Broadcast protocols deployed in wireless VANET networks

Abstract—In Vehicular ad-hoc networks (VANETs), multi-hop wireless broadcast communication is an essential component on which many applications employed in vehicles are built. To use wireless broadcast efficiently, the well-designed protocols play a key role. If the protocol is rational, during the broadcast communication, higher reachability and less bandwidth consumption of vehicles can be accomplished. Here, by analyzing and comparing different protocols, the statistical broadcast protocol is proved to be suitable to VANET broadcasting. The performance of the statistical broadcast protocol depends heavily on the value of the decision threshold which is affected by node density, spatial distribution pattern, and wireless channel quality. To compute the threshold value with these three factors, this protocol adapt various traffic scenarios and have high reachability and low bandwidth consumption. Lastly, a potential problem, which is to determine the precise value of channel quality is posed. The problem remains to be solved by future research.

1. INTRODUCTION

Vehicular ad-hoc networks (VANETs) are wireless networks that enable vehicles to communicate with each other to share information, get road condition, utilize multimedia applications and avoid traffic accidents. The vehicles on road such as cars, buses or vans are treated as nodes in VANET which move in all directions with various speeds. Based on the dynamic characteristic of nodes in VANET, the moving nodes may establish the communication paths and topologies with other vehicles or road infrastructures frequently, as well as often disconnect or re-connect to the VANET, which makes the topology of the VANET networks changes correspondingly. Due to the frequent changing of topology, the nodes which often join, disconnect or re-connect into the VANET networks through various new paths may suffer the relatively low performance such as low throughput, data transformation delay or high overhead. That poses a challenging task to design effective routing protocols to guarantee the communication quality in VANET.

Various routing protocols has been utilized in VANET, in these protocols, multi-hop broadcast routing protocol plays a critical role (Samara & Alsalihy, 2012). For many applications employed in vehicles are built on multi-hop wireless broadcast communication, it is an essential component in VANET (Tseng, Ni, Chen and Sheu, 2002). Obviously, by simple flooding, messages are also able to reach all nodes in certain network. However, since radio signals are likely to overlap with others in a geographical space, a straightforward broadcasting by flooding is commonly extraordinarily costly and will cause serious bandwidth redundancy, contention, and collision, to which is called the broadcast storm problem. By contrast, under the rational protocols, during broadcast communication, several schemes are designed to reduce redundant rebroadcasts and differentiate timing of rebroadcasts to moderate this broadcast storm problem. By employing well-designed broadcast protocols, higher reachability and less bandwidth consumption of vehicles in VANET can be accomplished.

2. SCOPE & METHOD

The paper emphasize on describing the well-designed broadcast protocols to guarantee higher reachability and less bandwidth consumption of vehicles in VANET broadcasting. The method this paper employed is to search relevant articles according to key words represented the research area from various databases, such as Google scholar. Among the searched journals, based on the times the journal has been cited, choose the core journals (which are cited for many times and are relevant to the research area) to conduct research. If the journal has been cited for many times, which means it is an authority journal or with high quality. After the core journal has been chosen, from the related work or the reference materials it presents, the relevant information concerning the research area is able to get. Thus I could analyze and synthesize the knowledge of this research area to draw conclusion.

3. REVIEW

Wireless broadcasting methods can be categorized into statistical and topological methods (Slavik & Mahgoub, 2010). As long as the network is connected, topological protocols are able to provide full coverage of a certain network. These topological protocols utilize as well as exchange the knowledge of the identity of nodes in the 2-hop neighborhood, which is called network topology, to enable each node in networks to know all their 2-hop neighbours, and then decide whether to retransmit the message received or not based on those data, thus topological protocols accomplish the full reachability of all nodes in network. The merit of topological protocols are that compared with simple flooding, these protocols reduce broadcast redundancy while provide reliable coverage of whole network (Lou & Wu, 2007). However, topological protocols have some shortcomings. For vehicles move at various speeds in all directions, the network topology and node density changes frequently. For example, in such scenario of a highway, the neighbors that proceed in the same direction of one vehicle are relatively constant, while the vehicles that move in opposite direction change rapidly. In this situation, large amount of the topological data are required to form accurate network topology as well as to renew neighbour information promptly. Thus vehicles in VANET need highly variable topology information, which will increase the transmission messages and consume more bandwidth.

On the other hand, statistical broadcast protocols, due to their simplicity, have been employed in many VANET applications as primary data delivery methods. Under statistical protocol, the threshold value is the key component which is influenced with many factors such as node density, distribution pattern and channel quality. Nodes in VANET collect and compute the nearest distance to all the retransmitting neighbours and decide whether to retransmit the received broadcast message or not. If the distance value is higher than threshold value, the broadcast message should be retransmitted by this node; otherwise the message should not be rebroadcasted (Slavik

& Mahgoub, 2011). The main difference between statistical and topological protocols is that statistical protocols do not need changing neighbour information to decide whether to rebroadcast the message or not. By contrary, statistical protocols simply need local variables to make the decision, which will reduce the bandwidth consumed. Furthermore, topological protocols require neighbour information and relevant identifiers to establish topology network. During the process of gathering and exchanging information, if the privacy is required to protect, some extra security method must be introduced into the topological protocols to guarantee the privacy security as well as to ensure the nodes in network are untraceable. To guarantee the privacy, some extra work should be fulfilled in topological protocols. By contrast, statistical protocols broadcast messages without exchanging identifying information, therefore are able to accomplish application privacy requirements more easily. Nevertheless, statistical protocols also have downside. Statistical protocols are stochastic in nature and usually cannot be proven to always cover full network, which means, it is unable to ensure all the nodes in VANET which use statistical protocols can gain full reachability.

For nodes in VANET are highly mobile, the topological protocols, which need up-to-date neighbour information, are not suitable to the scenario that the vehicles moves rapidly. Moreover, many VANET applications emphasize the privacy issues, which need extra workload for topological protocols. According to the characteristics of the two kinds of protocols, statistical protocols, the protocols that do not need or exchange neighbour information, are preferable to topological protocols in VANET broadcasting.

As the paper has mentioned, simple flooding approach is able to accomplish broadcasting messages. Unfortunately, flooding would result in broadcast problems such as redundant rebroadcasts, contention and collision. When a mobile host or node retransmits one broadcast message to its neighbors, all its neighbors already have the message, which causes redundant rebroadcasts. In addition to that, when some neighbour nodes which are clustering together receive one broadcast message and all of them decide to broadcast it, these transmissions may seriously contend with each other. Because of the lack of backoff-timer mechanism and the absence of collision detect, collisions are more likely to occur and cause more damage. In the fundamental statistic methods such as counter-based, distance-based and location-based methods, some schemes are introduced to alleviate broadcast problems (Tseng, et al., 2002).

Under counter-based scheme, before the received message is transmitted by one host, the host may hear the same broadcast message sent from other neighbours. With the number of times that the same message has received increases, the relative expected additional coverage of this host decreases. When the coverage of the host is lower than a threshold value, the broadcasting from this host is prevented.

Under distance-based method, suppose a host A receives a broadcast message from other host B for the first time. If the distance between two hosts is relatively small, which means additional coverage that host A may supplied is correspondingly little. If distance is larger, the additional coverage would increase. It is important to choose a threshold value to decide the activity that the host would do after it hears a broadcasting message. If the distance is larger that threshold value, the broadcast message should be retransmitted, otherwise not.

Under location-based scheme, the more precise additional coverage can be derived by collecting the location information between various nodes. Such method may be provided by positioning devices such as GPS (Global Positioning System) receivers. When the host that receives the retransmitted message from its neighbour, by getting location information from GPS at the same time, it is more easily to calculate the distance between them, thus the more accurate additional coverage can be estimated. If the coverage is smaller than threshold value, the host is not allowed to retransmit the broadcasting message.

It appears that fundamental statistic approaches to moderate the broadcast storm problem are to prevent certain hosts from rebroadcasting to reduce the possibility of redundancy, and together with that, contention and collision. To accomplish that, an appropriate threshold value is crucial. If the distance between the sender host (which retransmits the broadcast message) with receiver host (which hears this message) is lower than the threshold value, the receiver host is prevented to rebroadcast message.

In these approaches, the key is to design a threshold function to get the optimal threshold value, which enables relatively the highest reachability and the lowest bandwidth consumption for all nodes in VANET. If the threshold value is too low, then two nodes that are close to each other would retransmit same message, which cause many redundant messages. If the threshold value is too high, then some nodes in network may not receive the broadcast messages. So the appropriate threshold value is very important. The fundamental statistic schemes are much better choices than flooding, for they are capable of getting rid of most redundant rebroadcasts under various host distributions without reduction of reachability.

Though the fundamental statistic methods are able to alleviate the broadcast problems, they merely concern about the distance factor to decide whether to rebroadcast the message or not. Other crucial factors such as node density, distribution pattern and channel quality are not considered (Slavik, Mahgoub & Rathod, 2011). In different scenarios, these factors are differentiated. For example, in urban area, many vehicles are clustered close to each other, and various buildings, especially ones covered by glass materials, may reflect or refract the broadcast signals, which would make the signals interfere with each other to suffer the fading. In this scenario, node density is high, distribution pattern is two-dimension and the channel quality is low. On the other hand, under a two-lane highway scenario, the vehicles with little signal interference are distributed uniformly in one-dimension area, thus the node density is low, distribution pattern is one-dimension and the channel quality is relatively high. Compared with fundamental statistic methods, all these factors are considered in statistical broadcast protocols (Tonguz, Wisitpongphan, Parikh, Bait, Mudaliget & Sadekart, 2006). In these protocols, similar to fundamental statistic methods, the key is to design a threshold function to get optimal threshold value. However, the node density, distribution pattern and channel quality are variables of the threshold function to compute the optimal threshold value, which enables statistical broadcast protocols to adapt to different traffic scenarios with high reachability and low bandwidth consumption. For each node in VANET, after computing the threshold value with three factors (node density, distribution pattern and channel quality) and getting the distance from the nearest neighbour that rebroadcast the message, the node would retransmit the broadcast message to all its neighbours provided the distance value is larger than threshold value. By using this protocol, under various traffic scenarios, almost all vehicles in VANET are able to get broadcasting messages without redundant rebroadcasts (Slavik & Mahgoub, 2013).

4. INTERPRETATION & CONCLUSION

The article describes that in different circumstances, through employing well-designed broadcast protocols, higher reachability and less bandwidth consumption of vehicles in VANET can be accomplished. In VANET, using broadcast transmission to either discover a route or disseminate information plays a key role (Samara & Alsalihy, 2012). Many VANET applications are built on broadcasting transmission (Tseng, et al., 2002). Wireless broadcasting methods can be classified into statistical and topological methods (Slavik & Mahgoub, 2010). Through comparison with statistical and topological methods, statistical methods are preferable for the topological protocols are not suitable to the characteristic of VANET, which is that nodes in it are highly mobile. Based on designing threshold function, the fundamental statistic methods can alleviate the broadcast problems occur in simple flooding (Tseng, et al., 2002). However, fundamental statistic methods pay little attention on node density, distribution pattern and channel quality. In different traffic circumstances, fundamental statistic methods may not adapt well. Statistical broadcast protocols are proposed to take these three factors into consideration (Tonguz, et al., 2006). By determining the optimal threshold value with node density, distribution pattern and channel quality, statistical broadcast protocols can adapt to different traffic scenarios with high reachability and low bandwidth consumption (Slavik & Mahgoub, 2013). Among the three factors, node density and distribution pattern are easily collected and computed. However, the precise value of channel quality is hard to measure and calculate. If the value is not accurate enough, it would influence on the results of statistical broadcast protocols. Future research should emphasize on computing the precise value of channel quality to improve the performance of the statistical broadcast protocols.

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