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Message Aggregation in VANETs for Delay Sensitive Applications

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Abstract

A Vehicular Ad-Hoc Network (VANET) is categorized as a Mobile Ad-Hoc Network (MANET) which delivers wireless network servies with an aim to improve road safety and enhance driving comfort. Diverse applications of Vehicular Ad-Hoc Networks such as infotainment, road safety and public safety have made VANETs as a notable and emerging area of research and development. As of now, numerous vehicular ad-hoc network research projects have been mainly aimed at data security and routing. This has raised a critical problem of data congestion and loss of data accuracy in VANETs. A major challenge in VANETs is to provide efficient data communication and propogation for precise and valuable information. This paper presents a generalized framework for message aggregation. Message Aggregation can be used to transmit minimal data and to enhance the communication efficiency thus reducing the communication overhead in VANETs. This will help in reducing the redundancy in VANETs resulting in dissemination of precise information

Keywords: *Data Aggregation, ITS, Vehicular Ad-hoc Networks, Framework*

1. Introduction

It is unquestionable case that areas around the world have increased use of vehicle leading to number of casualties and mishaps on the road; which has been acknowledge as a serious problem by present-day society due to its exorbitant dangerous nature. As per the statistics of National Highway Traffic Safety Administration (NHTSA), road fatalities have claimed lifes exceeding 30,000 per annum while injuring 421,000 people [1]. The concept of a networked vehicle was proposed by Delphi and IBM corporation. The foremost goal of Vehicular Ad-Hoc Network (VANET) is to bestow applications that improve public safety and traffic flow. Numerous projects have aimed at improving safety in collaboration with vehicular ad-hoc networks. Network On Wheels and its forerunner FleetNet in Germany, IP PreVENT in Europe and the Vehicular Safet Consortium and its successor VSC2 in United States are few to be named. It leads to the conclusion that there is lots of effort all around the globe to prove this new technology [3]. United States Federal Communication Commission (FCC) approved Dedicated Short Range Communication (DSRC) to support Intelligent Transport System applications for VANETs which collaborated with Institute of Engineering Electrical and Electronics (IEEE) in 2004 which is know as IEEE 802.11 [4]. The objective of this paper is to design a generalized framework for message aggregation. The remaining of the paper is organized as follows. Section 2 illustrates the background of Vehicular Adhoc networks. Section 3 explores related works. We give the issues regarding the existing aggregation schemes in Section 4. Section 5 presents the proposal and finally Section 6 gives the conclusion.

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2. Vanet Overview

A Vehicular Ad-Hoc Network (VANET) enables communication using Wireless Access in Vehicular Environment (WAVE). Today a usual vehicle is considered to be equipped with atleast the following of the devices: a GPS equipment, a camera and variety of sensors with different functionalities with a computer in the vehicle to process it. The foremost goal of VANET is to ensure traffic safety and improve traffic efficiency. Wireless Access in Vehicular Environment (WAVE) is used by vehicles to establish connectivity with other vehicles which is know as Vehicle to Vehicle communication(V2V) or with a firm structure along the road mainly reffered to as a road side unit (RSU), known as a vehicle to infrastructure communication (V2I) [6].

2.1. Vanet Architecture

The Vehicular Ad-Hoc Network consist of three different domains as shown in Figure 1.0 [8]. They are namely In-Vehicle Domain, Ad Hoc Domain, Infrastructure Domain.

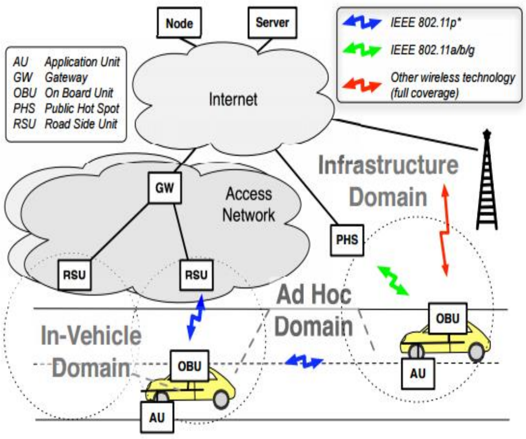

Figure 1.0. Vanet Architecture

The In-Vehicle Domain communication is between the On Board Unit (OBU) and the Application Unit (AU) of the vehicle. An Application Unit uses OBUs communication capabilities. The On Board Unit (OBU) and the Application Unit (AU) are only logically different but can be physically located together [7]. An Ad hoc domain consist of communication between the vheicles OBU and the Road Side Unit (RSU) which creates a VANET.

2.2. VANET Components

The three main components of VANET are: Application Unit (AU), Road Side Unit (RSU) and the On Board Unit (OBU). A Road Side Unit (RSU) host vast range of applications which are used by the peer device called the On Board Unit (OBU). These applications can be a part of Road Side Unit (RSU) or the On-Board Unit (OBU). Every vehicle has a On-Board Unit (OBU) and group of sensors which gather and process data, then message it to other vehicles or Road Side Unit (RSU). An Application Unit (AU) utilizes the applications hosted by the Road Side Unit (RSU) using the On Board Unit (OBU). The primary purpose of OBU is to facilitate wireless radio access, ad-hoc, IP mobility, dependable data transfer, congestion control and security [7]. The On Board Unit (OBU) and the Application Unit (AU) are only logically different but can be physically located together [7]. RSU is know as a wave device, positioned along the road or POI such as junctions, restaurants or parking lots. RSU consist of a network device used to communicate based on the IEEE 802.11p radio technology.

The primary purpose of RSU are as below [11, 12].

1. Extending the range by re-distributing data from RSU to OBUs and to other RSUs.
2. Safety Application Information.
3. Internet services are offered by the Road Side Unit (RSU).

3. Related Work

This section illustrates the related work in field of Vehicular Ad-Hoc Network. Section 3.1 gives the information regarding the vanet use cases and applications. Futher more, we discuss about data aggregation in the section 3.2 and section 3.3.

3.1. Vanet Use Cases and Applications

Vehicle to Vehicle (V2V) and Vehicle to Infrastructure (V2I) communications supply drivers with diverse information through use of number of applications. GPS receivers, Sensors, on-board devices collaborate with network interfaces to allow vehicles to perform data processing and propogation about itself and its surroundings to other vehicles within the communication area. This has improved road safety and driver comfort.

VANET applications are divided into two main categories known as Safety Applications and Infotainment.

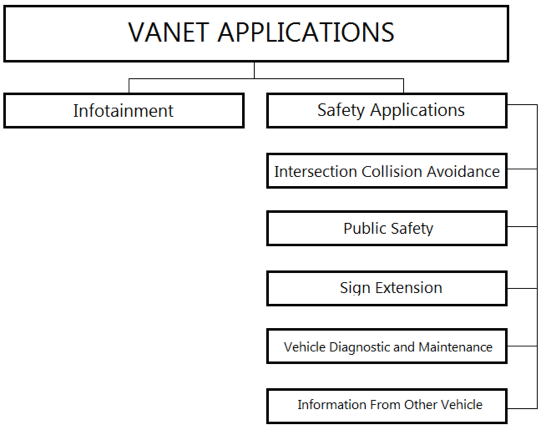

Figure 2.0. Vanets Applications

3.1.1. Safety Application: The safety application are responsible delivering a safe driving environment by bestowing road safety and avoiding accidents to save human life. This is achieved by using wireless communication between V2V and V2I. Safety applications use data collected by the vehicle sensors and processes the data to create a safety message and distributes the messages to other vehicles. This paper covers 2 primary safety applications namely Collision Avoidance and Public Safety.

- Collision Avoidance

This application uses the V2V and V2I communication to avoid accidents. The Road Side Unit collect data from the vehicles that pass the intersection. The data is processed and distributed and depending up the output, if there is a probability of collision, a notification is sent to caution the vehicles in the intersection area so as to follow evasive manoeuvre [9]. Intersection collision warning, Pedestrian crossing information designated intersection are some of the applications in this category.

• Public Safety

Public Safety applications aids drivers with emergency services by reducing the time taken by the emergency services to reach the destination and provide service[8]. Common applications in this category are Curve Speed Warning, Information from Other Vehicles, Cooperative Forward Collision Warning

3.1.2. Infotainment Services: These are non-safety application with an objective to make a drive entertaining and improve the comfort levels. Examples of these application are weather updates, traffic updates, Point of Interest like gas stations, restaurants and the providing services like internet and online games.

3.2. Data Aggregation

In VANETs, bandwidth allocation and channel collision are couple of serious issues regarding the communication between V2V and V2I. DSRC channel is shared by a range of applications including safety applications resulting into bandwidth limitation and channel collision [10]. Message Aggregation is a process used to transmit minimal data and to enhance the communication efficiency thus reducing the communication overhead in VANETs. Number of adaptive methods are used to collaborate data from various messages and form them into one organized and filtered information. The aggregation process consist of three phases known as the *decision phase*, where decision regarding the selection of data items to be fused is made, the *fusion phase* consist of a fusion function and the *dissemination phase*, where the data forwarding process is carried out as shown in figure 3.0 [11].

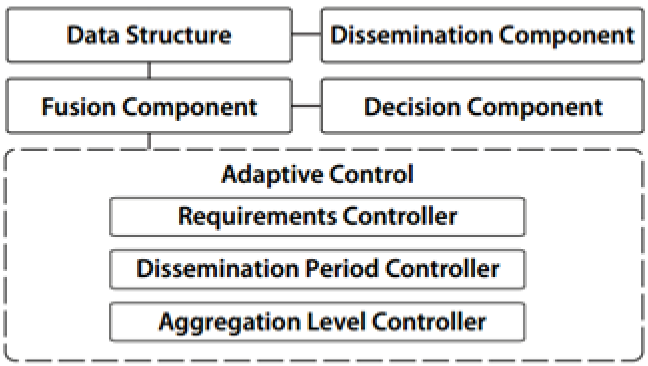

Figure 3.0. Data Aggregation Phases

Data aggregation is known for preserving the performance of vehicular networks and safe guarding data dissemination.Vehicular Event Sharing with a mobile P2P Architecture (VESPA) is presented in [12]. VESPA aggregates and disseminates all type of events (e.g., available parking spaces, accidents etc.). Hierarchical aggregation consist of an algorithm which is dissemination based, distributed traffic information systems as presented in [13]. Recent research have put forward that hierarchical aggregation is a key element to achieve scalable systems [14-16]. Hierarchy is implicitly present, because information is stored with reduced accuracy [16-17]. While many other schemes have put forward a flexible approach asserting that data quality and communication efficiency is improved [18-21].

Table 1. Aggregation Scheme

No	Aggregation Scheme	VANET Scenario	Type Of Message	Aggregation accuracy	Processing Time
1.	ESSMD	Hybrid	Safety	Medium	Medium

2.	VESPA	V2V	Non-Safety	High	Low
3.	Probabilistic &Hierarchical	Hybrid	Non-Safety	Medium	Medium
4.	Role differentiated	Hybrid	Safety	High	Low
5.	AEMA	V2V	Safety	Medium	Medium
6.	Aggregation for traffic flow	Hybrid	Safety and Non-Safety	High	High
7.	SLMA	Hybrid	Safety	Medium	Medium
8.	CASCADE	V2V	Safety	High	Medium

3.3. Message Aggregation Schemes

Some of the aggregation schemes such as Flat Aggregation Scheme, Binary Interval Aggregation Scheme and Free Hierarchical Aggregation Scheme are introduced in the following section.

3.3.1. Flat Aggregation Scheme: An adaptive control consisting of aggregation tree of depth is used. Data nodes consisting of Vehicular data are direct children of the root node. By curbing the number of data nodes, the tree size can be limited. Clarity and rapid processing are the benefits of this scheme. While the limitation is that the data record is fused as a whole [11].

3.3.2. Binary Interval Aggregation Scheme: The minimum quality metrics is represented by nodes of length 2 in binary interval aggregation scheme. A certain number of interval levels in the aggregation tree are used. This tree layout allows multiple ways to reduce the tree size. For network aggregation, The different interval nodes can be combined in a network aggregation. The bounded imprecision by design which is due to the interval nodes is a advantage of this scheme.

3.3.3. Free Hierarchical Aggregation Scheme: Free hierarchical aggregation scheme only contains data nodes. The intermediate node in the tree consist of one metric for eg. Location therefore diminishing the tree depth and allowing the fusion component to decide the metric to fuse. The fusion component is free to decide which metric to fuse. Figure shows the fusion based on location metric which creates a new parent from the leaf nodes.. Free hierarchical scheme allows fusion on dynamically selected metrics while keeping the other metrics separately [11].

4. Issues In Exisiting Schemes

Even though the schemes support different types of application data, they do not disseminates collaborated data from different applications. Therefore existing aggregation schemes have limitations which are noted below:

- Aggregation schemes suffer form absence of intelligence,
- less flexible for dynamic varying critical information parameters,
- lack of combination of aggregation and dissemination mechanisms,
- they have medium aggregation time as well as low scalability.

VESPA is an efficient data aggregation and dissemination scheme if the collected data is limited. Hierarchical aggregation is based on modified Flajolet–Martin sketch as a probabilistic approximation. The main contribution of this approach is to merge two aggregates while avoiding the occurrence of duplicates. TAG [2] stores data into simple tables. But tables do not support selective fusion which collaborates selected metrics of a data. As TAG uses absolute values stored, CASCADE [3] stores only the relative values. Nearly all the data aggregation schemes in the fusion process aim at averaging data and optimizing one selected component of the aggregation process. Therefore a system supporting a flexible configuration on data precision with non-predefined metrics predefined metrics is required which can support highly dynamic environments like VANETs.

5. Framerwork Architecture

Our aim is propose a generalized framework for Message aggregation on how data received from many applications can be aggregated to deliver a precise, usefull and detailed message. This will help a vehicle view beyond its local view using the aggregated data from the surrounding. Also it can reduce the overheads and increase the vehicular networks performance.

Consider, for example, an accident has occurred which is creating an obstacle in one of the road lane. A vehicle heading towards the obstacle or a infrastructure detects the obstacle. Without aggregation, the vehicle would send a message reporting the condition toward vehicles approaching the obstacle. Now, instead of transmitting the same messages numerous times, data received from the vehicles can aggregate their own view with warnings received from other vehicles and only disseminate the aggregate. For e.g. the data can be aggregated to form a usefull message assisting driver to change lane.

Framework For Message Aggregation

Based on the limitations listed in section 4.0, one of the limitation is lack of intelligence in aggregation. Therefore we have proposed a framework to classify parameter which will remove problems such as redundancy. There are number of stages in the framework. The proposed framework consist of 2 main components.

1. Resources
2. Application

5.1. Framework Overview

The proposed framework consist of 2 main component as illustrated in figure 4.

5.1.1. Resources: The first main component is Resources. In VANET, resources are responsible for providing/feeding data to the application. The application process the data and update the resources The resources consist of 3 types. They are known as Infrastructure, Vehicles and Providers .

Infrastructure : An example of an Infrastructure can be a Road Side Unit. These Road Side Unit help in providing real time data related to road condition, traffic routing. These data can be used for different purposes like creating ITS. Some of the data provided by the Infrastructure are Traffic Light Signal status, Road Surface etc.

Vehicle: Vehicle has a On-Board Unit (OBU) and group of sensors which gather and process data, then message it.

Some of the data provided by Vehicles it the Vehicle Id, Vehicle Speed, Vehicle Length.

Providers: Providers can be of any sort which provide data. They can be business or public service providers.

5.1.2. Application: There are number of applications in VANETs. We catagorize them in 2 main sections namely Safety Applications and Infotainment. Applications in VANET include Safety applications such as Collision avoidance and various Infotainment applications. Each applications consist of messages which are delivered to a driver by means of notifications. The Applications are further classified into Safety Applications and Infotainment Application.

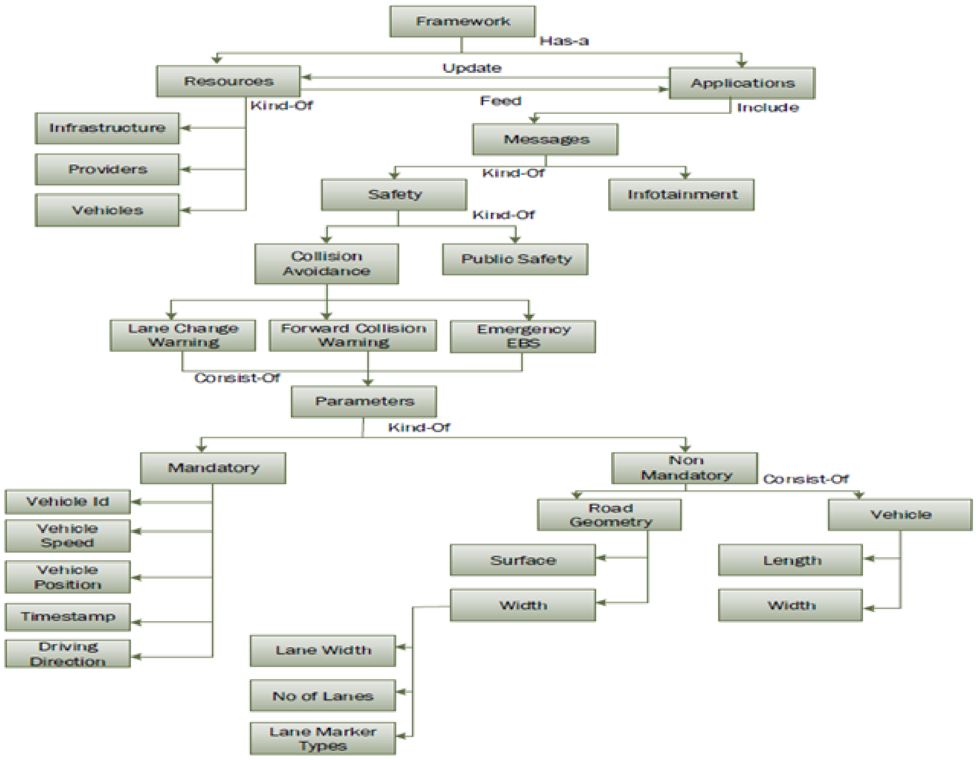

Figure 4.0. Framework

Safety Application: The safety application are responsible delivering a safe driving environment by bestowing road safety and avoiding accidents to save human life. The two primary type of safety applications are collision avoidance and public safety.

Public Safety: The safety application are responsible delivering a safe driving environment by bestowing road safety and avoiding accidents to save human life. The two primary type of safety applications are collision avoidance and public safety.

Collision Avoidance: Number of different applications are inherited from the Collision avoidance such as Lane Change Warning, Emergency EBS etc. These applications notify driver of possible hazardous situation or a scenario through messages.

Mandatory Parameters: The mandatory parameters are the ones which are part of every type of message of an application irrelevant of the application domain. Some examples of Mandatory paramters are Vehicle ID, Vehicle Position, Timestamp.

Non Mandatory Marameters: The Non Mandatory parameters are the ones which are selected depending upon the type of message sent by an application. A application such as forward collision warning may require date related to vehicle Speed but not the Road surface etc.

6. Conclusion

In this paper, we addressed the process of Message Aggregation which is widely used in VANETs. Message Aggregation is used to transmit minimal data and to enhance the communication efficiency thus reducing the communication overhead in VANETs .Several past research are focused more on the security and infrastructure issues of VANETs. Also various researches in message aggregation are carried out depending upon the use of the application i.e. application domain specific. None of the research are directly focused on this area. We are focused on using message aggregation process on the data gathered by all the applications as a whole, instead of application domain specific resulting in transmitting a precise message information and reduce redundancy.

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