International Journal of Research in Advent Technology (IJRAT) Special Issue
E-ISSN: 2321-9637
Available online at www.ijrat.org
*International Conference "*INTELINC 18*", 12th & 13th October 2018*

An adaptive Data Dissemination scheme for Vehicular Ad-hoc NETworks (VANET)

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Abstract— A Vehicular Ad Hoc Network (VANET) is a special kind of Mobile Ad Hoc Network (MANET) in which vehicles equipped with wireless and processing capabilities can create a spontaneous network while moving along roads. This paper proposes an efficient scheme for sharing location dependent data such as pictures of traffic, accidents and congestion for assisting car drivers using vehicular ad hoc networks. The vehicles holding data items understand a location where vehicles which demand that data item exist, by request messages that are disseminated with beacons. Vehicles holding data items adjust the area where vehicles disseminate data items according demand for data item, so that vehicles which demand data items can obtain it. Because vehicles repeatedly disseminate data item within the adjusted area, data items are disseminated to vehicles which demand data items after a short time. It will be important to select suitable data items to forward to satisfy demands from many vehicles and save wireless communication resources.

Keywords—Data Dissemination, VANET, MANET

1. Introduction

VANET is a new technology that integrates the potentials of new generation wireless networks into vehicles. VANET focuses to offer (i) continuous connectivity for mobile users while they are on the road, which enables them to link with other users through the latter's home or office based networks (ii) efficient wireless connection between vehicles without access to any fixed infrastructure which enables Intelligent Transportation System (ITS) [1]. VANET is also known as inter-vehicle communication (IVC) [2]. VANET devices such as on –board units are fixed in vehicles and functions as the nodes to transmit and receive messages through wireless networks. These devices provide drivers and passengers with the latest information on accidents, flooding, rain, traffic etc. By obtaining such information on time, drivers can make appropriate decisions and avoid misfortunes. Altering drivers about the conditions of roads, traffic and related aspects are crucial to safety and to the regulation of vehicle flow. In future vehicular networks, the requirements for communication between vehicles and the outside world will only increase.

We aim for a car navigation system that provides drivers with location dependent data items about traffic and road conditions at a location where the driver is interested[3]. In this system, when a driver sees an electric sign board or hears news about road traffic and notices that something happened at a specific location, in order to obtain detailed information about the specific location, the point of interest (POI) is given to the system by the driver with voice or manual operation. The system obtains pictures or video data generated by vehicles at the POI, using VANETs and presents the data to the driver. Pioneer Corporation has already developed a system based on a similar idea of us, Smart loop eye. In the system, when a vehicle equipped with a Pionneer's car navigation system passes through one of preset locations, the vehicle takes a picture at that location. After that, the vehicle uploads the picture to a server using the cellular network. A vehicle that moves toward a specific location where other vehicles have taken picture(s), obtains the picture(s). There are two differences between our system and the smart loop eye. The first one is that the smart loop eye system uses a cellular network. If a vehicle exists at the outside of a cellular network, the vehicle cannot obtain a picture. The other is that pictures that vehicles can obtain in the smart loop eye system are limited to those taken at the predefined location. The aim of our system is to supply pictures that have been taken at locations where drivers are interested. In order to achieve that aim, we use a VANET. However, it is not easy to disseminate large location-dependent data item to vehicles using only VANETs [4].

There are two basic strategies for sharing data items in VANETs. The first one is the push-based approach. In this approach, a vehicle that has generated a data item disseminates the data item proactively using broadcast to other vehicles. By using this approach, many vehicles can obtain the data item. However, it may be disseminated to vehicles that do not need it. There by disseminated data items may waste the communication resources if there are few vehicles that want the data items in the area. The larger area where vehicles disseminate data items is, the more communication resources are wasted. The other is the pull-based approach, in which vehicles send request messages intended for certain locations and then vehicles that have the requested data items reply to the request messages. This approach satisfies the aim of our system which supplies data items that drivers want. However, it is not easy to make vehicles share data items by using this approach. The connectivity between vehicles is often lost since vehicles are moving. Thus, request or reply messages may be lost before it reaches the destination. When drivers are caught in traffic congestion or want to see scenes that suggest a traffic accident, the driver would try to use the system that we assume in this paper. Thus, vehicles that exist within a specific location would generate request messages continuously. If the system tries to reply these request messages using a simple pull-based approach, multiple vehicles holding a data item will send it to each requester as a reply message. The communication resource is wasted by multiple replies. We need the efficient data dissemination scheme that vehicles can disseminate data items according to the temporal and geographical distribution of demands on them [5].

In this paper, we propose a data dissemination scheme for VANETs in which vehicles disseminate location dependent data items at within an area that is adjusted according to the geographical distribution of the source position of demands for the data item. Our scheme adopts both pull and push-based approaches [3]. Vehicles disseminate data items in a similar manner of a push-based approach. In the push-based approach, a vehicle may disseminate a data item to other vehicles which do not need it. In order to avoid unnecessary data dissemination, our scheme limits the area where vehicles disseminate the data item. Vehicles disseminate a data item within an area where many vehicles need it. In our scheme, a vehicle which wants to obtain a data item generates a request message and then disseminates it with beacons. When a vehicle holding a data item receives a request message, it does not send the data item like a simple pull based approach. The vehicle adjusts the area where vehicles disseminate the copy of a data item so that many requesters can obtain the data item immediately. Vehicles repeatedly disseminate the data item within the dynamically adjusted data dissemination area. The data item is delivered to a region near the location where requester has generated a request message.

2. Overview of VANET

A Vehicular Ad hoc Network (VANET) is a kind of wireless ad hoc network to provide communications among vehicles and nearby roadside equipments. Vehicular ad hoc networks are raising new technologies to combine the functionality of new wireless networks with vehicles. In fig (1) VANET consists of vehicles with on-board sensors and roadside units (RSUs) deployed along highways/sidewalks, which provides communications between vehicle-to-vehicle (V2V) and communications between vehicles-to-infrastructure (V2I). The key workings of a VANET are wireless on board unit (OBU), the roadside unit (RSU) and the authentication server (AS). OBUs are installed in vehicles to give wireless communication capability, while RSUs are deployed on intersections or hotspots as an infrastructure to provide information or access to the internet for vehicles within their radio coverage.

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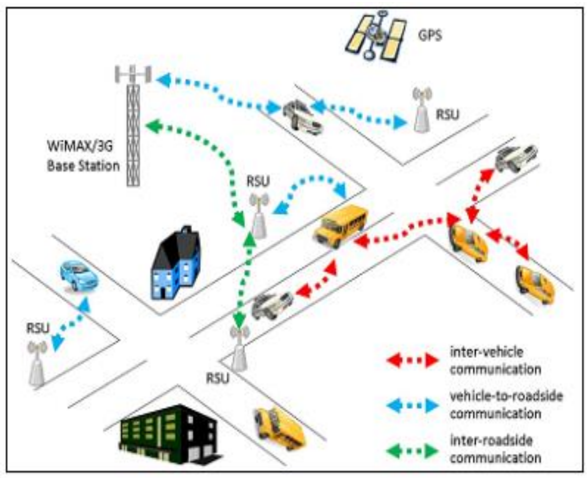

Fig (1) VANET architecture

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- **Wireless On Board Unit:-** On Board Units (OBU) work via GPS, the on-board odometer , a digital map and GSM (used to authorize payment via a wireless link).
- **Authentication Server:** The AS is liable for installing the secure parameters in the OBU to validate the user.

- **Roadside Unit:** RSU acts similar to a wireless LAN access point and can provide communications with infrastructure. Also, if required, RSU must be able to allocate channels to OBUs

3. DATA DISSEMINATION

Data Dissemination is the communication among the vehicles and roadside base station. Vehicles can access the data through V2V technique or V2I technique[4]. These vehicles can obtain information from the roadside base station. Each vehicle communicates with nearby vehicles in a highly dynamic ad hoc networking environment through V2V communication. Data dissemination is a process of distributing data or information over distributed wireless networks, which is superset of VANET s. Data aggregation is used to reduce the number of data transmit ion in communication medium. Basically it is used to reduce the redundant data transmission .but data aggregation approach are unsuitable for the dissemination of safety related data in VANETs. Characteristics of VANET [6] such as very high mobility, infinite extension, intermittent connectivity through the sparse infrastructure challenges the information exchange and data scheduling. Routing is the keystone of any data dissemination scheme in vehicular network. Parameters to be considered during data dissemination are size of network, intermittent connectivity, speed of vehicle. Another problem which can affect the entire the process is latency requirement. So, the content information must be discovered immediately and share between nodes.

For data dissemination, data broadcast is an attractive solution. Two major data broadcast tendencies are push based and pull based. In push based broadcasting to retrieve data items of interest without sending any request, all vehicles listen inactively to the broadcast channel. Push communication has objective of information exchange which may include data like speed, position and direction of vehicles to access traffic conditions. Pull based broadcast is called as on-demand broadcast. As a reply RSU disseminate data items to express clearly the requests submitted by vehicles [7]. It is more scalable as compared to push based.

a. Methods for data dissemination

- **Opportunistic Data Dissemination**

Opportunistic communication is proposed to overcome the limitation inflicted by lack of connectivity. When target vehicle come in contact with other vehicles or RSU, information is pulled or retrieved from them[8].

- **Vehicle Assisted Data Dissemination**

Vehicles carry information and delivers either to the RSU or to other vehicles when it comes across them. In order to spread data, this process involves mobility in supplementary to wireless transmission.

- **Cooperative Data Dissemination**

Some part of data can be downloaded by the vehicles and subsequently shared to obtain whole data. This method is relevant for content dissemination. As vehicles moves at high speed they resides in the region of RSU only for a while. Therefore scheduling of data is essential to service as much request as possible and to reduce downloading delay. Using some performance metrics like gain of scalability, service ratio, service delay, success transfer rate etc. any scheduling algorithm can be verified. Some scheduling algorithms noticed are Most Requested First (MRF), First Come First Serve (FCFS), Cooperative Data Dissemination (CDD), Earliest Deadline First (EDF), Multimedia Motion Prediction Scheduling (MMPS), etc [8]. In MRF most pending request data items are scheduled first. FCFS avoids data popularity and CDD marks the popularity of data item even though it is ranked behind.

4. RELATED WORK

The paper proposes vehicles with location-dependent data items about a specific location that drivers interested in. The vehicle holding a location-dependent data item disseminates it to other vehicles using a push-based approach, only within an area which is dynamically adjusted based on request messages that vehicles which want to obtain the data item send. Since vehicles send request messages, this scheme like to pull-based approaches. However, vehicles which have received a request message do not send a reply message. Therefore, this scheme is different from simple pull-based approaches [9]. In fig (2) when a vehicle holding a data item receives a request message, the vehicle adjusts the area where the copies of the data item are disseminated according to the geographical distribution of demands for the data item, instead of sending a reply message. The information of the data dissemination area is attached to the data item and is adjusted so as to include a location where the request message was generated and the shortest path between the location where the data item was generated and the location where the request message was generated, when a vehicle holding the data item receives the request message. Thus data items are delivered to the location where the request message was generated since vehicles repeatedly disseminate data items within the adjusted data dissemination area. This data item is not delivered to areas where no demands for the data items have been generated, and the radio communication resources are effectively used [10].

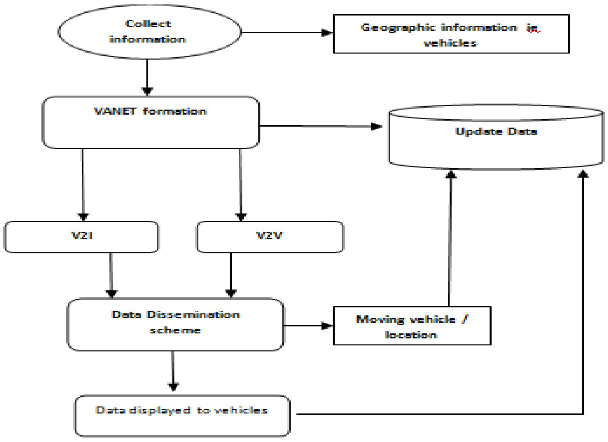

Fig 2.overview of data dissemination

A. Overview of data item dissemination

In the proposed scheme, if a vehicle generates a location-dependent data item, the copy of the data item are disseminated in the neighboring areas where the data item was generated.We call the area a basic dissemination area.Vehicles which travel in the basic dissemination area, if they receive the copy of the data item, they hold it within its valid term. A vehicle which needs to obtain a location-dependent data item generates a request message which contains the location of the point of interest (POI) and the current position of the vehicle [11]. The request message is added to a beacon which vehicles broadcast at fixed intervals. If a vehicle receives one of the beacons including the requestmessage, it adds the request message to beacons that it sends. When the request message reaches a vehicle holding a location-dependent data item which satisfies the request, the dissemination area of the data item is adjusted so that vehicles which travel in the neighboring areas where the request message was created can obtain the . We call that the newly added area an additional dissemination area. When vehicles holding a data item reach an intersection within the dissemination area, it broadcasts the data item. The data item continues to be disseminated within the basic dissemination area and the additional disseminationarea until the valid term of the request message or the location-dependent data is expired.

B. Two type dissemination areas

As mentioned before, there are two types of dissemination areas, one is the basic dissemination area, and the other is the additional dissemination area. We assume that each vehicle has the standardized digital map so as to construct the data dissemination area.

1) Basic dissemination area: When a vehicle generates a location-dependent data item, it sets this area. This area consists of road segments which exist within a few blocks from the road segment where the data item was created. Each location-dependent data item has its own dissemination area associated to the road segment where the data item was generated. The basic dissemination area is represented by IDs of road segments within the area. This is included in each location-dependent data item [12]. The basic dissemination area is valid until the valid term of the location-dependent data item expires.

If a data item continues to be disseminated within this area, its many copies would exist within this area, even if a vehicle which has generated the data item leaves this area. If a data item exists in a specific area, vehicles can obtain the data item by sending a request message to the specific location. If the request message reaches one of vehicles holding the data item within this area, the vehicle can take action so that the requester can obtain the data item. The size of the basic dissemination area is important. If that size is large, many vehicles may disseminate the location- dependent data item. This wastes the wireless communication resources. On the other hand, if the size of the basic dissemination area is small, the data item may not be disseminated sufficiently many vehicles [13]. Thus, the location-dependent data item may be lost from the network. However, it is difficult to calculate the optimal size of the basic dissemination area, because the distribution of demands may be different depending on the situation.

2) Additional dissemination area: An additional dissemination area is an area which is added to the basic dissemination area of a data item according to the geographical distribution of demands for the data item. The additional dissemination area consists of a supply route and a demand area.

Supply route: The purpose of this part is to deliver a location-dependent item to the area where vehicles need the data item from the basic dissemination area. This part consists of road segments of the shortest path from the road segment where the data item was generated and the road segment where the request message was generated.

Demand area: The purpose of this part is to disseminate a location-dependent data item in the vicinity of vehicles which need that data item. This area consists of road segments which exist within a few blocks from the road segment where request messages were generated.

The information about the additional dissemination area is attached to each location-dependent data item. Each road segment which is a part of the additional dissemination area is set an individual valid term. This is for removing road segments where request messages have no longer generated from the data dissemination area. If the valid term of a road segment in the additional dissemination area expires, the road segment is removed from the additional dissemination area.

C. Request dissemination

In order to adjust the dissemination area of a location-dependent data item, it is important to inform many vehicles about the location where demands have been generated, because vehicles do not know which vehicle has a particular data item. When a vehicle needs to obtain a location-dependent data item, it generates a request message. The request message contains requester's ID, the ID of the road segment where the demand generated, destination (POI) road segment ID, timestamp of the request issue time, and the time to live (TTL = length of the valid term) of the request. Thereafter, the requester adds the request message to beacons that are broadcast periodically [14].

If a vehicle receives one of the beacons including the request message, the vehicle adds the request message to its beacons that the vehicle sends. The request message continues to be piggybacked on beacons until the expiration of the valid term of the request message. In this way, many vehicles will know the demands of the road network. If a vehicle has some request messages, all of them are piggybacked on beacons sent from the vehicle. However, if a vehicle has some request messages that the information of the pair of the source and destination road segment ID is the same, the vehicle keeps the newest one of them, and discards others. Expired request messages are discarded.

Whenever a vehicle which has generated a request message moves to another road segment, it updates the request message so that the source of the request message is the new road segment ID. In the updated request message, the source road segment ID and the timestamp are changed. If a vehicle has some request messages for the same destination road segment ID that are generated by the same vehicle, the vehicle discards older ones.

When a vehicle receives a beacon including a request message, it checks the destination road segment ID of the request message. If the vehicle has a data item which satisfies the request (source road ID of the data item and destination road ID of request messages is the same), the vehicle checks the dissemination area of that data item. If the source road segment ID of the request message is not included in the dissemination area of that data item, the vehicle adjusts the data item's dissemination area. The vehicle calculates an additional dissemination area according to the source road segment ID of the request message and that of the location-dependent data item. The valid term of each road segment in the additional dissemination area is set according to the generated time of the request message that vehicle received.

Vehicles which have adjusted the dissemination area of a location-dependent data item add the information of the additional dissemination area to the data item. When a vehicle disseminates a data item, it checks the valid term of the additional dissemination area of the data item. If the vehicle finds that the valid term of a road segment in the additional dissemination area expires, it deletes the road segment ID from the additional dissemination area. When a vehicle receives a new request message, the valid term of each road segment ID in the additional dissemination area of the corresponding data item is updated according to the request message.

D. Cancellation of request

After a vehicle has obtained the demanded data item, it is useless that the vehicle continues to send request messages for the data item. If the requester vehicle continues to send request messages, it may receive data items from a neighbor holding data items frequently. Therefore, once a vehicle has obtained the demanded data item, it stops including request messages to its beacons.

Several vehicles may hold a location-dependent data item after sufficiently long time has elapsed since the location- dependent data item had been generated. In some cases, when a driver wants to know the information about a specific location, the data item for the information may has been held by his/her vehicle. In this case, should the vehicle issue a new request message for the data item? The answer is yes. If vehicles do not issue the request message, any vehicle would not adjust the dissemination area for the data item. If the dissemination area is not adjusted, it would be difficult for a vehicle which has not obtained the data item but will generate a request for the same data item at the same position, to obtain the data item [15]. Thus, even if a vehicle has a location-dependent data item, the vehicle generates a request message for the data item that it has already obtained, and then sends it with beacon at least once. In our scheme, vehicles cannot stop other vehicles adding request messages to their beacons. Thus, if a requester sends a request message at least once, the request message will exist in the network for a while since a vehicle which has received a request message continues to add the request message to beacons that the vehicle continues to send until the valid term of the request message expires.

5. C ONCLUSIONS

We proposed a location-dependent data sharing scheme to provide data items about a specific location that drivers are interested in for drivers, using VANETs. The vehicles holding data items understand a location where vehicles which demand that data item exist, by request messages that are disseminated with beacons. Vehicles holding data items adjust the area where vehicles disseminate data items according demand for data item, so that vehicles which demand data items can obtain it. Because vehicles repeatedly disseminate data item within the adjusted area, data items are disseminated to vehicles which demand data items after a short. In our future work, we plan to evaluate the performance of the scheme with big data items and request message are generated at multiple locations in detail. The scalability is a crucial issue of the proposed scheme. It will be important to select suitable data items to forward to satisfy demands from many vehicles and save wireless communication resources.

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