Spanning Tree Based Broadcasting for VANET

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Abstract— To assure public safety, Intelligent Transportation systems provide different modes of traffic management. Vehicular ad-hoc network not only provides public safety, but also provide other communication between the vehicles. Generally VANET relies on broadcasting emergency messages. Simply broadcasting the messages will lead to congestion and collision in the network which is termed as broadcasting storm problem. Many researches have gone into the process of reducing the broadcast storm problem. While concentrating on alleviating the broadcast storm problem in VANET, time management is also to be considered. Emergency messages must be reachable within the accidental zone in a short period of time. This paper, proposes a Spanning Tree based broadcasting for VANET which effectively reduces the end-to-end delay, latency and considerably improves the packet delivery ratio. The proposed algorithm is implemented in the NS-2 simulator and compared with the best known TLO (The last one) approach and found to perform better. Since the number of rebroadcasts in this spanning tree based algorithm is considerably reduced, the number of collisions also decreases, thereby resulting in an efficient utilization of the network bandwidth.

Keywords — Broadcasting, VANET, Delay, Packet Delivery Ratio, Throughput, ITS, Emergency Messages.

I. Introduction

VANET is a special type of mobile Ad-Hoc Network which is highly dynamic in nature as the nodes here are fast moving vehicles. VANET consists of two types of communication, namely V2V and V2I. It provides a large number of safety information to the drivers. This can be done with the help of sensor and GPS receivers by integrating on-board devices with network interface [1]. It is a technology that uses moving vehicles as nodes in a network to create mobile network. The main purpose of VANET is during an emergency event such as road slippery, breakdown, car accident, traffic congestion etc., wherein an alert message should be sent to the nearby drivers in that particular zone. By means of these alerts further accidents can be avoided and it makes way to rescue the people in the particular zone.

VANET mostly relies on broadcast transmission rather than route discovery to disseminate emergency information to wider geographical areas in a short span of time. The main objective of VANET is to cover the maximum area in a short span with efficient bandwidth utilization. Safety applications would require that each message is delivered to most vehicles in an area within a message lifetime. Multi-hop transmission can be employed to deliver these messages beyond the transmission range of the message source and to increase the message delivery ratio. The issues with existing protocol in the safety alert application are broadcast storm problem, delayed packet delivery, network congestion and network disconnection problem. The broadcast storm problem is caused by flooding of the same messages due to repeated broadcast by the various nodes within the transmission range of each other in a dense traffic scenario. Several nodes rebroadcast the same packet at the same time. These nodes suffer from redundant transmission, channel contention and collision. In the existing system, the vehicle which meets with an accident or any traffic congestion sends an alert message to the nearby driver which again acts as a broadcast node and sends the message to their nearby driver and so on. These messages continue until the farthest vehicle is reached thus avoiding further accidents. The main drawback of the existing system is the duplicate message sent to the drivers of the nearby vehicles from each vehicle because all vehicles in the transmission range of a particular vehicle overhear their neighbours and engage themselves in rebroadcasting the same message multiple times. This makes the system to engulf in network collision causing irritation to the drivers. Some protocols in an attempt to reduce this duplicate message delivery will result in message loss. To avoid this, the proposed algorithm comes with the process of avoiding duplication of messages by means of the spanning tree algorithm. The rest of the paper is organized as follows: Section-2 presents a survey of the related work in Vanet broadcasting. Section-3 deals with the proposed protocol, section-4 highlights the experimental setup and simulation results and section-5 concludes the paper followed by references.

II. Related Work

Broadcasting an emergency message in VANET is more complicated. Since VANET is highly mobile in nature, disseminating emergency messages is highly challenging. In MANET many protocols have been proposed such as AODV, DSR, DSDV, and ZRP. But these traditional protocols does not work effectively in VANET due to its highly dynamic nature. Simple broadcasting is the simplest method to disseminate messages to all the vehicles, but it causes high overhead to the network. It means simply flooding the message to all the vehicles in the network; each and every vehicle in the wireless range of a particular vehicle again rebroadcast the same messages many times. This may cause congestion and that will deteriorate the quality of services. It may result in packet loss and delay. If many node attempts to broadcast the same packet at the same time leading to a collision, it is called as broadcast storm problem.

In the existing system, to reduce the broadcast storm problem, many suppression techniques have been used such as simple broadcasting, weighted p-persistence, and slotted 1-persistence, slotted p-persistence and TLO (The Last One in transmission). They are discussed in the following subsections.

A. Simple Broadcasting

It is the simplest method which is used in safety alert applications for VANET. It will simply send an alert message to all the vehicles just like flooding. When the vehicle receives a broadcast message, it retransmits the same message to all the vehicles, even if the vehicle already receives the same alert message. This will lead to duplication of messages, channel contention and collision.

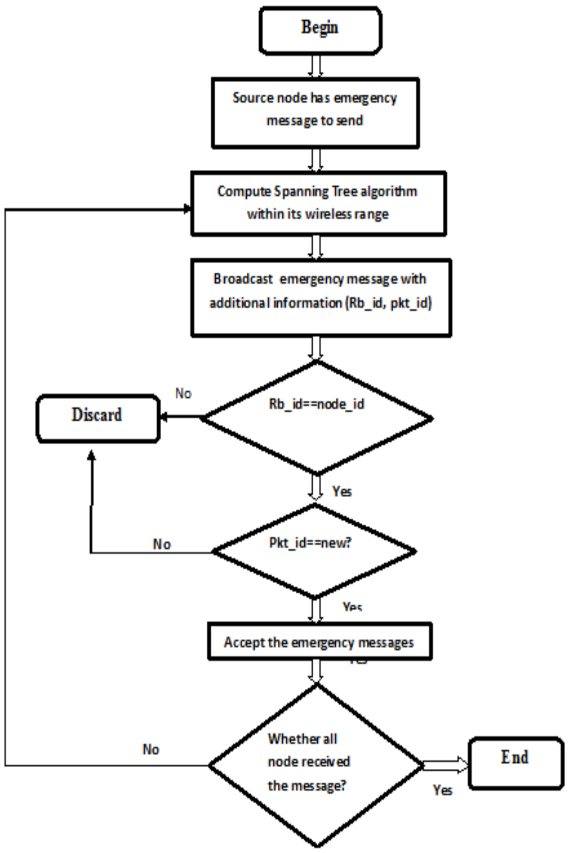
B. Different Broadcast Suppression Techniques

With weighted p-persistence [4], it tries to reduce the broadcast storm problem by using probability to decide the vehicle that will rebroadcast the alert message. When a vehicle receives a broadcast message for the first time, the vehicle will rebroadcast the alert message with a random probability. The main drawback with this method is, it does not have a full answer to avoid broadcast storm, and it just reduces the chance of its occurrence. In, Slotted 1-persistence scheme, upon receiving a packet, a node checks the packet ID and rebroadcasts with probability 1 at the assigned time slot (T) if it receives the packet for the first time and has not received any duplicates before its assigned time slot; otherwise it discards the packet. With p-persistence, upon receiving a packet, a node checks the packet ID and rebroadcasts with the pre-determined probability ‘p’ at the assigned time slot. If it receives the packet for the first time and has not received any duplicates before its assigned time slot; otherwise it discards the packet. In [2], Mongkut, K., & Ladkrabang, T. (2008) proposed TLO algorithm for storm suppression in VANET. In TLO all vehicles which receive an emergency message do not rebroadcast the message immediately. Rather, it uses the TLO algorithm to find the farthest vehicle from the accident vehicle. Only that farthest vehicle will broadcast the emergency message to all the vehicles in the next transmission range. In the above broadcast suppression techniques weighted-persistence, slotted 1-persistence, slotted p-persistence are distance based schemes and TLO is a cluster based scheme. The main drawback of TLO is that, on receiving an emergency message each node has to wait for some threshold time to hear the broadcasting message from the relay node and then proceed for retransmission. So the delay time is high in TLO.

III. PROPOSED SPANNING TREE ALGORITHM FOR BROADCASTING IN VANET

In this paper, we propose a spanning tree based broadcasting scheme which will disseminate the emergency messages to all nearby vehicles in that accidental zone with a goal to reduce the duplicate message flooding problem and end to end delay also improving the packet delivery ratio. When an accident occurs, the victimized vehicle initiates an emergency message. When a vehicle ‘N’ receives a broadcast message from the victimized vehicle, it will compute a spanning tree of the vehicular network within its transmission range. Now ‘N’ is the source node which will decide which node to act as a rebroadcasting node by executing the Prim’s algorithm for finding the minimum cost spanning tree of the vehicular network in its wireless range. In this case, the source node will broadcast an emergency message with additional information such as rebroadcast id (rb_id) and packet id (pkt_id) to the neighbour node, thereby reducing the time taken by each node to decide whether to act as rebroadcasting node or not. At the same time, the receiving node will compare its node_id with rebroadcast_node_id. If it is same then the receiving node checks for the freshness of the packet by using “packet ID”. If it is not new, it simply discards the packet. Similarly, each vehicle follows the above procedure and thereby disseminate the emergency messages to another zone. This algorithm reduces the end to end delay compared with TLO.

During emergency warning services, time plays an important role. By using Spanning tree method the time taken to spread the message to all the vehicles in that accidental zone is also reduced along with a reduction in the message flooding.



INPUT : Emergency message to broadcast,
Number of vehicles, transmission range,
channel type.

OUTPUT: Every vehicle should receive emergency
message with minimal delay to improve
packet delivery ratio

The following Notations are used to describe the algorithm.

Source Node: N_i

Neighbour Node: N_j

Emergency Message: EM

rb_id_i: Geographical position of the shortest discovered node

$node\_id_j$: Geographical position of Node j

When N_i has EM
RUN Spanning Tree algorithm
//Calculate distance between N_i & N_j
Do //within the transmission range of the current
spanning tree
WHILE (N_i is nearest neighbor of N_i)
SEND EM from N_i to N_j
WHILE (N_j Receive EM)
IF (rb_id_i = = $node\_id_j$)
Accept EM
Go to Step2
ELSE
Discard EM
END IF
END WHILE
END WHILE

Fig.1. Flowchart of Spanning Tree Algorithm

Pseudo Code for Proposed Algorithm

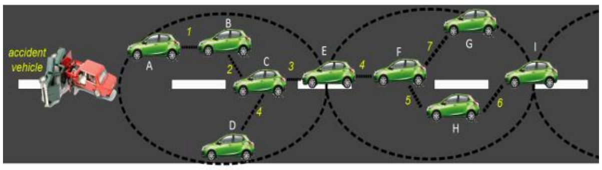


Fig.2. Example Scenario

In fig 2, when a car met with an accident the vehicle (i.e. A) which is nearer to the victimized vehicle will initiate spanning tree of the node within its transmission range, which means it find the rebroadcast node through the spanning tree. It finds the nearest neighbour as a rebroadcast node. In such a case car B is nearer to car A and hence car A broadcasts the emergency message to car B. Emergency message consist of the following contents: rb_id, pkt_id. Before accepting the emergency message, car B checks whether rb_id == node_id. Then car B checks for the freshness of the packet. If both conditions are satisfied, then car B will accept the emergency message and now car B act as a rebroadcasting node. Now car B checks for the nearest neighbour (i.e. Car C). Car B rebroadcast the emergency message to car C. During this rebroadcasting, car A also hears the broadcasting packet, but car A discards the packet since rb_id is not equal to its own node_id. Now car C is the rebroadcasting node. Nearest neighbour of car C is car E and hence it will send emergency message to car E. Car E checks for rb_id, pkt_id and finally accept the emergency message. During this time car E starts rebroadcasting to F and car C rebroadcasts the message to D since it follows the prim's algorithm. The path of transmitting the emergency message is shown in the above fig 2. In this algorithm, though Vehicles B and D are within the wireless range of A and C and they overhear the messages, they do not rebroadcast the message as in other broadcasting algorithms. Hence vehicle E receives emergency message only from one vehicle compared to receiving the message from 3 vehicles. This reduces the message flooding and also improves the packet delivery ratio, also reducing the latency.

IV. PERFORMANCE EVALUATION

The performance of the proposed spanning tree based algorithm is evaluated by implementing it in a simulation environment namely NS2 simulator NS2 is a real Network Simulator and also provides simulation for unicast and multicast routing protocol over wired or wireless network. For mobility in NS2 external utility called setdest[14] has been used. Along with the proposed technique, the competing TLO algorithm with changing node density and mobility of each node has also been implemented. The parameters of the simulation environment are given in table-1. The algorithm is evaluated against TLO based on the following evaluation metrics:

TABLE I
PARAMETERS SETUP

Parameters	Value
Transmission Radius	200
MAC Protocol	802.11
Physical Propagation Model	Wireless
Number of Nodes	5, 10, 15, 20
Simulation Time	200
Vehicle Speed	50, 100, 150, 200
Antenna Type	Omni Antenna
Mobility Model	Random Two Way

A. Evaluation Metrics

- **Packet Delivery Ratio:** The ratio of number of packets delivered to the destination node to the number of packets sent. If packet delivery ratio is high the better the performance of the protocol.
- **Average End-to-End Delay:** The average time taken by the packets to be delivered across the network.
- **Throughput:** The amount of message that can be delivered within the given period of time from one node to another node.

TABLE III
IMPROVEMENT PERCENTAGE OF END-TO-END DELAY BY CHANGING DENSITY OF NODE

Algorithm	End to End Delay			
	Number of Nodes			
	5	10	15	20
TLO	83 %	56 %	59 %	45 %
Proposed Algorithm	27 %	40 %	45 %	36 %

TABLE IIIII
IMPROVEMENT PERCENTAGE OF PACKET DELIVERY RATIO BY CHANGING DENSITY OF NODE

Algorithm	Packet Delivery Ratio (%)			
	Number of Nodes			
	5	10	15	20
TLO	99.7289	99.3767	97.4318	97.3606
Proposed Algorithm	99.7954	99.4710	99.4175	99.4178

TABLE IVV
IMPROVEMENT PERCENTAGE OF END-TO-END DELAY BY CHANGING SPEED OF EACH NODE

Algorithm	End to End Delay			
	Mobility Speed (m/s)			
	50	100	150	200
TLO	81 %	83 %	85 %	71 %
Proposed Algorithm	25 %	27 %	26 %	25 %

TABLE V
IMPROVEMENT PERCENTAGE OF PACKET DELIVERY RATIO BY CHANGING SPEED OF EACH NODE

Algorithm	Packet Delivery Ratio (%)			
	Mobility Speed (m/s)			
	50	100	150	200
TLO	99.6460	99.6337	99.7323	99.7728
Proposed Algorithm	99.7954	99.8312	99.8193	99.8051

TABLE VI
IMPROVEMENT IN THROUGHPUT OF SPANNING TREE BASED ALGORITHM WITH TLO BY CHANGING DENSITY OF NODE

Algorithm	Throughput			
	Number of Nodes			
	5	10	15	20
TLO	324	214	291	432
Proposed Algorithm	429	433	830	1242

TABLE VII
IMPROVEMENT IN THROUGHPUT OF SPANNING TREE BASED ALGORITHM WITH TLO BY CHANGING SPEED OF EACH NODE

Algorithm	Throughput (kbps)			
	Mobility Speed (m/s)			
	50	100	150	200
TLO	325	317	324	333
Proposed Algorithm	430	430	430	430

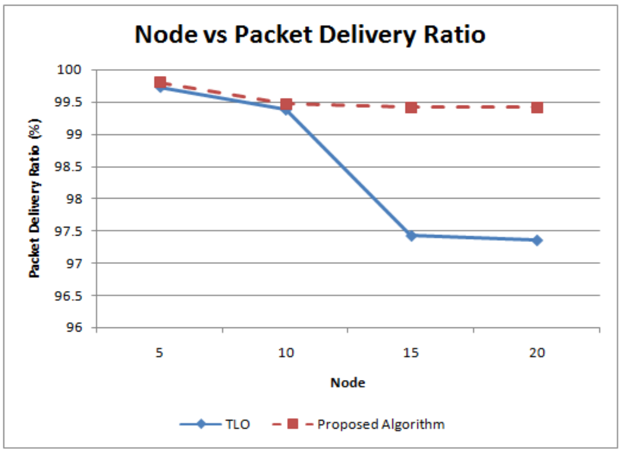


Fig.3. Packet Delivery Ratio with change in node density

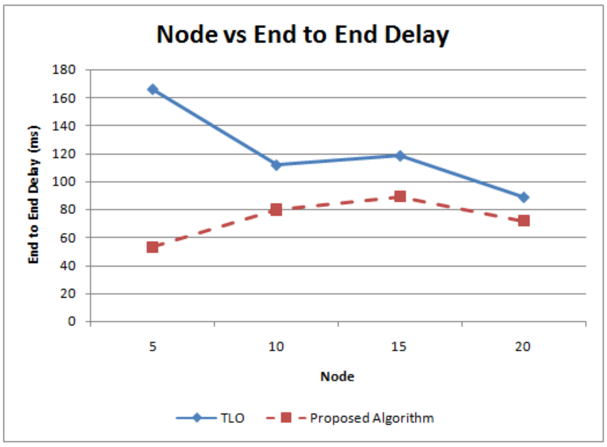


Fig.4.End-to-End delay with change in node density

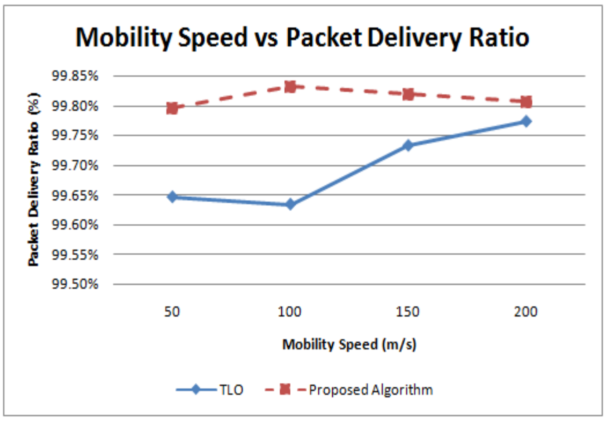


Fig.5. Packet delivery ratio with different mobility speed

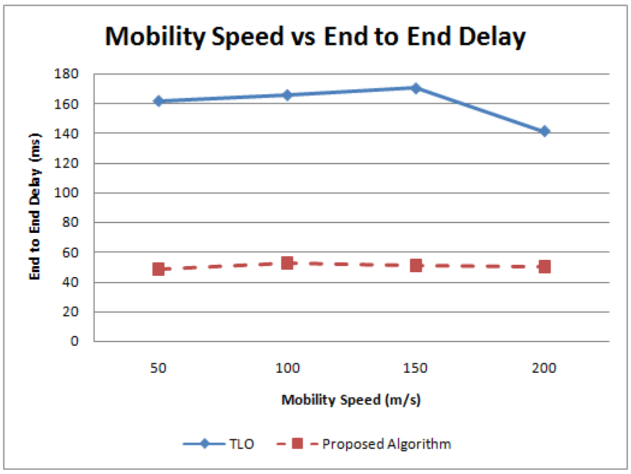


Fig.6. End-to-end delay with different mobility speed

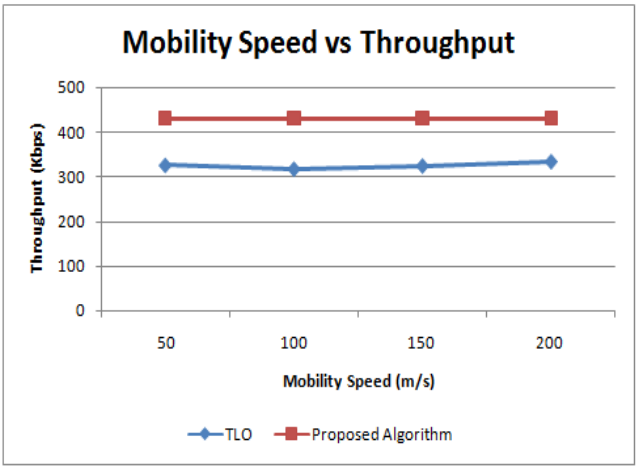


Fig.7. Throughput with different mobility speed

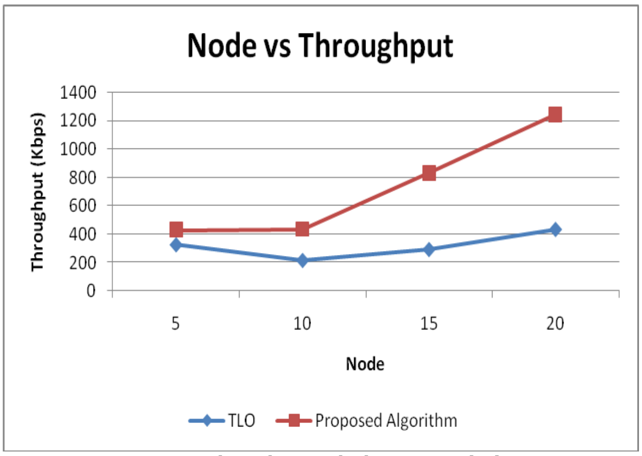


Fig.8. Throughput with change in node density

Fig 3 and 5 shows the packet delivery ratio with different node density and different mobility speed. Fig 4 and 6 shows average end-to-end delay with different node density and different mobility speed. Fig 8 and 7 shows throughput with different node density and different mobility speed. Different changes in the density and speed of the node was made and analyzed for the metrics namely packet delivery ratio and end-to-end delay. We can see that packet delivery ratio is greater in spanning tree based algorithm and lesser end-to-end delay than TLO. Finally, it is concluded that the performance of spanning tree based algorithm is better than TLO in terms of packet delivery ratio, end-to-end delay, throughput and reduced message flooding.

V. CONCLUSION

In this paper, a spanning tree based broadcasting technique has been proposed and it determines the rebroadcast node to rebroadcast the emergency message. By reducing the rebroadcasting node, this technique reduces the redundant message flooding problem that normally occurs in simple broadcasting algorithms for VANET. This algorithm works effective by disseminating an emergency message over a short period of time in that prescribed area. When it is compared with other existing techniques, the proposed technique is effective by means of reducing the end-to-end delay and improving the packet delivery Ratio. The end-to-end delay is low even if node density is high when it is compared with TLO. Also it shows an improvement by reducing the duplicate message flooding thereby providing a comfortable environment to the vehicle drivers.

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