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An Efficient Message Protocol Using Multichannel with Clustering

Jaejeong Lee[1] and Byoungchul Ahn[2*]
Dept. of Computer Engineering, Yeungnam University, Gyeongsan, Korea.

**Corresponding author: Byoungchul Ahn*

[1]ORCID: 0000-0001-6637-3502 [2]ORCID: 0000-0003-0111-9882

Abstract
To deliver messages in the VANET (Vehicular Ad hoc Network) environment, vehicles are connected by wireless communications. The communications among vehicles is not stable by the vehicle speeds or the surrounding environments of roads. It is required to maintain stable communications between vehicles. In this paper, we modify the WAVE (Wireless Access in Vehicular Environments) communication standard and propose a method for fast emergency message delivery. The proposed method uses a multi-channel and clusters by considering communication capacity. The performance has been measured through simulations and compared with EMDOR (Emergency Message Dissemination with ACK-Overhearing based Retransmission). The proposed method reduces average message delay time and improves the reception ratio compared with EMDOR.

Keywords: Vanet; Protocol; Cluster; Multichannel

INTRODUCTION

By vehicular the communications, ITS (Intelligent Transportation System) studies that support efficient traffic information service and vehicle security service are being accelerated. In order to provide safety information, it is required a reliable high-speed moving environment and the autonomous vehicle network connected between vehicles. In the actual communication environment, the road is influenced by the surrounding environments, such as moving vehicles, the shape of the road and terrain. In particular, the surroundings of the location and distribution of the nearby vehicles give influence communications when vehicles move at a high speed. Because of rapid changes in the environment, an accident information needs to be delivered other vehicles in real time. There have been studies on multi-hop transmission method between vehicles with beacon-based or non-beacon-based in VANET (Vehicular Ad hoc Network). Multi-hop transmission provides a safe driving information for drivers transmits quickly around the incident. The reliable message delivery is important because sending and receiving messages are not implemented in a vehicle communication system.

To convey information in the communication between these vehicles has been enacted WAVE (Wireless Access in Vehicular Environments) vehicle communication standard consisting of IEEE 802.11p and IEEE 1609 series. In North America and Europe, a test-bed with the technology have developed through several projects committed in commercial service. Since WAVE communication standard has been made, many studies have been conducted for algorithms to apply on the WAVE communication standard using a multi-hop transmission method in the existing VANET [4-6].

In this paper, we propose a multi-channel and multi-hop message algorithm using the multi-channel to reduce the propagation delay time. The rest of the paper is organized as follows. At section 2, related works are presented. Section 3 proposes a multi-channel and multi-hop message algorithm. Section 4 describes simulation results. Section 5 concludes the paper and discussed some directions of the future research.

RELATED WORK

There have been many studies to transmit messages by multi-hop on VANET. The multi-hop is basically applied to deliver messages. If many vehicles transmit messages at same time, network traffics are increased dramatically. This increases channel congestion and decreases the message reception ratio.

Felice et al. proposed a method to transmit a message on the SCH interval as well as the CCH interval to reduce a transmission delay[5]. But this method cannot deliver a message if neighbors are not in the same SCH interval. This case does not reduce a delay time efficiently. Wu et al. also proposed a method to transmit a message over the SCH interval[6]. This method switches SCH frequency to transmit messages to all vehicles to avoid collisions. However, this method has an overhead since each vehicle should manage connections of its 1-hop and 2-hop neighbors. A forwarding vehicle should be set the SCH switching of neighbor vehicles

Heissenbuttel et al. proposed the DDB(Delayed Dynamic Broadcasting) scheme, which increases the reliability of message delivery while minimizing the number of retransmissions[11]. This algorithm is scheduled a retransmission time of vehicles and introduces a DFD(Dynamic Forwarding Delay) technique instead of directly forwarding a received message. This prevents a possible phenomenon of packet collisions at a MAC layer. And it reduces a packet loss and transmission delay.

Wisitpongphan et al. proposed the weighted *p*-Persistence technique, which is a dynamic gossip by utilizing the location information[12, 13]. The gossip retransmits to neighbor nodes with fixed probability *p* when a node receives a first message. It reduces message retransmissions. But, the weighted *p*-Persistence scheme sets a probability dynamically based on the location of nodes.

Shin et al. proposed the EMDOR(Emergency Message Dissemination with ACK-Overhearing based Retransmission) method, which is a distance-based algorithm for the emergency message[10]. A vehicle at the end of the communication radius of a source node has the shortest back-off time and forwards a message. Duplicate packets and messages are not forwarded to neighbor vehicles. All vehicles overhear an ACK signal that sends back to its sources to increase a reception ratio. Vehicles that do not receive a message request the message to the forwarded vehicle.

An emergency message is delivered only through a CCH(Control Channel) in the WAVE communication standard, which is IEEE 802.11p and 1609 series. The WAVE communication utilizes a multi-channel by using CCH and SCH(Service Channel) alternately. An emergency message such as an accident uses the CCH and messages such as informational and convenience services use the SCH. The CCH is a common channel used by all vehicles and the SCH is optionally used six channels according to the service[1-3]. To access the wireless channel, it uses the random back-off method and EDCA(Enhanced Distributed Channel Access), to improve the QoS(Quality of Service) [1,4]. Therefore, even if a guard interval is over at the CCH, it does not to send a message immediately. This is the main reason for increasing the delay time.

To increase a vehicle mobility, it is important to configure and manage clusters for VANET[9,14-16]. In this paper, we propose a multi-channel method to transmit emergency messages fast and propose a cluster management in order to reduce collisions and delays.

PROPOSED PROTOCOL

We propose a transmission scheme for an emergency alert message in the VANET environment based on the WAVE communications standard. The method is to extend to the SCH interval using a multiple-channel transmission for the emergency message as well as the CCH interval of WAVE switching mode. Through this method, the transmission time for emergency messages is reduced. Therefore, the SCH channel synchronization between neighbor vehicles which use different SCH channel is required. We propose a method using clusters that are commonly used in traditional MANET.

The benefit of the proposed method is a simple clustering algorithm and there is no a cluster header selection process. By reducing message collisions, the proposed method enhances the reception ratio and reduces the delay time of message delivery. Now, prior to describing the proposed method, the cluster size and the cluster configuration method are discussed.

A. Clustering

In the VANET environment, the network topology is changed very quickly and frequently by the shape of roads and high mobility of vehicles. At the wide intersection of the road, hundreds of vehicles are waiting traffic signals simultaneously. It is necessary to configure and maintain clusters efficiently since a good clustering algorithm for the VANET environment should be considered to manage communications efficiently between vehicles.

The WAVE communication standard uses a multi-channel in the switching system and its channel intervals are divided into SCH interval for service messages and CCH interval for public use. For emergency message transmissions, the number of the acceptable vehicles is depended upon the communication capacity.

As it switches every cycle of 100*ms* in the system model, the available time to the CCH interval is 46*ms*. To decide the time of a slot according to the message size and data transmission ratio, the number of acceptable vehicles for clusters is finally settled depending on the time of slots. The experiment results depending on the contents of the above are accommodated up to 25 vehicles in a cluster.

B. Cluster Configuration

Several studies have presented to calculate the movement of vehicles to elect a header in a cluster[7-9]. By comparing the speed and distance of the surrounding vehicles, the slowest moving vehicle is elected as a header of a cluster and the header configures and manages the cluster. In this paper, to configure a cluster with vehicles traveling the same directed pathway, speeds of vehicles are used. In the VANET environment, even if it is limited by the shape of roads, some vehicles may move fast in a short time. Therefore, the basic configuration for a cluster is a group of vehicles on the same directed way unlike conventional MANET[8]. Vehicles of the opposite direction are not considered as a node of a cluster. This makes to prevent the frequent entry and exit of a cluster and maintain the cluster in a stable manner.

CH_i : header of cluster i
CH_j : header of cluster j

if (CH_NUM_i + CH_NUM_j > MAX_NUM)
    return;
if (CH_DIR_i == CH_DIR_j && CH_VEL_i – CH_VEL_j < THR_VEL)
{
    if (CH_NUM_i > CH_NUM_j)
        CH_{New} = CH_i;
    else
        CH_{New} = CH_j;
    CMs update CH_{Old} to CH_{New}
}

Figure 1. Cluster Configuration

In the proposed scheme, before a cluster is configured, all nodes start as a cluster header unlike existing methods. They are merged and configured a new cluster, and they elect a new cluster head first. Configuration process is as follows. If clusters travel the same directed way and their traveling speeds are similar, two clusters start merging. But they do not merge when they exceed the communication capacity. When two clusters start merging, all nodes of two clusters have to update a new cluster header. When two clusters are merged and the number of their nodes is the same, a header which has a smaller ID number becomes a new cluster header. And nodes which have old header ID number update with the new header ID. Figure 1 shows the algorithm to configure a cluster.

In Figure 1, CH_NUM is the number of vehicles in a cluster. MAX_NUM is the maximum number of vehicles in a cluster. Also, CH_DIR, CH_VEL and THR_VEL, are represented as the direction of movement of cluster, cluster's speed, the maximum speed difference for the merged cluster respectively. CH_{New} is a new cluster after merged and CH_{Old} is an old cluster before merged.

```
if (Rx emergency message)
{
    if (CH)
    {
        if (Not exist message info)
            Forward to CM and other CH on CCH
        else
            drop
    }
    else
    {
        if (RX from CH)
            Tx ACK to CH on SCH
        else
            Tx to CH and CM on SCH
    }
}
if (CH)
{
    Tx beacon to CM or other CH on CCH
    Rx beacon from other CH
}
if (CM == head || CM == tail)
{
    Tx beacon on CCH
    Rx other head or tail CM on CCH
    if (Rx message in SCH)
    {
        Switch to near cluster's SCH
        Forward emergency message to other cluster's CM
    }
}
else
    Tx beacon to CH on SCH
```

Figure 2. Proposed Multi-channel Algorithm

C. Proposed Algorithm

The proposed method is to reduce the delay time of messages through the multi-channel of the WAVE communication standard when it transmits emergency messages. By building a cluster, it uses the same SCH for multi-channel. Within the same cluster it can reduce the delay time because it enables the emergency message transmitted through the SCH. To exchange a beacon between nodes in each cluster, clusters transmit beacon through the SCH. Figure 2 shows a multi-channel message transmission algorithm using clusters.

The primary role of a header in a cluster transmits a beacon message using the CCH and receives the information message of a header from the other cluster. If nodes in the front and rear of each cluster transmit a beacon through the CCH, it enables nodes of a cluster to communicate with a node at the head or tail of other clusters. This enables the transmission in the SCH when it transmits an emergency message. When a header is received messages at the end of CCH interval and is converted to the SCH interval, it is possible to transmit to a node at the head or tail of a cluster over the SCH. If there are neighbor clusters, edge nodes already know the SCH of neighbor clusters through beacon messages. Therefore, they can deliver messages between clusters in the SCH interval and reduce a delay time. Also, cluster nodes transmit a beacon over the SCH to reduce the traffic load on the CCH interval. Each cluster node after merged is assigned its communication slot from a new header after setting the SCH. Because the node information periodically transmits to a header through the SCH interval instead of the CCH interval, the traffic of the CCH interval is lowered. When it receives messages, it is possible to increase the reception by reducing possibility of collision.

SIMULATION

In order to test the performance of the proposed method, we have simulated the network simulator, NS3. For simulation, vehicles are assumed to travel along a 4-lane highway. 50 vehicles are assumed to travel each lane on a highway. The communication radius is 300*m*. Vehicles communicate to the CCH and SCH switching mode, and data rate is set to 6Mbps. Table 1 shows the parameters used in the simulation.

Table 1. Simulation parameters

Parameters	Value
SlotTime	16 *us*
SIFS	32 *us*
CWmin	15
CWmax	1023
AIFSN	2
EIFS	188 *us*
Header duration(PLCP)	40 *us*
Packet generation rate	10Hz

A. Number of Cluster Nodes

First simulations have been conducted to find the number of available vehicles to communicate in a cluster. The reception ratio of vehicles is measured by sending a message every 100*ms* and measured by changing packet sizes as 100 bytes, 150 bytes and 200 bytes. Figure 3 shows the reception of messages for multi-channel switching mode.

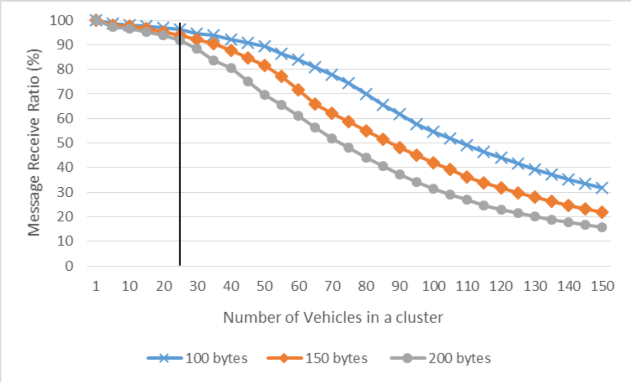

Figure 3. Message Reception Rate vs Cluster Size

The simulation results show that the reception rate of messages is decreased as the size of messages is increased and the number of vehicles is increased.

$$T_{Total} = T_{Backoff} + \text{Packet\_length/Data\_rate} \quad (1)$$

Since the transmission time is determined as Equation 1, the larger packet size needs the longer transmission time and it affects the reception ratio. In Figure 3, it is clear that the message reception rate is more than 95% or higher when the number of vehicles in a cluster is 25 or less. When the number of vehicles is higher than 25, reception ratio is dropped sharply by collisions.

B. Message Delay

Message delay time is measured by transmitting messages for 100 seconds. Table 2 shows the minimum, maximum and average delay times. The multi-hop delay time of the proposed method is compared with that of EMDOR[10].

Table 2. Packet Delay Time

	Maximum	Minimum	Average
Proposed	234*ms*	5*ms*	95*ms*
EMDOR	534*ms*	5*ms*	194*ms*

Figure 4 shows that the average delay times of the proposed method and EMDOR. Figure 5 shows the reception ratios of the proposed method and EMDOR. The reception ratio is measured by the transmission and reception packets at application layer. To prevent collision, the proposed method configures a cluster to communication capacity and allocates communication slots to each node in the cluster. The reception ratios of the proposed method are 17.5 percent higher than those of EMDOR.

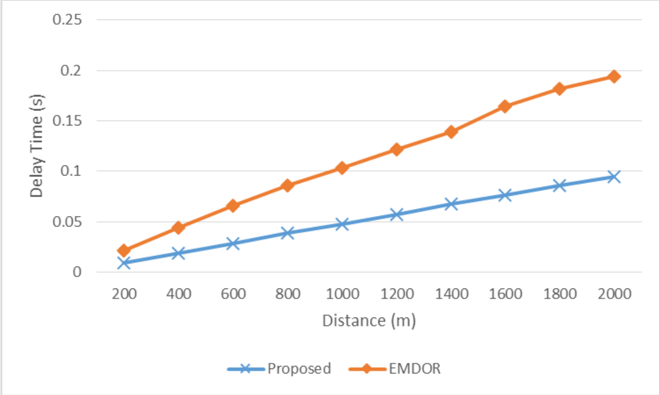

Figure 4. Packet Delay Time

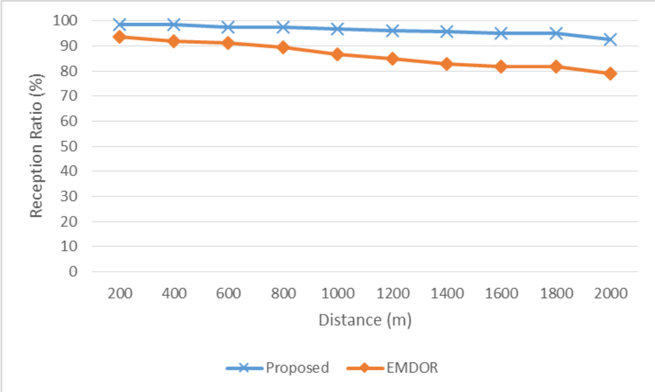

Figure 5. Message Reception Ratio

CONCLUSION

In this paper, we have proposed to improve the problem of the message transmission on WAVE communication standard. The proposed method is implemented on a multi-channel with clustering at the VANET environment. Messages are transmitted both the CCH interval and the SCH interval to enable faster message propagation. And the cluster management by reducing message collision can also improves the channel reception ratio. The proposed method is 43.8 percent delay time of the EMDOR at the maximum delay time. The delay time of the proposed method is 49 percent of the EMDOR at the average delay time. The reception ratios of the proposed method is 17.5 percent higher than those of EMDOR.

In the future, we need to find communication slots to manage nodes efficiently within clusters. Also through comparison with other cluster algorithms in VANET, we have to find an efficient clustering algorithm for the multi-channel.

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