Data Dissemination Techniques and Publish/Subscribe Architecture in Vehicular Adhoc Networks

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Abstract— Vehicular Adhoc network (VANET) is a subset of Mobile Adhoc Network (MANET). It integrates mobile connectivity protocols to expedite data transfer between vehicles as well as between roadside equipment and available traffic in the network. There are main two types of communication carried out in VANET i.e. Vehicle to Vehicle (V2V) and Vehicle to Infrastructure (V2I). There is a large number of interesting applications for vehicular networks: traffic information dissemination, warnings, free parking spots finders, fuel prices advertising, etc. The Publish/ Subscribe (P/S) communication paradigm enables the application developers to easily design flexible notification systems. Furthermore, it enables the drivers/vehicles to indicate their interests about certain types of notifications (e.g. receive warnings concerning traffic jams only within 1km from the vehicle's route). And finally, P/S is an asynchronous communication protocol (spatial and temporal decoupling) that is suitable for the delay-tolerant network conditions. In the section I, brief introduction to Vehicular Adhoc Network is described. In section II, VANET applications and characteristics are discussed. In section III, various Data Dissemination techniques are explained in detail. In section IV, Publish/Subscribe architecture is explained and information flow in the network is described.

Keywords: vanet, publish/subscribe architecture, data dissemination, broadcast

I. INTRODUCTION

VANETs are new type of networks which are expected to support a large spectrum of mobile distributed applications that performed in vehicles. One of the most considerable services in VANET on the roads is that it can give drivers safety in driving. VANET can transmit useful information about road and traffic conditions as well as other noticeable information for people who drive in the range of the typical road. For example, if a car encounters a dangerous situation, then it can communicate with other cars and warn those cars which have not arrived at that place yet using Vehicle to Vehicle (V2V) communication. This information may also be sent to or from fixed roadside base units using vehicle to roadside communication (V2R). But VANET does not have any specific protocol at all and all Adhoc protocols are usable in VANETs. Unfortunately, most of Adhoc protocols do not propose special security mechanisms due to the nature of Adhoc which is focused on reducing the consumption of energy and resource. However, it is critical for VANET to meet robust security policy to ensure users about issues that can make them worry. To guard against misuse activities, the overall organization for VANET security architecture must be carefully designed especially when it is a worldwide implemented VANET[1][2][3].

II. APPLICATIONS AND CHARACTERISTICS

A. Applications

Applications of VANET can be classified into three major categories 1) Safety applications, 2) Traffic monitoring and management applications and 3) Infotainment applications.

1) Safety Applications

Safety applications are the most important applications type that is primarily focused on to decrease the chances of road accidents and the loss of life of the occupants of vehicles. A large number of accidents that occur in all parts of the world are associated with vehicle collisions. This class of applications primarily provides active road safety to avoid collisions by assisting the drivers with timely information. Information is shared between vehicles and road side units which is further used to predict vehicle collisions. Safety information can be represented with vehicle's speed, position, intersection position distance heading. Moreover, hazardous locations, such as slippery sections or potholes on roads can be easily located using the exchange of information between the vehicles and the road side units. Few use cases of safety applications are given below Curve Speed Warning: In this use case, a combination of GPS and digital maps are used to judge threat levels for a driver approaching a curve too quickly. If the driver enters a curve at a high speed and will not be able to drive through the curve safely, he will be warned automatically with a message. Acoustic as well as visual symbols may be used to warn the driver. The signal may directly appear on the instrument panel or in the navigation system.

a) Traffic Signal Violation Warning:

This use case is designed to send a warning message to a driver when it detects that the vehicle is in risk of running the traffic signal. The decision to send a massage is made on the basis of traffic signal status and timing and the vehicle's speed and position. The road surface and weather conditions are some other factors that are considered in such situations. This traffic violation information is further broadcasted by the RSU to all other vehicles in the neighborhood.

b) Emergency Electronic Brake Lights:

In this use case, the driver is alerted with a message when a preceding vehicle makes a severe braking maneuver. This alert notification is sent using the cooperation of other vehicles and/or road side units. Surrounding vehicles that receive this warning message will act accordingly if the event is relevant or ignore if it is not concerned with them.

c) Pre-Crash Sensing / Warning:

In this use case, it is assumed that a crash is unavoidable and will take place. The system is designed in a way to reduce the effect of an accident using equipment's like actuators, air bags, motorized seat belt pre-tensioners and extensible bumpers. Also the driver is warned, brakes are pre-charged, seat belts are retracted, excess slack is removed and automatically applying partial or full braking to minimize the crash severity. Vehicles and the available RSUs also share information periodically to predict collisions. The exchanged information includes detailed position data and vehicle size.

d) Collision Risk Warning:

In this system, vehicles and RSU detect chances of collision between multiple vehicles that are not able to communicate amongst themselves. The system will collect data about vehicles that are coming from opposite direction and are approaching towards the intersection, using sensors or DSRC communications. The collected information is further disseminated to inform vehicles that are going to take turn. One way to implement such system is by collecting the data continuously, and when there is a vehicle with its turn signal on, the system will send a message to that vehicle about the traffic traveling in the opposite direction of the vehicle. The other way is to have an in-vehicle system that sends a request to be notified about the traffic in the opposite direction when the turn signal is activated. The system will then collects data about the traffic in the opposite direction and sends a message to the vehicle that requested the information. In both ways, the driver will be informed and warned about the traffic coming in the opposite direction.

e) Lane Change Assistance / Warning:

In this application, electronic systems incorporated in vehicle monitor the position of a vehicle within a roadway lane and warn a driver if it is unsafe to change lanes or merge into a line of traffic at any instant. These systems are backward looking and assist drivers who are intentionally changing lanes by detecting vehicles in the driver's blind spot. Therefore, the risk of lateral collisions for vehicles is reduced by accomplishing a lane change with blind spot.

f) Stop Sign Movements Assistance:

In this system both V2V and V2I communications are used. This system is designed in way to avoid accidents at stop sign intersections. Data is collected by sensors or DSRC communications that is further used to inform the driver when it is unsafe to pass through an intersection. Moreover it also warns drivers if there is any traffic coming through the intersection at the same time.

g) Control Loss Warning:

In this use case the system is intended to enable the driver of a vehicle to generate and broadcast a message to all surrounding vehicles in case of controlloss. Upon receiving such information, the nearby vehicles decide the relevance of the event and provide a warning to the drivers, if appropriate.

2) Traffic Monitoring and Management Applications

This class of application mainly focuses on improving the vehicle traffic flow, traffic coordination and traffic assistance. It provides updated local information, maps and relevant messages bounded in space and/or time. Traffic monitoring and management applications can be further categorized into two classes known as Speed management applications and Cooperative navigation applications.

a) Speed Management Applications:

The aim of speed management applications is to assist the driver in managing the speed of his/her vehicle. The driving is made smoother and it avoids unnecessary stopping. The examples of this type of application are regulatory/contextual speed limit notifications and green light optimal speed advisory.

b) Co-operative Navigation Applications:

This type of application is intended to increase the efficiency of vehicular traffic by managing the navigation. The vehicles navigate through cooperation among themselves and through cooperation between vehicles and RSUs. Few examples of co-operative navigation are traffic information and recommended itinerary provisioning, co-operative adaptive cruise control and platooning.

3) Infotainment Applications

Infotainment applications offer convenience and comfort to drivers and passengers. The gist of infotainment applications intend to provide all kind of messages that offer entertainment and useful messages to the driver and passenger. Locating the nearest coffee shop, cinema, mall, fuel station which offers the best price in that area, or available parking spot are the few examples of infotainment applications. Infotainment applications can be further subdivided into two categories 1) Co-operative local applications and 2) Global Internet Applications.

a) Co-operative Local Applications:

The services provided by co-operative local applications focus on infotainment that can be obtained locally such as point of interest notification, local electronic commerce and media downloading.

b) Global Internet Applications:

In this class of applications the focus is on data that can be obtained from global Internet services. Few examples of global internet applications are community's services, which includes insurance and financial services, fleet management and parking zone management, and ITS station life cycle, which focuses on software and data updates.

B. Characteristics

In addition to the similarities to ad hoc networks, VANETs possess unique network characteristics that distinguish it from other kinds of ad hoc networks and influence research in this area. Few important characteristics of VANETs are as follows:

1) Somewhat predictable but Highly Dynamic Topology:

In VANET, the movement of each vehicle is restricted to roads patterns. With the knowledge of roadway geometry, the mobility pattern of vehicles can be predicted to a certain extent. Although mobility pattern of vehicles can be predicted in VANET but vehicles move at a very high speed and hence the topology of VANETs changes frequently.

2) Frequent Network Disconnection:

Due to the highly dynamic topology, the link connectivity in VANETs also changes frequently. Especially when the

density of vehicles is low, the chances of network disconnection are quite high.

3) Mobility Modeling and Predication:

Due to the high vehicle movement and dynamic topology, mobility models and predication play key role in designing the data dissemination approaches for VANETs.

4) Geographical Type of Communication:

In contrast to other mobile wireless networks that only use either unicast or multicast way for communication where the end points are defined by ID or group ID, the VANETs also supports a different type of communication that deals with packet forwarding based on geographical area.

5) Different Communication Environments:

Generally VANET operates in two typical communication environments known as highway scenarios and city scenarios. In highway traffic scenarios, the communication environment is comparatively simpler and straightforward (e.g., constrained one-dimensional movement), while in city traffic conditions it becomes quite complex.

6) Adequate Storage and Energy:

In VANET, nodes have sufficient amount of energy and computing power including both processing and storage because nodes are vehicles in VANET instead of small handheld devices in other networks.

7) Hard Delay Constraints:

Some of the applications in VANET do not require high data rates but has hard delay constraints.

8) Interaction with On-Board Sensors:

Each node in VANET is equipped with on-board sensors and GPS to provide information that can be further used to form communication links and data dissemination [2] [3] [4] [5].

III. DATA DISSEMINATION TECHNIQUES

Many of the problems are resolved by the process of effective data dissemination. There are many parameters that have to be kept under consideration during disseminating the data like network size, vehicle's speed, patchy and intermittent connectivity between mobile nodes. In addition to these difficulties, there is one more problem which can severely affect the entire process i.e. latency requirements. Consequently, content information has to be discovered quickly and distributed among nodes. According to the literature, there are many methods of information delivery in VANET. Generally speaking, following are the distinguished approaches for data dissemination:

A. Opportunistic Data Dissemination:

Information is retrieved from infrastructure/vehicles as the target vehicle encounters them.

B. Vehicle-Assisted Data Dissemination:

All vehicles carry information along with them and deliver it either to the infrastructure RSU or to other vehicles when they are encountered. In order to disseminate the information, mobility is also involved apart from the wireless transmissions.

C. Cooperative Data Dissemination:

Partial information can be downloaded by the vehicles that can be shared later to obtain the complete information. This method is mainly appropriate for content dissemination.

IV. PUBLISH/SUBSCRIBE ARCHITECTURE

Publish/subscribe [6] [7] has been evolved as the most suitable communication paradigm for building applications where underlying interaction mechanisms are required to be flexible, asynchronous and highly dynamic in nature. The main strength of this paradigm lies in decoupling in time, space and flow between event producers, called publishers and event consumers, called subscribers. Another component, called broker, which acts as a mediator between publishers and subscribers, assists in creating a decoupled environment where publishers and subscribers are unaware about each other and can dynamically leave or join the system.

VANET is a delay tolerant network and asynchrony, anonymity and autonomy are its inherent characteristics. As publish/subscribe communication paradigm provides decoupling in time, space and flow between communicating entities, it is most suitable for VANET like environments. Decoupling in time means the event subscriber and event publisher need not be up at the same time. Decoupling in flow means sending and receiving does not block participants. Decoupling in space means the subscriber can move from one location to another without informing the publisher. Moreover, in VANET the vehicles are mobile and autonomous and it is not possible to establish any central administrative authority, which makes publish/subscribe approach most suitable for such environments.

Recently, some approaches [6] [7] [8] have been proposed which are using publish/subscribe paradigm for information dissemination in VANET like settings. These approaches have contributed significantly towards understanding the applicability of publish/subscribe over VANET. In these approaches, a hybrid setup is assumed where there are stationary info-stations and moving vehicles communicating in cooperative manner. These info-stations are assumed to be connected to internet for timely information spreading. Vehicles are assumed to be installed with navigation system and GPS (Global Positioning System) and they behave like mobile sensors that collect information about traffic condition, parking situation etc. Then with the help of GPS and navigation system a publish/subscribe middleware is used to disseminate information geographically [6].

In these approaches, the main goal is to design a P/S middleware for vehicular networks that considers location and time in its design objectives. This middleware enables the application developers to easily publish notification in [6] [7] [8].

V. CONCLUSION

Data dissemination is vital in any type of vehicular adhoc network communication. Publish/subscribe architecture is used for information dissemination in VANET. Efficient mechanism can be designed using publish/subscribe architecture for fast information dissemination.

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The main strength of this paradigm lies in decoupling in time, space and flow between event producers, called publishers and event consumers, called subscribers. Publish/Subscribe architecture is beneficial for many applications in VANET.

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