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ME-MAC Protocol for MAC Layer in MANET to Overcome HET Problem

S. Hemalatha, Harikumar Pallathadka, Rajesh P Chinchewadi

Abstract: ***Medium Access layer in Mobile Adhoc Network is responsible of transmission of packet through the wireless medium, while transmitting the packet all nodes has to intellect the medium before sending the packet. Every node can able to transmit the packet when the medium if free otherwise the nodes have to wait until the medium becomes free. Some cases the transmission range of the node can be idle but due to Hidden and Exposed node, the node could not be sending the packet to other nodes. Node has to wait unnecessarily event the transmission medium is free. This research article proposed the Mutual Exclusion MAC protocol for avoiding hidden and exposed terminal problem in MANET. The proposed protocol is implemented with the support of Network simulator 3 and results are compared with the existing different protocol proposed for the MAC layer with the parameter and better results shown.***

Key words: ***MANET, Hidden and Exposed Terminal, ME-MAC Protocol, MAC layer***

I. INTRODUCTION

Carrier Sense Multiple Access (CSMA) [3] scheme is design in wireless medium for transmitting packet among the node, Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA) and Carrier Sense Multiple Access with Collision Detection (CSMA/CD) [11] is enhance design of collision issues in MANET [2] [9]. All the nodes in the network sense the medium before sending the packet, when a packet is transmit, if the medium is free otherwise wait until medium becomes free. MANET MAC [14] protocol are in two classification lie contention based scheme and Contention free scheme. The TDMA, CDMA and FDMA are comes under contention based scheme used to avoid contention. Contention free scheme are static network with centralized node control.

Again contention based MAC protocol is further classified in to two more categories like Random access protocol and dynamic Reservation Collision Resolution protocol. Pure aloha and slotted Aloha are under Random access protocol, CSMA [10] belongs to Dynamic Reservation Collision Protocol. Contention based MAC protocol further classified in to single channel, multi channel, directional antenna based, power aware and QoS aware schemes. The Classification of MAC protocol depict in the figure 1.1 shown below.

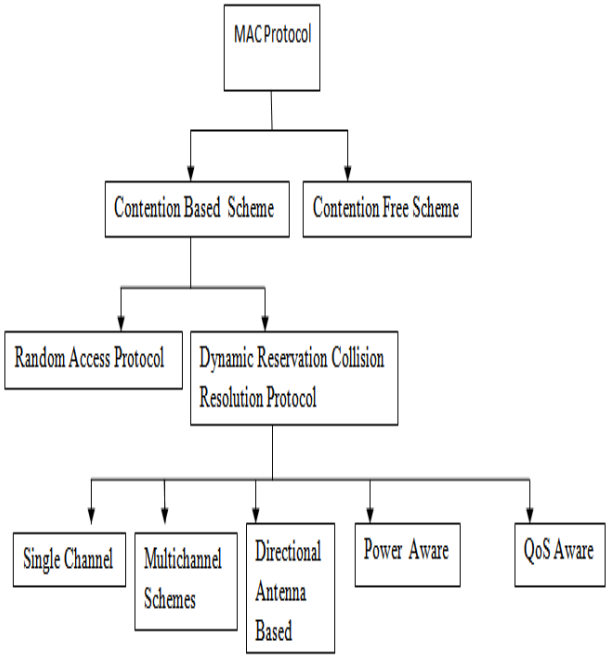

Figure 1.1: Classification of MAC Protocols

Initially the MAC protocol based on the implementation of single channel scheme, all information are shared in the single channel which causes many problem also decreases the efficiency of the MANET. Later Hand shake signals were introduced between the sender and the receiver. Multiple channels uses Request to send and Clear to send communication handshake to eliminate the Hidden and Exposed problem but this does not provide the acknowledgement to the data link layer. MACA problem was overcome by MACA Wireless (MACAW) [12] with the uses of frame sequence RTS-CTS-DS-DATA-ACK, data link layer is responsible for error recovery process with the support of ACK as a result MACAW produces high throughout. Even though MACAW could not completely solve the Hidden and Exposed Problem. Later Floor acquisition multiple access (FAMA) and Group allocation multiple accesses with packet sensing (GAMA-PS) were becomes to support collision avoidance with RTS and CTS exchange. Finally the demerit of single channel is if number of nodes increases in MANET gradually the collisions gets increased which leads the introduction of multichannel.

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Later Multi channel CSMA MAC protocol applies dividing the bandwidth by number of channels Sender checks the channel is idle or busy, if it is used and choose another free available channel. Next Hope reservation multiple access (HRMA) [13] protocol relies based on FHSH with low frequency which uses frequency hopping using handshake and reservation scheme. This produces the data transmission without collision for hidden terminal. Another protocol named Dynamic channel assignment with power control (DCAPC) uses control channels and multiple data channels with the support of RTS-CTS-RES exchange control messages.

In this paper, the Hidden and Exposed Terminal Problem in MANET is the main topic, and the Mutual Exclusion MAC (MEMAC) protocol is suggested as a solution. The hidden and exposed table, which is maintained in all nodes and contains information on hidden and exposed nodes, will be used to facilitate the operation of the proposed MEMAC protocol. This node discovery is based on the mathematical computation of the Venn diagram with the aid of intersection and union. The proposed protocol is implemented in Network Simulator, and the outcomes are evaluated in comparison to previous research.

The article is organised as follows: Section 2 elaborated the related research work conducted in the Hidden and exposed problem, followed by Section 3's discussion of the mathematical background used in maintaining the hidden and exposed table, Section 4 elaborated the research work's origin, which included a brief description of the proposed Mutual Exclusion MAC (ME-MAC) Protocol, Section 5 discussed the results, and Section 6 provided a discussion and conclusion about the research work.

II. MAC PROTOCOL RESEARCH WORK

From the Table 2.1,which summaries about the related research work proposed towards MAC protocol implementation of overcome the Hidden and Exposed terminal problem [4] [8] [20]. Many of the authors centric on RTS/CTS mechanism which solve the collision in hidden terminal but fails [1][16][17][18][19] on exposed terminal problem. Another Set of authors concentrates on usages of directional and Omni directional antenna to overcome the Hidden and Exposed Terminal problem but this also fails on giving solution to exposed problem.

Finally single channel and multi channel adoption with data streaming also support the MAC protocol implementation that mechanism also fails on the overcome the problem. Still the need of new protocol invention to resolve the MAC layer Hidden and Exposed Terminal problem. This article focus on the new MAC layer Protocol named Mutual Exclusion MAC Protocol with the support of Hidden and Exposed table creation among the MANET nodes

Table 2.1: Literature Review Summary

Authors	Invented Mechanism Used
Caishi Huang et all [6]	RTS/CTS mechanism DATA broadcast.
Viral V. Kapadia [4]	RTS/CTS mechanism with Omni directional antenna.
Ms. Ritu Patidar et. al [5]	MAC protocol with antenna support.
Lu Wang et. al	Attachment Coding technique was suggested attaching control information to data stream.
Khaled H. Almotairi et. al [7]	MMAC -HR resolving the exposed terminal problem.
Ketema Adere, Ramamurthy [8]	Antennas based MAC Protocol.
KiHong Kim et. [9]	MAC light weight low power authentication mechanism
Caishi Huang, Chin-Tau Lea Albert Kai-Sun [7]Wong [10]	• Contention Based Protocol • Busy Tone Signal Based Protocol • Power Aware Protocol • Multiple Channel Based Protocols Etc
Viral V. Kapadia, Sudarshan et al [11]	Adhoc network with control schemes like RTS/CTS mechanism.
Chen J, Sheu S, Yang C [12]	R-CA named for dynamic channel interference which made for channel assignment.
Liu K, Wong T, Li J, et al	Simple DCF MAC protocol allows the parallel transmission.
Liu Kai*, Xing Xiaoqin	Back - off criteria used by the Virtual Base Station
Lu Wang, Krishan Wu Mounir Hamdi [3]	Virtual jamming that could prevent the various problems of RTS /CTS problem.

III. MATHEMATICAL BACKGROUND WORK RELATED TO PROPOSED ME-MAC PROTOCOL

The Proposed Mutual Exclusion MAC protocol incorporates by maintaining the table called Hidden and Exposed nodes table which support for doing MEMAC protocol works. In order to create the Table, The MANET every nodes region assumes as a Venn diagram plotting [15]. The union intersection, Symmetric difference, relative symmetric, absolute complement of the Venn diagram notations are support for the Table creation. The Details of the Venn diagram logical relationship and the set shown in the Figure 3.1 below.

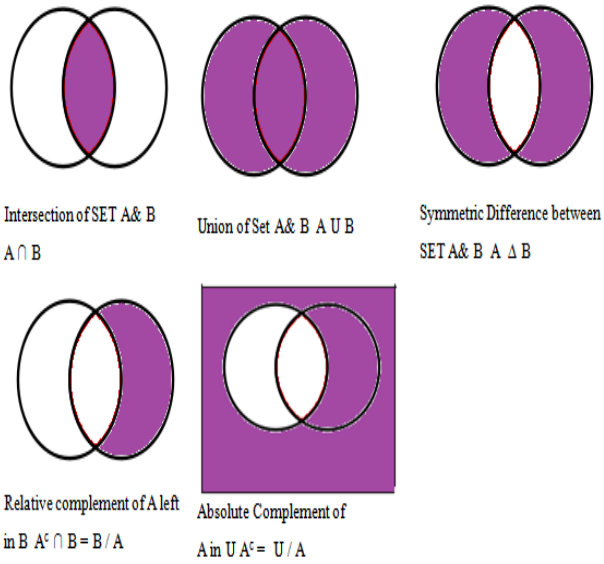

Figure 3.1: Logical Relationships of Venn Diagram

A Venn diagram is also called set diagram or logic diagram which supports to show all possible logical relationship between the set. In this research paper uses Venn diagram for each set S defines as a node A under the region all the other nodes. Likewise for all other nodes sets are defined as well periodic updated. The research focus on extension of higher number of sets probably takes four intersection forms spheres, to 16 intersections of 16 cells. The n set diagram for different topologically diagram sin curve equation is shown below Eq 1.

$$y_i = \frac{\sin(2^i x)}{2^i} \text{ where } 0 \le i \le n-1 \text{ and } i \in \mathbb{N}. \quad \text{---------- (1)}$$

IV. RESEARCH WORK ABOUT PROPOSED MUTUAL EXCLUSION MAC (ME-MAC) PROTOCOL

In order to overcome the Hidden and Exposed terminal problem in the MANET Physical layer challenges there are the several techniques are proposed, but all the proposed method are having the pits and fall on it. In this article proposed the Mutual exclusion Protocol for MAC layer by maintain the hidden and exposed terminal in each node which support to Finding out hidden and exposed terminal in each region. Sample MANET node forming shown in the Figure 3.1 and its Hidden and exposed Terminal nodes shown in the Table 3.1 below. As like the route finding before transmitting the packets the hidden and exposed nodes fining also done parallel which makes the nodes to avoid collision.

A. Mutual Exclusion MAC (ME-MAC) Protocol works as follows in the stages

1. For all the nodes in the MANET form the region Maintain the hidden and exposed node table
2, Generate the beacon signal by collecting the node available position
3. Upon receiving the node position form the nodes which are in the nodes region called the SET node a single node region

B. Hidden Node Table Creation

1. MANET Set of NODEs N = Node $\{n_1, n_2, n_3, \ldots\ldots n_m\}$ m is a total number of nodes in a MANET
2. For each node i from 1 to N
Generate location aware of other node in each i th node transmission range
3. All the node shares the nodes which are in the region to its Transmission range nodes.
4. Repeat for (i=1 to N)
{Select adjacent three nodes one by one n_i, n_{i+1},n_{i+2}
Hidden node of ni = n_{i+2} if n_i -> n_{i+1}, n_{i+1} -> n_{i+2} then n_i -> n_{i+2} .
Also in generalize
Hidden node of n_i = (List of nodes in (n_i)U (n_{i+1}) U (n_{i+2})) ~ ((List of node n_i^{th} node transmission range) U (List of node in n_{i+1}^{th} transmission range))}

C. Exposed Node Table Creation

1. MANET Set of NODEs N = Node $\{n_1, n_2, n_3, \ldots\ldots n_m\}$ m is a total number of nodes in a MANET.
2. For each node i from 1 to N
Generate location aware of other node in each i th node transmission range
3. All the node shares the nodes which are in the region to its Transmission range nodes.
4. Repeat for (i=1 to N)
{Select adjacent Four nodes one by one n_i, n_{i+1}, n_{i+2}, n_{i+3}
Exposed node of n_{i+1} = n_{i+3} if n_i -> n_{i+1}, n_{i+2} -> n_{i+3} then n_{i+2} and n_{i+2} are exposed nodes.
Also, in generalize
Exposed node of i = If i and j are in the same transmission range and List of node i^{th} node transmission range is not equal to List of node in j^{th} transmission range then i is exposed node to j}

Example of Hidden and Exposed node in following figure 4.1 is shown in the Table 4.1, totally four regions is created for the MANET communication Network. Each and every region applies the Mutual exclusion MAC Protocol for finding out hidden and exposed terminal of each region. This table will be available in all the nodes in buffering and updated by all the nodes in every beacon signal generation.

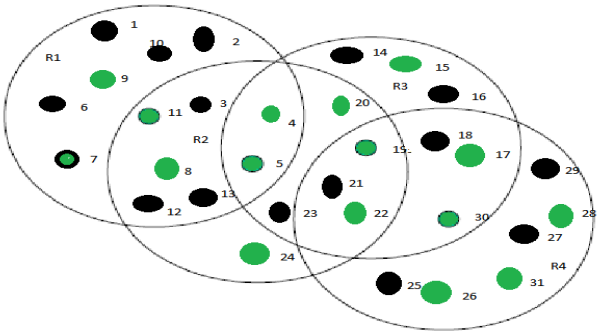

Figure 4.1: MANET Hidden and Exposed Nodes

Table 4.1: Hidden and Exposed Terminal Table

Region	Hidden Terminal	Exposed Terminal
R1	6- 20	11-5-21
R2	3 -14	3-4-14
R3	15 - 2	15-14-25
R4	27-16	22-30-27

V. SIMULATION SETUP AND RESULT DISCUSSION

The Proposed Mutual Exclusion MAC protocol is implemented with the Network simulator 3with total 250 nodes designed in and following the Parameter set up in table 5.1. Two new signals are added with the Network simulator for giving solution to the Hidden and Exposed Terminal Mutual Exclusion agreement name as Hidden signal and Exposed Signal. Every beacon signal updated the table of Hidden and exposed nodes in the MANET, when nodes want to communicate with the other nodes it check the medium is free also check the Hidden and exposed nodes updated table. If the source node is Hidden node, the node could not wait to the medium become free, as well as the Exposed nodes follows the same. Initially the NS3 GUI is plotted and shows the Collision possibilities with the support of Hidden and Exposed Terminal nodes. Initially three nodes are plotted to show the collisionN1, n2 and N3 are the MANET nodes, N1 and N2 wants to communicate with the N3, both sense the carrier it is free then both N1 and N2 start sending the packet , but collision occur at the N3. To come such a scenario the two signals are generated Hidden and exposed signal to make mutual agreement on sending the packet to the destination.

Table 5.1: Network Simulator Parameter Setup

S. No	Parameter	Value set
1	PHY	DSSS
2	CWmin	32 bit
3	CWmax	1024 bit

4	Channel Data Rate	11Mbps
5	Basic Data Rate	1Mbps
6	SIFS	15 µs
7	DIFS	45 µs
8	Slot time	15 µs
9	Propagation delay	1 µs
10	Packet Payload	10000bits
11	MAC Header	200 bits
12	PHY Header	150bits
13	ACK	250 bits
14	RTS	250 bits
15	CTS	250 bits
16	Hidden signal	250 bits
17	Exposed Signal	250 bits

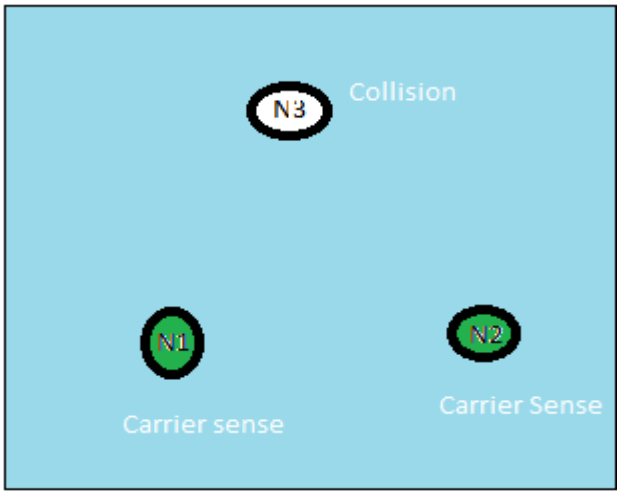

Figure 5.1: NS 3 GUI SETUP

In order to compare the performance, the proposed ME-MAC protocol is compared with the existing protocol in shown in the Table 2.1 methods. The Methods taken for comparisons are RTS/CTS, MAC protocol; simple DCF MAC and parameter is packet drop due to transmission rate, broadcast received. Simulation nodes are placed in 500m*500m with constant increasing the nodes from 1 to 100. Maximum speed of each node varies from 0 to 10 m/s.

Case 1. When simulation made static and traffic increases the ME-MAC performs high delivery ratio over 85 % compare to the existing protocols shown in the Figure 5.2 result graph. Throughput is better than existing but there no variation on the power consumption.

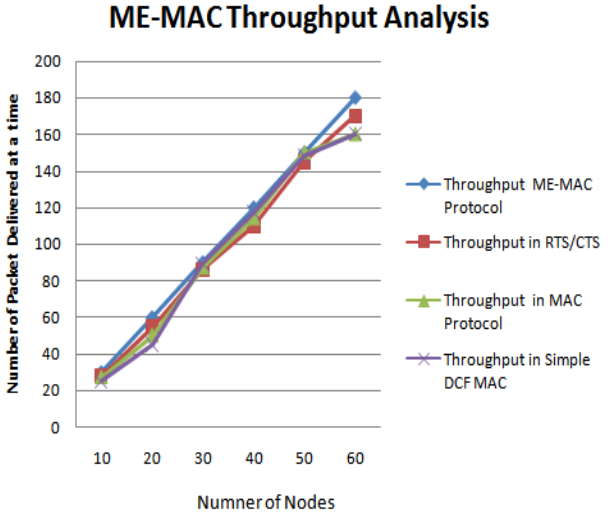

Figure 5.2: ME-MAC Packet Delivery Ratio Analyses with other Methods

Case **2.** When a nodes moves in the speed of maximum 10m/s the drastic packet delivery ratio in the existing protocol, even some performance slow down in ME-MAC due to the updating of hidden and exposed terminal maintenance table and Hidden and exposed signals. The entire summary depict in the Figure 5.3.

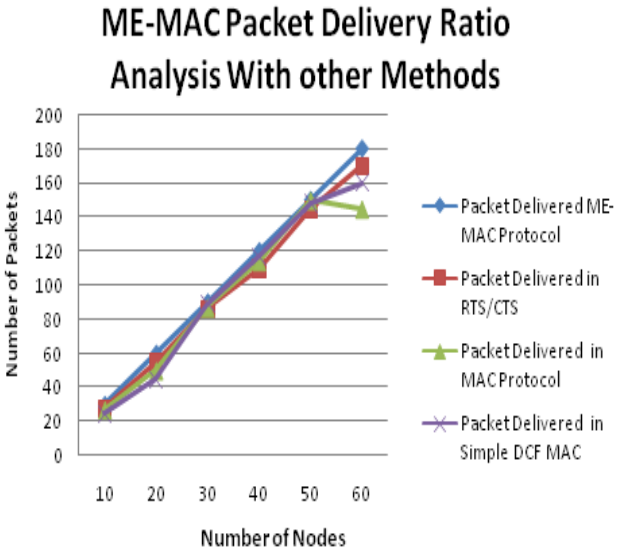

Figure 5.3: ME-MAC Packet Delivery Ratio Analyses with other Methods

Case **3.** When the packet drop due to node mobility or collision causes retransmission of packets. The ME- MAC protocol support avoiding the collision and retransmission of packet reduced to 25 % comparing with the existing protocol scenario as depicted in the Figure 5.4. The ME-MAC Protocol works well even the number of nodes increases in the MANET.

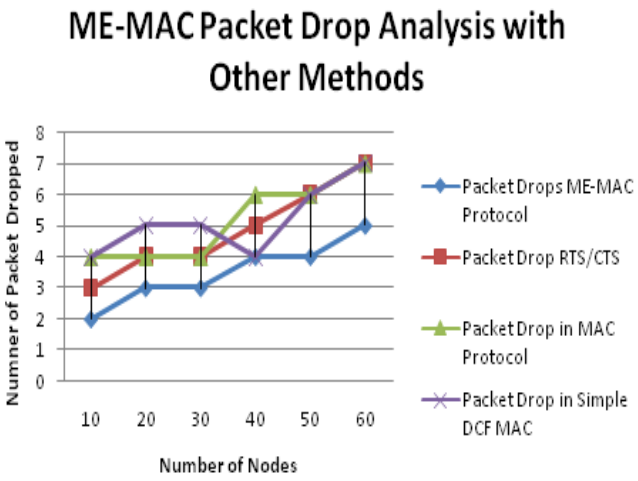

Figure 5.4 ME-MAC Packet Drop Analyses with Other Methods

Case **4**. The Impact of Hidden and exposed Signals introduces in the MANET, MAC layer which support the broadcast of hidden and exposed nodes which makes more number of routing path selection among the MANET.

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VI. CONCLUSION

The Proposed ME-MAC protocol for MAC layer helps to support to create the hidden and exposed nodes in MANET nodes, which reduced the nodes waiting for the medium become free even the medium, is free. Also this protocol support the MANET performance in comparing with the existing MANET MAC Methodology. In feature this Protocol can be incorporate to the data link layer for forming the enhanced MANET protocol with overcoming many challenges in the MANET protocol issues.

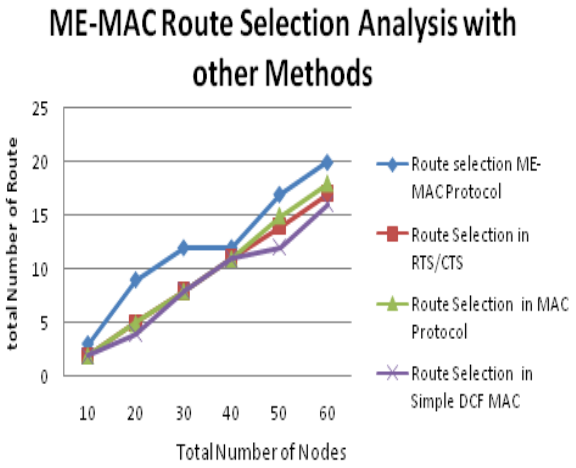

Figure 5.5: ME-MAC Route Selection Analysis with Other Methods

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Ethical Approval and Consent to Participate	No, the article does not require ethical approval and consent to participate with evidence.
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Authors Contributions	All authors have equal participation in this article.

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