An Improved MAC Protocol to Reduce Packet Loss and Energy Wastage in Ad-Hoc Networks

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Abstract: - An Ad-Hoc network is a wireless, decentralized, dynamic network in which devices associate with each other in their link range, in which the basic 802.11 MAC protocol uses the Distributed Coordination Function (DCF) to share the media between various devices. But use of 802.11 MAC protocol in Ad-Hoc networks affected by different issues such as restricted power capacity, packet loss because of transmission error, various control traffic and failure to avoid packet collision. To solve these problems various protocols have been proposed. But we don't have any perfect protocol which can resolve the issues related to power management, packet collision and packet loss efficiently. In this research paper, we suggest a new protocol to adjust the upper & lower bounds for the contention window to decrease the number of collisions. As well as it proposes a power control scheme, triggered by the MAC layer to reduce the packet loss, energy wastage and decrease the number of collisions during transmission. The proposed MAC protocol is implemented and performance is compared with existing 802.11 MAC protocol. We computed the Packet Delivery Fraction(PDF), average End-to-End(e-e) delay, average throughput and packet loss in several conditions. We find proposed protocol is comparatively improved than the existing protocol.

Keywords: - *Ad-Hoc network, MAC protocol, power control scheme, contention window Packet Delivery Fraction, average End-to-End delay, average throughput, packet loss.*

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1. INTRODUCTION

The Medium Access Control (MAC) Layer [12] is one among the two sublayers that structure up the Data Link Layer of the Open Systems Interconnect (OSI) model. The MAC layer is responsible for moving data packets from one Network Interface Card (NIC) to an another NIC over common shared channel. Avoiding the collisions among interfering nodes is one of the basic tasks of the MAC protocol. The MAC sublayer utilizes MAC protocols to ensure that signals sent from distinct stations over a same channel don't collide.

The distributed coordination function (DCF) is an element of the IEEE 802.11 standard which relies on the CSMA/CA mechanism. Within the DCF mechanism a Contention Window (CW) is employed by a node so as to regulate the back-off window. Every node pick indiscriminately a contention slot from the [0, CW] interval. In every retransmission the CW is doubled by the Binary Exponential Back-off (BEB) algorithmic rule. As the amount of active neighbours increase, the amount of collisions also increases. When the CW is doubled, there is a continuous likelihood that competitive nodes selects an equivalent rivalry slots, as a result of the edge of the CW continuously tends to zero. The adjustment of the bound doesn't take care about the network load or channel conditions. It offers rise to unessential collisions, in consequence with the retransmissions of a packet that results in loss of energy and a shorter lifespan of the network (only applicable when nodes are battery powered).

On the other side, once a transmission is at boom or a packet is born, the bound of the CW is reset to the static minimum CW (CWmin and CWmax are fastened within the 802.11 DCF freelance of the environment). However, receiving a packet with success doesn't say anything regarding the competition level while choosing a convenient CW worth. It's not known in a better way whether the competition level is born or not. Just like in case of a born packet, this assumption also holds a lot of uncertainly. The optimum minimum worth of the CW depends closely on the amount of competitive nodes active within the network. As a result, DCF will neither consider the network load nor the remaining energy offer any chance for prioritizing, there are various approaches planned that do take consideration of the conditions and offer enough flexibility to be able to placed.

2. LITERATURE SURVEY

The MAC sublayer uses MAC protocol to ensure that signals sent from different stations across the same channel does not collide. There are various MAC protocols that have been developed for Wireless Voice and Data Communication networks. MAC protocols are of two types-

1. Scheduled based protocols (TDMA, FDMA, CDMA etc.)
2. Contention based protocols (IEEE 802.11, CSMA etc.)

Because of much packet loss and energy wastage, none of the above mentioned protocols are suitable for Ad-Hoc network and WSN. Therefore it is very much clear that there is a need of different MAC protocols for Ad-Hoc network and WSN. Prior to discuss about the MAC protocols for Ad-Hoc network and WSN, we give for a look in the most important source of energy wastage in the existing MAC protocols [10]. The first one is collision. Once a transmitted packet is corrupted, it has to be discarded and follow-on re-

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transmissions that increase energy consumption. Collision will increase latency as well. Another source of power wastage is overhearing, which means that a node picks up packets that are destined to different nodes. The third source is control packet overhead (Sending and receiving control packets consume energy too). The last major source of inefficiency in power management and wastage control is idle listening, i.e., listening to receive possible traffic that has not been sent really. This is often true in several sensor network applications. If nothing is sensed, nodes are in idle mode for most of the time. However, in several MAC protocols like IEEE 802.11 Ad-Hoc mode or CDMA nodes have to listen to the channel to receive possible traffic. Facts and Figures have shown that idle listening consumes 50%–100% of the energy required for receiving. For example, Stemm and Katz measure that the idle: receive: send ratios are 1:1.05:1.4 [25], whereas the Digital Wireless LAN module (IEEE 802.11/2 Mb/s) Specification shows idle: receive: send ratios is 1:2:2.5 [26]. Most of sensor networks are designed to control for a long time and nodes are in idle state for a longer time. Thus, idle listening is an important issue of energy wastage in such cases.

3. PROPOSED SOLUTION

The goal of the proposed MAC protocol is to save energy (which leads to an extension of the period of time of nodes) and to reduce the amount of collisions. However, the proposed MAC protocol doesn't degrade the throughput performance and fairness in terms of the throughput and sending rate, while achieving these goals.

To improve the protocol we use a modified and enhanced selection bounds (ESB) algorithm for flexible adjustments in the upper and lower bounds of contention window to minimize the number of collisions. As well as, we use the power control recovery and enhanced power control-dropped packet scheme to limit the waste of energy.

Algorithm (ESB Algorithm)

-Upon first transmission

$lB0 = lBDCF = 0$; $uB0$ = CWmin = CW_DCFmin ;

-Upon each retransmission-

(1) $lBtmp = (uBi/2 - 1/2 + NrN + nrATT)$* log10 $(nrATT + \gamma)$

(2) $lBi = lBtmp$ * coeRE;

Where a constant $\gamma = 3.0$;

(3) $uBi = (2 * uBi - 1) * \log10 (NrN$ * coeRE + $nrATT + \gamma)$

Where $\gamma = 3.0$ if $NrN < 2$, and 0 otherwise;

(4) IF (uBi > CWmax) then uBi = CWmax,

Where CWmax = CW_DCFmax +CW_DCFmin;

Algorithm (Power Control –Recovery Part)

(1)PtDIFF=ε*log10*(NrNCURRENT/NrNDESIRED) **PtTR−1;

Where ε = 1/NrNDESIRED is a constant -recovery mechanism-

(2) IF (SINRCURRENT > SINRTHRESHOLD)

(3) PtTR = PtTR−1 + (ζ − 1)*PtDIFF;

(4) ELSE

(5)PtTR = PtMAX − (ζ)*PtDIFF;

Algorithm (Enhanced Power Control-Dropped Packet Scheme)

1)PtDIFF=ε*log10*(NrNCURRENT/NrNDESIRED)*PtTR −1;

Where ε = 1 NrNDESIRED is a constant -dropped packet-

(2) IF (Drop and RatioColl > RatioCollTHR)

(3) PtTR = PtMAX − (ζ + 1)*PtDIFF;

(4) ELSE

(5) PtTR = PtMAX − (ζ)*PtDIFF;

4. IMPLEMENTATION AND RESULTS

In this research paper, we used NS-2 to simulate proposed protocol. The data rate of mobile hosts is set to a same value: 2 Mbps. The active mobile nodes 30, 40, 50 and 60 are move about in 850 x 850 meter rectangular region for a thousand seconds simulation time. Initial locations and movements of the nodes are obtained using the random way point model of NS-2. There is a common trend to assume that every node moves independently with a same average speed. All nodes have an equivalent transmission range of 250 meters.

During this mobility model, a node randomly selects a destination from the physical terrain. It moves in the direction of the destination in a speed uniformly chosen between the minimal speed and highest speed. When it reaches its destination, the node stays there for an interruption time and then moves once more. In this simulation, the speed is 20 m/s. and pause time is 10 seconds. The simulated traffic is CBR. For every situation, constant seeds were conducted and therefore the results were averaged.

The following factors are computed according to the table 4.1:-

➢ (a) Packet Delivery Fraction (PDF)
➢ (b) Average (e-e) Delay
➢ (c)Average Throughput
➢ (d) Packet Loss

Table 4.1 Simulation Parameter

Parameters	**Values**
Number of Active Nodes	30,40,50,60
Simulation Area	850 x 850 meter^2
Initial Energy (in J)	5.0
Radio Propagation Model	Two Ray Ground
Payload Size (in B)	1460
Maximal Speed (m/s)	20 m/s

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Routing Protocol	DSDV
Pt_max (W)	0.2818
SINR thr. (in dB)	24.05
Capture Threshold (in dB)	10
CWmin – CWmax (slots)	15-1023
Simulation Time (s)	1000.0
Movement	Random
Mobility model	Random Waypoint
Average Speed (m/s)	0-2|| < 20; 1.5 – (default)
Access scheme	RTS/CTS (default)

Packet Delivery Fraction (PDF):-

Table 4.2 Comparison on Packet Delivery Fraction

S.No.	**Number of Nodes**	**Protocol Name**		
		Proposed MAC	**802.11 MAC**	**S-MAC**
1	30	72.15	70.29	68.03
2	40	75.52	73.11	70.09
3	50	84.45	80.13	79.89
4	60	87.82	85.61	82.77

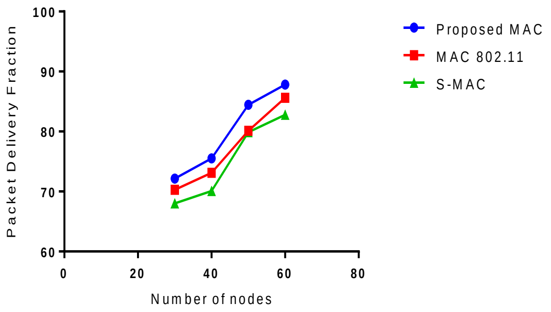

Figure 4.1 Comparison of MAC Protocol based on PDF

Performance of MAC protocol has been compared based on the ratio of the number of delivered data packets to the destination in Figure 4.1. Result of our proposed system and previously derived systems are compared. The result cleanly shows that proposed MAC is much better than other two MAC protocols.

Average (e-e) Delay:-

Table 4.3 Comparison on Average (e-e) Delay

S.No.	**Number of Nodes**	**Protocol Name**		
		Proposed MAC	**802.11 MAC**	**S-MAC**
1	30	79.72	84.67	91.34
2	40	97.39	105.79	112.27
3	50	615.81	610.19	721.32
4	60	608.26	653.87	739.45

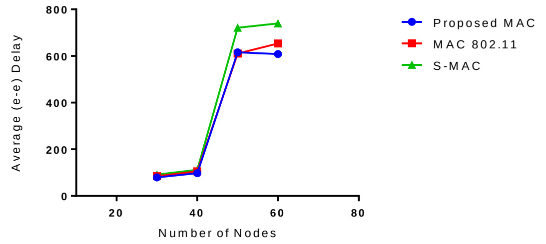

Figure 4.2 Comparison of MAC Protocol based on Average (e-e) Delay

Similarly, Figure 4.2 shows the performance of MAC protocols based on the Average (e-e) Delay. The X-Axis notes the number of nodes and Y-Axis shows the average (e-e) delay.

Average Throughput:-

Table 4.4 Comparison on Average Throughput

S.No.	**Number of Nodes**	**Protocol Name**		
		Proposed MAC	**802.11 MAC**	**S-MAC**
1	30	13.95	12.58	10.17
2	40	14.71	14.10	13.34
3	50	16.33	14.65	13.01
4	60	16.96	15.77	14.29

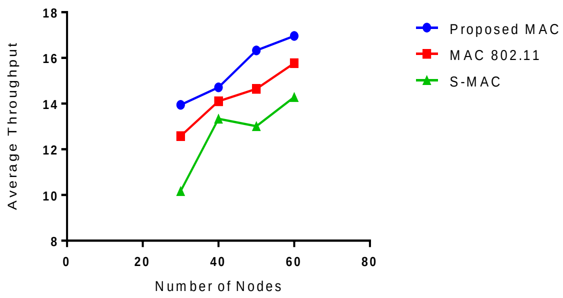

Figure 4.3 Comparison of MAC protocol based on Average Throughput

S.No.	**Number of Nodes**	**Protocol Name**		
		Proposed MAC	**802.11 MAC**	**S-MAC**
1	30	79.72	84.67	91.34
2	40	97.39	105.79	112.27
3	50	615.81	610.19	721.32
4	60	608.26	653.87	739.45

The performance of MAC protocols is shown in figure 4.3 which depends upon the Average Throughput. As the throughput of proposed MAC protocol is higher, it is clearly visible that for given scenario our proposed system is performing better than other MAC protocols.

Packet Loss:-

Table 4.5 Comparison on Packet Loss

S.No.	Number of Nodes	Protocol Name		
		Proposed MAC	802.11 MAC	S-MAC
1	30	11.71	12.59	14.17
2	40	6.86	8.23	11.27
3	50	2.43	5.37	7.52
4	60	1.17	3.49	5.11

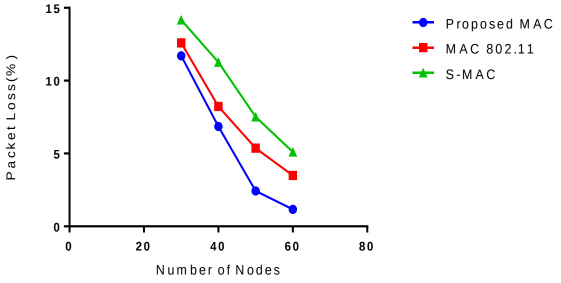

Figure 4.4 Comparison of MAC Protocol based on Packet Loss

The above results show that the proposed MAC protocol much better than the MAC 802.11 protocol.

5. Conclusion and Future Work

In this research paper, we proposed and implemented an improved MAC protocol to handle the limited power efficiently and packet loss issues of existing MAC protocol with concern of average throughput. We implemented an improved and enhanced selection bounds (ESB) algorithm for flexible adjustments in the upper and lower bounds of contention window to minimize the number of collisions. As well as, we used power control recovery and enhanced power control-dropped packet scheme to decrease the wastage of energy. To evaluate the performance of proposed protocol, we have measured the packet delivery fraction, average (e-e) delay, average throughput and packet losses in various situations. We found our proposed protocol is fairly better than the existing protocol. In given scenario proposed MAC protocol produced better results in terms of count of collisions and average throughput.

The proposed protocol works well for small size networks. We found that the increase in network size increases packet loss and average throughput decreases. For further work efforts are needed to minimize the packet loss for large size networks.

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