Performance Evaluation of Efficient MAC in Mobile Ad Hoc Wireless Networks

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Abstract

Wireless media is in very much demand because of high mobility of the users and establishing ad hoc network in emergency situations, which requires the designing of an efficient and priority based MAC (Medium Access Protocol) as a resource to support MANET (Mobile Ad hoc Networks) adequately. There are various MAC standards used in MANET. The IEEE 802.11 is one of them MAC layer standard and most frequently applied to such networks presently. We found that the IEEE 802.11 MAC standard is not very much suitable into wireless network scenario because its poor performance results in lower throughput, higher delay ,large number of collisions and poor fair access of cannels. In this paper, we propose a dynamic PBC-MAC protocol for wireless ad hoc networks - named as Priority Based Contention-MAC protocol- in which contention window size increases or decreases dynamically and non-uniformly after the collision depending upon the priority levels of nodes in the network. It decides its lower Backoff time as per higher priority level of the nodes to access channel adequately. The simulation result show that PBC-MAC scheme is outperform than the Binary Exponential Backoff (BEB) scheme in the IEEE 802.11 MAC in respect of delay.

Keywords: *Ad hoc Networks, Contention Window, Delay, MAC, PBC-MAC*

1. Introduction

An ad hoc network can be formed on-the-fly and spontaneously without the required intervention of a centralized access point or any pre-existing infrastructure. An ad hoc network provides a co st effective means of communication among many mobile hosts. These networks are very useful in disaster recovery situations or where there is not enough time or resources to configure a wired network [1] [12]. Of late, a significant number of researchers have moved towards studying MANETs and its various characteristics out of its increasing importance in terms of user mobility and establishing ad hoc network in emergency situations. Each node may be equipped with one or more radio interfaces that have varying transmission/receiving capabilities and operate across different frequency bands. This heterogeneity in node radio capabilities and different software/hardware configuration, can result in possibly asymmetric links and variability in processing capabilities [13].Designing network protocols and algorithms for this heterogeneous network can be complex, requiring dynamic adaptation to the changing conditions (power and channel conditions, traffic load/distribution variations, congestion, etc.) [13].All these parameters may be used as for deciding node priority. On the other hand, if fairness and efficiency are required, QoS guarantees may be expected. IEEE 802 standards recommend an international standard 802.11 [2] for WLANs. Quality of Service (QoS) means that the network should provide some kind of guarantee or assurance about the level or grade of service provided to an application.

The IEEE 802.11 standard has two functions i.e. Distributed coordination Function and Point Coordination Function. In 802.11 DCF is based on Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA). In MANET CSMA/CD is not used because a station is unable to listen to the channel while transmitting. The Distributed Coordination Function (DCF) is used for synchronous, contention-based, distributed access to the channel [3]. The performance of IEEE 802.11 MAC mechanism is determined by contention window control scheme, RTS/CTS mechanism, transmission range, etc. In addition, whether or not the IEEE 802.11 MAC protocol is efficient will affect the performance of ad hoc networks. The metrics for the performance of 802.11 ad hoc networks may have throughput, delay, jitter, energy dissipation, etc. [14].

The DCF access scheme is based on the carrier sense multiple accesses with collision avoidance (CSMA/CA) protocol [14]. Before initiating a transmission, a station senses the channel to determine whether another station is transmitting. If the medium is found to be idle for an interval that exceeds the distributed inter-frame space (DIFS), the station starts its transmission. Otherwise, if the medium is busy, the station continues monitoring the channel until it is found idle for a DIFS. A random back off interval is then selected and used to initialize the back off timer. This timer is decreased as long as the channel is sensed as being idle, stopped when a transmission is detected and reactivated when the channel is idle again for more than a DIFS. When a receiver receives a successful data frame then, it then sends an acknowledgement frame (ACK) after a time interval called a short inter-frame space (SIFS) to the sender. Backoff is a well-known method for resolving contentions between different stations willing to access the medium. The method requires each station to choose a random number between 0 and a given number, and wait for this number of slots before accessing the medium, while always checking whether a different station accessed the medium before. The integer number of back off time slots is uniformly drawn in a defined interval called the contention window. The algorithm used by 802.11 to make this contention window evolve is called Binary Exponential Backoff (BEB). After each successful transmission, the contention window is set to [CWmin-1] (its initial value). When node successive collisions occur, the contention window is set to [0, min (1024, 2i CWmin-1)]; i is the number of retransmission; if i > 7, the contention window is reset to its initial value. It is the retry limit of the BEB algorithm.

Upon received a packet correctly, the destination station waits for a SIFS interval immediately following the reception of the data frame and transmits a MAC ACK back to the source station, indicating that the data frame has been received correctly. In case the source station does not receive an ACK, the data frame is assumed to be lost and the source station schedules retransmission with the CW doubled [4].

The paper is organized as - Section 2 briefly describes the review of literature, in section 3 the new CW resetting scheme is introduced and an algorithm is proposed. Section 4 displays the simulation results as in form of delay. Finally, section 5 having conclusion, section 6 acknowledgments and section 7 References.

2 A REVIEW ON RELATED WORKS

DCF scheme of IEEE802.11 [3] [4], the contention window (CW) is dynamically controlled by the back off algorithm named Binary Exponential Backoff (BEB). In this algorithm the contention window is doubled every time when a node experiences a packet collision that results in failure of transmission. On the other hand when a node is successful in its packet transmission, the contention window resets itself to the minimum value irrespective of the number of active nodes within the range of the node or number of previous consecutive collisions encountered by the node. The BEB algorithm leads to unfairness, particularly when the offered load is high and low throughput when network size is large [5]. Besides this, it sharply falls to the minimum. For removing such type of fairness problem in BEB scheme, the Multiplicative Increase and Linear Decrease (MILD) algorithm was introduced in the MACAW scheme [6]. In this scheme, a collided node increases its CW by multiplying it by 1.5.

As a modified version of MILD later Multiplicative Increase and Multiplicative Decrease (MIMD) scheme is proposed [6]. In MIMD whenever a packet transmitted from a node is involved in a collision, the contention window size for the node is increased by back off factor 2 and the contention window for the node is decreased by factor 2 if the node transmits a packet successfully. But here we can see increment and decrement are predetermined and uniformly. Basically MIMD is a special case of Exponential Increase and Exponential Decrease Backoff Algorithm (EIED) [7]. In EIED the contention window size for the node is increased by back off factor rI and the contention window for the node is decreased by factor rD in case of collision and success respectively [7][8]. The main drawback of both MIMD and EIED are-CW becomes too large after some failures in the packet transmission, because of its exponential increase irrespective of the window size. Similarly, it will come down too fast to the minimum level with some successful transmission, because of its exponential decrease. That's why throughput loss occurs especially in heavy loaded network as number of collisions is high. Several other proposals are appeared in recent years in this regard [8].

3. Priority Based Contention Protocol

In Priority Based Contention Protocol unlike in the case of BEF and other above mentioned schemes in literature review, contention window size of the sender node increases or decreases dynamically in a non-uniform rates depending upon the current situation of priority of the nodes. If we do not maintain the priority of the protocol, we cannot get desired optimum outcome in any transmissions. This aspect is most sought after in emergency situations like in battlefield or military

operations etc. where flow of sensitive data has to take place.
Generally contention window size is incremented on a collision i.e. failure of a transmission. Similarly, contention window size is decremented on a s uccess (absence of collision) [3] [8].In this scheme, we have one set of value A1, A2, A3 etc. (incrementing factors) and another set of values say D1, D2, D3 etc. (decrementing factors) by which we increment and decrement CW size dynamically depending on the priority of the nodes. We divide the priorities to the various levels as 1, 2, 3, etc. Number of priority levels may vary depending on the types of networks. As the type of network increases, number of priority levels also increases.
When there is collision or failure in case of the higher priority level, we increment the CW by incrementing factor of Ai where Ai is the least incremental factor and i=1 denotes the highest level of priority. Similarly on success in transmission in case of the higher level of priority, we considerably decrement the CW to the minimum level by decrementing factor Di where Di is the highest decremental factor and i=1 denotes the highest level of priority.
This can be written mathematically as follows:

When a failure occurred under priority level i:

CWnew = CWcurrent increment by Ai
CWcurrent = CWnew
(Where i = 1, 2, 3…. And A1<A2<A3……)

When a success occurred under priority level i:

CWnew = CWcurrent decrement by Di
CWcurrent = CWnew
(Where i = 1, 2, 3 … And D1>D2>D3……)

Reduction in back off time causes for the increase in collision because nodes would get a p remature access to the shared channel and result in collision with packets from other nodes [8][9]. This increase in the collision will reduce the throughput! Because, to get higher throughput either we have to decrease the CW size (to reduce the back off time) or we have to minimize the collisions [8]. Our proposed works is based on to increase or decrease the CW size as per priority concept such that overall delay of the system will be decreased. We effectively achieve this goal in PBC (Priority Based Contention)-MAC scheme. Unlike BEB scheme, in PBC-MAC if two or more nodes of different priorities are collide with each other than the contention window size are incremented according to their priority level. For example at if node at highest priority stage (level 1) we increment contention window by a least factor (A1). In this way, we always get an optimum sized window to prevent large CW size, which causes reduction in back off time to high priority node. Here we fairly assign channel to high priority node first than low priority node after collision.
Similarly, when we have a s uccess for transmission, we reduce the size of the contention window by the largest decrementing factor D1 in case of higher priority level. When the window size becomes smaller and smaller (it means number of successful transmission is large), we decrement the factor for reduction of CW on the basis of priority levels to avoid unnecessary delay in transmission due to large sized contention window as occurs in BEF scheme. In the PBC-MAC scheme CW size changes in between maximum and minimum value, which depends upon priority levels. So, successful node and other node will have different priorities for seizing the channel. This will result in a not too large and not too small CW after a minimum number of success and failure in transmission respectively. In this case most of the time CW size will be more than enough or less than enough. In most of the cases this algorithm will not justify the behavior of actual computer networks. Since PBC-MAC scheme changes the CW size depending upon the priority levels and network types.

3.1 Proposed Algorithm for PBC

Because of the peculiarity of our scheme having high increment on least priority level, we can initially set a very small value for CWmin. Since ad hoc networks are usually applied in the rescue operations and other emergency situations as mentioned in the first section, nodes in ad hoc networks become active in large volume simultaneously i.e. at a time rather than consecutively i.e., one by one. Therefore, we have made a reasonable assumption that if there is a higher priority initially in the network, there is a high probability for lower contention window size which causes success in transmission of higher priority node than lower priority nodes. Taking this assumption, we have made relatively least value for initial increment in case of collision so that it later increases by a factor for increment. Similar logic is applied for decrementing CW when a success in transmission comes. Taking into account the major network parameters like throughput, fairness, delay and collisions, selection of Ai has been made reasonably depending upon total number of priority levels.

4. Simulation Parameter and Result

4.1 Simulation Environment

Qualnet-5.0 is a discrete-event simulator [10]. We have used this network simulator, for evaluating the performance of our proposed PBC algorithm. Because of its efficient kernel, Qualnet models large scale networks with heavy traffic and mobility in reasonable simulation times [10]. T his simulator is widely used by research scholars. It supports simulation of TCP, routing, multicast protocols over wired and wireless (local and satellite) networks etc. adequately [10][11]. We have used window Operating System to run our simulation code. We have taken the different networking scenario for the evaluations with different number of nodes. Each pair of node comprises a transmitter and a r eceiver. We have taken SIFS = 10µs, DIFS = 50µs and slot time = 20µs. Packet interval is five milliseconds. We have evaluated the performance by adding new nodes in the network as the time varies or expedites at arrival of several nodes priority wise simultaneously. Simulation time is taken for the simulation in order to enable chances for every node to participate in the network activity.

Table 1. Simulation Parameter

Parameter	Value
Phy	wireless
Packet size	1500
Antenna type	Omni directional
Number of nodes	50 or 100
DIFS	50µs
SIFS	10µs
ProType	Free Space
CWmin	15 or 31
CWmax	1023
Simulation time	30 s
Queue length	500

4.2 Delay

We have calculated the network delay when we apply PBC-MAC and BEB. Figure 1 shows the delay experienced by different packets in a n etwork with PBC and BEB in MAC layer. The graph shows that PBC-MAC decrement the packet delay considerably in the network. Unlike in the case of BEB [3] our algorithm performs well in lightly loaded network as well as heavily loaded network. Taking the average of the delay for every packet transmitted we get the average delay in the network. Average packet delay is defined as the time duration from the time the packet is at the head of the MAC queue ready to be transmitted until the packet delivery is confirmed by an ACK [8]. Delay for one packet = Tps −Tpr , where Tps is the sending time of a p acket and Tpr is the receiving time of that packet.

$$\text{Average Delay} = \left(\sum_{i=0}^{N} T_{ps} - T_{pr}\right) \div N$$

Wh

ere N is the total number of packets

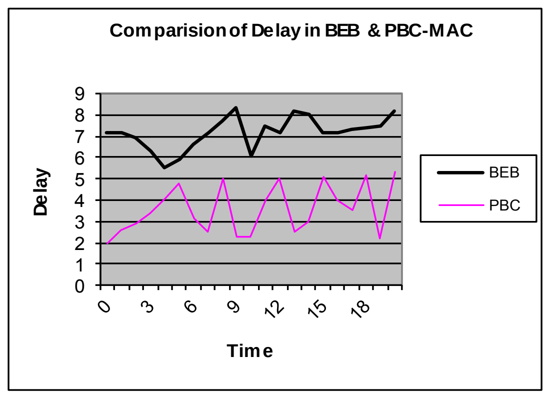

Figure 1 Comparison of Delay in BEB and PBC

5. CONCLUSION

We have proposed a new PBC-MAC scheme for mobile ad hoc network in this paper. To get PBC-MAC, we have analyzed the BEB algorithm and made some correction to support our propositions. We found that the different alternatives in comparison to PBC are complicated, non-portable and unsuitable for Ad hoc networks in case of any emergency situation. We have also evaluated its performance separately by using the qualnet-4.0 network simulator. The simulation results showed that PBC-MAC performs better than the BEB in the given domain. We have applied an approach based on the matrix of the priority levels of the nodes where contending nodes dynamically decides its lower Backoff value avoiding long waiting before access to the shared medium itself. PBC-MAC scheme prevents suitably CW from growing maximum on failure and shrinking minimum on a successful transmission and hence prevents unnecessary delay for the transmission and throughput degradation thereafter. So the successful node and the other nodes in queue will have certain priority for seizing and accessing the channel. Therefore, this algorithm enhances the fairness among the nodes on the priority basis in selection of channel and transmission.

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7. REFERENCES

[1] P Mohapatra, S Krishnamurthy. "Ad-Hoc Networks - Technologies and Protocols", Springer Publishers, 2004 (ISBN: 0-387-22689-3).

[2] IEEE standard for wireless LAN medium Access Control (MAC) and Physical Layer (PHY) specifications, ISO/IEC 8802-11:1999(E), Aug.1999.

[3] L. Bononi, et al., "A differentiated distributed coordination function MAC protocol for cluster-based wireless ad hoc networks", Proceedings of the 1st ACM international workshop on performance evaluation of wireless ad hoc, sensor, and ubiquitous networks, pp. 77 - 86, 2004.

[4] Haitao Wu, Shiduan Cheng,et al, "IEEE 802.11 Distributed Coordination Function(DCF)" 0-7803-7400-2/02/$17.00 (C) 2002 IEEE

[5] Jae H K, Ajith W, Injong R. "Experimental Evaluation of MAC Protocols for Fairness and QOS Support in Wireless Networks". In the proc. of International Conference on Networking Protocols, pages 298—307, 2008.

[6] C. Siva Ram Murthy and B. S. Manoj. "Ad Hoc Wireless Networks: Architectures and Protocols", Pearson Education, ISBN13: 9780131470231 ISBN10: 0-13-147023-X, 2008.

[7] Bianchi G, "Performance analysis of the IEEE802.11 Distributed Coordination Function". IEEE,2000

[8] Abdul Gafur, Niraj Upadhayaya and S A Sattar, "Achieving Enhanced Throughput in Mobile Ad hoc Network using Collision Aware MAC Protocol," International Journal of Ad hoc, Sensor & Ubiquitous Computing (IJASUC) Vol.2, No.1, March 2011

[9] Hastad J, Leighton T, and Regoff B, (1996). "Analysis of backoff protocol for multiple access channels". SIAM Journal on Computing, pages 740—774.

[10] QualNet 4.5 Programmer's Guide, Scalable Network Technologies, Inc., 6701 Center Drive West, Suite 520, Los Angeles, CA 90045.

[11] Scalable Network Technologies, "QualNet simulator 4.0 Version", tutorial on http://www.cs.binghamton.edu /~vinkolar/QualNet/qualnet-tut1.pdf.

[12] C.K. Toh. "*Ad* Hoc Mobile Wireless Networks: Protocols and Systems", Springer Prentice Hall Publishers, ISBN 013 007 8174, 2001.

[13] Imrich Chlamtac and et al., "Mobile ad hoc networking: imperatives and challenges", Ad Hoc Networks 1,pp.13-64,2003

[14] Chien-Min Wu, Hui-Kai Su, Wang-Hasi Yang, "Efficient Backoff Algorithm in Wireless Multihop Ad Hoc Networks", International Journal of Advancements in Computing Technology, Volume 3, Number 1, February 2011.