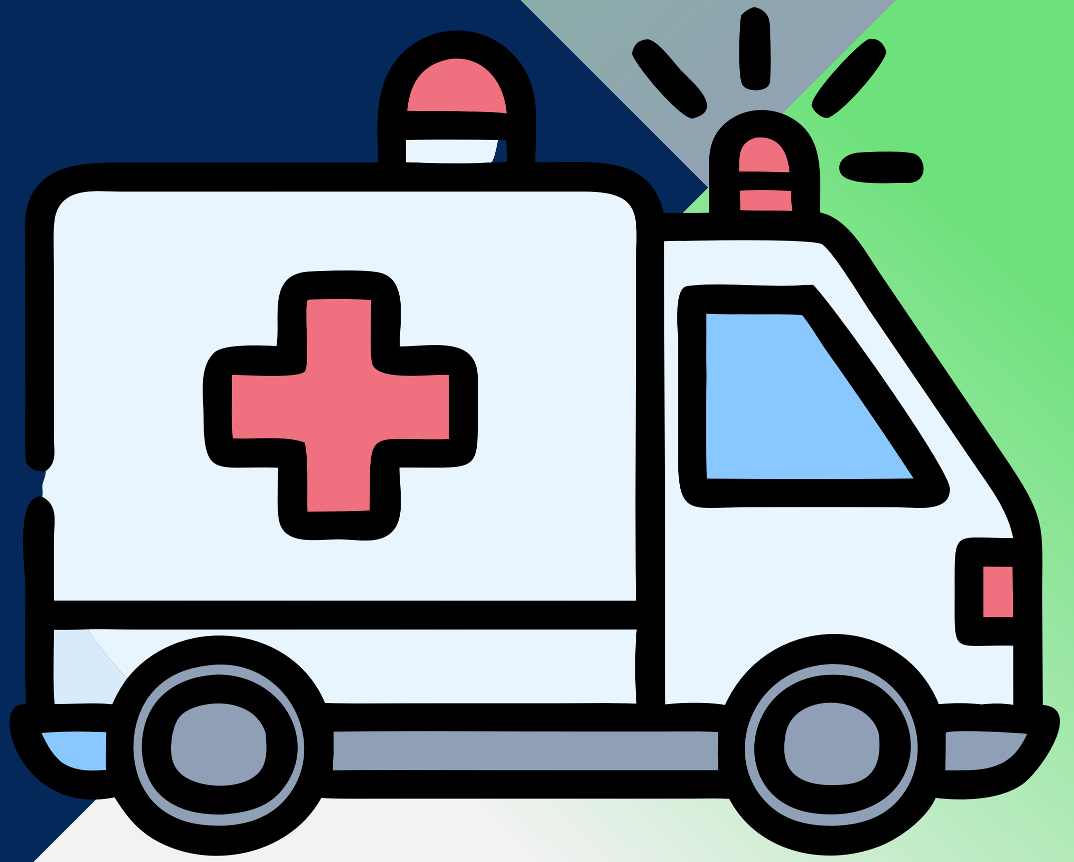
Efficient Traffic Emergency Response

EDGE-BASED V2X PROTOCOL

Conference: DIVANet '21



Introduction & Problem Statement

Traffic accidents cause major damage and fatalities globally.
Reducing ERV (Emergency Response Vehicle) response time is key to saving lives.
Existing Traffic Management Systems (TMS) prioritize congestion, not emergency access.
Manual reporting is often delayed; this protocol enables automated, fast response.

Why Edge-based Solution?

- Edge nodes = proximity = reduced latency
- Real-time awareness of accident zones via edge data collection.
- Uses multi-hop VANET (Vehicular Ad-Hoc Network) messaging for resilience.
- Ideal for decentralized, dynamic traffic environments.

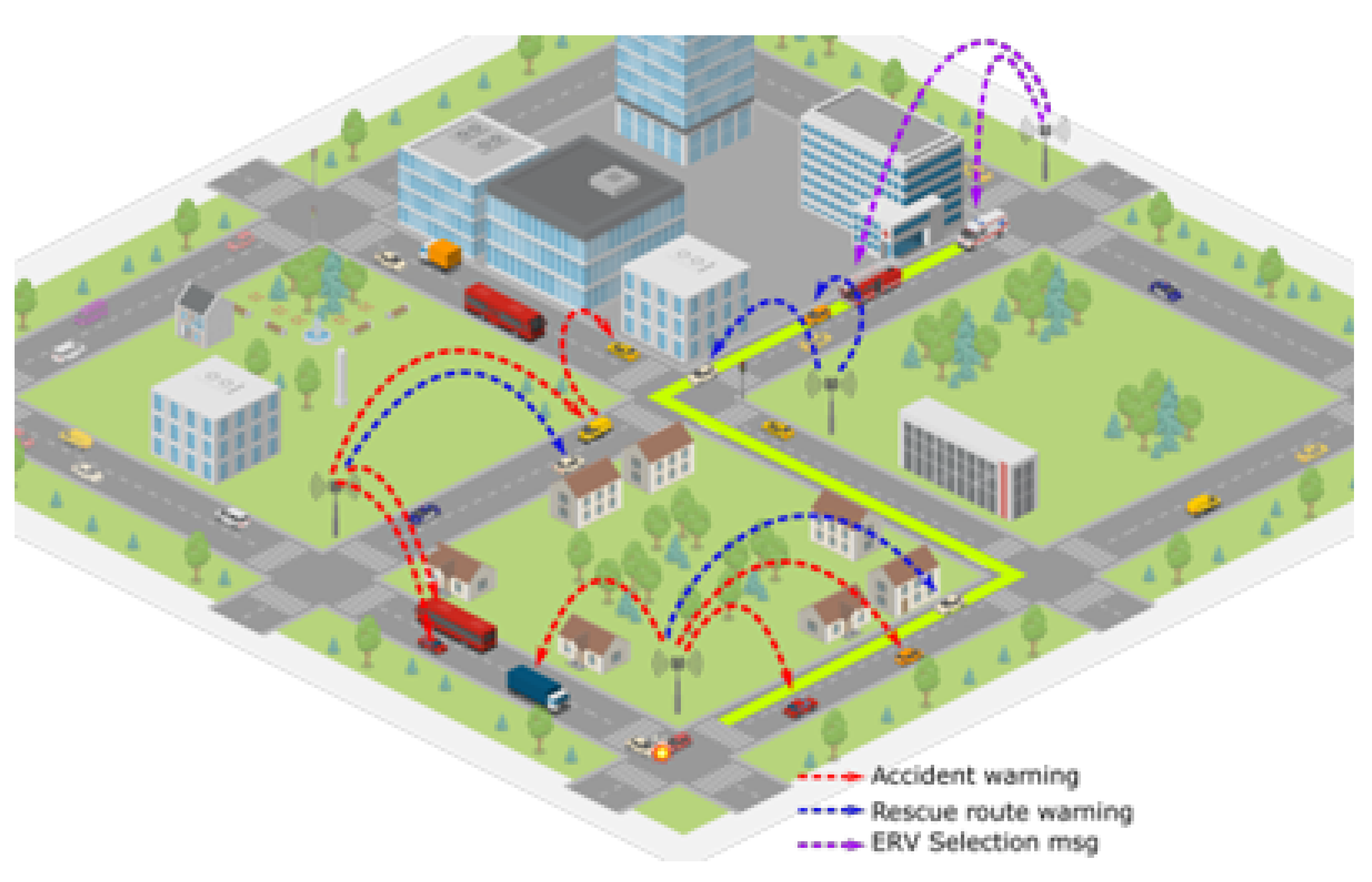
Challenges in Emergency Response

Current traffic systems face significant **delays and inefficiencies** in emergency response, prompting the need for an innovative protocol that enhances communication and coordination among vehicles and responders.

Advantages of Edge-based Solutions for V2X

Implementing an edge-based approach for V2X communication allows for **reduced latency** and improved response times, enhancing traffic management capabilities and ensuring timely emergency responses.

This strategy also optimizes bandwidth usage by processing data locally, leading to **increased efficiency** in managing traffic and ultimately improving overall road safety and user experience.


Accident warning
Rescue route warning
ERV Selection msg

State of the Art in V2X Emergency Response

- Detection methods: Video-based analysis, smartphone sensors.
- Traffic control: NRR, ALIVE protocols; ML-based severity prediction.
- Gap: Existing systems lack ERV-centric response routing.
- Our solution: Combines V2X, edge-based ERV selection, and rerouting.

Proposed Protocol Timeline

Step 1

Accident Detection: Vehicle alerts nearest Cloud Edge Node (CEN).

Step 2

ERV Discovery: CEN queries network for available ERVs.

Step 3

ERV Selection: CEN selects nearest/fastest ERV.

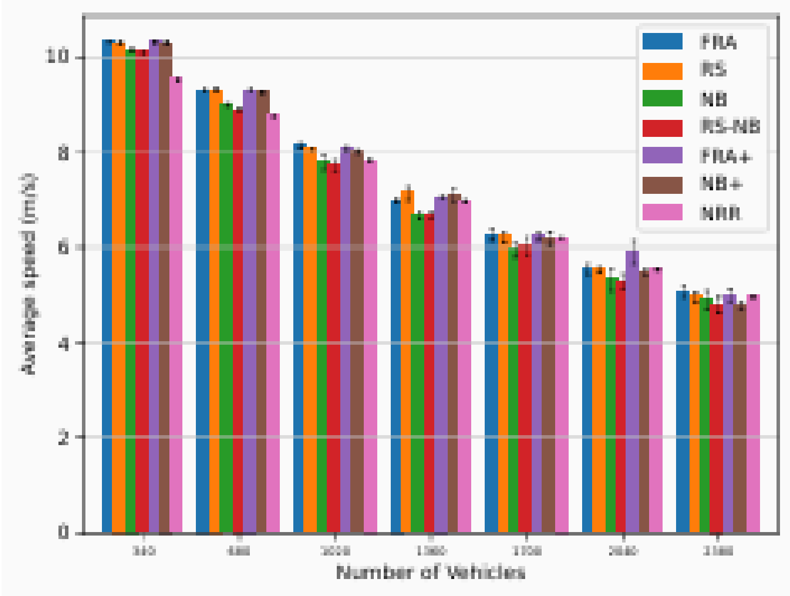
Step 4

Route Dissemination: ERV broadcasts its route so vehicles can move.

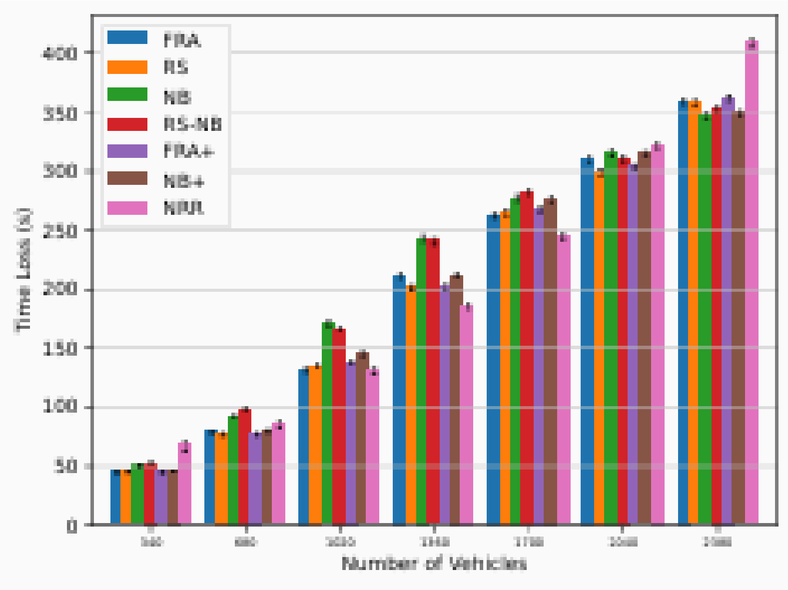
Step 5

Resolution: ERV confirms arrival and clears the case.

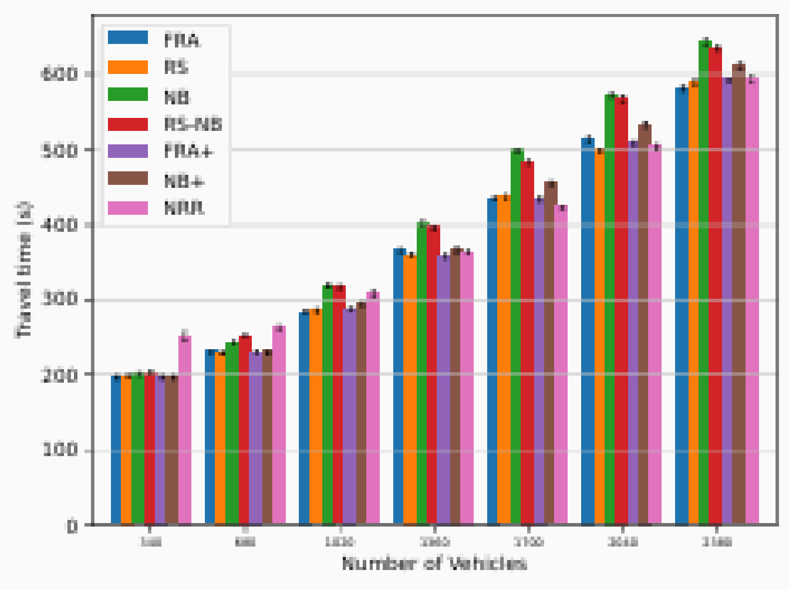
Results



(a) Average Speed

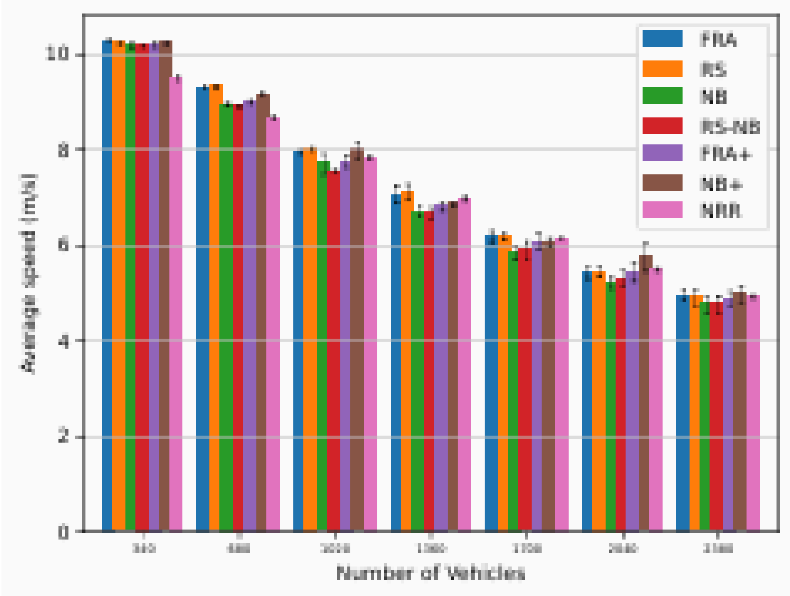


(b) Time Loss

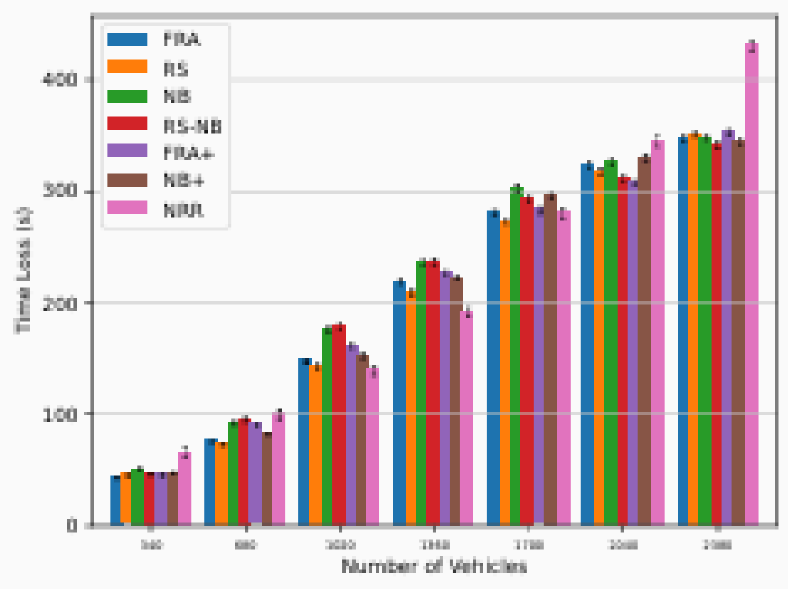


(c) Travel Time

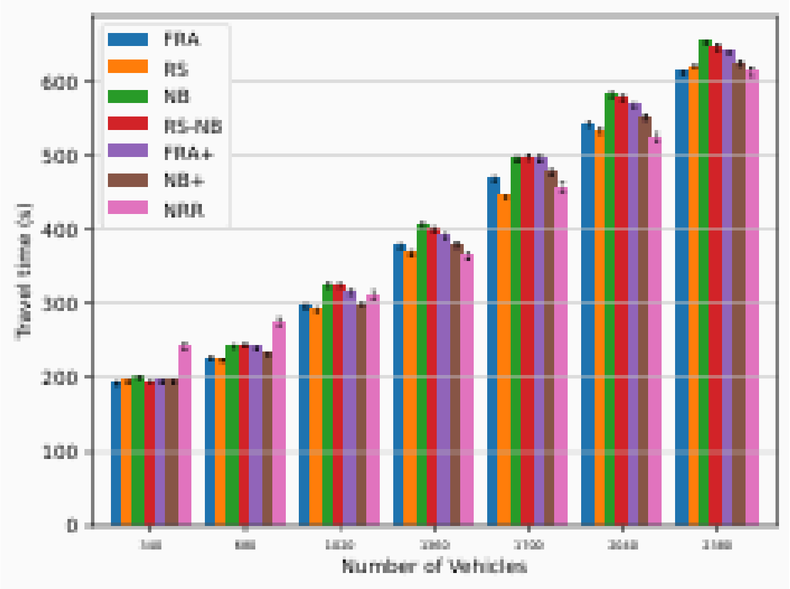
Figure 4: Traffic congestion analysis of open scenario.



(a) Average Speed



(b) Time Loss



(c) Travel Time

Figure 5: Traffic congestion analysis of partitioned scenario.

Simulation & Evaluation

Tools Used:
- Veins (OMNet++ + SUMO) for network and traffic simulation
- iFogSim for modeling edge resource allocation and delay

Scenarios:
- Open Map (random)
- Partitioned Map (ERs separated from accidents)

Key Metrics:
- ERV response time
- Average speed
- Time loss
- Control overhead (packets sent)

Key Findings

- Response Time: FRA and FRA+ provided shortest ERV response.
- Congestion Relief: Accident clearance helped traffic flow.
- Broadcasting: Not sharing ERV path increased travel delays.
- Fastest vs. Shortest: Minimal difference in dynamic setups.
- Overhead: Similar across all variants; scalable to density.

"Efficient traffic emergency response requires real-time data processing at the edge to enhance safety and reduce delays."

– Research Insight

iFogSim Tool Utilization

- Why iFogSim? Models computational delay in CEN/ERV decisions.
- Analyzes edge-based resource usage and processing efficiency.
- Helps evaluate response time impact in fog/edge infrastructure.
- Integrated with Veins for smart city scale testing.

Conclusion and Future Research Directions

- Conclusion:
    - Edge-based V2X protocol = faster ERV dispatch + less congestion.
    - Works well in dynamic, high-density environments.
- Future Plans:
    - Enable re-routing for ERVs when paths become blocked.
    - Use ML to predict ERV availability and accident severity.
    - Extend to V2P (Vehicle-to-Pedestrian) alerts.
    - Tackle variability from real-world randomness.

Thank you & Q&A