AN EFFICIENT ROUTING WITH CONGESTION CONTROL PROTOCOL FOR MULTIHOP BROADCAST ROUTING IN VANETS

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Abstract— Vehicular Ad-Hoc Networks (VANET) helps to improve the traffic safety by exchanging information between each other and hence the drivers can prepare for a dangerous situation. The Routing protocol for multihop broadcast helps to provide efficient routing in broadcast communications. This protocol has some routing overhead in different network scenarios. Here in the proposed method the network traffic is reduced using the congestion control mechanism and it performs well as compared with the existing protocols. The proposed protocol is simulated using NS2 simulator to analyze the efficiency and effectiveness of the protocol.

Keyword - Broadcast, VANET, Congestion Control

I. INTRODUCTION

VEHICULAR ad hoc networks (VANETs) can be used to alert drivers of traffic jams ahead, help balance traffic loads, and reduce traveling time. It can also be used to propagate emergency warnings to drivers already taken place.

VANETs have particular features like: distributed processing and organized networking, a great number of nodes, the distribution and the speed of these nodes, a constrained but highly variable network topology, communication conditions and mobility patterns, signal transmissions blocked by buildings, frequent partition due to the high mobility, and finally there are no significant power constraints.

In VANET broadcast is a frequently used method. Possible applications relying on broadcast include sharing emergency, traffic, weather, road data among vehicles, as well as delivering advertisements and announcements.

MULTIHOP wireless broadcast plays an impORTANT ROLE IN THE wireless systems. AODV and DSR, use broadcast method to discover routes from a sender to receiver. Broadcast storm problem addresses in the retransmission of packets will attenuate the broadcast performance as a result of collisions and congestion. There exists number of VANET applications uses broadcast for communication.

Wireless broadcasting methods can be classified into At least statistical and topological methods. Topological protocols use the network topology to select nodes to forward broadcast messages. The key advantages of topological protocols are that they reduce broadcast redundancy in a way that is agnostic to node distribution and they can be proven to not degrade reachability compared to flooding, provided communications are perfectly reliable.

Statistical broadcast protocols typically do not use rapidly changing neighborhood information. Statistical protocols measure the value of one or more locally available variables and make a decision to rebroadcast based on the measured value and a cutoff threshold. For example, the statistical method used in this work, the distance method, measures the distance to the nearest neighbor from which a node has received the broadcast message. If that distance is greater than a threshold value, then the node rebroadcasts the message. The threshold value is calculated as a function of more slowly changing topological factors such as node density and spatial distribution pattern.

This protocol combines local spatial distribution information and other factors with the distance method heuristic to select rebroadcasting nodes. This paper combines a congestion control mechanism with the Routing protocol and results an efficient routing method for broadcasting. We develop a simple yet generic congestion control mechanism which pro-actively detects and mitigates congestion in order to maintain the desired reliability requirements.

An optimal value of the threshold must be found that gives the best efficiency possible without sacrificing reachability. A main objective of this work is to demonstrate how to design a threshold function that is adaptive to a wide range of these factors. The proposed design scheme builds a threshold function using three independent input variables chosen to allow the threshold to be adaptive to the environmental conditions of primary interest. These variables measure local node density, the distribution pattern of nearby nodes, and the wireless channel quality. Thus, the resulting threshold function of these three inputs causes the protocol to operate efficiently across a broad range of conditions.

The rest of the paper is organized as follows. Section 2 presents the related work followed by Section 3 detailing the system design and algorithms an the congestion control scheme. We evaluate protocol in Section 4. Our conclusions and directions for future work appear in Section 5.

II. RELATED WORKS

Unlike other forms of MANETs, applications developed for VANETs have a very specific and clear goal of providing intelligent and safe transport systems. Emergency warning for public safety is one of many applications that is highly time-critical and requires a more intelligent broadcast mechanism than just blind flooding. Multihop broadcast in VANET mainly supports two types of broadcast applications. One type is safety application such as Collective Collision Avoidance (CCA) where in the event of an emergency an alert message is propagated as quickly as possible into oncoming traffic. Broadcast protocols for these applications are usually designed to propagate messages in one or two directions with high reliability and minimum latency.

In congestion control, the major focus is on the detection and mitigation of congestion. The existing approaches limit information rate to mitigate the congestion which may not be desired for fulfilling the application requirements. All these works consider that if the path is congested, the whole network is congested which may not be the case. These approaches require feedback from the sensor nodes, which results in an extra network overhead. Moreover, none of these approaches focuses on the tunable reliability. Our approach provides reliability and mitigates congestion proactively before it actually happens by monitoring the incoming and outgoing information across sensor nodes.

There are few works in this area which consider both reliability and congestion control. The Event to Sink Reliable Transport (ESRT) protocol achieves reliability by adjusting the reporting rate of sensor nodes depending on the current network load. Upon congestion detection sensor nodes inform the sink for appropriate reaction. This approach may not reflect the current status of the network appropriately thus resulting in
wastage of network resources. Our work provides tunable reliability at the hop level, whereas ESRT provides best effort end-to-end level reliability which is difficult to maintain, especially in large scale WSN. Each sink receives either low or high priority information based on its role. The proposed algorithms degrade the low priority data by suppressing them to forward high priority data. Our approach provides tunable reliability compared to existing protocol which provides only two levels. Also we provide equal opportunity for all information to transport towards the single sink, however under different reliability guarantees.

III. PROTOCOL DESIGN

Wireless broadcasting methods can be divided into at least statistical and topological methods. Statistical methods use a priori knowledge of the impact of an external variable present at each node to decide whether or not to rebroadcast. These methods share a common framework where nodes measure the value of the variable at their location, calculate a threshold value, and make a rebroadcast determination based on whether or not the value of the variable exceeds the value of the threshold. Here, used a technique called the distance method that is designed to select nodes to rebroadcast that will add the most coverage area.

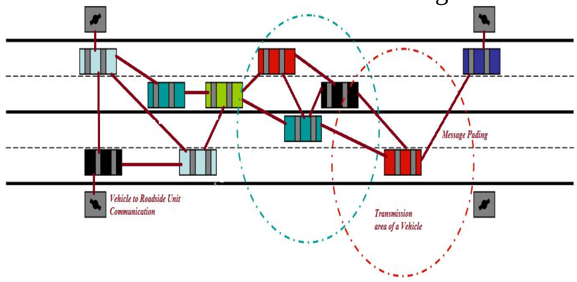

Fig 1: Transmission path of Routing protocol

3.1 Routing Protocol

This protocol utilizes the distance method to select forwarding nodes. The distance method uses the minimum distance from sender to receiver (one-hop distance) as the variable of discrimination between rebroadcasters and nonrebroadcasters. The method appeals to the intuition that if a node has received a message from another node very close to it, there is little benefit in terms of additional coverage achieved by rebroadcasting. Nodes then should favor rebroadcasting when this distance is large.

The key to any statistical broadcast protocol is the decision cutoff, in this case Dc. If the value is set too high, reachability will be degraded. If the value is set too low, the protocol will not prevent many nodes from rebroadcasting. Thus, protocol behavior exhibits a phase transition relative to Dc. In the supercritical phase, when Dc is less than the critical value, reachability is nearly one in all simulation runs. Around the critical value, the reachability quickly transitions from one to zero and the variance of the reachability spikes, indicating the reachability is highly variable from run to run. In the subcritical phase, message propagation is suppressed so that only nodes near the source will receive the message. The design tradeoff is with bandwidth consumption. When Dc is set deep into supercritical phase, the protocol will propagate messages to the entire network with high reliability, but it comes at a cost of decreased broadcast efficiency. Our goal then is to set Dc as high as possible while maintaining acceptable reachability.

This optimal value for Dc varies with node density (among several factors). At low densities, Dc must be lower to allow the message to propagate to the entire network. When the node density is high, we can set Dc more aggressively to eliminate excess transmissions.

Here, defines acceptable reachability as broadcast messages are propagated to at least 99 percent of all nodes 95 percent of the time. In previous work, we found that using an exponential curve for Dc(N) provided good performance across the range of N.

This determination was made by empircally finding optimal values of Dc versus N while holding node distribution pattern and channel quality constant. For low node densities, the threshold should be low to allow many nodes to retransmit. As the density increases, the threshold can quickly become more aggressive to prevent unnecessary rebroadcasts.
Therefore use the following general form for the threshold function:

$$Dc(N)=Dmax-\beta e^{\alpha N} \quad (1)$$

The values of the function parameters Dmax ,α , and β depend on external factors such as node distribution pattern and channel quality.
In the wireless broadcast context, when the area being measured (the node's transmission area) and the number of sample points (neighbors) are small, sampling seems to work better than censusing. Thus, results shown here use sampling. Selecting values for the number of samples and the cell size is complicated and does not have a one-size-fits-all solution. Through experimentation, chosen a sample size of 30 and a circular cell with radius r=5 (where r is the transmission radius).
At each node, when the measured value of D (distance to the nearest neighbor from whom the broadcast message has been received) is above the curve, the node will retransmit the message. Thus, higher values of Dc imply that less nodes in the system will rebroadcast. The plots clearly show that increasing N and K causes Dc to increase, indicating that as node density increases or the channel quality improves, less nodes need to rebroadcast. Q is the opposite; as the node distribution becomes more clustered, more nodes need to rebroadcast.
The protocol can then be summarized as follows: For every independent broadcast message, nodes perform the following procedure:

- Calculate d as the distance to neighbor the message was received from, and initialize D =d/r.
- Set a random backoff timer with duration chosen uniformly between 0 and Tmax.
- If the message is received again before the timer expires, calculate d (distance to the sender) and update D=min{D,d/r}. Cancel the timer and go to 2.
- When the backoff expires, calculate t = Dc(N,Q,K) according to (6)-(8) and (1) and rebroadcast if D > t.

For dynamically measuring K, nodes in practice will have several options. First, designers may be aware of a worst case (minimum) value of K that nodes can use in all circumstances. Results show K is almost always greater than 5. Statically employing this value of K, reachability should always exceed the application requirements, provided the true value of K is not less than the assumed minimum. However, since the value of K may often be higher than the minimum, this method may result in excessive rebroadcasts and thus inefficient use of wireless bandwidth.

3.2 Congestion Control Mechanism

In order to provide proactive congestion control each sensor node in the WSN monitors the local network conditions and the information rate across itself. This protocol provides more generic and simple method to precisely measure the information rate at each intermediate sensor node using w1 and w2 Algorithm describes the overall congestion control mechanism. Each sensor node keeps an exponentially weighted moving average (EWMA) w1(t) and w2(t) over a short time window T of the number of messages that it is transporting where α is a weight-factor ranging between $0 < \alpha < 1$. The EWMA approach avoids the wrong node decisions due to sudden or abrupt changes. Based on this the transient congestion (Ct) can be defined as

$$Ct = w1(t) / w2i(t) \quad (2)$$

The ratio of w1(t) and w1(t) is an efficient indicator of transient congestion and is more robust where congestion is detected based on some threshold on buffer occupancy or complex mechanism of timer for incoming and servicing the messages. This protocol requires count of incoming and outgoing messages. If at time t the ratio $w1(t)/w2(t) < 1$, the sensor node detect the presence of congestion due to high information rate, i.e., w2 is higher than w1. On the other hand $w1(t)/w2(t) > 1$ represent low information rate across the node and thus no congestion is observed.
To this end, a set of Nd, Ne as well as Nu is maintained for each sensor node sorted in the order of highest hop reliability across neighbors. More specifically, each Node X maintains the hop reliability R□hop(X,Yi) and hop distance to the sink (h(Yi)) to each of its one hop neighbor Yi. The sensor node which detects the congestion determines the neighbor nodes in Nd and transports the next information in qo to it. Node X traverses the whole set and sends information to each neighbor one by one. If there are no more neighbors to choose from (i.e., Nd = ∅), the nodes from Ne are selected to transport the information. In the worst case if both sets are empty, the information is transported to the neighbors in Nu. This mechanism utilizes only the local knowledge to disperse the information to its neighbors. If Node X selects the neighbor node in Nd it will not change the reliability assigned by the source node, i.e., R□hd since the number of hops remains same for information to travel. If neighbor node is from set Ne or Nu, Node X recalculates the desired hop reliability.

- for each time interval T do
- each node monitors the current w2(t) and w1(t)
- update:

- w2(t) = α · w2(t) + (1 − α) · w2(t − T)
- w1(t) = α · w1(t) + (1 − α) · w1(t − T)
- if |(w1(t)/w2(t))| < 1 then
- organizeNeighbors(); disperseInfo()
- else
- transport(msg, Yi, FALSE)
- end if
- end for
- function organizeNeighbors():
- 1-hop neighbors → Nd,Ne,Nu
- sort Nd,Ne,Nu according to max Rhop
- end function
- function disperseInfo():
- for each information in qo do
- if Nd =∅ then
- select next Yi ∈ Nd; transport(msg, Yi, TRUE)
- else if Ne =∅ then
- select next Yi ∈ Ne
- calculate R▪ hd
- msg.R▪ hd← R▪ hd ; transport(msg, Yi, TRUE)
- else
- select next Yi ∈ Nu
- calculate R▪ hd
- msg.R▪ hd← R▪ hd ; transport(msg, Yi, TRUE)
- end if
- end for
- end function

IV. SIMULATION RESULTS

To evaluate the proposed protocol, Network Simulator-2 (NS-2) is used, which is an open-source network communication simulator that has been used and accepted by many researchers. In NS-2, there are three types of propagation models: (i) free space (ii) two-ray ground reflection and (iii) shadowing propagation. All the propagation models helps to evaluate the protocol under different scenarios.

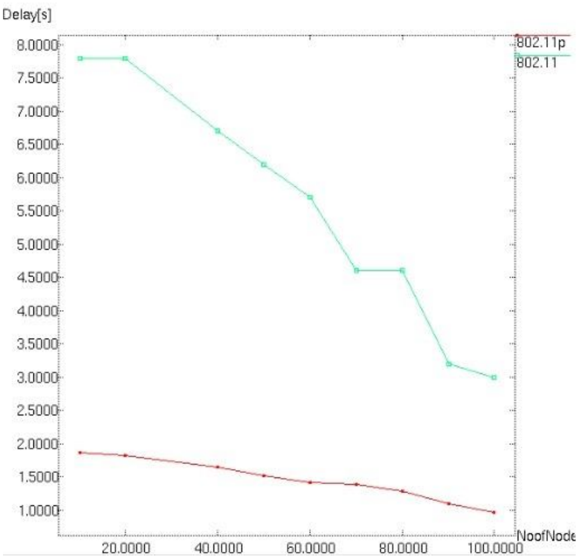

Fig 2. End-to-End delay

The above figure explains how the protocol is minimizing the delay of packet sending as compared to the existing protocols

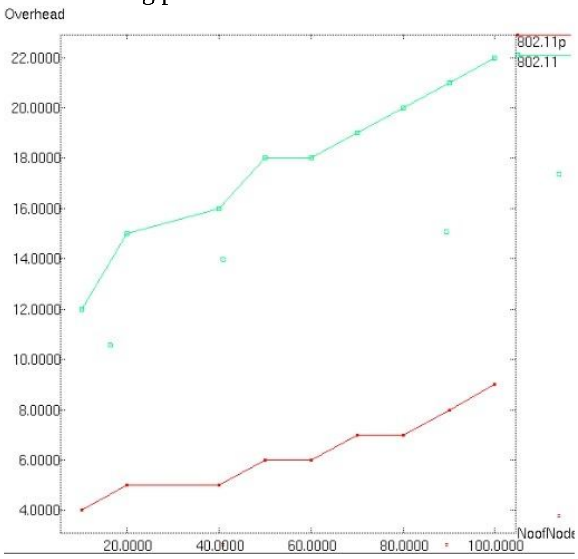

Fig 3. Routing Overhead

Figure 3 explains the Routing Overhead of the protocol based on the existing protocols. The protocol with congestion control mechanism helps to reduce the routing overhead viewed in the protocol.

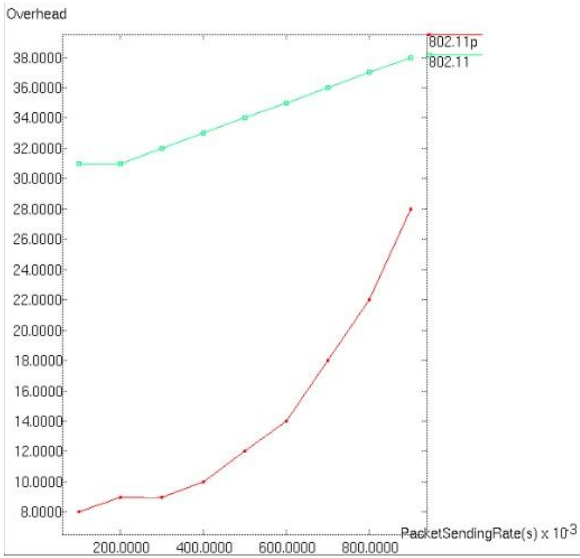

Fig4. Routing overhead with congestion control

The protocol is giving better routing and high packet delivery ratio in the rebroadcasting of messages.

CONCLUSION

The proposed protocol along with Congestion control for multihop broadcasting in VANET performed well as compared to the existing protocols. VANETs exhibit wide variability in node density, distribution pattern, and channel quality. The protocol along with CC adopts the quadrat method of spatial analysis to characterize the distribution pattern at each node. The resulting metric, the Q statistic, is combined with local node density N and the Rician fading parameter K to create a decision surface used by the distance method.

Simulation results with NS-2 demonstrate this protocol along with CC provides high reachability and efficient use of bandwidth in both urban and highway scenarios with varying node density and fading intensity. This protocol along with CC achieves better than 95 percent reachability across all network scenarios while showing efficient use of bandwidth. In most cases, protocols used for comparison either fails to match this level of reachability or do so using a higher level of bandwidth consumption.

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