Broadcast protocols used 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. If the wireless broadcast protocol is rational, during the broadcast communication, higher reachability and less bandwidth consumption of vehicles can be accomplished. By analyzing and comparing different protocols, the statistical broadcast protocols are proved to be suitable to VANET broadcasting. The performance of the statistical broadcast protocol depends heavily on the value of the decision threshold. In traditional statistic protocols, the threshold values are only determined by the distance to the nearest neighbour, which causes the problem that the protocols are difficult to choose appropriate threshold value in various traffic scenarios. In practice, the threshold value is also affected by node density, spatial distribution pattern and wireless channel quality. In this study, by computing the threshold value with these three factors, the improved statistic protocol is able to adapt various traffic scenarios together with high reachability and low bandwidth consumption. The tool SWANS is used to simulate the process in which nodes broadcast messages. The simulation results are used to design and improve threshold function for the improved protocol.

Index Terms—wireless broadcast, statistical broadcast, traffic scenario, SWANS, VANET

1. INTRODUCTION

Vehicular ad-hoc networks (VANETs) are wireless networks that enable vehicles to communicate with each other to share traffic information 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. The frequently changing topology of VANET networks poses a challenging task to design effective routing protocols to guarantee the communication quality in VANET (Rani & Gill, 2012).

Various routing protocols has been utilized in VANET, in these protocols, multi-hop broadcast routing protocol plays a critical role (Samara & Alsalihy, 2012). 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 broadcast by simple 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 wireless broadcast methods are designed to reduce redundant rebroadcasts to moderate this broadcast storm problem.

Wireless broadcast methods can be categorized into statistical and topological methods (Slavik & Mahgoub, 2010). The merit of topological protocols is that compared with simple flooding, these protocols reduce broadcast redundancy while provide reliable coverage of whole network (Lou & Wu, 2007).

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 mainly influenced by the distance to the nearest neighbour node that transmits the broadcasting message (Slavik & Mahgoub, 2011). Nodes in VANET collect and compute the nearest distance to all the retransmitting neighbours and decide whether to retransmit the received broadcasting message or not. If the distance value is higher than threshold value, the broadcasting message should be retransmitted by this node; otherwise the message should not be rebroadcasted.

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 methods must be introduced into the topological protocols to guarantee the privacy security as well as to ensure the nodes in network are untraceable. By contrast, statistical protocols broadcasting messages without exchanging identifying information therefore are able to accomplish application privacy requirements more easily. 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 broadcast.

In statistical protocols, the traditional methods are the fundamental statistic methods including counter-based, distance-based and location-based methods (Tseng et al., 2002). The basic idea of these traditional statistical methods is: Suppose a host A receives a broadcasting message from other host B for the first time. If the distance between two hosts is relatively small, which means additional coverage area that host A supplies is correspondingly small. If distance is larger, the additional coverage area of A would be larger. It is important to choose a threshold value to decide the activity that the host would do after it hears a broadcasting message. Provided the distance between the sender host B (which retransmits the broadcast message) with receiver host A (which hears this message) is lower than the threshold value, the receiver host is prevented to rebroadcast message.

In the traditional statistical methods, 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 (Tseng et al., 2002). 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 rebroadcast messages 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 (Slavik et al., 2011). This feature of the fundamental statistic methods may cause the problem that the methods are difficult to choose appropriate threshold value in various traffic scenarios therefore are not able to adapt to different traffic circumstances. This study aims to solve this problem.

2. OBJECTIVES

In different traffic scenarios, the crucial factors including node density, distribution pattern and channel quality 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 should be considered in statistical broadcast protocols (Tonguz et al., 2006).

Similar to fundamental statistic methods, the key is to design a threshold function to get optimal threshold value. Therefore, the node density, distribution pattern and channel quality are measured as variables of the threshold function to compute the optimal threshold value, which enables statistical broadcast protocols to adapt to different traffic scenarios. 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 (Slavik & Mahgoub, 2013). By using this improved protocol, under various traffic scenarios, almost all vehicles in VANET are able to get broadcast messages without redundant rebroadcasts.

3. METHODOLOGY

There are some existing famous network simulators utilized to simulate wireless broadcast protocols with all essential details, such as ns2, GloMoSim and SWANS. In these simulators, the SWANS is the most appropriate simulator for my study for it is able to model signal propagation efficiently in scalable wireless simulation. By using SWANS, during simulation, when a traffic node needs to retransmit a signal, the

SWANS would deliver that signal to all nodes that could be affected, after considering fading or path-loss. In SWANS, the small subnet within the range of one node's transmission radius will receive the rebroadcast messages sent from this node, which is suitable for my study (Martinez et al., 2011). Accordingly, I utilized the SWANS to simulate the process in which nodes in one network broadcast messages in different traffic scenarios by using the improved statistic protocol. The simulation results include reachability for all nodes in network, rebroadcast rate per covered node, bytes sent per covered node and so on. These results reflect the reachability and bandwidth consumption of nodes in broadcasting messages under the improved statistic protocol. By modifying the threshold function and therefore improving the threshold value, based on the simulation results, the higher reachability and lower bandwidth consumption would be accomplished. Thus I could establish and modify the threshold function to enable the improved statistic protocol to get relatively good performance.

4. NOVELTY

Compared with the fundamental statistic methods, the improved statistic protocol takes node density, distribution pattern and channel quality into consideration. Simply count the number of neighbours, the node density is easy to get. However, it is difficult to measure the value of distribution pattern and channel quality. To compute the distribution pattern, the study introduces the quadrat method to characterize the node distribution pattern. By using quadrat sampling method, the number of neighbours within various random nodes' transmission radius can be derived, which follows a Poisson distribution pattern. For the characteristic of Poisson distribution is that the mean is equal to variance, the parameter Q, which is ratio of the variance to mean is introduced to characterize the spatial distribution pattern. If Q is smaller than one, which means nodes are evenly spaced. If Q is bigger than one, which means nodes are clustered together with each other. If Q is equal to one, which means nodes are spaced normally. Thus the value of distribution pattern can be measured (Slavik & Mahgoub, 2013).

On the other hand, in others' study, the Rician fading has been used to measure the extent of signal fading (Boban et al., 2011). In this study, the fading intensity can be quantified by using Rician fading method. Thus the parameter K is introduced to measure the channel quality. The bigger K is, the better the channel quality is. Normally the value of K is from 0 to 20. Then all the variables are able to be measured and computed to get the appropriate threshold value for improved statistic protocols.

5. CONCLUSION & SIGNIFICANCE

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. Wireless broadcasting methods can be classified into statistical and topological methods. Through comparison with statistical and topological methods, statistical methods are preferable. Based on designing threshold function, the fundamental statistic methods can alleviate the broadcasting problems occur in simple flooding. 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. Improved statistical broadcast protocols are proposed to take these three factors into consideration. By using quadrat sampling method and Rician fading model, the factors distribution pattern and channel quality can be measured. By determining the optimal threshold value with the three factors, statistical broadcast protocols can adapt to different traffic scenarios with high reachability and low bandwidth consumption. Among the three factors, node density and distribution pattern are easily collected and computed. Nevertheless, the precise value of channel quality is relatively hard to measure. If the value is not accurate enough, it would influence on the results of improved 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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