Improving Performance in Manets by Optimizing Contention Window in IEEE 802.11

GnanaPrakasi O.S,R.Srinisha,N.Sasi,M.Deepa,Dr.Varalakshmi.P

Abstract- In MANETS, it has been observed that channels suffer from poor bandwidth utilization and extreme unfairness in IEEE 802.11 has been questioned. Existing MAC layer protocols do not cope well with this high level of change fairly. Unlike the existing schemes, the main objective of our proposed approach is to increase the fairness by allowing each node to adapt its transmission rate and contention window. The channel quality is determined based on probability of successful transmission from competing nodes in a particular channel. We validate the proposed modified_MAC using ns2.34 recording the probability to access the channel at regular intervals and comparing throughput, delay with original MAC.

Index Terms— Channel quality, Contention Window, Competing nodes,Fairness, Mobile nodes,Performance,Throughput.

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1 INTRODUCTION

A Mobile Ad hoc Network (MANET) is a self-organized group of mobile nodes (MN's)with no infrastructure [2]. These networks are primarily used in military, disaster zones where easily deployable temporary networks are needed. MN's causes frequent link failures in MANET which results not only in packet loss but also increased contention reducing fairness of the network [9]. When this occurs the existing static mechanisms reset the Contention Window (CW) to the minimum value. This results in reduced throughput and increased delay. The existing wired MAC layer protocols to achieve fairness cannot be generalized for MANETs because of the unique characteristics of the wireless channel, such as location-dependent contention, inherent conflict between optimizing channel utilization and achieving fairness, and the absence of any centralized control.

The IEEE 802.11 technology implements different Medium Access Control (MAC) methods for both centralized (e.g., wireless LAN) and ad hoc networks. The Distributed Coordination Function (DCF) is the fundamental MAC technique. It is based on the Carrier Sense Multiple Access and Collision Avoidance (CSMA/CA) scheme [3]. There are various transmission rates available in IEEE802.11, there is no standard approach defined to select the appropriate rate while ensuring fairness among the competing nodes. Indeed, fairness and throughput optimization have never been jointly thought of. With this in mind, it should be noted that without ensuring fairness, the whole network becomes unable to reach its optimum status.

In this paper we propose a mechanism which gradually resets the CW, based on information on channel quality and also scales the transmission rates according to number of consecutive successful or failure transmissions. In general, nodes competing for a particular channel have access to the channel under different conditions characterized by different parameters such as nodes mobility, nodes density, traffic intensity, etc. We take into account the channel quality which is evaluated by the transmitter before it resets its Contention window.

The rest of the paper is organized as follows. In the following Section, we discuss the issues that degrade the fairness in MANETs. Section III elaborates about some of the related methodologies to our work. Section IV describes our proposed methodology for adapting the contention window. Section V contains the simulation parameters and analysis of obtained results. Section VI discusses the conclusions of our work and discusses opportunities for future work.

2 FAIRNESS ISSUES IN MANETS

Fairness is of important concern in wireless networks in which resources are limited and channel condition is highly dynamic. In unfair configuration, not only the traffic condition involved in resources sharing, but also the relative location of nodes affects the effective utilization of these resources. Therefore, it is difficult to manage resources in such situations. We show that the main causes of unfairness phenomena come from an incomplete knowledge of neighborhood activities (or a lack of synchronization) for nodes. The reasons for unfair situations to occur in MANETs are elaborated below.

2.1 Unbalanced level of contention

This happens when a flow in the middle of other flows undergoes more contention than the neighbor flows.

2.2 The well-known hidden station problem

A In a 802.11 world, a RTS/CTS handshake was designed to overcome this problem. However such a scheme becomes inefficient in a configuration where the interferer transmitter is out of the transmission range of the receiver that may therfore not decode the received CTS.

2.3 Mobility-induced route changes and packet losses

The mobility of the nodes affects the number of average connected paths in routing layer, which in turn affect the performance of the MAC protocol.

2.4 Limited wireless transmission range

Transmission range of a node refers to the average maximum distance in usual operating conditions between two nodes.

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3 RELATED WORK

In the works of [5], [6], [7], a cross-layer solution from MAC to TCP is proposed. Here at the MAC layer, differentiating losses due to signal failure caused by displacement or by noise from other loss types is analyzed and data is collected. Based on the obtained information at MAC layer, the TCP layer distinguishes a loss due to interferences from those due to congestions and to adapt consequently the TCP behavior. The disadvantage in these mechanisms is that the competing nature of MN's in a MANET is not taken into account.

In [13] a similar mechanism to [5], [6], [7], is proposed but with the difference the probabilistic analysis for contention and congestion control was done with the help of a snooping agent. Here the snooping agent in the source node does not wait for the usual TCP Acknowledgement to be received in a backward direction from the destination node instead it generates a TCP Acknowledgement on its own and delivers it to the transport layer [12]. Here when a TCP data packet is received from wire-line network, the snoop agent will cache the TCP data packet in base station and monitor packet transfer at the base station. If the packet is lost in the wireless medium, the base station will automatically retransmit the TCP data packet and avoids TCP senders to retransmit again. When the base station forwards a packet to a TCP receiver, the snoop agent will evaluate the probability of packet collision. If the packet is lost, the snoop agent will use the previous evaluation to adjust the contention window of the MAC layer.

In [14] a Cross layer Congestion Control for TCP (C3TCP) congestion control over wireless local area networks where data delivery is performed over multiple wireless hops. It is assumed that every node has an appropriate output FIFO buffer, where the link layer packets are queued while the wireless medium is busy due to transmissions of other nodes. The second assumption consists in the availability of a routing path to every node of the multi hop network.

In [15] proposes an extended EDCF with a dynamic adaptation algorithm of the maximum contention window (CWmax) for enhanced service differentiation in wireless ad-hoc networks. The purpose of their scheme was to reduce delay and jitter and increase the efficiency of the transmission channel. Priorities between access categories are provisioned by updating the size of the CWmax according to application requirements and channel conditions. Here the contention window has been set twice. First whenever collision occurred and then after every successful transmission.

A new scheme called SAM-MAC (Self-Adjustable Multichannel MAC) [16], which features with one common channel and two half-duplex transceivers for each node. A method called self-adjustment is used to reassign the channels and balance the traffic on different channels. Due to less contention in common channel and smaller channel assignment overhead, this scheme increases the throughput compared with previous approaches. Control channels are free from saturation problem and can furthermore be used for data transmission. Here two metrics are used for the channel reassignment algorithm: the number of neighbors and the channel busyness ratio, which can both be counted or calculated from the information heard on the common channel.

In [3], [4] *channel based schemes,* propose that the channel assigned to a mobile node based on a traffic license. Here for each period of time, every node in the network is initialized to determine which channel to transmit data is used, according to the RTS/CTS packet exchanging with neighbors. The basic idea of this method is that the channel assigned to a mobile node must be different from those of its two-hop neighbors. By doing so, the nodes in the neighborhood will select different channels to transmit their packets, so that the hidden/exposed terminal problem can be alleviated, the fairness problem can be mitigated, and the system throughput can further be increased.

A mechanism similar to our work is the Enhanced Distributed Channel Access (EDCA) [10], which resets the Contention Window (CW) of the mobile station statically after each successful transmission and proposes a new adaptive differentiation technique that takes into account the network state before resetting the contention window and the congestion level of the network is sensed by using previous CW values. The disadvantage is that it fails to include the network data from competing nodes of a channel while calculating the CW value which as shown later does make a difference in terms throughput and delay.

4 PROPOSED FRAMEWORK

The proposed method in Contention window adaption algorithm has been employed in IEEE 802.11 based on the competing nodes to successfully access the channel according to the probability of any transmission failure for nodes. In this scheme, each node calculates its probability to access the channel by taking into account all its competing nodes. Based on the transmission rate levels and probability to successfully access the channel contention window is adjusted. By the way delay is reduced and throughput is increased.This method follows the flow as shown in the following Figure 1.

Proposed scheme considered two parameters packet loss and channel quality. Determining packet loss mechanism is to detect the causes of packet loss based on probability of collisions, either by timeout or by triple duplicated Acknowledgements. The P_d - probability of transmission failure has been defined to exploit the information about the actual channel status.

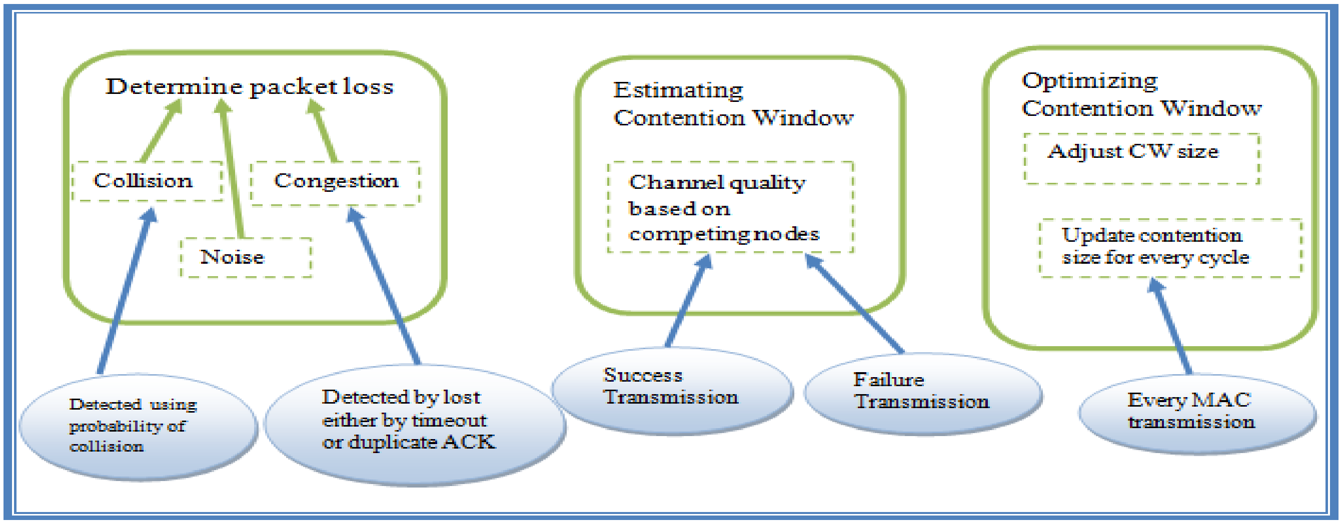

Fig. 1. System Flow of modified_MAC

P_d is obtained from [8] by counting the number of observed transmission failures, divided by the total number of transmission attempts on which the measurement is taken.

$$P_d = F_d / K_d \quad (1)$$

We propose that of all the competing nodes (Φ_c) for channel j, each node x transmits its rate- r_x and probability-P_x to its next node. Then summation ($\sum$) is done for these received values from the competing nodes based on the below formula.

Probability that a transmission fails for node d for channel j is given by,

$$P^j_d = \frac{\sum_{x \in \Phi_c} P_x r_x}{\sum_{x \in \Phi_c} r_x}$$

The next parameter is channel quality which is estimated on the assessment of transmission failures, transmission successes and transmission rates from all the competing nodes that are using that channel. The probability to access the channel is calculated based on the rates and individual probabilities of nodes competing for channel access. Before a node selects its transmission rate it assesses the number of its consecutive failure transmissions and the number of consecutive successful transmissions with their respective threshold values. Every node calculates the probability to access channel. After that for each transmission cycle contention window is adjusted according to the probability to access the channel. During the initial stage, the probability to successfully access the channel is 1 which essentially keeps the minimum contention window as CWcurr itself. The reason is that, when a node connects to a channel, it does not have prior knowledge on the presence of other competing nodes. When a node has prior knowledge of all its competing nodes CWcurr is adjusted based on CWmin and increased probability to access a channel successfully (Q^j_d)

Algorithm for Adapting Contention Window

The terms and notations used in the CW adaption algorithm in Fig .2 are explained below in Table 1

TABLE 1
NOTATIONS OF CW ADAPTION ALGORITHM

Notations	Explanation
Q^j_d	Probability to successfully access the channel
P_d	Probability of any transmission failure for node 'd'
F_d	Total number of failure transmissions
K_d	Total number of transmissions
P^j_d	Probability of a failure transmission for channel j
Φ_j	Competing nodes for channel j
r_x	rate at which the node d transmits
Cw_{curr}	Current congestion window set according to the value of Q^j_d .

While (packets are in queue)
If no of Failure transmissions>=Nth
Probability of any transmission failure for node d
$P_d = F_d / K_d$
Probability that a transmission fails for node d
$$P^j_d = \frac{\sum_{x\in\Phi_c} P_x r_x}{\sum_{x\in\Phi_c} r_x}$$
Φ_c -Competing nodes for channel j each node d transmits r_d and P_d to its neighbors

Each node calculates the probability to successfully access channel:
$$Q^j_d = \frac{(1-P^j_d)}{\sum_{x\in\Phi_j}(1-P^j_x)}$$
If Q^j_d != to 1
$Cw_{curr} = Cw_{min} * Q^j_d$
Adjust to an increased transmission rate.
Else
$(Cw_{min}) \leftarrow Cw_{curr}$
Adjust to an increased transmission rate.
Else
Packet is transmitted with no change in Cw_{min} and transmission rate

End

Fig. 2. Algorithm of modified_MAC

$$P^j_d = \frac{\sum_{x\in\Phi_c} P_x r_x}{\sum_{x\in\Phi_c} r_x} \quad (1)$$

$$Cw_{curr} = Cw_{min} * Q^j_d \quad (2)$$

For example if at a particular time stamp t, Q^j_d, Cw_{min} values were Q^j_d= 0.857143, Cw_{min}= 32, then based equation (2)the Cw_{cur} will be adapted as

Cw_{cur}= 32 * 0.857143
$\mathbf{Cw_{min}}$=Cw_{curr} = 27.428576

A sampling value of probability for successfully accessing a channel is given in table 1. The modified_MAC shows improvement in delay in accessing a channel as shown in Figure 3. There was a also an increased average throughput in Figure 4 obtained from XGraph utility based on data sets from AWK scripts processing.

TABLE 2
Comparison of Modified_MAC and Original MAC Probabilities

TIME LAPSED (µs)	ORG_PROBABILITY	MODIFIED_PROBABILITY
0	1.000000	1.000000
5	0.521739	0.750000
10	0.526316	0.857143
20	0.529412	1.000000
22	0.520000	0.833333
24	0.571429	0.500000
25	0.666667	0.857143

5 Simulation Model

In this section, we have evaluated the performance of our proposed solution on the following metrics [1],

Average Delay: The average delay calculates the required time to receive the packet.

Average Throughput: The average throughput which is the amount of data received successfully over a given period of time in terms of kilo bytes per second (kbps).

The simulation is carried out in ns2.34 simulator [11] with 15 nodes using flat grid topology as in Figure 5.1. The MODIFIED_MAC was created with changes to mac.cc, mac.h, mac802_11.cc and mac802_11.h.The Simulation was done with underlying DSDV routing protocol.

The MODIFIED_MAC yielded an average value of 0.84881 for probability to successfully access a channel. These new values show a marked improvement over values from original MAC, which gave an average probability of 0.570094 only. As explained in our proposed mechanism, probability that a transmission fails for node d is set based on formula (1) from which the probability of success is calculated and then the contention window is reset based on (2),

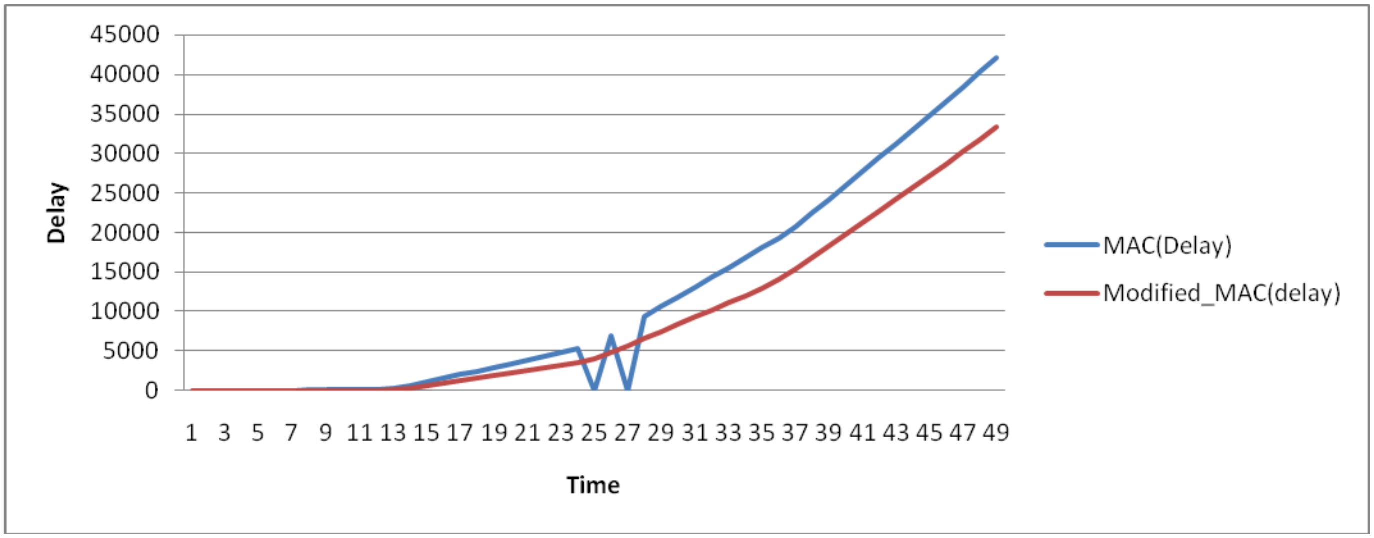

Fig. 3. Comparing Delay between MAC and MODIFIED_MAC

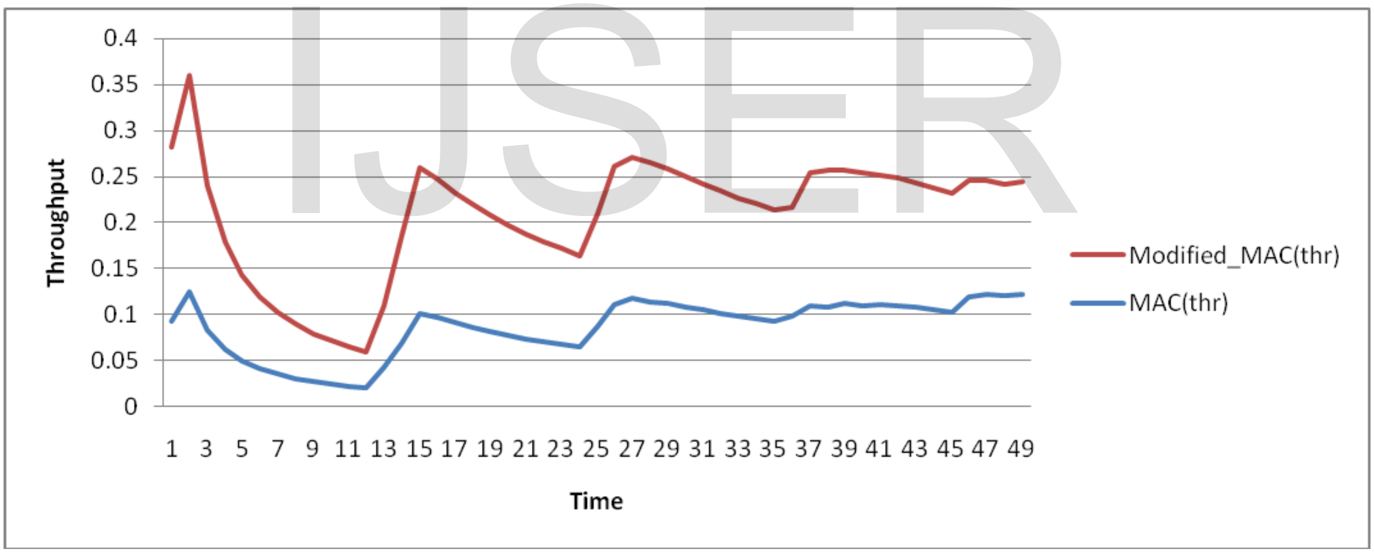

Fig. 4. Comparing Throughput between MAC and MODIFIED_MAC.

6 Conclusion

In this paper, our proposed method has increased network throughput by minimizing the channel access delay. In addition we reset the contention window based on probability to successfully access the channel. Further we can extend our work to increase the end to end network throughput by designing an efficient cross layer congestion control from MAC to TCP based on probabilistic predictions.

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REFERENCES

[1] Ali Balador, Mahtab Ghasemi, Ali Movaghar, "An Adaptive Contention Window Control for Improving DCF Throughput and Fairness," European Journal of Scientific Research ISSN 1450-216X Vol.45 No.2 (2010), pp.310-323.

[2] Adlen Ksentini, Abdel hamid. Nafa, AbdelhakGuerou, Mohammed Naimi, "Determinist Contention Window Algorithm for IEEE 802.11,"IEEE 802.11 standard 2007.

[3] RongGeng, Lei Guo, Xingwei Wang, "A new Adaptive MAC protocol with Qos support on IEEE 802.11 in ad hoc networks" ,ELSIEVER journal, pp. 582-590, Jul. 2010

[4] Der-Jiunn Deng, Yang-Sheng Chen, Yu Shiang Wong, "Adaptive channel allocation strategy for mobile adhoc networks," ELSIEVER journal, vol. 57, pp. 2720-2730, Aug. 2011.

[5] Xinming Zhang, Member, IEEE, Nana Li, Wenbo Zhu, and Dan Keun Sung, "TCP Transmission Rate Control Mechanism Based on Channel Utilization and Contention Ratio in Ad hoc Networks", IEEE communications letters, vol. 13, no. 4, April 2009.

[6] Diyar K. Arab, Amine Berqia, Sofiane Hamrioui, Mustapha Lalam Usthb, Algeria Lari,Ummto,Tizi Ouzou, Algeri, Pascal Lorenz Ilab, Fct-Deei, "Improving TCP Performance in MANET by Exploiting MAC Layer Algorithms", IRACST- International Journal of Research in Management & Technology (IJRMT),Vol. 1, No.2, December 2011.

[7] Stephane Lohier, Yacine Ghamri Doudane, and Guy Pujolle,Cross-Layer Loss Differentiation Algorithms to improve TCP Performance in WLANs, "IEEE Conference on Network Communication", vol. 4217, pp. 297-309, 2006.

[8] Stephane Lohier, Yacine Ghamri Doudane, and Guy Pujolle,Cross-Layer Loss Differentiation Algorithms to improve TCP Performance in WLANs,"IEEE CONFERENCE ON NETWORK COMMUNICATION",2005.

[9] Karim El Defrawy, Gene Tsudik, " Privacy Preserving Location-Based On-Demand Routing in MANETS," IEEE journal on Selected Areas, Vol.29, No.10, DEC. 2011.

[10] Hassan Artail, Haidar Safa , Joe Naoum-Sawaya, Bissan Ghaddar, Sami Khawam, " A simple recursive scheme for adjusting the contention window size in IEEE 802.11e wireless ad hoc networks", Elsevier Journal on Computer communications, 29 (2006) 3789–3803

[11] Network simulator, NS-2. http://www.isi.edu/nsnam/ns/

[12] Lucas Dias Palhao Mendes; Jose Marcos Camara Brito, "Effects of the use of an IEEE 802.11 Snoop Agent on TCP timeouts," Wireless Communications, Networking and Information Security (WCNIS), 2010 IEEE International Conference on , vol., no., pp.493,497, 25-27 June 2010

[13] Gnana Prakasi O.S, Dr. Varalakshmi. P, "Enhancing Performance of TCP in Multihop Networks", International Journal of Computer Networks & Communications (IJCNC) Vol.4, No.5, pp. 203-221, Sept.2012

[14] Dzmitry Kliazovich, Fabrizio Granelli, "Cross-layer congestion control in ad hoc wireless networks", Department of Information and Communication Technologies, University of Trento, Via Sommarive 14, I-38050 Trento, Italy,2005.

[15] Lassad Gannoune, Stephan Robert, Neha Tomar, and Tarun Agarwal,"Results on Dynamic Adaptation of the Contention Window Max (CWmax) for Enhanced Service Differentiation in IEEE 802.11 Wireless Ad-Hoc Networks", 2007.

[16] Rongsheng Huang, HongqiangZhai, Chi Zhang, Yuguang Fang," SAM-MAC: An efficient channel assignment scheme for multi-channel ad hoc networks", Department of Electrical and Computer Engineering, University of Florida, Gainesville, FL 32611, United States, Feb 2008.