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Vehicular Collision Avoidance Using Inter-Vehicular Communication (IVC) Protocols Based on IEEE 802.11

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Abrstract – **Road safety remains a major concern as traditional driver-assistance systems fall short in preventing high-speed collisions. Recent advances in wireless communication enable real-time data sharing between vehicles, giving rise to Inter-Vehicular Communication (IVC) systems. This paper presents a study and design of a Vehicular Collision Warning Communication (VCWC) protocol, which uses IEEE 802.11 standards to detect and respond to abnormal vehicle behavior. The protocol supports message differentiation, congestion control, and adaptive retransmission, reducing emergency message delays and preventing redundant broadcasts. The proposed approach provides an effective, scalable solution for real-time vehicular safety applications.**

Index Terms - **Inter-Vehicular Communication (IVC), VCWC, IEEE 802.11, V2V, Emergency Warning Messages (EWM), VANET, Collision Avoidance.**

I. INTRODUCTION

Studies show that over 60% of roadway accidents could be avoided if drivers were alerted just half a second earlier. InterVehicular Communication (IVC) systems have emerged to bridge this gap, offering safer and more reliable vehicular coordination. IVC enables real-time information sharing between vehicles and infrastructure, supporting accident prevention, traffic monitoring, and driving efficiency. This research focuses on Vehicle-toVehicle (V2V) communication as part of IVC systems. V2V is crucial for decentralized traffic data sharing and cooperative driving at critical junctions. Projects like FleetNet, WILLWARN, Car2Car, and CHAUFFEUR have demonstrated practical IVC applications using wireless LAN and protocols such as IEEE 802.11.

II. SYSTEM REQUIREMENTS AND NETWORK TOPOLOGY

A. *Requirements*

Reliable, low-latency communication is vital for real-time collision warnings. Challenges include packet loss due to fading, shadowing, and Doppler effects from high-speed movement. Latency must be minimized to allow timely driver responses.

B. *Topology*

Most vehicular networks adopt a linear topology, especially on highways. Nodes are aligned linearly, with some acting as gateways to infrastructure. This topology demands specialized routing and message dissemination techniques.

III. NETWORK LAYERS AND PROTOCOL STACK

A. *MAC/PHY Layer*

IEEE 802.11-based protocols are preferred for their support of distributed coordination in ad hoc networks. Alternatives include CDMA and infrared, but 802.11p (5.9 GHz band) is standard for vehicular communication.

B. *Network Layer*

Position-based routing is the norm, using GPS/GIS data to optimize forwarding. However, challenges like 'dead ends' in greedy forwarding must be addressed through adaptive routing strategies.

IV. VEHICULAR COLLISION WARNING COMMUNICATION (VCWC) PROTOCOL

The VCWC protocol is event-triggered (active) and prioritizes Emergency Warning Messages (EWMs). It handles:

- Message Differentiation: Prioritizes EWMs using Interframe Spacing (IFS) variations.

- Congestion Control: Uses decreasing EWM transmission rate to reduce redundant messages.

- State Transitions: Vehicles shift between Initial, Flagger, and Non-Flagger states based on context, minimizing unnecessary retransmissions.

A mathematical model ensures optimal retransmission timing:

$$F(\lambda o, k) = \max(\lambda\_min, \lambda o / a\hat{}k / L)$$

V. CONCLUSION

The VCWC protocol enhances vehicular safety by enabling rapid and reliable emergency message dissemination. It accommodates high vehicle mobility and network density, while minimizing redundant messaging through intelligent state transitions. Future work may integrate ML-based congestion prediction for further optimization.

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