to ensure continuous operation during network or cloud service interruptions.
- **Pre-Deployment Training:** RL models undergo extensive training during the initial deployment phase, so they are optimized and require minimal ongoing adjustments.

IMPACT AND BENEFITS

Potential Impact on the Target Audience:-

- **Drivers**: Reduced waiting times by up to ***20%,*** leading to smoother commutes and fewer delays—saving drivers an average of ***15-30 minutes*** daily.
- **Emergency Services**: Faster response times with priority-based signal control, reducing ambulance delays by ***70%***.
- **City Authorities**: Improved traffic management, reducing road incidents. Authorities can dynamically block routes during emergencies, enhancing control.
- **Public Safety**: Fewer accidents and better emergency control, reducing traffic-related through real-time updates and manual overrides.

Benefits of the Solution:

Social:

- Reduced traffic stress and faster commutes save commuters up to ***30 minutes*** per day.
- Real-time notifications improve drivers' experience by avoiding congested areas, reducing delays by ***35%***.

Economic:

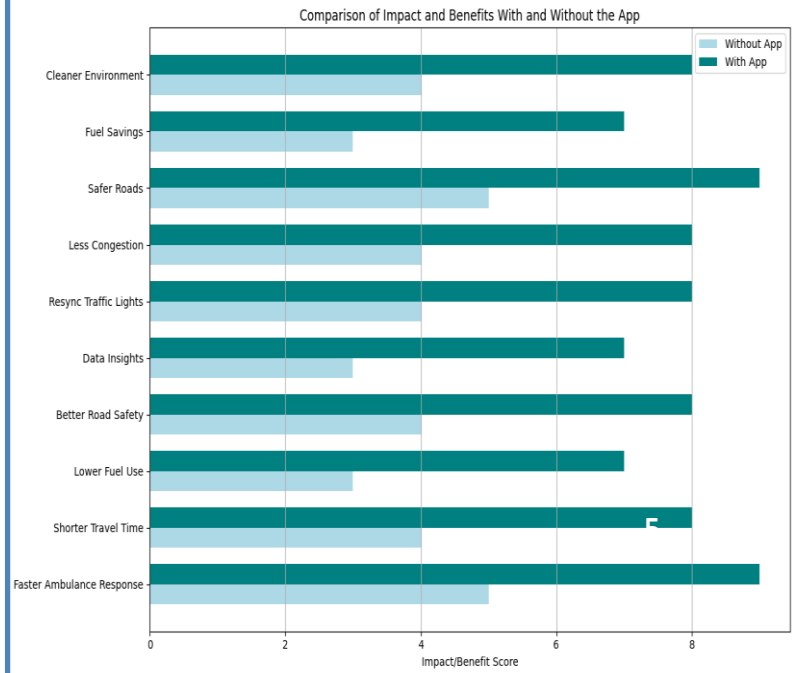
- Reduced fuel consumption and vehicle operating costs through optimized traffic flow.
- City governments saves on traffic management costs by minimizing manual control.
- Increased productivity, as people spend less time in traffic, boost their efficiency for daily commuters.

Environmental:

- Lower carbon emissions, reducing CO2 output by up to ***12% ,***contributing to a cleaner urban environment.
- More efficient traffic flow reduces pollution, helping cities meet sustainability goals with up to ***10%*** improvement in air quality.

Technological Advancement:

- Cities adopting AI-driven technologies can position themselves as smart city leaders, potentially increasing investment.
- AI resynchronizes traffic lights within few cycles after emergency disruptions, restoring signal sync quickly.
- Authorities can dynamically block routes and paths during unexpected events, enhancing traffic control



Note :
These numbers are predicted in the simulated environment using our AI models.

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RESEARCH AND REFERENCES

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- Prototype Web Application
- Prototype Video
- Application GitHub Repository
- Innominds Research Paper
- Traffic Light Control System for Emergency Vehicle Using Radio Frequency Documentation
- Documentation of AWS Video Kinesis
- Documentation of MQTT
- IIIT Paper for Traffic Clustering
- Synchronised_Traffic_Light_Demo