Enhanced Multicast Algorithm (EMA-CAH-MAC) for Mobile ADHOC using Cooperative ADHOC MAC in Vehicular AD-HOC Network

E. Kamalavathi and Dr.R. Radhakrishnan

Abstract--- VANET emerges as a promising approach to provide road safety, vehicle traffic management and some applications like, cooperative scheme for medium access control (MAC), referred as CAH-MAC. Thus the main aim of the paper is neighboring nodes are cooperate by utilizing unreserved time slots, for retransmission of a packets when it failed by poor channel condition. Network life time is accomplished by finding multicast path that tends to minimize the variation energy of all the nodes. So this scheme increase the probability of successful packet transmission using relative mobility and hence to improve the network throughput.

Keywords--- Multicast Routing Algorithm, VANET, Communication System, Cooperative ADHOC MAC

I. INTRODUCTION

A wireless Ad-hoc network [1] is a decentralized type of network, and it does not rely on a pre-existing infrastructure, such as routers or access points. Each node itself acts as a router to take its decision to route or relay the data packets. There are many types of ad-hoc network. Wireless Mesh network (WMN) has communications network made up of radio nodes organized in a mesh topology. It has a more planned configuration. Next, mobile ad-hoc network (MANET) .It has a self-configuring infrastructure less network of mobile devices connected by wireless links. Each device in a MANET is free to move independently in any direction, and will therefore change its links to other devices frequently. Another is the wireless sensor network (WSN). It consists of spatially distributed autonomous sensors to monitor physical or environmental conditions, such as temperature, sound, vibration, pressure, motion or pollutants and to cooperatively [2,3] pass their data through the network to a main location. And another type is the Vehicular Ad-hoc network (VANET). A variation of Ad-hoc network called VANET is discussed, which support communication among smart vehicles and roadside equipment [4,5]. A node stores and carries messages and forwards the message to another node whenever two nodes come into communication range [6].

In VANET, the communication between vehicle to vehicle and vehicle to RSU unit is interrupted due to the unique characteristics such as high dynamic topology and predictable mobility. Cooperative communication, on the other hand, can enhance the reliability of communication links in VANETs, thus mitigating wireless channel impairments due to the user mobility. In this paper, cooperative scheme for medium access control (MAC) in VANETs, referred to as Cooperative ADHOC MAC (CAH-MAC) is proposed. In CAH-MAC, neighboring nodes cooperate by utilizing unreserved time slots, for retransmission of a packet which failed to reach the target receiver due to a poor channel condition. In order to avoid this interruption multicast routing is used to communicate among a group of vehicles in some vehicular situations, such as intersections, roadblocks, high traffic density, accidents, and dangerous road surface conditions. The Medium Access Protocol (MAC) is used to improve the performance of VANETs. However, even with these

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improvements, VANETs still have problems with traffic contention, hidden terminals, data transmission delays, decreasing throughput, and dynamic assigned channels for MAC protocols.

The proposed Cooperative MAC protocol and the enhanced multicast routing algorithm (EMA) are also explained for betterment of the system. The multicasting routing protocols consist of several challenges that are described in the below section. Scarce bandwidth of ad hoc networks, rapidly moving nodes with limited resources (battery power, memory usage), hidden terminal problem and security concerns remains a great challenge for multicast protocols design. In addition to these challenges there are several issues to be considered but not limited to robustness (link stability), efficiency (ratio of total number of data packets received by receivers to the total number of packets (data and control) transmitted in the network, control overhead (control packets exchanged), Quality of service (throughput, delay, delay jitter, and reliability), dependency on unicast routing protocol, Resource management (battery power, memory).

II. System Model

The proposed Enhanced Multicast Algorithm (EMA) uses cooperative MAC. The main aim of the multicasting routing protocol is to reduce the number of packet retransmissions in VANET. The unreserved time slots are used for retransmission of packets, when it fails due to poor channel condition. The proposed system model is explained in the below section.

2.1. Network Topology and Channel Model

Consider a VANET consisting of vehicles moving along a multi-lane road. Vehicles are distributed randomly. Let L be the number of lanes, each with width $w_l, l \in \{1, 2, 3, \ldots, L\}$. All vehicles move with negligible relative movements over an observation period. Hence, they are stationary with respect to each other, maintaining a fixed network topology is shown in the figure 1. All vehicles are identical with respect to their communication capabilities with transmission range r. Vehicles within the transmission range of a source node can successfully receive the transmitted packets with probability p, taking account of a possible poor channel condition. The probability p depends on channel characteristics. The smaller the p value, the poorer the channel quality. The parameter p does not account for transmission errors due to the collision when multiple nodes within an interference range transmit simultaneously [7,8].

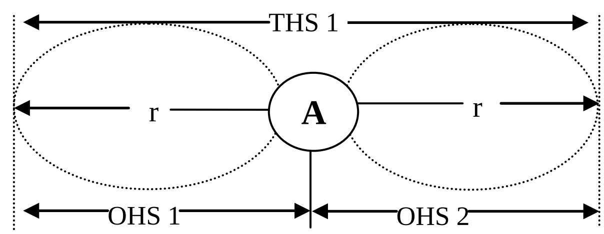


Fig. 1: Illustration of a two-hop set, where an Ellipse Represents an OHS such that All Nodes Inside One Ellipse can Directly Communicate with Each Other, with Node A as a Reference

2.1.1. Neighboring Nodes

Each vehicle maintains a list of its one-hop and two-hop neighbors. One-hop and two-hop nodes are those which can be reached at maximum one and two hops of transmission respectively from a reference node. Sets of these nodes are called one-hop set (OHS) and two-hop set (THS) respectively. For example in Figure 3.1, node A is a member of two OHSs namely OHS 1 and OHS 2. In addition, it is also a member of two-hop set, THS 1. Node A can communicate directly with any nodes in its OHSs i.e., nodes in OHS 1 and OHS 2. Similarly, all nodes in the same THS can communicate with each other with maximum two hops.

2.1.2. Channel Access

The channel access mechanism is based on distributed TDMA scheme such that the channel time is partitioned into frames and each frame is further partitioned into time slots. Each time slot is of a constant time interval and each frame consists of a fixed number of time slots, denoted by F. Each vehicle is capable of detecting the start time of a frame and, consequently, the start time of a time slot. Accessing a time slot thus demands precise time synchronization among nodes. When a vehicle is equipped with a Global Positioning System (GPS) receiver, the one-pulse-per-second (1PPS) signal that a GPS receiver gets every second can be use for the synchronization. If the GPS signal is lost, a GPS receiver's local oscillator can be used for a short duration and a distributed synchronization scheme can be used for a longer duration, to synchronize nodes. Nodes support broadcast, multicast, or point to-point modes of communication. However, to evaluate the performance of CAH-MAC, consider the nodes communicating in a point-to-point mode only. A helper node performs cooperation to retransmit an overheard packet from the source node.

Nodes form clusters of two-hop neighbors. Here a cluster refers to a group of nodes which are at maximum two-hop transmission distance from each other. There is no cluster head, and a node can be a member of multiple clusters. Formation of a THS stops simultaneous usage of a time slot by more than one node within the same interference range and thus avoids the hidden node problem. Nodes belonging to the same THS contend with each other to reserve a time slot. To Frame Information (FI) Packet Header Payload Data CRC Cooperation Header (COH) IDF-1 ida IDF-2 φ IDF-3 idb φ idz IDF-(F-1) IDF-F contend for a time slot, a node first listens to the channel over the period of F consecutive time slots (not necessarily in the same frame), then attempts to reserves one time slot among the unreserved ones if available. Access collisions occur when multiple nodes within the same interference range attempt to reserve the same time slot. After successfully reserving a time slot, a node transmits a packet in its own time slot in every frame until it encounters a merging collision due to relative mobility. Merging collision occurs when nodes using the same time slot but belonging to different clusters approach each other, resulting in a transmission collision in the corresponding time slot. It is shown that ADHOC MAC suffers from throughput reduction due to node mobility [9] [10].

III. PROPOSED ENHANCED MULTICAST ALGORITHM FOR MOBILE ADHOC USING COOPERATIVE ADHOC MAC IN VANET TO IMPROVE THROUGHOUT PERFORMANCE

In order to overcome the throughput reduction, EMAC is proposed in this work. Here, with a focus on cooperation to improve transmission reliability, consider a network where all nodes are perfectly synchronized and have already reserved their time slots. Hence, access collisions do not occur and cooperation is performed by only those nodes which have their own slots for transmission. Also as relative mobility among nodes is negligible, merging collisions do not occur; hence a reserved time slot is always dedicated to its owner. All operations such as reserving a time slot, synchronization among nodes, cooperation decision, and cooperative transmission are done in a distributed manner, making it suitable for VANETs.

In a frame, each time slot will be under one of conditions: i) Reserved: Time slot which are reserved during which data packet are successfully transmitted to destination are considered as successful time slots. ii) Unreserved: Time slot which are not yet reserved by any node are unreserved time slots. Any time slots in a frame are reserved time slots other than unreserved. iii) Failed: A Time slot other than an unreserved and successful belongs to failed time slots

Due to VANET dynamic topology, the MAC protocols may lead to wastage of time slots. The wastage occurs when there are not enough nodes in a neighborhood to use all the time slots of a frame. In addition, upon a transmission failure, the source node has to wait until the next frame for retransmission even if the channel is idle during unreserved time slots [11, 12].

In this proposed algorithm the unreserved time slots are used for retransmission of failed packets from source to destination using the cooperative communication. Cooperative communication, on the other hand, can enhance the reliability of communication links in VANETs, thus mitigating wireless channel impairments due to the user mobility. A cooperative scheme for medium access control (MAC) in VANETs, referred to as Cooperative ADHOC MAC (CAH-MAC) is presented in the following section.

3.1. CAH-MAC Protocol Description

In this section, CAH-MAC protocol detailed operation including cooperation decision, helper selection and dynamic time slot allocation using STDMA is also discussed. A node in its own time slot transmits a packet that consists of frame information, cooperation header, packet header, pay load data, and Cyclic Redundancy Check (CRC). Figure 2 shows the structure of a packet that a node transmits. The structure and purpose of the signaling fields is described, namely the frame information and cooperation header.

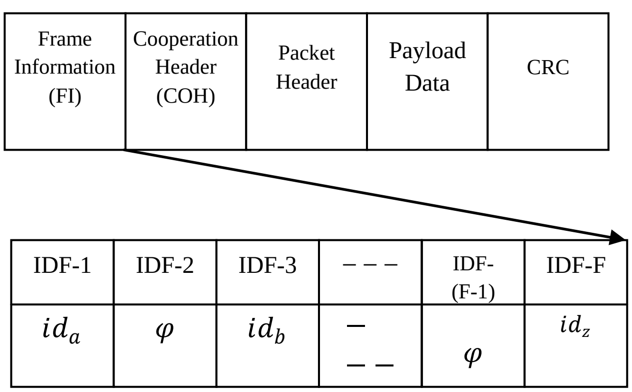


Fig. 2: Structure of a Packet and a Frame Information Field in CAH-MAC, where φ Indicates an Empty Field

3.1.1. Frame Information (FI)

The FI is a collection of ID fields (IDFs). The number of IDFs in an FI field is equal to F, i.e., the number of time slots per frame. Each IDF is dedicated to the corresponding time slot of a frame. Temporary (or short) identifier which is shorter (1−2 bytes) than the size of a MAC address, can be used as an ID of a node. Such a short ID can be selected randomly by a node and changed if there is a conflict. Use of such a short ID reduces the size of the FI in a packet and, hence, reduces the MAC overhead [13].

Destination node D, upon receiving a packet successfully from the source node S in the s^{th} time slot, concludes that the s^{th} time slot belongs to S. Node D then puts the ID of node S in the s^{th} IDF of its FI. By successfully receiving a packet from node S, node D knows (a) the existence of node S as its one-hop neighbor, (b) node S is the owner of the s^{th} time slot, and finally (c) all the one-hop neighbors of node S and their corresponding time slots. Hence, by successfully receiving FIs from all of its one-hop neighbors, a node maintains a neighbor table which includes: (i) all of its one-hop neighbors, (ii) all of its two-hop neighbors, and (iii) the owner of each time slot in a frame. If there is no signal in a time slot, then a node considers it as an unreserved time slot. In such a case, corresponding IDFs of unreserved time slots are left empty in an FI field as illustrated in Figure 2 for IDF-2 [14, 15].

A node can identify an unreserved time slot in which it can transmit without causing any collision in its one-hop neighborhood. It is to be noted that a node updates its neighbor-table based on any packets received successfully from new neighbors. These packets can be broadcast, unicast, or multicast packets. In addition to the neighborhood discovery, formation of a THS cluster, and time slot reservation, the FI also helps for transmission acknowledgement. For example, consider that node D does not include the ID of node S in the IDF-S of its FI. Upon receiving FI from D, node S concludes a transmission failure between itself and D in the s^{th} time slot, which is basically a negative acknowledgement (NACK). Similarly, inclusion of the node S ID in the FI of node D serves as acknowledgement of a successful transmission from S to D.

3.1.2. *Cooperation among Neighboring Nodes*

Cooperation is always performed through a one-hop neighbor of the source and destination nodes. Since the channel condition may remain the same during the unused time slot as that during the source node's time slot, retransmission by the source node during the unused time slot is not likely to be helpful and will waste the transmission opportunity. On the other hand, cooperative relay transmission of a packet, through an independent channel (i.e., between the helper and destination) during an unreserved time slot provides transmission diversity and, hence, improves transmission reliability even if the channel condition between an $s-d$ pair is poor. Here the node decides and performs cooperation. Let $F = \{1, 2, 3, \ldots, F\}$ be the set of time slots in a frame. Consider O_x and T_x as the OHS and THS of a node x. Let R_x be a set of all time slots which belongs to the THS of node x, i.e., any time slot $t \in R_x$ is reserved from the perspective of node x. Consider S and D as the source and destination nodes with the s^{th} and d^{th} time slots respectively and node H as the helper node. Cooperation decision and cooperative relay transmission are performed only if all the following conditions are satisfied:

The direct transmission fails: Cooperation is trigged when the direct transmission between the source and the destination fails. Upon a transmission failure, node D does not acknowledge the transmission from node S, such that S /$\in O_D$. Potential helper nodes have the transmission failure information after receiving the FI from node D.

The helper successfully receives a packet for retransmission: A node can potentially offer cooperation only if it receives the packet successfully from the source node S during the s^{th} time slot.

There is an available time slot: Helper node H, when conditions 1) $-$ 3) are satisfied, can offer and perform cooperation if there exists at least one unreserved time slot $h \in F$ during which it can transmit. The transmission from H in time slot h shall not cause any collision at its one-hop neighbors, i.e. $\forall h \notin RH$.

If all the preceding conditions are satisfied, the helper node H offers cooperation to the source and destination and the cooperative transmission is performed in time slot h. If there are multiple potential helper nodes, the one which first announces to help will relay the packet while all other potential helpers will not proceed with cooperation for the same packet. Figure 3.3 shows necessary information exchanges for cooperation in the CAH-MAC. When the destination node D fails to receive a packet from the sender node S (in Figure 3(a)), it announces transmission failure through its FI as shown in Figure 3(b). Upon deciding to cooperate, the helper node H transmits its intention of cooperation using cooperation header (COH) as in Figure 3(c). In the hth time slot, after receiving a cooperation acknowledgement (C-ACK) from the destination node D, helper node H transmits the packet that node D failed to receive (in Figure 3(d)). Next, the cooperation header is discussed wherein a helper node uses to offer cooperation and similarly, CACK is explained wherein a destination node uses to avoid collision during cooperative relay transmission.

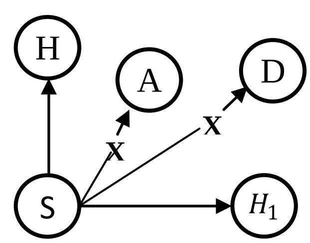


Fig. 3 (a): Source Node Transmits a Packet to the Destination

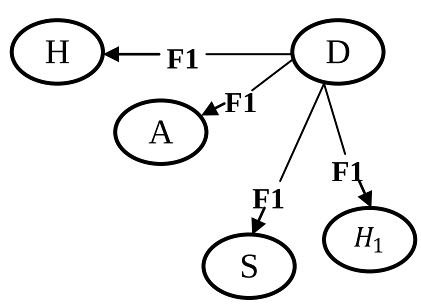


Fig. 3(b): Neighboring Nodes Detect Transmission Failure after Examining the FI from the Destination

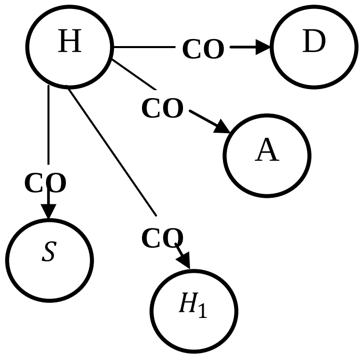


Fig. 3(c): Helper Node H, Offers Cooperation

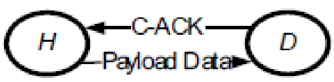


Fig. 3(d): Helper Node H, re-transmits the Packet that Failed to Reach the Destination after Receiving a Cooperation Acknowledgement from the Destination

Fig. 3: Information Exchanges in the CAH-MAC

Once a node decides to cooperate, it transmits its decision via cooperation header in its packet. The following information is included in the cooperation header:

- its intention to cooperate,
- The index of time slot of the source during which transmission failure occurred
- The index of the selected unreserved time slot in which the packet will be retransmitted from the helper to the destination.

The aforementioned information is embedded in the cooperation header and transmitted in the helper's time slot. Other potential helpers (which can offer cooperation and are in the OHS of helper node) suspend their intentions, once they receive cooperation decision from the helper H. Hence, helper node H is the one which first offers cooperation and performs cooperation for the $s-d$ pair. Such a suspension of cooperation intention avoids collision among potential helpers during cooperative relay transmission. However, collisions may occur at the destination node when two or more potential helpers, which are not in each other's OHS, offer cooperation at the same unreserved time slot. In order to avoid such collisions, a cooperation acknowledgement (C-ACK) from the destination node is transmitted during the selected unreserved time slot, which is illustrated in Figure 3.4. In C-ACK, the destination node puts the ID of the first potential helper which offered cooperation to accept cooperation. Transmission of a C-ACK from the destination node forces other potential helpers to suspend their transmissions, thus avoiding any possible collision. The helper node retransmits the packet that failed to reach the destination in the direct transmission from the source node.

The size of a short ID is always enough to be shared among the nodes that are sharing a frame. Hence, the size of an index of a time slot is comparable with the size of a short ID. Consequently, the size of a cooperation header is negligible as compared to the size of FI (and obviously the size a time slot), which has a space for F IDs. Generally, the F value is set large enough to guarantee a time slot for each node. In addition, cooperation acknowledgement (C-ACK) and cooperative transmission are performed in an unreserved time slot. Hence, cooperation can be performed at the cost of negligible overhead as compared to a time slot which would be wasted in absence of cooperation. It is to be noted that, in the proposed CAH-MAC, only one helper performs the cooperative relay transmission for a failed $s-d$ direct transmission. Potential helpers, which can offer cooperation to the failed $s-d$ direct transmission, suspend their cooperation intentions once they receive cooperation decision from the helper node. Hence, a potential helper offers cooperation to only those failed $s-d$ direct transmissions which are not offered with cooperation, but not to every failed $s-d$ direct transmission. This reduces the size of COH and hence the communication overhead due to cooperation.

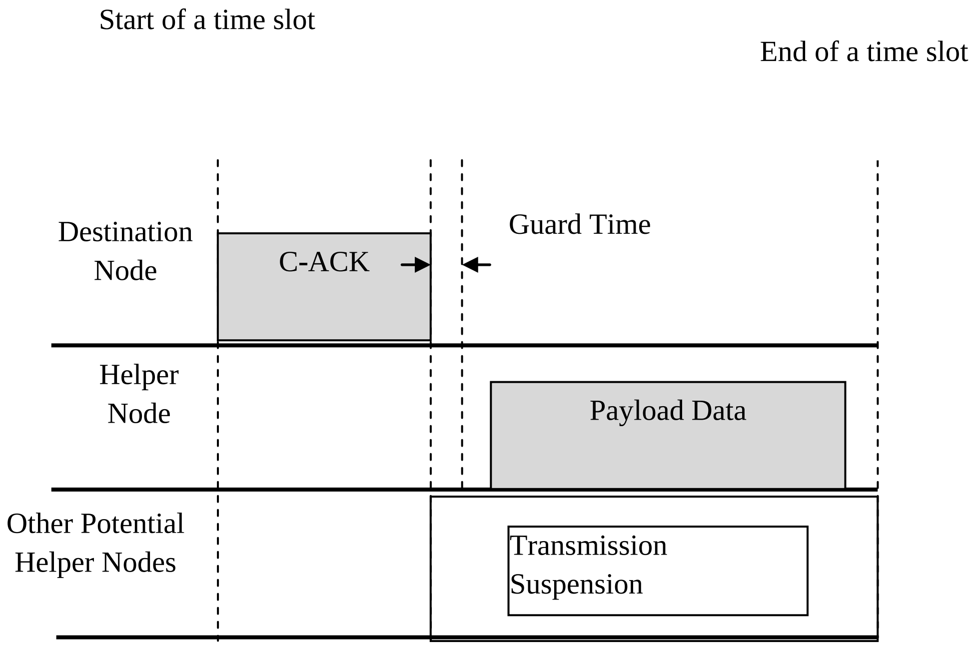


Fig. 4: Cooperative Relay Transmissions during an Unreserved Time Slot

Transmission of CACK signal from the destination node forces other potential helper nodes to suspend their transmissions, thus avoiding any possible collision. The collision avoidance process is discussed below

3.1.3. *Cooperation Collision Avoidance*

CAH-MAC suffers from cooperation collisions, when a reservation packet from a new node collides with C-ACK from the destination node and/or payload data from the helper node. One possible way to avoid cooperation collisions is to delay the cooperative relay transmission by some time interval, say α1 time units. Duration of α1 is long enough for a node to sense whether the channel is idle or busy, such as the distributed inter-frame space (DIFS) as in the IEEE 802.11 based MAC protocols. Destination node D waits for α1 time units and transmits C-ACK if the channel is idle during the waited time (i.e., if there is no transmission in that unreserved time slot), which is illustrated in Figure 4. Note that in CAH-MAC, the destination node transmits C-ACK as soon as the unreserved time slot starts, i.e., $\alpha_1 = 0$. Helper node, after receiving its ID in the C-ACK from the destination node, transmits a payload data from the source after a guard time. Since the length of C-ACK (in bits) and guard time are constant, the helper node always performs cooperative relay transmission after the fixed duration from the start of a time slot, i.e., $\alpha = \alpha_1 + \alpha_2$ time units as in Figure 3.4, where α_2 is the transmission time of a C-ACK plus the guard time.

A new node attempts to reserve the unreserved time slot by transmitting a packet in the same time slot. When the destination node detects the reservation packet(s) from the new node(s), it suspends the cooperation or transmission of the C-ACK. As the helper node does not receive any C-ACK, it also suspends cooperative relay transmission after α time units, from the start of a time slot. Delaying the cooperative relay transmission phase allows the destination node to detect the reservation packet from a new node and avoid a collision between C-ACK and the reservation packet. Such collision occurs only if a new node and the destination node are in each others' two-hop distance but not in the one-hop distance. In such a case, destination node does not sense the transmission of reservation packet from the new node and transmits C-ACK. Collisions occur when there is a simultaneous transmission from the destination and new nodes, at their common one-hop nodes.

Note that a helper node does not transmit the FI during cooperative relay transmission, i.e., the packet from a helper node consists of packet header (PH), payload data and CRC only. As each node has its own time slot in which it can transmit a complete packet, repeated transmission of the FI during cooperative relay transmission can be avoided. The absence of FI compensates for the delay time of cooperative relay transmission phase and does not affect the normal operations of CAH-MAC. In addition, new nodes transmit reservation packets without cooperation header as they are not eligible to perform cooperation.

Then in this research a set of new features are proposed both in the data plane and the control plane of the 802.11 MAC layers, while maintaining backward compatibility to the current MAC. A major component of CooperativeMAC control plane design is the mechanism for each station to learn about candidate helper stations, and the corresponding data structures used to store the information related to those identified candidates. In the data plane, a station can choose a helper from this list of potential helpers to use at the time of its transmissions, depending on the possibility of reducing the transmission time for the packet in hand.

3.1.4. Cooperative Media Access Control

In this section, the learning process and the corresponding data structure are described and then the cooperative operation in the data plane is explained in detail.

3.1.4.1. Helper Detection

Each Road side unit in a basic service set (BSS) should maintain a table, referred to as the CoopTable, of potential helpers that can be used for assistance during transmission between the vehicle to vehicle or vehicle to RSU. The creation and updating of a cooperative table for each possible destination address can be done by listening on-going transmissions. As each station in an 802.11 network is required to check the packet header of all the packets it receives in order to pick up the packets intended for itself, this requirement does not require additional hardware. These stations are also required to decode the entire Request- To-Send (RTS), Clear-To-Send (CTS) and acknowledgment (ACK) frames to get the channel reservation information to avoid the hidden node problem. The control frames and headers of data frames are always modulated at the base rate (e.g., 1 Mbps for 802.11b and 6 Mbps for 802.11a and 802.11g), so that all stations within the transmission range will be able to receive this information successfully.

When a transmission from a station (denoted by S_h) is overheard, a CoopMAC station S_s estimates the channel condition (e.g. path loss) between the sender of that packet and itself by measuring the received signal strength. Since all stations use the same frequency band for transmission and reception, the channel between any two stations is assumed to be symmetric. Path loss can be calculated by subtracting the transmission power (in dB), which is typically fixed for all stations, from the received signal power (in dB). The availability of such information is supported by the IEEE 802. protocol. By checking the threshold value, which is precalculated and guarantees a certain bit error rate for each modulation scheme, it can find the corresponding data rate between S_h and S_s, denoted by R_{sh}. When station Ss overhears a data packet transmission between a pair of other stations (from $S_h\ to\ S_d$), it will identify the data rate used for this transmission from the Physical Layer Convergence Procedure (PLCP) header. This rate will be referred to as R_{hd}.

ID (48 bits)	Time (8 bits)	R_{hd} (8 bits)	R_{sd} (8 bits)	Number of Failures
MAC address of helper 1	Time the last packet heard from helper 1	Transmission rate between helper 1 and the destination	Transmission rate between the source and the helper 1	Count of Sequential transmission failures
……	……	……	……	……
MAC address of helper N	Time the last packet heard from helper N	Transmission rate between helper N and the destination	Transmission rate between the source and the helper N	Count of Sequential transmission failures

Fig. 5: Format of the Cooperative Table

The fields contained in the Cooperative Table are shown in Figure 5. Entries are ordered by the timestamp values, based on the last time a packet from that station is overheard. A helper station is stored in the Cooperative Table by S_s if it satisfies

$$\frac{1}{\mathrm{R_{sh}}} + \frac{1}{\mathrm{R_{hd}}} > \frac{1}{\mathrm{R_{sd}}} \quad (3.1)$$

where R_{sd} is the rate for direct transmission between S_s *and* S_d. The first column in Figure 5, namely the ID field, stores the MAC address of the potential helpers learned from the RTS frames transmitted by the helper. The Time field stores the time of the last frame transmission heard from this helper. As described above, R_{hd} *and* R_{sh} store the data rate from the helper station to the destination S_d, and from the source Ss to the helper station, respectively. The last field in the table, Num of failures tracks the number of sequential failures associated with the particular helper station. When this number exceeds predefined threshold values, which recommended to be in the proposed protocol, the corresponding entry is removed from the Cooperative Table. The value of Num of Failures is incremented after every failed transmission attempt through the helper station, and this value is reset to zero after a successful transmission through the particular helper station. Each of these entries is updated to reflect the current channel conditions and status. Cooperative Table entries can also be populated using information gained from cooperative transmissions received by a station.

3.1.4.2. Transmission Algorithm

When a source station Ss has data of length L octets to send, it checks each entry in the Cooperative Table to decide whether to transmit through a particular helper. The transmission time for such a two hop transmission is $8L/R_{sh} + 8L/R_{hd}$, ignoring the overhead. The helper through which the minimum transmission time can be achieved will be chosen as the candidate helper. If multiple stations have the same value, choose the one with the most recent time value.

As in the existing standard, the mode selection is based on a configurable RTS threshold. If the packet length is over this threshold, the RTS/CTS mode is chosen. If transmission through the chosen helper is more time efficient than a direct transmission, will start a cooperative transmission. For the RTS/CTS mode, the condition for a cooperative transmission can be expressed as

$$\frac{8L}{R_{sh}} + \frac{8L}{R_{hd}} + T_{PLCP} + T_{HTS} + 2T_{SIFS} < \frac{8L}{R_{direct}} \quad (3.2)$$

where R_{direct} is the sustainable data rate for a direct transmission from S_s to the destination S_d and T_{PLCP}, T_{HTS} *and* T_{SIFS} are the additional time associated with a helper-aided transmission for the physical layer overhead, HTS and SIFS, respectively. The HTS is a new message introduced to facilitate the cooperation, and will be explained in the following protocol description.

For the base mode, where the data packets are not preceded by RTS/CTS, the condition would be

$$\frac{8L}{R_{sh}} + \frac{8L}{R_{hd}} + T_{PLCP} + T_{SIFS} < \frac{8L}{R_{direct}} \quad (3.3)$$

If the condition is not satisfied for any of the entries in the Cooperative Table, the data frame is transmitted directly to S_d.

Algorithm 1

A source station S_s has data of a length L octets to send the transmission for a such two hop transmission is $\frac{8L}{R_{sh}} + \frac{8L}{R_{hd}}$.

Step 1: If multiple stations have the same value,

Step 2: Prefer the one with the most recent Time value Source station S_s:

Step 3: The duration field in the Cooperative RTS is given by

Duration Cooperative RTS = 4TSIFS + TCTS + 8L / Rdirect + TPLCP + TACK Helper station S_h.

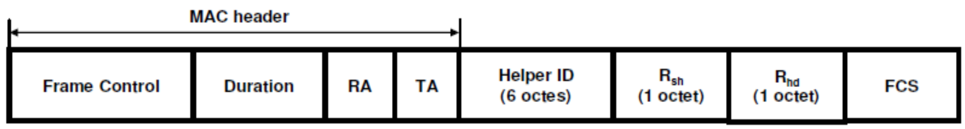
Were S_h receives a Cooperative RTS message, S_h should verify conditions of the rate RS_hbetween its and S_s,

S_d recommended in the Cooperative RTS messages are sustainable Destination station S_d:

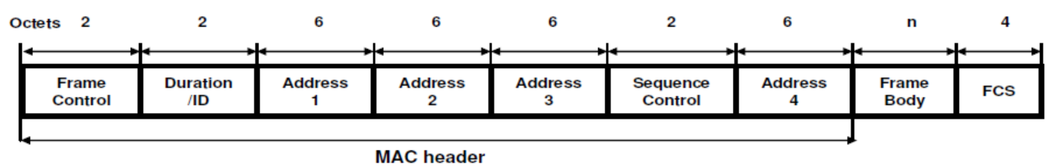
If $S_d$receives a Coop RTS , whose RA fields is set to the MAC address of S_d.

3.1.4.3. CoopMAC - RTS/CTS Mode

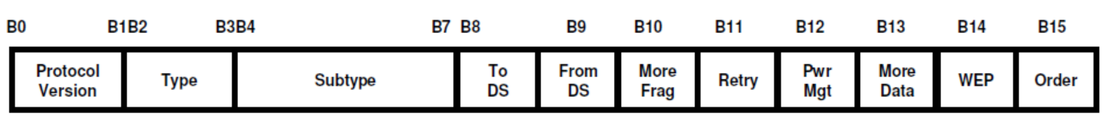
The RTS/CTS mode defined by 802.11 is extended to include an HTS (Helper ready To Send) for the helper station to acknowledge its participation. The HTS packet has the same format as CTS in the 802.11 standard and hence the legacy stations can successfully decode this packet. The source station Ss selects one of the potential helpers Sh from the Cooperative Table and specifies the helper in the modified CooperativeRTS message. The format for CooperativeRTS message is shown in Figure 6.



(a) Frame Format for CooperativeRTS



(b) MAC Header Format for 802.11



(c) Frame Control Format for 802.11

Fig. 6: Frame Format

The exchange of control messages in CooperativeMAC and the corresponding NAV settings are shown explained in (Liu et al 2007).

3.1.4.4. CooperativeMAC - Data transmission

Each CooperativeMAC station should be able to discriminate whether a packet is for itself or is to be forwarded to another station. In a RTS/CTS protected data transmission, each station will be able to do so. However, in the base mode operation of 802.11 MAC, CooperativeMAC allows the nodes to transmit a data frame directly to one of the potential helper nodes without going through the RTS/CTS procedure. Hence a unique CooperativeMAC data frame is needed.

The Address 4 field in the IEEE 802.11 frame format (Fig. 7(b)) is never used for data frames, except when the data frame is exchanged between APs, where the $toDS\ and\ fromDS$ subfields within the frame control field are both set to 1. Here the following frame format is proposed for data transmission both in the base mode and in the CooperativeRTS-HTS-CTS mode. To retain the same functionalities for $toDS\ and\ fromDS$ while utilizing the reserved data frame Subtype value of 1000 for CoopMAC data frames. In the first hop, source station S_S puts the helper S_h address in the Address 1 field of the MAC header and the final destination address S_d in Address 4. When the packet arrives at the helper, the helper will move the address of Sd in Address 4 to Address 1, recalculate the Frame Check Sequence (FCS) and forward the data frame to the final destination S_d after a SIFS interval. S_d sends an ACK message directly to S_S. In the case where an ACK message is not received byS_S, it must increment the $NumOfFailures$ and remove the potential helper station from its CooperativeTable, if $NumOfFailures > Threshold$.

It is to be observed that the CooperativeMAC can be readily extended to other higher data rate extensions of 802.11, even though the current CooperativeMAC is evaluated for IEEE 802.11b. Through analysis and simulation has been able to demonstrate that the energy-per-bit experienced by the helper stations is decreased by participating in cooperation. This counter-intuitive result is due to the reduction in idle energy consumption incurred by the helper as it waits for its transmission opportunity while a slow node is occupying the channel. An initial implementation of the cooperative transmission has been completed and experimental results from the implementation were presented.

IV. SIMULATION AND RESULTS

The simulations are based on the IEEE 802.11b of MAC layer, which is included in the NS2. The vehicles move from a random starting point to a random destination along the road (the speed is uniformly distributed between 0 - 20 m/s). The transport protocol is User Datagram Protocol (UDP). Traffic sources are Constant-Bit Rate (CBR). The source and destination pairs are randomly spread over the entire network. The packet generating rate is 4 CBR. The number of sources is 10 in the network. These scenario files are generated by the scene generator of the simulator. The mobility model is a random way point model in a rectangular field. The related parameters are shown in the Table 1.

Table 1: Simulation Parameter

Parameter	*Value*
Topology area	1.000 * 1000
Simulation time	2,000 sec
Traffic type	CBR
CBR packet size	512 bytes
Mobility model	Random way point
Pause time	1 sec
Voltage	5V

Each node is initially placed at a random position within the defined area the throughput with minimum safety distance, d_0, between adjacent vehicles in a lane, and the analytical results with $d_0 = 0$. The better channel quality increases the probability of successful relay transmission, as the channel quality further depicts the throughput gain of CAH-MAC over ADHOC MAC versus the channel parameter p for different vehicle density values. As increases from 0.01 to 0.03, the throughput gain increases with p.

The throughput gain decreases when the number of THS members is large as compared with F. For the parameter pair it can be seen that the throughput gain reaches its peak at a certain p value and starts decreasing as p further increases With a Maximum p value, the probability of successful direct transmissions increases and hence cooperation may not be sparked. Once p is moderate, direct transmissions may suffer from channel errors and hence cooperation helps to retransmit the packet that failed to reach the destination.

4.1. Packet Drop Comparison

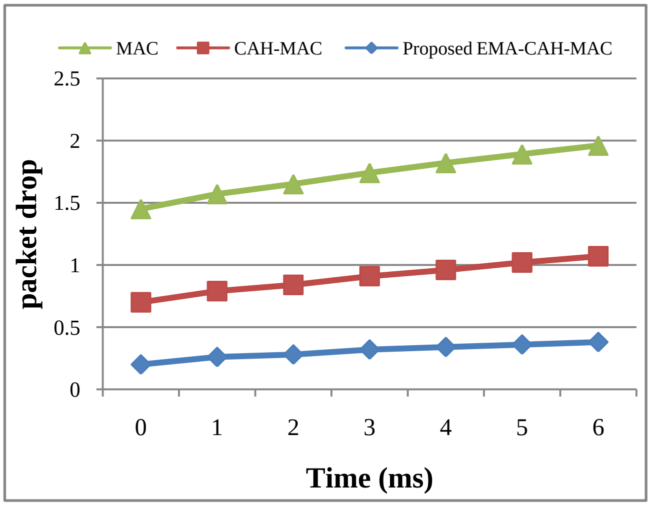


Fig. 7: Comparison of Packet Drop for Different Protocols

In figure 7 the graphical representation of packet drop for proposed enhanced multicast algorithm (EMA-CAH-MAC) protocol and existing protocols such as CAH-MAC and MAC is shown. It is observed that the EMA-CAH-MAC protocol has low packet drop value when compared with other techniques such as EMA-CAH-MAC, CAH-MAC and MAC. The usage of unreserved time slots for retransmission of failed packets in network. The helper nodes are used to allocate the unused time slots for sending failed packets. This is the main reason for reducing delay. Table 2 shows that the experimental values of the proposed algorithm and existing algorithms

Table 2: Comparison of Packet Drop for Different Routing Protocols

Time (in milliseconds)	*Routing protocols*		
	Proposed EMA-CAH-MAC	*CAH-MAC*	*MA C*
0	0.2	0.5	0.75
1	0.26	0.53	0.78
2	0.28	0.56	0.81
3	0.32	0.59	0.83
4	0.34	0.62	0.86
5	0.36	0.66	0.87
6	0.38	0.69	0.89

The table 2 shows that packet drop values for different protocols such as EMA-CAH-MAC, CAH-MAC and MAC. The simulation is carried out and the corresponding values are tabulated for existing approaches such as CAH-MAC and MAC. The proposed EMA-CAH-MAC approach produces significant results with low packet delay value inspite of time increment. The packet drop value of proposed EMA-CAH-MAC for 5 milliseconds in the network is 0.36 which is lower than 88.95% of CAH-MAC and 75.48% of MAC approaches respectively.

4.2. Packet Delivery Ratio

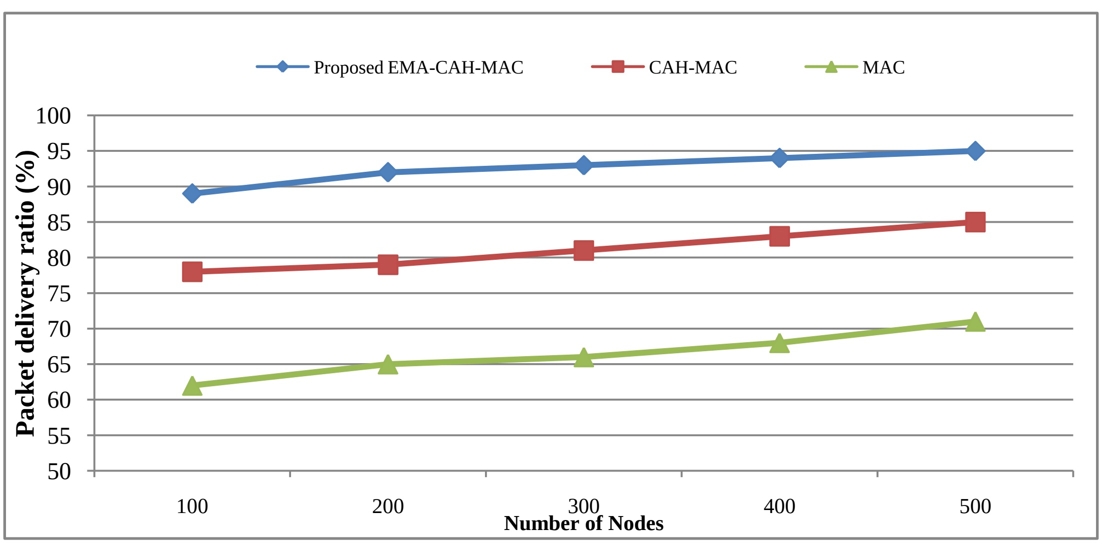


Fig. 8: Comparison of Packet Delivery Ratio for Different Routing Protocols

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In figure 8 the graphical representation of packet delivery ratio for proposed enhanced multicast algorithm (EMA-CAH-MAC) protocol and existing protocols such as CAH-MAC and MAC is shown. It is observed that the EMA-CAH-MAC protocol has high packet delivery ratio value when compared with other techniques such as CAH-MAC and MAC. The usage of unreserved time slots for retransmission of failed packets in network. This is the main reason for reducing delay and increasing packet delivery ratio. Table 3 shows that the experimental values of the proposed algorithm and existing algorithms.

Table 3: Comparison of Packet Delivery Ratio for Different Routing Protocols

Number of nodes	*Packet delivery ratio(in %)*		
	Proposed EMA-CAH-MAC	*CAH-MAC*	*MAC*
100	89	78	62
200	92	79	65
300	93	81	66
400	94	83	68
500	95	85	71

The table 3 shows that packet delivery ratio values for different protocols such as EMA-CAH-MAC, CAH-MAC and MAC. The simulation is carried out and the corresponding values are tabulated for existing approaches such as CAH-MAC and MAC. The proposed EMA-CAH-MAC approach produces significant results with high throughput value for increased time. The throughput value of proposed EMA-CAH-MAC for 400 nodes in the network is higher than 27.65% of CAH-MAC and 11.70% of MAC approaches respectively.

4.3. Throughput

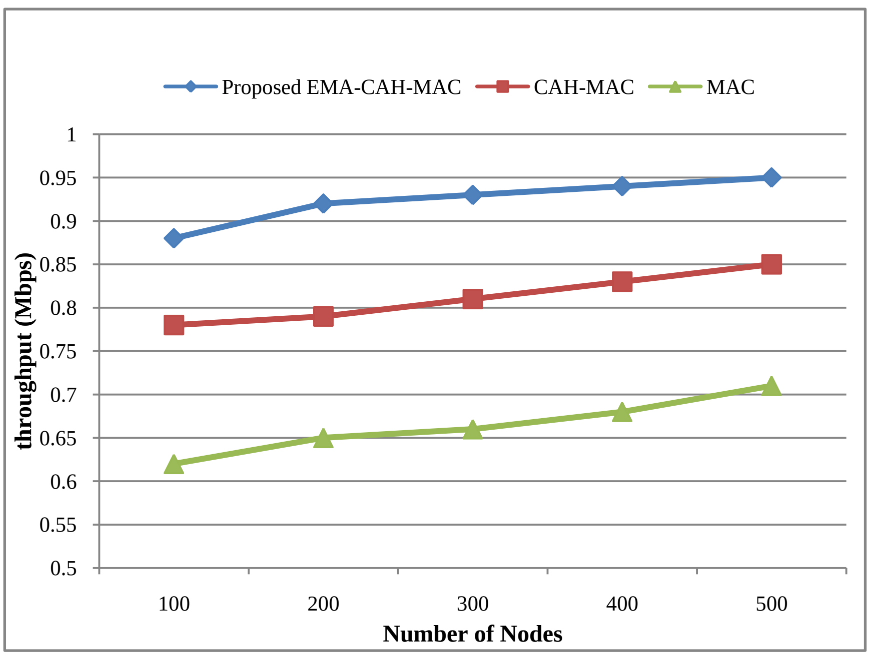

Fig. 9: Comparison of throughput for Different Routing Protocols

In figure 9 the representation of throughput for proposed enhanced multicast algorithm (EMA-CAH-MAC) protocol and existing protocols such as CAH-MAC and MAC is shown. It is observed that the EMA-CAH-MAC protocol has high throughput value when compared with other techniques such as CAH-MAC and MAC. Table 4 shows that the experimental values of the proposed algorithm and existing algorithms.

Table 4: Comparison of throughput for Different Routing Protocols

Number of nodes	*Routing protocols*		
	Proposed EMA-CAH-MAC	*CAH-MAC*	*MAC*
100	0.88	0.78	0.62
200	0.92	0.79	0.65
300	0.93	0.81	0.66
400	0.94	0.83	0.68
500	0.95	0.85	0.71

The table 4 shows that throughput values for different protocols such as EMA-CAH-MAC, CAH-MAC and MAC. The simulation is carried out and the corresponding values are tabulated for existing approaches such as CAH-MAC and MAC. The proposed EMA-CAH-MAC approach produces significant results with high throughput value for increased time. The throughput value of proposed EMA-CAH-MAC for 300 nodes in the network is higher than 29.03% of CAH-MAC and 12.90% of MAC approaches respectively.

4.4. Implications

From the above results, it is evident that high traffic scenario such as the parking spot reservation where there is high traffic in roads, proposed EMA-CAH-MAC are highly suitable for multicasting operation. During the high traffic the message cannot be forwarded to all nodes in efficient manner. As a result either collision will occur or the rate of packet dropping will be high. The proposed EMA-CAH-MAC solves the problem by using the unused time slots for retransmission of packets. Therefore the packet delivery ratio, throughputs are high and packet delay is low for proposed EMA-CAH-MAC.

V. CONCLUSION

The implementation of the Enhanced multicast algorithm (EMA-CAH-MAC) is discussed briefly which is used to reduces the delay shown by the vehicles as they pass through the intersection (RSU). Each and every node time slot is allocated using the process of STDMA process in this proposed approach. The major advantage of the proposed approach is improving the packet delivery ratio in dynamic topology of VANET. Network lifetime is accomplished by finding multicast path that tends to minimize the variation of remaining energy of all the nodes and increase the throughput using header table. Numerical results demonstrate that throughput gain by cooperation is significant for a moderate channel condition. In addition, the throughput gain is significant in the presence of a moderate number of nodes in a two-hop neighborhood as compared with the total number of time slots available in a frame. The performance of this proposed technique is validated and characterized by comparing with existing MAC and the proposed multicasting schemes.

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