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Research paper

An Integrated Communication Message Framework of Inter-Vehicles for Connected Vehicles using Mobile Virtual Fence(MVF)

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Abstract

In this paper, we present an integrated message framework of BSM and CAM/DENM as safety messages for V2X communications of connected vehicles in VANETs, and apply it to the mobile virtual fence(MVF), which has been preliminarily researched and developed. To do this, the proposed message framework become united an integrated framework adding up context-aware information of the MVF after comparing and analyzing whether or not the common fields between are. And then, the integrated messages are parsed according to the type of original messages at the destination such as vehicles, ITS(Intelligent Transportation Systems), pedestrians that it received.

Keywords: *Use about five key words or phrases in alphabetical order, Separated by Semicolon.*

1. Introduction

Nowadays, V2X(Vehicle to Everything) is considered as a promising technology to support safety related applications in C-ITS(Connected Intelligent Transport System)[1-9]. Smart vehicles on V2X periodically send messages in which they have driving status information about what they are doing to mobile everything such as vehicles, ITS, pedestrians, and so forth. Safety messages for V2X communications as international standards are BSM(Basic Safety Message) Part 1, Part II by US-led SAE and CAM(Cooperative Awareness Message)/DENM(Decentralized Environmental Notification Message) by EU-led ETSI[1,3,10-13]. But two specifications were not integrated into one unique message while trying to integrate by ISO(International Standard Organization).

Therefore, we propose an integrated message framework for V2X communications of connected vehicles in VANETs, and apply it to the mobile virtual fence(MVF), which has been preliminarily researched and developed, and. based on the flexible mobile three-dimensional geofence and the FloGeo[9,14-18]. In order to integrate these messages, the proposed message framework become united an integrated framework adding up context-awareness information of the MVF after comparing and analyzing whether or not the common fields between BSM and CAM/DENM are[8,9]. And then, the integrated messages are parsed according to the type of original messages at the MVFs mounted on each vehicle that it received. If it will be the connected MVFs like connected cars in the future and any traffic accidents or road traffic jam, etc. occur, these messages will be communicated to each other to avoid these events.

The paper begins with a review of related works, then goes on to describe an integrated message sets, before providing experimental results from an early user study, followed by a discussion and conclusion.

2. Related Works

2.1. BSM

SAE J2735 DSRC(Dedicated Short Range Communications standard) standard defines fifteen types of messages which are used for communication inter-vehicles in the VANET[10,11]. An important type is a Basic Safety Message (BSM), which is mainly used by V2V safety applications.

Part I	msgID	msgID	DSRCmsgID
		msgCnt	
		id	
		secMark	
	Position	latitude	
		longitude	
		elevation	
		accuracy	PositionalAccuuracy
	Motion	speed	TrasmissionAndSpeed
		heading	Heading
		angle	SteeringWheelAngle
		accelset	AccelerationSet4Way
	Control	brakes	BrakeSystemStatus
	VehicleBasic	size	VehicleSize
Part II	VehicleSafetyExtensions(OP)	events	EventFlag
		pathHistory	PathHistory
		pathDirection	PathDirection
		theRTCM	RTCMpackge
		extevents	EventsFlagsExt

Fig. 1: The message set of BSM

As shown in Fig. 1, BSM consists of Part I and II, where Part I contains mainly current vehicle status information related to vehicle operation such as position, motion, control, vehicle basic information and Part II contains event information including path related to safety extension of vehicle[10]. Periodic broadcasting of BSMs by all vehicles typically allows other vehicles to be aware of the nearby vehicles at an interval 100 to 300ms. Also, to avoid messages transmission delays, there is no acknowledgment or handshaking in BSM delivery, and they are only broadcast to all wireless neighbors[10].

2.2 CAM/DENM

Cooperative Awareness Message(CAM) set is the message set exchanged in the ITS network between ITS-Ss to create and maintain awareness of each other and to support cooperative performance of vehicles using the wired/wireless road networks[12].

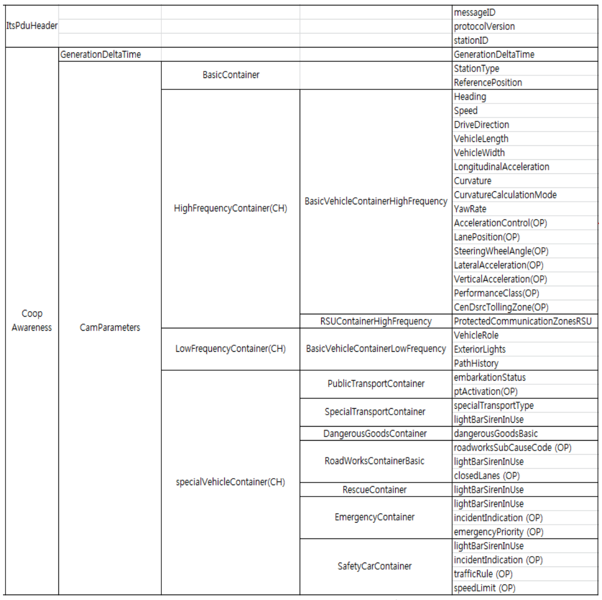

Fig. 2: The message set of CAM

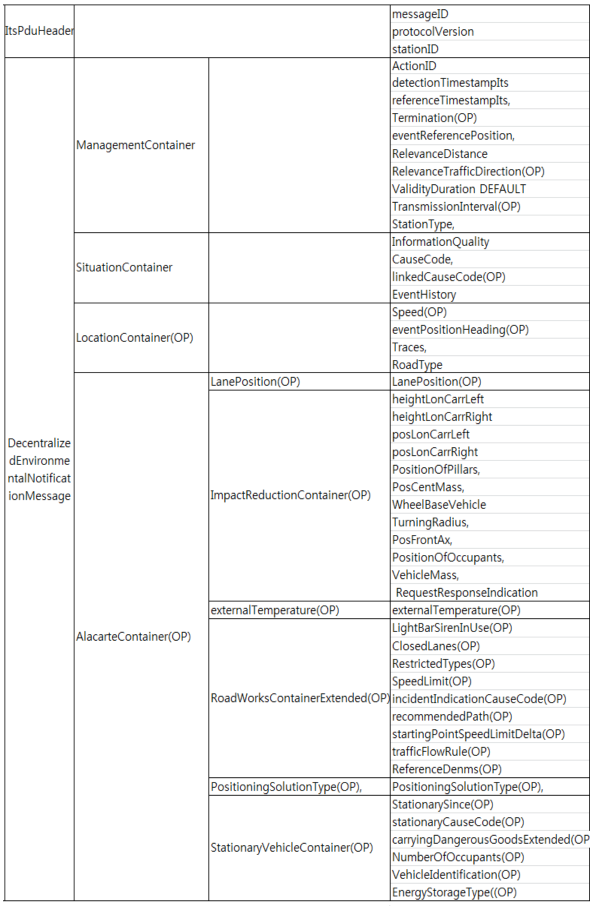

Fig. 3: The message set of DENM

As shown in Fig. 2, the message set of CAM contains status and attribute information of the originating ITS-S, and varies depending on the type of the ITS-S[12]. The status information for vehicle ITS-Ss includes time, position, motion state, activated systems, etc. and the attribute information includes data about the dimensions, vehicle type and role in the road traffic, and so on. Also, Decentralized Environmental Notification Message(DENM) set is a facilities layer message that is mainly send by ITS applications to alert road users of any detected events using ITS communication networks[13]. As shown in Fig. 3, DENM is used to describe any variety of events that can be detected by ITS-S[13].

3. An Integrated Message Set

In this chapter, the message sets of both BSM and CAM are compared, analyzed and extracted as communication messages for V2V, and the integrated messages are constructed. First of all, we distinguish the roles and functions of common and essential message fields in BSM and CSM/DENM. And then we concatenate the fields with the highest mutual similarity, and ignore the other unrelated fields. The result is shown in Fig. 4, which shows the fields matched by the arrows according to the correlation, and the fields of the duplicated arrows exist. This is because some fields are defined as too granular specifications. For example, in the message field of CAM, there is only one field of the current vehicle position information, ReferencePosition. In the message field of BSM Part I, four fields such as latitude, longitude, elevation and accuracy are matched with the ReferencePosition field. On the other hand, the dashed arrows are semantically similar, but are marked because they are ambiguous and implicit to match directly.

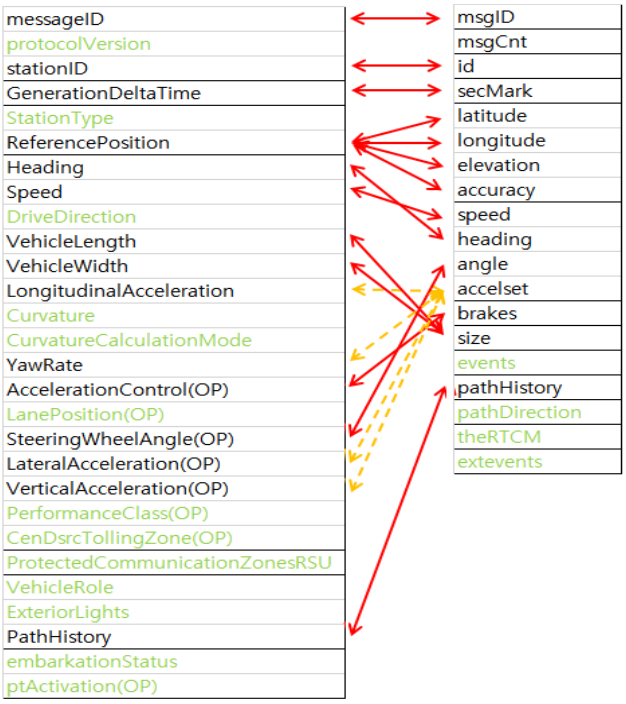

Fig. 4: Comparison between the message sets of CAM and BSM Part I/II.

3.1 A Mandatory Message Set

The fields included in the basic message set include the msgID as a message identifier for distinguishing messages since a large number of messages are transmitted and received in the connected car environment based on VANETs. In order to distinguish vehicles that send and receive any messages, we include the id field as a device identifier of the vehicle to distinguish each vehicle and the secMark to know the time it took to sense the environment. In addition, the latitude and longitude, which are information for locating the vehicle, the speed and heading as the movement information of the vehicle and the vehicle position, are included in the mandatory message because they are essential information for each vehicle of the connected car service.

Table 1: A mandatory message set

msgID	Message Type	CAM(0) / DENM(1) / BSM Part I(2) / BSM Part II(3) / BasicMsg(4) / EventMsg(5)
id	Unique number of the device such as Mac address	
secMark	Messages are generated every 0.5 second depending on the movement of the vehicle after message creation.	
latitude	Latitude detection per 0.5 seconds	
longitude	Longitude detection per 0.5 seconds	
speed	Speed information at the time the message was detected	
heading	Direction information when a message is detected	

3.2 A Message Set of MVF

Hereafter, since we will use MVF instead of vehicle, so the vehicle in the following text is assumed to be equal to the MVF, which also needs a message set. Therefore, the message set of MVF of constructs a message set focusing on the emergency event detection point and message movement from the detected emergency event location. As shown in Table 2, message information about MVF applied for network environment for message is as follows.

Table 2: The message set of MVF

MVFRadius	Each device is basically 10m radius, and the radius varies with speed.
AlertAction	Receiver's response according to event type (hard stop, low speed, lane change, etc.)
DetectionTimestamp	The accident detection time of the device that detected the event
RelevanceDistance	The distance between the event occurrence location and the current receiving vehicle
HopCount	Information on the number of relay after first event detection
ConnectedMVF	A collection of recognized MVF IDs

The integrated communication message framework proposed in this paper is implemented as a messages set of MVF class in client and server respectively. It is created as an object using the data collected by the client and transmitted to the server through serialization communication, and the server de-serializes the object to configure the connected car environment and processes the event.

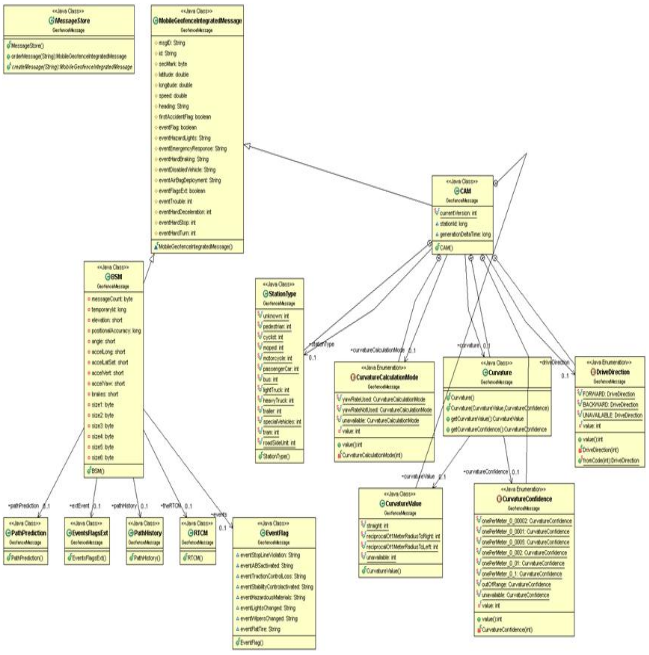

Fig. 5: A Class Diagram of the Integrated Message Sets

Fig. 5 shows a class diagram of message set of MVF that implements the integrated message sets. The fields of the integrated message proposed in this paper are defined in the 'MobileGeofenceIntegratedMessage' class as shown in Fig. 5, and two message sets of both BSM and CAM/DENM inherit the necessary fields so that they are used by the MVFs.

4. Experimental Results

This chapter shows an example of the situation where the integrated message designed in the previous chapter is generated. To do this, we used the MVFs in six mobile devices, which are implemented using smartphones based on Android OS.
As an experimental environment, Fig. 6 shows the unique IDs, the geographical location, and the distance among the MVFs of each device[8,9]. It also indicates that a service environment of the connected car is configured. So, assuming that an event has occurred experimentally manually in the first car in Fig. 6, Fig. 7 shows a captured screenshot of a smartphone with messages about the event that the fourth MVF received from the first MVF.

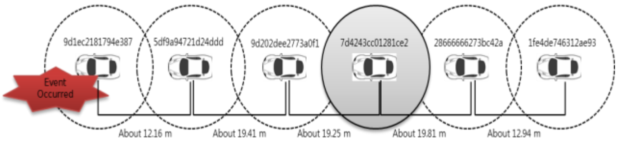

Fig. 6: Connected MVFs by Context-Awareness

In Fig. 7, the mandatory message set appears on the left, and that of MVF appears on the right. In the mandatory message set, the msgID corresponding to the EventMsg is 5, and has the fourth MVF ID as shown in Fig. 6. In the message set of MVF as shown in the right area of Fig. 7, the AlertAction field is to decelerate as a response of the receiver according to the event, and the geographical distance from the MVF where the event occurred is about 50.82 meters. In addition, it shows that the number of hopping of the message delivered from the MVF on which the event occurred is three times. Finally, the bottom shows the MVF IDs that indicate which of the neighboring MVFs are connected to the current MVF.

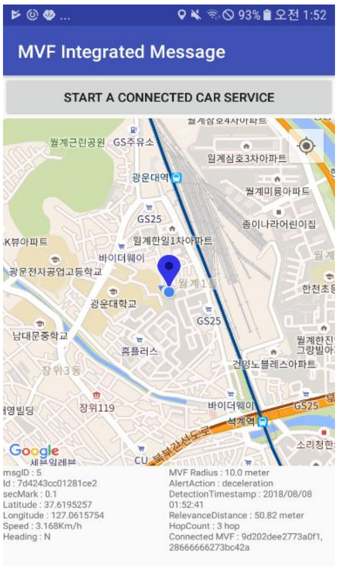

Fig. 7: A screenshot of one of MVFs

5. Conclusion

In the era of smart cars, everything such as vehicles, ITS, pedestrians will be connected. Also, CAM/DENM and BSM as a message standard for current C-ITS are expected to be unified in the international standardization organization.
Therefore, we proposed an integrated message framework for V2X communications of connected vehicles in VANETs, and

applied it to the MVF instead of vehicle, which has been preliminarily researched and developed. The proposed integrated message framework became one class diagram united an integrated framework adding up context-aware information of the MVF after comparing and analyzing whether or not the common message fields between BSM and CAM/DENM are. And then, the integrated messages are parsed according to the type of original messages such as BSM, CAM/DENM at the MVFs mounted on each vehicle that it received. Moreover, since MVF supports the connected car service, it is expected to be suitable for autonomous driving of smart cars.

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