An Improved Scheme for Vehicular Platooning using Adaptive Acknowledgement Timeout method

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Abstract. Platooning provides the potential for substantial benefits in terms of safety, energy conservation and cost reduction. Early analysis has already demonstrated that 65 percent of existing long-haul freight miles could feasibly form platoons, lowering the usage of cumulative vehicle fuel by 4 percent. The emergence of newer communication technologies like the vehicle-to-vehicle networking in the short-range paradigm and device to device communication in 5G paradigm can be used to setup virtual links among multiple vehicles like trucks to form platoons. The vehicular networks are prone to varying channel conditions due to high mobility of nodes. The present work addresses the issue of forming platoons using an adaptive acknowledgement scheme to offer better channel usage and less packet loss. It outperforms existing schemes that uses a static model for message exchange to form vehicular platoons.

1. Introduction
Inter-Vehicle Connectivity (IVC) can be accomplished by various wireless technology solutions such as traditional cellular networks, short-range connectivity solutions, Visible Light Communication [1], etc. Different innovative technologies have distinct features, benefits, and disadvantages, and perhaps each one may be best tailored for a specific purpose. Short-range connectivity solutions like Wi-Fi are more suitable to facilitate low latency communications, since; in particular, safety-related data is only helpful in the vicinity of the incident. When an automobile crashes on a highway, it is appropriate to warn drivers to prevent potential additional accidents by warning cars significantly closer within one-kilometer distance. After IEEE 802.11p was first developed, a variety of potential road and pedestrian safety solutions by the National Highway Traffic Safety Administration were proposed [2]. The engineering of communications and distribution standards which can accommodate and also inhibit network and channel congestion remains an active area of research within vehicular communications. Channel oblivious strategies could also improperly populate these networks that could disrupt system capabilities in effect [3].

2. Related work
The authors [4] proposed a new vehicle platooning system based on agreement. The authors created a structure whose configuration of the control may be modified to the actual network condition, in contrast to existing methods, which define the conceptual topology of the regulation even before to and then construct the control measures. Furthermore, the controller needs no radar equipment and automatically accommodates for aged network lag information. The work described and evaluated control laws, demonstrating its solidity in multiple network contexts. [5] Given the absence of an appropriate modeling and theoretical environment, and the extreme expense of just using models for random experiments, use of simulation tools for evaluation of whole collaborative driving systems was proposed. It presented an open access addition to Veins, which provides researchers with a simulated
setting to perform studies in practical situations that reflect the reality of vehicle dynamics, connectivity and infrastructure abnormalities, and inter-vehicle links. [6] Two new vehicle cognitive transportation network implementations called platooning and associative cruise control were studied. It clarified related concepts and defined ongoing standard practices. It helped in the conduct of assessment of efficiency of the basic communication technologies.

The work [7] applied a maneuverability simulator, with a broad research study to demonstrate the complex characteristics and efficiency of a facility through a series of structured platoon maneuvers, such as entering and leaving a platoon. Both models provide practical knowledge on mechanics for vehicles, high-definition communications network modeling, from specifics of the 802.11p standard, to congestion and packet faults. [8] Mostly as limited range innovation for vehicle networks, communications using visible light has increased in popularity. It is generally employed to support IEEE 802.11p and improve efficiency as well as manageability of platooning networks. The authors carried out a comprehensive simulation effort with the use of visible light for platooning combined with DSRC. The pros and cons of this diverse networking are specifically illustrated. [9] The platooning systems need a considerably higher chunk of the communication channel that endangers cohesive inclusion with non platooning vehicles in the vicinity. In order to resolve this problem, the authors investigated an educated choice of message transmission for platoon formation. Pseudo-broadcasting is the method proposed. In this technique, the leader tries to unicast to the worse receiving platoon follower. The message is then provocatively distributed to other participants. It increases platoon interaction efficiency as well as reducing beaconing while fulfilling the latency criteria.

3. Proposed Approach

3.1. Overview

In this paper, the planned solution is meant for setting up platooning, which generally can provide driver safety related services. In platooning, vehicles advance collectively to form tightly moving platoons. This scheme is a helpful method to isolate a complex network to from variable-sized homogenous platoons. We make a distinction of two different types of roles for vehicles in platooning, namely:

- Platoon Leader: Local manager of a platoon.
- Platoon Joiner: Ordinary vehicle.

In this project we are implementing a Platoon formation in VANet in order to solve distribution of traffic and packet loss due to more traffic network congestion. The following project consists of three Phases.

- Leader Selection.
- Formation of Platoon.
- Updating of Platoon.

In the first phase platoon leader is selected for the formation of platoon based on the vehicle’s direction which implies it should be a forward moving vehicle and also the vehicle that has gap left behind it. In the second phase platoons are formed. The joiners request the platoon leader and send their information in order to join the platoon. The leader accepts their information and allows them for joining and completes the manoeuvres else it is aborted.

In the third phase if the platoon is stable and the gap after the last vehicle is closed then the platoon is updated for its completion (figure 1).
The following describes the steps in building up a platoon. When the joiner is in idle condition in this algorithm, a message is sent to the platoon leader with a request to join the platoon (Join Platoon request to Leader (JOINER_WAIT_REPLY state)). If the joiner received reply from the leader Joiner sends its information (Joiner Info) to the leader (JOINER_WAIT_INFORMATION_STATE). If the leader accepts the joiner information, it sends the position where it can be added in platoon (Send joiner information (JOINER_MOVE_IN_POSITION state)). If the joiner received join permission, the maneuver is completed and the joiner enters the platoon at the designated position else the maneuver is aborted.

Platoons diminish the electronic and mechanical coupling distances between cars or trucks. Because of this capability, several trucks may pick up the pace or slow down at the same time. These mechanisms consent to for a tightly-closed path between collective set of vehicles moving on the same lane. It removes the reaction distance needed for human reaction. The capability of platoons is a maximum of four cars in the suggested approach. The platoon contains a leader and joiners are other vehicles. The velocity of the platoon leader is 100 kmph. They are built on the basis of path and destination. The platoon formation is explained in detail below.

3.2. Algorithm for Platoon Formation

i. Insert the joiner.

ii. Check if the joiner is in idle state

iii. If the joiner is in idle state, it sends request for joining the platoon to the leader.

iv. If the leader replies the joiner. The joiner sends its information to the leader.

v. After receiving the joiner information the leader allots a position in the maneuver if the joiner satisfies the criteria of the platoon.

vi. Joiner receives the position from the leader then the leader allows the joiner to join the maneuver.

vii. The maneuver thus gets completed. If the joiner fails to join or if it does not fulfil the criteria the maneuver gets aborted.

3.3. Adaptive Acknowledgment Timeout using Cross-Layer Approach

The value of the channel busy time (CH_BT) from the physical layer is compared to the initial acknowledgment timeout (ACK_TO). We use the following equations to assign new ACK_TO values for retransmitted messages.
4. Performance measurements using network simulation

Using Plexe software extended from veins framework [10], the proposed mechanism is simulated. The Sumo tool is used for generating node mobility. In our work, through comprehensive theoretical analysis and simulations, we research the efficiency of an adaptive acknowledgment time–out based for communication between the leader and joiner vehicles. Our detailed experimental results are presented in this section. The performance of adaptive dissemination approach is specifically studied in terms of data packet loss, generated wave short messages, channel busy time, platoon size, acknowledgement timeout. This segment describes the experimental findings.

To elevate the performance of the system two varied types of network simulator has been employed. For the simulation of vehicle mobility we have used Simulation of Urban Mobility (SUMO) [12]. For the implementation of VANet OMNET++ [11] has been employed. An urban scenario is expected for evaluating the proposed methodology and the pattern of highway road was taken into consideration. IEEE 802.11p which adapts the CSMA / CA mechanism was considered as the communication protocol and MAC layer transmission technique. Table 1 has tabulated the criteria used to test the proposed approach.

| Table 1. Simulation Parameters used in Highway Scenario |
|---------------------------------|-------------|
| Parameter                      | Value       |
| Length of the Road             | 3 km        |
| Total number of Lanes          | 1 lane      |
| Speed of the vehicles          | 0-25 m/sec  |
| Transmission Rate              | 3-27 Mbps   |
| Transmission Range             | 300 mtr     |
| Size of each message           | 1024 Bytes  |
| MAC Type                       | IEEE 802.11p|

In the existing methodology non-adaptive data dissemination mechanism has been used. This mechanism was a static one where we could not change the size of the acknowledgement timeout as it has a predefined value. This improved the busy time of the channel and the acknowledgment timeout. The proposed methodology i.e., adaptive data dissemination is a dynamic mechanism which helps in changing the size of acknowledgement timeout. Focused on the available data we make the system efficient in terms of channel busy time and acknowledgement timeout.
Figure 2. Total no. of lost packets vs. packet loss ratio

Figure 2 presents the graph to depict the reduction of packet loss ratio by applying the proposed approach in comparison to the existing methodology.

Figure 3. Total no. of WSMs vs. Packet loss ratio

Figure 3 shows the total no. of generated Wave Short Messages (WSM) when taken into consideration the packet loss ratio is comparatively less.
Figure 4. Channel busy time vs. Acknowledgement timeout

Figure 4 presents the nearly invariant channel busy time for varying acknowledgement timeout values by using the proposed approach.

Figure 5. Total no. of broadcasts received vs. acknowledgement timeout

Figure 5 shows the graph to presents reduction in total no. of broadcasts received with respect to acknowledgement timeout changes.
5. Conclusion
The presented solution was directed towards improving the performance delays caused when using a fixed acknowledgement timeout value. The simulation results confirmed and proved that the amount of lost packets is considerably brought down compared to fixed dissemination method. Apart from fuel efficiency and compact usage of roads, platooning definitely will improve the road traffic management. Other technologies are expected to make considerable progress in future decades, especially distributed control combined supported by AI can change the way platooning applications can be improved. The said innovations will facilitate a wider range of perspectives to address challenges like as optimal broadcast period, accuracy of locality and estimation of speed of nodes.

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