A Study on Broadcasting in VANETs

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Abstract: ***The revolution in wireless communication have brought fundamental changes in communication and data networking. Vehicular Ad hoc Networks(VANETs) are an emerging area of interest in Wireless communication. The main characteristic of a VANET is the movement and self organization of the nodes. The nodes in a VANET are vehicles which are in constant motion. VANETs have been extremely useful in areas like Military Applications, vehicle and road safety etc. Considering the impact these networks are having, there should be efficient broadcasting techniques for communication. In this paper we present a study of the various broadcasting techniques being used in VANETs.***

Keywords: VANETs, Broadcast Storm Problem, Store Carry Forward, Broadcast Supression, DV-CAST, UV-CAST

1. Introduction

Substantial advances in the wireless technologies is resulting in vehicles emerging as an integral part of global networks. A type of wireless ad hoc network, characterized by having high mobility of the nodes and very quick changes in the topology, is the Vehicular Ad hoc Network (VANET). Due to its tremendous potential to increase the safety of the roads and the vehicles, to make the traffic more efficient and convenient, the VANETs are emerging as an active area for development and research. A VANET makes use of the vehicles as nodes. The vehicles communicate with each other using the wireless transmission devices, and they do so in a hop by hop manner. The costly infrastructure is not required by VANETs, rather, the information such as navigation information, weather information and traffic and safety information is distributed by a vehicle to vehicle transmission. Network connectivity is required for information dissemination in a VANET.

The VANETs have two types of connectivity mechanisms: the Vehicle-to-Infrastructure (V2I) type, and the Vehicle-to-Vehicle (V2V) type. The V2I types of VANETs have some fixed base locations. The communication between two vehicles is facilitated by a Base Station. The communication using the V2I network connectivity increases the time required for the communication as every time the message is to be sent to the base location. However, this also proves to be advantageous as the cost, and complexity decreases. And as no intermediate vehicles are required, which means fewer vehicles and hence the chances for collision are less. The second type of connectivity, V2V, does not have any fixed infrastructure. Here, the communication between vehicles is direct without the involvement of any base location. As there is no dedicated route in this type of communication, there should be some routing scheme. Irrespective of the chosen routing scheme, the communication through V2V mechanism is faster than that happening through the V2I scheme, because no base station is present. Thus, the overhead of transferring the message to the base station is removed. But again, this advantage comes with its own set of drawbacks. The V2V communication requires a number of intermediate vehicles for completing the communication, thus increasing the cost, complexity and chances of collisions among the vehicles.

Due to the increasing use of VANETs in more and more applications, it is very important that a good broadcasting technique is used. Various routing schemes are available for providing this network connectivity in VANETs, which are broadly divided into two types: End-to-End Type (E2E), and Store-Carry-Forward (SCF) type. The E2E connection type is always adopted by the topology based routing. In this type, the route from the source to the destination is pre-calculated, and the packets from the source vehicles are then forwarded to the destination vehicle via the intermediate nodes (vehicles). As the nodes (vehicles) are mobile, there may be cases when forwarding node is not able to find the next hop. In such cases, the communication between the source and the destination nodes is lost along that particular formed path, and the forwarding node drops the packet. Opportunistic routing, on the other hand, always uses the SCF connection type. The intermediate vehicle, in the event of unavailability of the next hop, cache the data packet in their internal storage, keep carrying it, and then relay the packet when they find the next forwarding opportunity. Thus, with this type of routing, the packet reaches the destination at last.

2. Literature Survey

Wireless Networks are the unguided medium for the transmission of signals or electromagnetic waves [1][2]. In the recent years, there have been a rapid growth and deployment of IEEE based 802.11.. A broadcast protocol for VANET which is multi-hop in nature is being presented by O. Tonguz, et. al.,[10]. The three different regimes in which a vehicular broadcast protocol needs to work in are identified. These are (1) The dense traffic regime, (2) The Sparse traffic regime, and (3) The regular traffic regime. They propose DV-CAST (Distributed Vehicular Broadcast) protocol that can operate in all traffic regimes [9] [10]. This protocol relies only on the local topological information, in order to handle the broadcast messages in VANET. The proposed protocol is excellently reliable, scalable and efficient. Another broadcast routing protocol as suggested by Viriyasitavat, et al. [11] is UV-CAST (An Urban Vehicular

Broadcast Protocol). Both the broadcast storm problem and the disconnected network problem are addressed by the UVCAST protocol. Vegni, Biagi and Cusani[17], list the main applications of the Vehicular ad hoc networks in their paper

3. Broadcasting In Vehicular Ad Hoc Networks

The VANETs are gaining more and more importance these days. This increasing use of VANETs in critical applications like road safety, military applications and many more demands a basic need for a good and reliable Broadcasting technique. In this section we will talk about the properties that are desired as well as the limitations of the routing protocols in a vehicular networks. We then give the classification criteria and the limitations for the routing protocols. A few routing protocols are discussed next and finally the applications where vehicular networks find there use are listed.

A. Desirable Properties

A protocol designed for VANETs should possess the following properties [12]:

- Should be Reliable,
- Should be Robust against the nature of the traffic,
- Should be Efficient in terms of Bandwidth,
- Should be able to distribute the broadcast information to all the intended recipients,
- Should incur low overheads

B. Types of Routing Protocols

A number of routing protocols are available for the vehicular communication. These can be classified into 3 types based on the following [13]:

- The type of the VANET applications being supported (e.g., traffic safety applications, commercial applications or the traffic efficiency applications),
- The requirement for the infrastructure support (whether any Base station or Road side unit is required or not),
- (iii)The assumptions on the type of scenarios or environments (e.g., Dense or Sparse Networks, one dimensional highways, Multidimensional urban areas etc.).

We will now focus on the type of routing protocol that take into consideration the type of traffic regime in which the nodes in a vehicular networks exist. At any given time, the nodes are in one of the following three traffic regimes[12]:

- *Dense Traffic Regime* (extreme case) : This is one extreme case which occurs when the density of the traffic exceeds a certain value, and the network under consideration if fully connected. As the packets are being blindly broadcasted, and the wireless medium is shared, there are chances that the collision and contention among the resources will happen very frequently.
- *Sparse Traffic Regime* (extreme case): Another extreme case, the Sparse traffic means that the road have only a few vehicles at any given instant. It is also possible that there are no vehicles in the transmission range on either direction of the road, making the routing of the messages very troublesome.
- *Regular Traffic Regime*: In a regular traffic pattern, some areas (road intersections) will be dense while some other areas (areas beyond the intersections) will be sparse. Thus, there is no global topology. All the nodes will rely on their local topology. In order to preserve the network connectivity, the nodes in the dense areas will have to apply the suppression techniques while those in the sparse areas will make use of the store-carry-forward mechanisms

C. Limitations

A good protocol should be designed such that it is able to operate in any of these traffic regimes. This is not an easy task and the major problems which are encountered while designing the broadcast protocol for VANET [11] are as follows:

- The Disconnected Network Problem : This problem occurs in a sparse network. Here the density of the nodes is so low that even the minimum number of nodes required for message dissemination is not available.
- The Broadcast Storm Problem :This problem occurs when the network is dense. Here a number of nodes are trying to transmit the data packets or the messages at the same time, thereby exhausting the resources. This results in a number of packet collisions and also an increase in the delay of the transmission.

D. Broadcasting Techniques

We will now see a few protocols available for broadcasting in different types of traffic regimes. The most simple routing scheme is *Simple Flooding* but it fails to attain the desired properties as discussed earlier, and it also does not work on the listed limitations. Two protocols which address these limitations, and also possess the above mentioned properties are the *Distributed Vehicular Broadcast (DV-CAST)* and the *Urban Vehicular Broadcast (UV-CAST)* Routing Schemes. Let us now see these one by one.

1) Simple Flooding

The Simple Flooding type of broadcasting is the basic broadcasting technique wherein all the nodes in the network will broadcast all the packets available at all the times. Any type of check is not done before broadcasting and as a result the network congestion happens. Unnecessary and redundant messages create the Broadcast Storm Problem.

2) Distributed Vehicular Broadcast (DV-CAST)

The DV-CAST protocol is a new broadcasting protocol for the Vehicular ad-hoc network. In addition to the desirable properties listed in the previous section, it possesses a unique feature [12]: The framework depends on the local information from one-hop neighbours only. Periodic ‘hello’ messages are used by each node (car) to get this information.

One of the main pieces of information that DV-CAST make use of is the Local Topology Information, which assist in determining how to handle the packet [11][12]:. Each vehicle is required to continuously monitor its local topology so that it is able to determine:

- The relevance of the message being broadcasted i.e., whether or not it is the intended recipient of the message.

- Whether any neighbor is present in the direction in which the broadcasting is being done or whether this node is the last one in the cluster.
- Whether the node is connected to at least one of the nodes travelling in opposite direction.

The three main components of the DV-CAST protocol are as listed below [11]:
- Neighbour Detection
- Broadcast Suppression, and
- Store -Carry-Forward Mechanism

A node is in an Idle state initially. Once a packet arrives (either from another vehicle or from the Base station), the node performs the Neighbor Detection to get the local topological information. Separate actions are performed based on the information thus obtained. If a node finds itself in a well connected neighborhood, it performs the Broadcast Suppression using any of the algorithms present for this purpose. However, if the node finds itself in a neighborhood that is sparsely connected, it makes use of the Store-Carry-Forward mechanism for broadcasting the packets further.

3) Urban Vehicular Networks (UV-CAST)

UV-CAST is a broadcasting protocol designed for the VANETs present in urban areas. The UV-CAST protocol also overcomes the Disconnected Network Problem and the Broadcast Storm Problem (already discussed in the text above), occurring in the urban VANETs. The nature of the UV-CAST protocol is completely distributed. It requires zero infrastructure support and is capable of supporting both the connected as well as disconnected regimes of the network [13].

Because of the presence of the road intersections and, the additional dimensions of the network topology in the urban areas, the protocols being designed for such urban setting must address the following key routing issues:
- The omnidirectional messages and the regions of interest.
- The change of directions of the vehicles and hence the messages at the intersection areas.
- Availability of more than one point for entry or exits
- The dependency on the location of the vehicle for its connectivity.

These limitations require that the protocol designed for an urban network should possess the following properties [13]: (i) The Store-Carry-Forward (SCF) of the packets should be the responsibility of more than one vehicle. (ii) The messages or the packets should be forwarded by the vehicles carrying them (using the SCF) again and again. and (iii) The protocol should use the intersection based techniques for the broadcast storm mechanisms.

The the UV-CAST protocol operate in two different ways depending on whether it is in a dense network (the well connected regime) or in a Sparse network (the disconnected regime). Once a new message arrives at the vehicle, it determines whether or not the message is in its Region of Interest. If the message falls in the region of interest of the vehicle, a check is performed to see whether the vehicle should be assigned the task for the Store-Carry-Forward. If the answer comes out to be yes, this means that the vehicle falls in the disconnected regime and has to follow the steps laid out for the same (as shown in the flowchart). If the answer of the check comes out to be No, the vehicle falls in the Well connected Regime and proceeds in the corresponding way.

E. Applications

Vehicular applications are typically classified in following types[17]
- Applications for Road Safety,
- Applications related to traffic efficiency and management , and
- Applications related to the comfort and infotainment

The main aim of the first category of application is to make driving safer and to avoid the risk of car accidents. This is achieved by the distribution of the information about obstacles and hazards. The basic idea behind this is to make the range of perception of the driver broad, which will allow him to react more quickly. Such alerts are received through wireless communications.

The main focus of the second category is to optimize the vehicle flow by achieving a reduction in travel time and avoiding such situations where traffic jam may occur . The main intention of the applications like enhanced route guidance/navigation, optimal scheduling of the traffic lights, and assistance in lane merging , is to optimize routes, and to also reduce the gas emissions and fuel consumption.

The third category, aims mainly to offer comfort and convenience the drivers and/or passengers.

4. Conclusion

Vehicular ad-hoc networks (VANETs), a type of wireless networks, make use of vehicles to perform the wireless communications. Due to the high mobility of vehicles, there are very quick and very frequent topological changes and thus the broadcasting protocol used should be chosen very wisely such that it performs in packet transmission in a way that maximises the connectivity between the vehicles and reduces the network conflicts. A lot of routing protocols are being designed for making this broadcasting efficient. We have tried to explain the important aspects and techniques for Broadcasting in VANETs, but the list is not exhaustive. The main aim of this study is to give a fair idea about broadcasting in a VANETs, in order to help others with their research works

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