

Event Information Delivery Method Using Location Information for Route Replanning in V2I Local Environment

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Abstract—We propose a new method that transmits a frame containing event location information in V2I LAN environments upon the occurrence of an event. In traditional navigation systems, external servers connected via the internet analyze traffic conditions and calculate estimated travel times based on real-time traffic information, GPS data, and user information. The results are then transmitted to the in-vehicle navigation system. However, these systems have limitations in immediately reflecting delays caused by real-time accidents in route settings. We propose an event information delivery method that quickly triggers a change to a new route by transmitting event information (such as accidents or blockages) within the local area, without communicating with servers in external networks. In addition, we describe a packet format in which location information is included in the header to reduce the delay and algorithms applied to the proposed method for transmitting event information from the AMU and replanning route based on event information in the AMU. To evaluate the performance of this new system, we calculate the end-to-end delay in the worst case and assess the effectiveness of the proposed system based on this.

Keywords— LAN , Event information delivery , Route replanning , location data , V2I

I. INTRODUCTION

Nowadays, cities are growing rapidly due to business activities, commerce, and new technologies, leading to increased population pressure on limited infrastructure. Roads, in particular, are facing congestion due to the rise in vehicle numbers. V2I(Vehicle-to-Infrastructure) communications are necessary to properly manage traffic situations. V2I will enable RSUs(Road Side Units) or traffic infrastructures to transmit information such as vehicle accidents to complement V2V(Vehicle-to-Vehicle) applications. Cities and private companies are adopting data-driven applications to manage resources efficiently. Companies like Google, Apple, and Waze use crowd-sourced data and cloud environments to develop real-time navigation apps.

However, centralized cloud systems are suitable for current data processing but face limitations in future services like autonomous vehicles. Such services require low latency and

high-reliability communication, which traditional cloud-based systems are not fully equipped to support. Moreover, there is a challenge in promptly reflecting event information, such as accidents or road obstacles, in existing navigation systems due to increased traffic. Current navigation technologies primarily rely on central servers or cloud-based systems to collect and process data before recalculating routes. However, this approach presents the following drawbacks:

Information Delivery Delay: Accident information is transmitted from the vehicle to the RSU (Roadside Unit), then to the central server, and finally back to individual vehicles. During this process, network delays can occur, making it difficult to perform immediate route adjustments.

Insufficient Handling of Incidents in LANs: Traditional navigation systems have limitations in promptly adjusting routes for local incidents within specific LANs (e.g. accidents or road obstructions). While information is being sent to the central server, new incidents can arise, or traffic conditions can change rapidly, reducing the accuracy of the route recalculations. Therefore, research on task allocation algorithms for distributed path planning is being conducted recently [1]-[3].

To address these limitations, the proposed method is designed to reflect event information in real time within specific LAN environments and enable vehicles to immediately adjust their routes. The proposed packet format includes location and event information directly in the packet header, enabling the rapid transmission of accident information without additional delays. Additionally, through algorithms for transmitting event information from the AMU and replanning the route based on event information received from the AMU, event information occurring in the LAN can be immediately utilized for route planning in adjacent AMUs. This approach helps minimize latency between vehicles and contributes to maintaining smooth traffic flow.

The remainder of this paper is structured as follows. Section 2 explains the proposed system, the method for delivering event information within the system, and the packet format. Section 3 presents the performance analysis results of the proposed system. Finally, Section 4 concludes the paper and provides future research directions.

II. RELATED WORK

In related work, we describe research on event information transmission methods using existing communication technologies currently applied in vehicle communication systems and decentralized routing methods being conducted to escape from centralized cloud systems.

WAVE technology is a wireless communication technology based on the IEEE 802.11p standard, which supports communication between vehicles (V2V) and between vehicles and road infrastructure (V2I). This technology is designed to provide stable communication, particularly in high-speed vehicle environments. WSMP(WAVE Short Message Protocol) is a communication protocol, specifically designed for rapid message transmission in vehicular communication networks. WSMP operates within the IEEE 802.11p standard, which supports vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communication. The key purpose of WSMP is to facilitate the swift exchange of critical safety information, such as accident alerts or collision warnings, ensuring that vehicles and road infrastructure can respond quickly to dynamic traffic conditions. The method of accident information delivery via WSMP and the proposed system's accident information delivery method are compared and explained. First, WSMP is a protocol designed for short and fast message transmission in WAVE communication. WSMP primarily focuses on delivering essential information, and accident location data or detailed accident information can be transmitted through the Payload area. However, to deliver accident location or detailed accident information via WSMP, it must be added to the payload section using software, and the receiving vehicle must parse the payload to retrieve that information [4]-[6].

The services that utilizes the distributed characteristics of the architecture in RSU-Edge have been studied [1]. The study explains that RSUs store only the latest speed data for the roads within the grid to which they are assigned. The aggregated data is propagated to neighboring RSUs by each RSU at a set delay interval. In the study, it is assumed that each grid contains several road segments, with each road assigned to an RSU that processes all received speed data. The RSU collects mobility data from vehicles within its designated grid and stores the most up-to-date speed data. The RSU then propagates the aggregated data to neighboring RSUs at predetermined time intervals. This data reduces communication costs between RSUs and allows the system to maintain a snapshot of speed information across the entire target area.

III. PROPOSED SYSTEM

This chapter explains the environment of the proposed system, the packet format, and the algorithm applied to the system [8]-[9].

A. System environment

Figure 1 shows the system environment of the proposed system for route replanning in the event of an accident in a V2I LAN environment. The proposed system consists of a gateway, RSUs, and AMUs. The gateway serves as the central device within the LAN, communicating with RSUs (Road Side Units) through Ethernet (L2) connections. It plays a key role in relaying data packets within the LAN and transmitting event or route replanning information. RSUs are communication devices installed along the roadside. Each RSU communicates with vehicles (AMU, Autonomous Moving Unit) through a wireless network. RSUs are connected to the LAN and play a role in transmitting accident information to the vehicles in the event of an accident. The system is composed of N RSUs, with each RSU responsible for a specific road area (Coverage) and managing wireless communication with the vehicles within that area. AMUs refer to autonomous or operating vehicles. In Figure 1, they are represented by AMU 1 and AMU 2. Each vehicle sends event information collected via its cameras to the RSU and can adjust its route based on event and location data received from the RSU. Within the overall coverage area managed by the LAN, each RSU has its own coverage. Within this range, RSUs exchange event information from vehicles with the gateway, and deliver route replanning or accident information to vehicles within their coverage area.

In traditional navigation systems, data is transmitted to the central server via RSUs, where the server processes it and sends the updated route information back to the vehicles. This process makes it difficult for event information occurring within the LAN to be reflected in route planning in real time. Additionally, events within the LAN, such as accidents or obstacles, are not immediately incorporated, causing delays in route adjustments. This can reduce vehicle efficiency and lead to traffic congestion, resulting in further delays.

When an event occurs, the information collected through wireless communication between roadside RSUs and vehicles is transmitted in packet form to the gateway within the LAN. Instead of relying on a server to process the data and send it back to vehicles, the gateway broadcasts the packets to all RSUs within the LAN. These RSUs then forward the packets to the vehicles within their respective coverage areas. The vehicles that receive the event and location information can then use the data to maintain or adjust their routes accordingly.

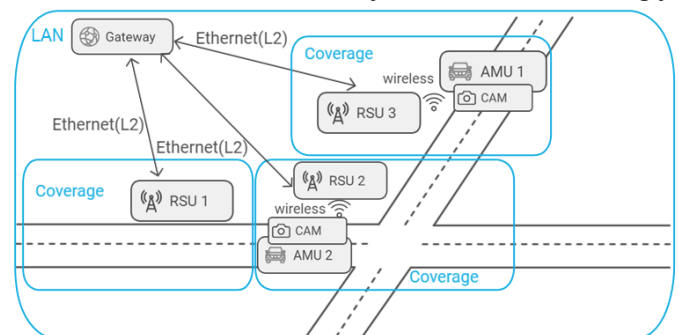


Figure 1. system environment

B. Packet format

The packet format newly proposed in this paper is designed to deliver location and event information more quickly. A key feature of this format is the addition of a fixed-size area called the proposed stack between the L2 header and the L3 header. The proposed stack has a fixed size and contains location information, event information, and other data. The location information can represent the area covered by a specific RSU. This allows vehicles or infrastructure to immediately identify the event location and details using the RSU location data included in the proposed stack, without the need for additional parsing of the payload area. This fixed-size structure enhances the efficiency of packet transmission and helps minimize communication delays. As a result, the system using the proposed packet format enables faster and more efficient event information delivery than existing methods, allowing vehicles to promptly replan their routes or take detours.

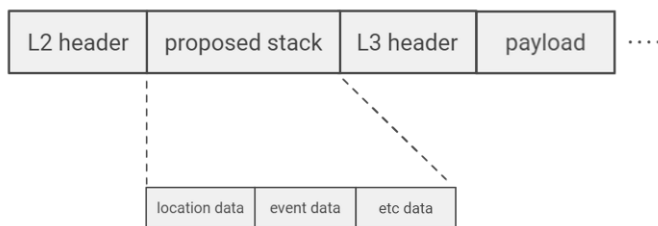


Figure 2. Packet format

C. Algorithm applied to system

Figures 4 and 5 represent, respectively, the information delivery algorithm from the AMU to the gateway upon event occurrence, and the route replanning algorithm for AMUs when an event occurs. Using Figure 3 as an example, we proceed to explain the system in which the two previously presented algorithms are applied.

When an accident occurs at AMU1, the vehicle collects accident information through its camera in the form of image and video data. The collected data may include details such as the accident location, severity, and the status of nearby vehicles. This data is encapsulated into a packet along with the accident event information and the location of the associated RSU, and transmitted wirelessly to RSU3, which is connected to AMU1. RSU3, upon receiving the packet from AMU1, forwards it to the gateway it is associated with. As the central node, the gateway transmits the received packet to all RSUs within its coverage. Since the packet is transmitted directly to local RSUs without passing through external network servers, latency is reduced. Each RSU that receives the packet from the gateway then forwards it to the AMUs connected to it. AMU2 parses the packet to determine that an accident has occurred along the originally planned route. Based on the event and location information, AMU2 decides whether to maintain the current route or set a new one. If a new route is required, the vehicle re-plans to take a detour, as illustrated in Figure 5, and continues driving accordingly.

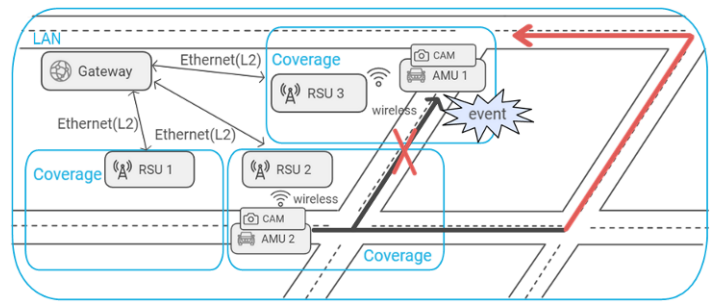


Figure 3. system operation upon event occurrence

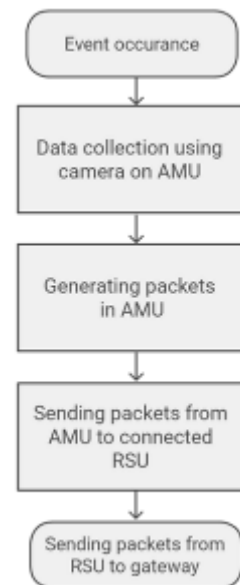


Figure 4. Algorithm of information transmission AMU to gateway upon event occurrence

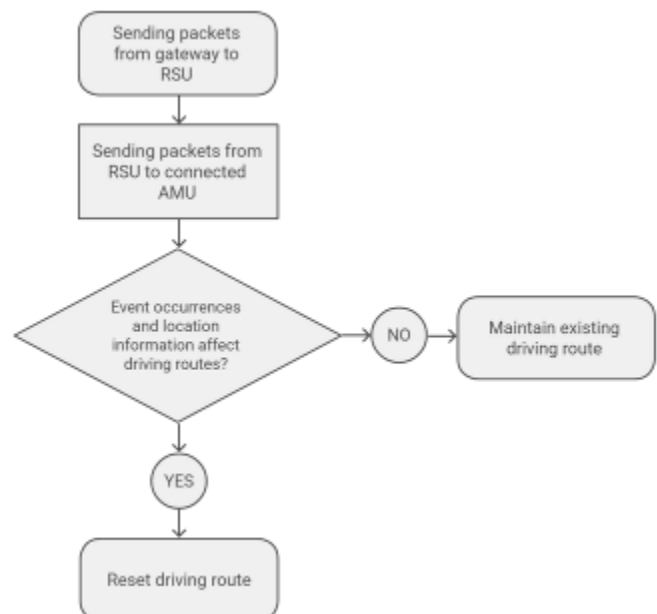


Figure 5. Algorithm of route replanning by the AMU upon event occurrence

IV. PERFORMANCE ANALYSIS

The following equation is used to calculate the end-to-end delay in the worst case. Through this equation, the delay boundary of the system proposed in this paper is calculated [7].

$$d_i^{End-to-end} \leq \sum_{k=1}^N \left(\theta'_{i,k} + I_{i,k} * \frac{\pi_{i,k}}{1 - \pi_{i,k}} \right)$$

Figure 6. Equation for determining the delay boundary in worst-case end-to-end communication

The Figure 7 is the graph below consists of the X-axis representing nodes and the Y-axis representing the worst-case end-to-end delay. As shown in Figure 1, the method proposed in this paper involves passing through three nodes, resulting in a delay value within the boundary for three nodes. In contrast, traditional navigation methods communicate with a navigation server in an external network, leading to a higher delay boundary.

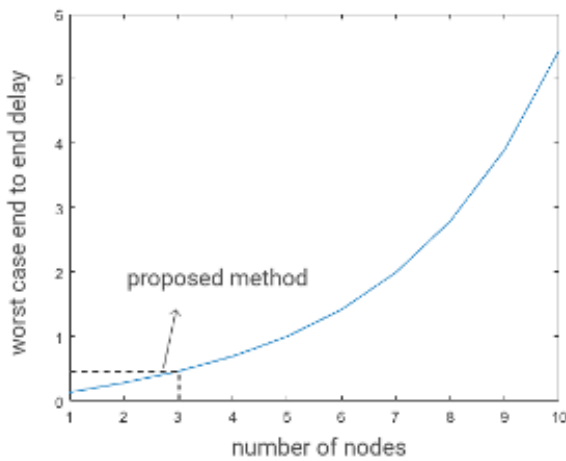


Figure 7. delay boundary in worst-case end-to-end communication

V. CONCLUSIONS

The system proposed in this paper can transmit information required for route planning more quickly than systems using traditional navigation methods in LAN environments. The packet format applied to the proposed system includes location and event information in the header section of the frame, rather than in the payload section. This design allows location and event information to be delivered and interpreted immediately, without the need for additional parsing of the payload. As a result, the system enables faster and more efficient responses to accidents, minimizing communication delays and facilitating quick route adjustments or detours.

Additionally, further research is required on the new packet format proposed in this paper. While we suggest including various data, such as event and location information, in the section between the L2 and L3 headers, more detailed definitions and standardization are needed. If the structure and

processing methods for the data in this section are not clearly defined, it may lead to issues with the system's scalability and compatibility. Therefore, future research should focus on refining the packet structure to accommodate various scenarios and evaluating its impact on network performance.

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