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A Study of Broadcasting Protocols and its Performance in VANETs

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ABSTRACT

Vehicular ad hoc networks (VANET) have become an very popular research application to improve traffic safety. The dissemination of emergency message is considered to be very important application of vanet. Unicast and multicast mode of communication used to communicate for general messages. To convey emergency message messages to all the vehicles, broadcasting is the suitable mode of communication. When an accident occurs, the messages have to be delivered to all the upcoming vehicles so that the congestion and traffic jam can be avoided. The message can help the drivers to enable smooth and safe driving by providing the drivers in various risk traffic environments. This paper describes a study on broadcasting protocols of vehicular ad hoc networks and discusses briefly about its characteristics, requirements and its applications. Classification is performed based on its advantages and disadvantages. Disadvantages helps in designing a new protocol for vanet broadcasting. This survey also helps to understand different schemes that are used for broadcasting the control information with high success rate and low broadcast delay in highly dynamic vanet environment.

Keywords: Vehicular Ad hoc Networks, Flooding, Message Dissemination, Broadcasting

INTRODUCTION

VANET are highly mobile wireless ad hoc networks for safety and other commercial applications. Vehicle moves faster in all directions when communicating with each other and also with infrastructure device. It provides two communications, vehicle to vehicle (V2V) and vehicle to infrastructure communication (V2I).V2I is for providing services like road traffic, weather and internet services where as V2V usually involved with traffic conditions and inter vehicle (IVC) (S.-H. Cha, K.-W. Lee, H.-S. Cho (2012), Q. Tse (2009)) based communication for accident prevention. When such a accident occurs, the messages has to be disseminated to all the direction to make the upcoming vehicles alert about the accident (J. Huang, Y. Huang, J. Wang (2014)). Accident prevention and traffic safety will be considered to the prime application of VANET. Emergency messages are considered to be delay sensitive and drivers will react in slower manner. To overcome that general safety messages has to be sent to the drivers about the speed limit, traffic conditions so on to drive them safely. The rest of the paper is as follows

- Characteristics of VANET
- Application of VANET
- Requirements of broadcasting
- Broadcasting protocols classifications
- Conclusion and future work

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CHARACTERISTICS OF VANET

Many different and sometimes competing design goals have to be taken into account for vanets to ensure their commercial success. It forms highly dynamic network. Some of the characteristics of vanet matches with characteristics of manet.

- *Dynamic Topology*

Very high speed of vehicles with multiple choices of path for traversing makes vanet highly dynamic in nature.

- *Frequent Disconnected Network*

Since the node moves faster in road, so there is a need for infrastructure to be available frequently for communication which is not possible. This makes frequent disconnection in the network.

- *Mobility Modeling and Prediction*

Prediction of vehicle position and the movement is very difficult. The prediction is completely based on the availability of predefine road maps. Speed of vehicle is again an important aspect to concentrate in designing.

- *Communication Environment*

Once mobility model is ready we need to concentrate more on the environment where we are deploying this mobility model is an important issue. The scenario may be a city environment or rural or urban. Depending on the road architecture the performance differs.

- *Hard Delay Constraints*

At emergency, delivery of messages on time is a critical problem in vanet

- Interaction with onboard sensors

Sensors are the point of communication sensors can read data related to speed, direction and can communicate to the data center. Thus sensors can be used in link formation and in routing protocols.

- *Inter Vehicle Communication*

As stated, highly dynamic topology of network with high speed nodes, onboard unit of one vehicle wants to communicate with other onboard unit of another vehicle at faster rate. So communication needs higher frequency bands to operate.

APPLICATION OF VANET

There are many applications of vanet. It is broadly classified into four categories.

- Safety applications
- Commercial applications
- Convenience oriented applications
- Productive applications

Safety Applications

Safety applications include monitoring of surrounding road, approaching vehicles, surface of the road, road curves etc. the road safety applications can be classified as

- *Real Time Traffic*

Real time traffic data can be stored in road side units (RSU). So that current traffic information can be retrieved from RSU to all the notes whenever and wherever. This will highly helpful in avoiding congestion and accidents.

- *Cooperative Message Transfer*

Slow and stopped vehicle can exchange messages and cooperate to help others. Latency in transfer and reliability has to be considered but this can be automated like emergency braking to avoid accidents.

- *Crash Notifications*

Vehicles who met with accidents should broadcast warning messages about its location to upcoming vehicles to take decision to avoid using the road.

- *Hazard Control Notifications*

Vehicles will notify other trailing vehicles about sudden downhill or deep turns or landslides in road to avoid unnecessary traffic and accidents.

- *Cooperative Collision Warning*

Alerting two drivers potentially under crash route so that they can mend their ways.

Commercial Applications

Commercial Applications provides the driver with entertainment and services as web access, streaming audio and video.

- Remote vehicle personalization/diagnostics
- Internet Access
- Digital Map Downloading
- Real time Video Relay
- Value added advertisements

Convenience Applications

Convenience application mainly deals with traffic management with the goal to improve the traffic efficiency by enhancing the degree of convenience of drivers.

Convenience applications can be classified as

- Route Diversion
- Electronic Toll Collection
- Parking availability
- Route Prediction

Productive Applications

Intentionally calling it productive as this application is additional with above all mentioned applications and it can be classified as

- Environmental Benefits
- Time Utilization
- Fuel Saving

REQUIREMENTS OF BROADCASTING IN VANET

The following are the requirements of vanet protocols when designing a protocol for broadcasting

- *Scalability*

Protocol should well with all terrain such as urban, rural, metro cities, dense and sparse areas. So designing a protocol that suits for all the areas is a challenging task.

- *Effectiveness*

The broadcast protocol has to ensure that all the vehicles in the destination region receive the broadcasted message.

- *Efficiency*

While broadcasting the messages, redundancy is s bigger issue. The protocol should work as efficient as possible to avoid redundancy of messages.

- *Dissemination Delay*

Emergency messages have to be notified immediately without delay. Separate treatment of emergency messages in the network is under research.

- *Delay Tolerant Dissemination*

The protocol should be capable of storing the messages for some amount of time when network is disconnected. The protocol has to forward it when new vehicles as connected to the network.

- *Robustness*

Broadcast protocol has to deal with packet loss with the purpose of operating accurately in vital safety applications.

CLASSIFICATION OF VANET BROADCASTING PROTOCOLS

Broadcasting is the best mechanism to communicate safety messages to the network. There are various methods of broadcasting exist. One simplest mechanism of broadcasting is flooding.

Flooding (Qayyum, L. Viennot, A. Laouiti (2002), S. Panichpapiboon, W. Pattara-Atikom (2012)) allows all vehicles to redeliver safety messages to all vehicles in their radio transmission range. But disadvantage of flooding is redundancy in messages and broadcast storm problem comes into picture. Broadcast storm problem (Y.-C. Tseng, S.-Y. Ni, Y.-S. Chen, J.-P. Sheu (2002)) means all the nodes who receive the message trying to participate in transmission. At that time, Network may gets congested. To overcome broadcast storm problem, selected vehicles are permitted to rebroadcasting and all other nodes are permitted only to receive within its radio range.

Broadcasting protocols for VANET can be classified into six broad categories

- Table driven broadcasting
- Cluster based broadcasting
- Topology based broadcasting
- Location based broadcasting
- Distance based broadcasting
- Probability based broadcasting

Table Driven Broadcasting

In this type of broadcasting, each node maintains the neighbor list based on the periodicals beacon messages. Some of the table driven schemes are

Advantages

- No route discovery is required
- Low latency for real time applications

Disadvantages

- Respective amount of data for maintenance
- Slow reaction on restricting and failures

Some Schemes

Least common neighbor (S. Yu, G. Cho (2006)):

Table driven based selective flooding scheme is used for broadcasting the emergency messages in vehicle safety communications. Here sender vehicle includes its own neighbor list in the message vehicle receiving the message will compare it with their own list of neighbors and broadcasting is permitted only for the least common neighbor.

Track Detection (M.T. Sun, W.-C. Feng, T.-H. Lai, K. Yamada, H. Okada (2000)):

It is a GPS based mechanism where the neighbors are categorized into different groups called vehicles in same lane vehicles road ahead, road behind. It then selects farthest vehicle for each group as the relay vehicle.

Vector based tracking detection (M.-T. Sun, W.-C. Feng, T.-H. Lai, K. Yamada, H. Okada, K. Fujimura (2000)):

It is an improved method of TRADE. It classifies neighbors and in each group a subset of member are permitted to relay. This improves bandwidth utilization but some overhead and redundancy occurs. Overhead occurs when selecting a relay vehicle in every hop.

Cluster Based Broadcasting

Selective Reliable Broadcast (A. M. Vegni, A. Stramacci, E. Natalizio(2012)):

It selects only one node to rebroadcast the message within the cluster. If the distance between the nearby vehicles is lower than a threshold value, the two vehicles belong to the same cluster, otherwise it belongs to different clusters. After detecting multiple clusters, the source node elects furthest vehicle inside each cluster as the cluster head. It works especially efficiently on highways.

Cluster based efficient broadcast (A. D. Ghodrati (2013)):

It is designed for unilateral streets. It consists of two phases: a setup phase and steady state phase. The setup phase creates two clusters one on front and one on rear based on speed and direction of the vehicle. The faster vehicle in the front cluster is elected as cluster head and the slower in the rear cluster is elected as cluster head. Steady state phase selects new cluster heads according to the following rules.

The vehicle that is farthest from the current cluster head is elected as the new cluster head. The vehicle which moves faster in the front cluster is elected as cluster head or the vehicle which moves slower in the rear cluster head or the vehicle that receives fewer messages is selected as the next cluster head. It reduces delay rate.

Dynamic back bone Assisted MAC (. Bononi, M. D. Felice, S. Pizzi(2009)):

DBA-MAC is a cluster based broadcasting protocol creates a dynamic backbone based on cross layer MAC approach inside vanet. The creation of backbone and maintenance are proactively performed, aiming to balance stability of backbone connections as well as the cost/efficiency trade off and hop reduction when forwarding broadcast messages. It guarantees a high deliver ratio and provide channel utilization.

Topology Based Broadcasting

Topology based broadcasting protocols use network topology information such as node density and link connectivity to perform packet forwarding. Some of the topology based broadcasting schemes are listed below.

DV-CAST: Distributed Vehicular Broadcast (O. K. Tonguz, N. Wisitpongphan, F. Bai (2010)):

It is a distributed broadcast protocol that relies on the local connectivity information provided by single hop behaviors via periodic beacon messages. It is especially robust against very sparse traffic conditions. When there can be a network disconnection. In this case it will take the message till the vehicle is connected to other vehicles. The vehicle counts the number of vehicles in its transmission ranges using a counter of received hello message, and then it calculates the density. It calculates the distance from current forwarder to itself. The waiting time is determined by the contention window in 802.11p mac protocols to assign different waiting time from the reception to rebroadcasting the message.

Spanning Tree based broadcasting (B. Muthamizh, S. S. Sathya, M. Chitra (2014)):

It is a spanning tree based broadcasting protocol which will disseminate the emergency messages to all nearby vehicles in that accidental zone. The goal is to reduce the duplicate message flooding problem and end to end delay also improving the packet delivery ratio. The vehicle becomes the source vehicle, and decides which vehicle by executing prim's algorithm for finding the minimum cost spanning tree of the network within its radio range.

Vehicle Density based forwarding (J. Huang, Y. Huang, J. Wang (2014)):

It adaptively selects the forwarder based on the vehicle density to achieve the tradeoff between contention delay and forwarding hops. It selects forwarder with an optimal hop distance according to vehicle density. Each vehicle uses the hello messages to inform its neighboring vehicles to detect vehicle density in its transmission range.

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Location Based Broadcasting

Location based broadcasting protocols spread messages to a specific geographic region. In these protocols, the vehicles will calculate the additional coverage ranges based on their current location. If the coverage area is less than a threshold, the vehicle does not broadcast the message. Some schemes are listed below.

Urban Multi hop broadcast (UMB) (G. Korkmaz, E. Ekici, F. Özgüner, Ü. Özgüner (2004)):

It is designed to handle broadcast storm, hidden node and reliability problem of multi hop broadcasts in urban areas. It splits the road sectors inside the transmission range into various segments and selects a vehicle in the furthest non empty segment. When there is an intersection in the message dissemination path, the repeaters located in the transmission perform new directional broadcasts.

Location Division Multi Access (R. Mangharam, R. Rajkumar, M. Hamilton, P. Mudalige, F. Bai(2007)):

It employs tightly coupled synchronization with GPS time to temporal slot schedules and spatial cell resolutions in the regional map via an out of band control channel. A vehicle in an active cell is allowed to broadcast a message by scheduling spatial cells like pipelining communication cells

adjacent to the active cell are inactive and vehicles in them are in receiving mode. In the next time slot, the active cells are at a different spatial location. It can reduce the number of collision due to concurrent transmissions.

Ad hoc Multi hop Broadcast (G. Korkmaz, E. Ekici, F. Ozguner (2006)):

It is ad hoc extension of urban multi hop broadcast protocol. It does not demand repeaters which are impossible to keep in roads. Instead, the vehicle closest to the intersection performs new directional broadcast to all road segments through fully ad hoc algorithm.

Distance based Broadcasting

In distance based broadcasting protocols, vehicles use the relative distance to select the vehicles for broadcasting. Each vehicle is having inbuilt GPS device within it using that it can able to determine the signal strength of a neighbor vehicle. Some of the distance based broadcasting schemes are listed below.

Distance Defer Transmission (M.-T. Sun, W.-C. Feng, T.-H. Lai, K. Yamada, H. Okada (2000)):

In DDT, the vehicle which is far from the source vehicle will be treated as the broadcasting border vehicle. The border vehicle can transmit messages by using the shortest delay time. The delay time is inversely proportional to the distance of the sender vehicle. Each vehicle determines its own delay time by using the distance to the sender vehicle.

Optimal ODAM- based Broadcast (W. Sun, F. Xia, J. Ma, T. Fu, Y. Sun (2012)):

It improves the packet delivery rate by two mechanisms based on forwarding features of it. By considering angles between source nodes, forwarding nodes, and receiving nodes, it reduces possibility of packet loss. The second mechanism guarantees the packet success delivery ratio by increasing the redundancy of forwarding nodes.

Optimal Multi hop Broadcast (A. Benaidja, S. Moussaoui, F. Naït-Abdesselam (2013)):

It operates similar to distance defer transmission. The farthest vehicle is selected as the broadcasting vehicle. The aim of the forwarding vehicle is to cover the maximum geographical area that was not covered by the source vehicle. The only difference between DDT and optimal multihop broadcast is, it modifies the formula used to calculate the waiting time value.

Cut Through Rebroadcasting (P. Akkhara, Y. Sekiya, Y. Wakahara (2009)):

It gives highest priority to the farthest vehicle from the source in its transmission coverage range to reduce the number of forwarding nodes. In CTR, each vehicle has two transceivers. Each operates in different channels to avoid collision during broadcasting.

Multi hop Vehicular Broadcast (M. N. Mariyasagayam, T. Osafune, M. Lenardi (2007)):

It is another form of flooding which uses the positions and the velocity of the vehicle and the angle of the transmission sector. This can be through two steps: By altering the shape of the back time region and by introducing a new dynamic scheduling algorithm. Back time algorithm used to detect the opt vehicle to broadcast based on its relative position from the sender by changing the angle of the sector. Dynamic scheduling algorithm sets the delay time of each vehicle inversely proportional to the distance of the sender vehicle.

Probability based Broadcasting

The probability based broadcasting protocols uses a predefined fixed probability to choose the relay vehicle for rebroadcasting. These protocols work well with dense areas in which multiple vehicles having same coverage. Some of the schemes of probability based broadcasting schemes are listed below.

Optimistic Adaptive probabilistic broadcast (H. Alshaer, E. Horlait(2005)):

It uses the rebroadcast probability of the vehicles that regularly changes with number of the vehicles within two hops. It uses beacon messages to get local density and then using the calculated density value it calculates the forwarding probability. In this protocol, more number of vehicle, larger the probability value calculated. Vehicle with larger probability value are assigned a shorter delay time.

Reception Estimation Alarm Routing (H. Jiang, H. Guo, L. Chen (2008)):

It uses the reception probability to select next reception based on the theory model of wireless channels. In Rear, to participate in relay selection, only vehicles in the message propagation direct calculate its reception proportional to its reception probability. The vehicle with least contention delay will be selected as the relay vehicle.

CONCLUSION

Broadcasting is a best way of communicating to vehicles to disseminate safety messages. This paper summaries various broadcasting protocols for vanets. All categories of broadcast protocols are analyzed and evaluated through simulation. The performance completely depends on the parameters such as terrain environment, maps, mobility model, speed of the vehicle and so on. There is no general framework that exists to consider all these parameters for the performance evaluation of broadcasting protocols. So researches can be done to form a general common simulation framework that will improve the reliability and performance of the protocols. This study gives clarity about the things what one should consider when designing a new broadcasting protocol for vanet.

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