Performance of Collision Alleviating DCF Protocol with Synchronized Contention Windows Algorithm for Wireless Ad hoc Networks

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Abstract : Ad hoc networks have been proposed for emergency communication wherein the required infrastructure is unavailable. .Even in infrastructure based wireless networks, when the number of contending nodes is high, more number of frame collisions occur which leads to drastic reduction in network performance.However, a major concern in Ad hoc networks is collisions .Furthermore, the packet transmission procedure of the DCF protocol is modified to avoid channel capture effect and this is represented with a Markov chain model. In SCW algorithm, each station (STA) actively tracks the transmission cases of the network and when the channel state is changed, the contention window (CW) of each station which participates in the competition is synchronized by resetting the CW, which makes each station get the medium access grant with the same probability in next channel contention. The experimental results show that with the increase of the number of the stations, the fairness index of the SCW algorithm is nearly equal to 1 and always keeps stable, and when the number of stations is large (nearly 36 STAs), the throughput and delay of the network are respectively increased and reduced by nearly 11% and 6% than the conventional BEB algorithm. The proposed algorithm can effectively improve the performance of throughput and delay, and it has an excellent fairness of network. Therefore, it is especially suitable the wireless networks with the dense stations.higher throughput, and high fairness.

***IndexTerms* - IEEE 802.11, Channel Contention, Backoff Algorithm, Fairness, Contention Window, distributed coordination function, Collision Avoidance**

I. INTRODUCTION

The DCF is the generic protocol used in all IEEE 802.11 standards that employ Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA) method using binary exponential backoff algorithm. The IEEE 802.11-based WLANs have become the most popular wireless network standard, and the IEEE 802.11 standard [1] has two basic operation modes: distributed coordination function (DCF) and optional point coordination function (PCF). However, DCF is a contention-based access scheme and is based on the carrier sensing multiple access/collision avoidance (CSMA/CA) mechanism using the binary exponential backoff (BEB) algorithm. The BEB algorithm is the main backoff scheme employed in the IEEE 802.11 DCF. In our previous research, we have proposed an exact Markov chain model to accurately predict the performance of the DCF protocol [8]. To alleviate the collisions and avoid channel capture effect, a post backoff stage is introduced to provide inter packet backoff (IPB) delay between successive packet transmissions. The modified model is named as Collision Alleviating DCF (CAD) protocol and showed that the performance of the proposed model is better than the existing models. In this paper, we aim to develop a new adaptive and robust backoff algorithm that improves the performance in terms of maximizing the system throughput, reducing the collision robability, and ensuring good fairness for the DCF in an IEEE 802.11 WLAN under dense network conditions. In this paper, active stations. Motivated by solving the problem mentioned above on the backoff algorithm and improving the performance of the networks, a novel backoff algorithm with the synchronized contention windows (SCW) is proposed for IEEE 802.11 wireless networks. By monitoring the transmission situation and the channel state, and then adaptively reset the size of the contention windows, the contention windows of all the participated stations are synchronized. Consequently, the same probability of channel access is obtained by each station in the network. The rest of the paper is organized as follows. In Section II, the motivation of our work is provided and the proposed synchronized contention windows backoff algorithm will be described

II. SYNCHRONIZED CONTENTION WINDOWS BACKOFF ALGORITHM

In this section, the proposed SCW backoff algorithm isde-scribed in detail and an specific example is utilized to further illustrate the backoff process of the SCW algorithm.

A. SCW Algorithm

In SCW algorithm, in order to synchronize the contention windows, all participated station tracks the current channel state, and resets the contention window when the channel state is changed.

Assuming the size of the initialized contention windows is CWMIN, and the maximum contention window is CWMAX. When a station has packet to transmit, it first randomly chooses a number of the backoff slots from the initialized windows. When the counter of the backoff slots is decreased to zero, the packet is send by the station immediately. During the backoff period, the station senses the channel state at the same time. If the sender does not receive the response frame at the expected time, or the responded packet is received but the MAC header of the packet can not be successfully demodulated. Then the station thinks that a collision occurs. As shown in Fig. 2, assume that the current contention window of the station is CWN, and when the channel state changes, the station will reset up the contention window and perform the backoff process according to the following steps:

Before the counter of the backoff slots decreases to zero, the station detects that the channel is always idle, which indicates that the current station obtains the channel grant to transmit the packet:

(a) if the transmission of the station is successful, in order to avoid the unfairness of the contention windows size, the size of the next contention window (denoted by CWN+1) is reduced to half of the original contention window, i.e., CWN+1 = M AX{CWMIN, 1/2 · CWN}.

(b) if the packet transmission is failure, i.e., the collision occurs, in order to avoid further collision in next transmission,the size of the next contention window is extended to two times of the CWN, i.e., CWN+1 = M IN{CWMAX, 2 · CWN}.

2) Before the counter of the backoff slots decreases to zero, the station detects that the channel is busy, which indicates that a packet is transmitting on the channel:

(a) if the current station cannot demodulate the MAC header of the ongoing transmitted packet, it indicates that the packet is collided. Then the station resets the contention window and the next contention window is extended to two times of the CWN, i.e., CWN+1 = M IN{CWMAX, 2 · CWN}.

(b) if the current station successfully demodulates the MAC header of the ongoing transmitted packet and the destination of the packet is not itself, this indicates that the packet is successful transmitted. Then the station resets the contention window and the next contention window is reduced to half of the CWN, i.e., CWN+1 = M AX{CW MIN, 1/2 · CWN}.

3) To the idle stations in the network which have no packet to send temporarily, in order to make their contention windows are the same with others when they have packets to transmit, they will record and maintain a contention window which is synchronized with other stations by detecting the change of the current channel state:

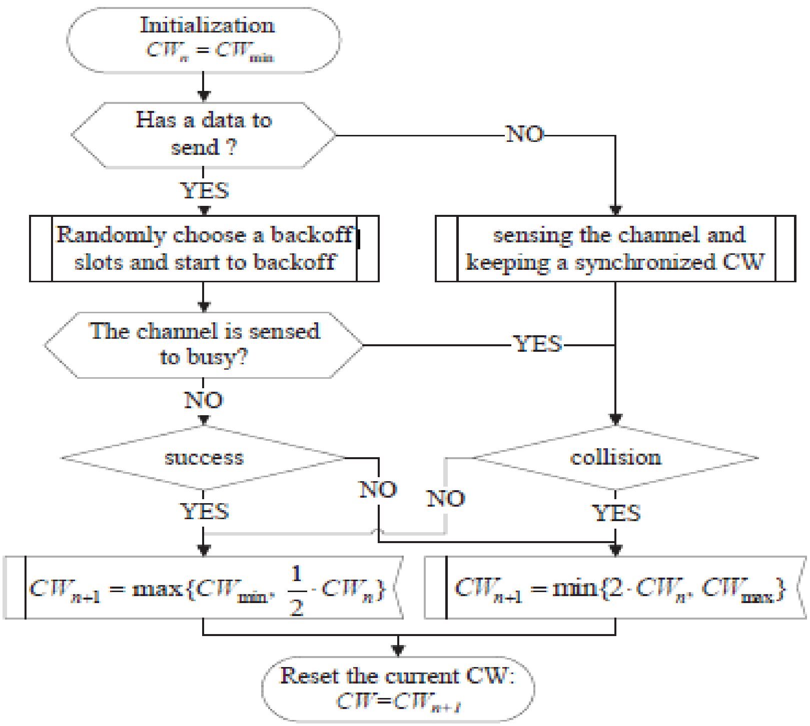

Fig. 2. Flow chart of the SCW algorithm

(a) if the idle station detects that a packet is successfully delivered on the current channel (i.e., it demodulates the MAC header of the packet),then the idle station resets and maintains a synchronized contention window whose size is reduced to half of the CWN, i.e., CWN+1 = M AX{CWMIN, 1/2 · CWN}.

(b) if the idle station detects that a collision occurs on the current channel, then the idle station will reset and maintain a synchronized contention window whose size is extended totwo times of the CWN, i.e., CWN+1 = M IN{CWMAX, 2 · CWN}.

B. Backoff Process of SCW Algorithm

Herein, the backoff process of the SCW algorithm will be further described by using an example. As shown in Fig. 3 (For the sake of clarity, the transmission slots of the packet are not included), station A, B and C all have packets to send when the ith channel access competition. Since the backoff slots randomly selected by station A and B are the same, the collision is inevitable. In the next channel competition, the contention windows of station A and B are increased to two times of the original contention window. To the station C, since a collision is detected on channel, it does not continue to backoff from the rest of the backoff slots but resets a synchronized contention window with station A and B, i.e., it also increases the contention windows to two times of the original one. At the same time, the station D also detects the channel conflict, it thus also keeps a synchronized contention window with station A and B. It can be seen that when station D has a packet to send in the (i + 1)th channel competition, it has the same size of the contention window as the others. In the (i + 1)th channel competition, station A obtains the channel transmission opportunities, and after the successful transmission station A decreases the contention window to half of the (i+1)th CW. As the same as, station B, C and D, which all detect the successful transmission, decrease and reset the contention windows to synchronize with station A.

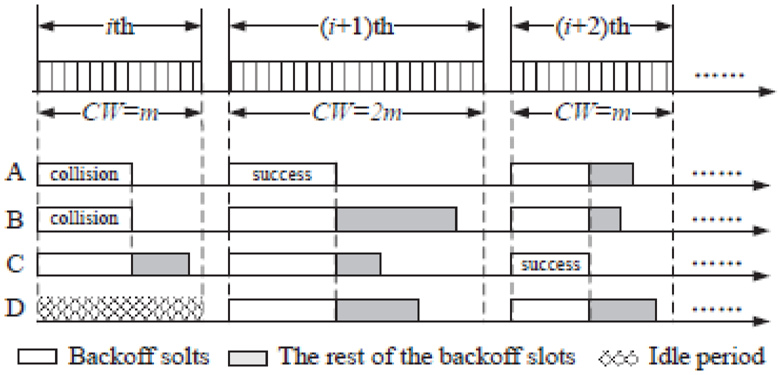

Fig. 3. Backoff process of the SCW algorithm

As shown in Fig. 3, in the process of the SCW backoff, through tracking the transmission of the network, when the current channel state is changed, all participated stations will rest their contention windows and keep synchronization each other. Therefore, all stations have the same probabilities to get the channel grant, and thus the fairness and the performance of the network are improved .

TABLE I
PARAMETERS USED IN SIMULATIONS

Parameter	Value	Parameter	Value
PHY Header	16 bytes	RTS	20 bytes+PHY Header
MAC Header	34 bytes	CTS	14 bytes+PHY Header
Basic Rate	6.5 Mbps	DATA Rate	11 Mbps
STAs	20	Solt Time	9 us
DIFS	34 us	CWmin	15
SIFS	16 us	CWmax	1023

III. SIMULATION RESULTS

Simulation experiments are conducted with the ns-2 sim-ulation tool [12] in order to analyze the performance of the proposed SCW backoff algorithm. In simulations, we consider a single-hop wireless network in which all nodes are uniformly distributed in a 200m × 200 area, and the RTS/CTS access mode is enabled. In order to evaluate the performance of the proposed SCW algorithm, we will compare the performance of the SCW with the the legacy BEB scheme, and some improved schemes on BEB, such as the EIED algorithm and the MILD algorithm. The settings of some main simulation parameters are listed in Table I. Fig. 4 shows the throughput of the backoff algorithm responds with the number of the stations. As shown in Fig. 4, with the increase of the number of stations, the throughput of all the backoff algorithms gradually decrease. It is mainly because that with the increase of number of stations, the collision probability of the network also increases. From Fig.4, it can be clearly seen that the throughput performance of the proposed SCW backoff algorithm is larger than the conventional BEB algorithm and the MILD algorithm. In addition, we can see that when the number of stations is less than 20, the throughput of the SCW algorithm is very close to the EIED algorithm, and with the increase of the number of stations, the gap of the throughput between the SCW algorithm and the EIED algorithm is gradually increased. Specifically, as shown in Fig. 4, when the number of stations is nearly 36, the throughput of the SCW algorithm is higher than the BEB, the MILD and the EIED algorithm by nearly 11%, 4% and 2%, respectively.

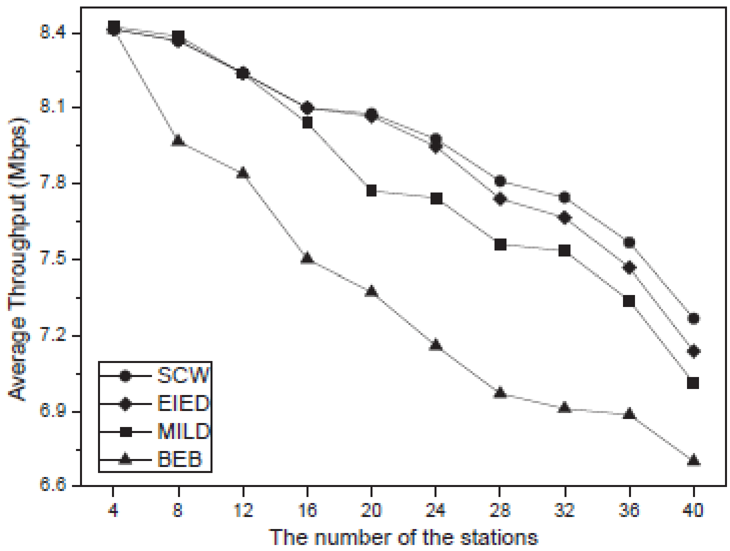

Fig. 4. Throughput vs. the number of the stations

Fig. 5 gives the normalized delay versus the number of the stations for various backoff algorithms. From Fig. 5, it can be clearly seen that the delay of the IEEE 802.11 BEB algorithm is the worst than other algorithms, especially when the network site number is large. This is mainly because that the contention window of the BEB algorithm will back to the smallest contention window after a successful transmission, which will lead to more collision when the number of the station is large. In addition, as seen from the Fig. 5, when the number of network nodes is less than 20, the delay of the proposed SCW algorithm is slightly large than the EIED and MILD. But when the number of stations is beyond 20, the SCW algorithm obviously outperforms the the EIED and MILD in respect of network delay. It is mainly because that when the number of the stations is less, in order to maintain fairness the average size of the network backoff contention window will be increase caused by synchronizing the contention windows. Hence,it can increase the average network delay. However, with the increase of the number of the stations, the collision probability will be reduced by using the synchronized the contention windows, which can avoid the size of the contention windows further increases, the network delay thus can be improved significantly.

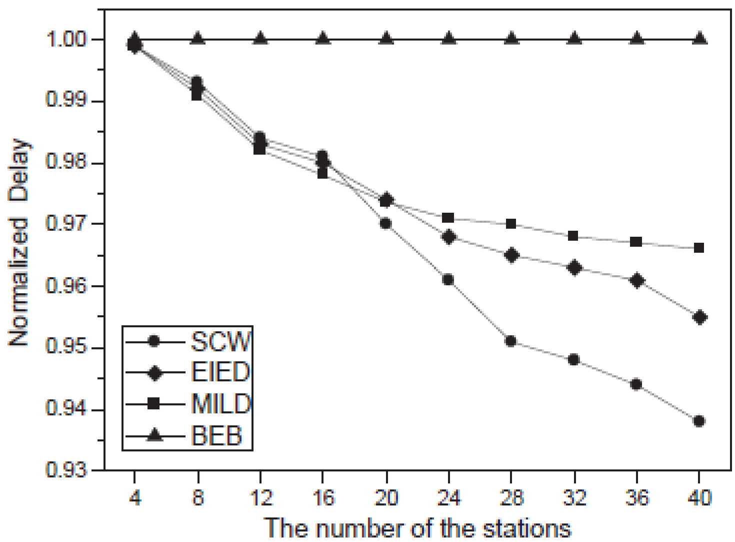

Fig. 5. Normalized Delay vs. the number of the stations

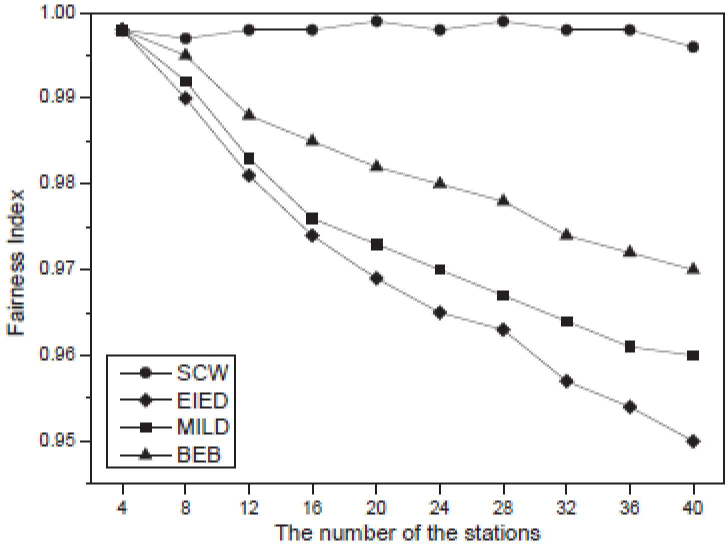

Fig. 6. Fairness index vs. the number of the stations

Fig. 6 depicts the fairness index [13] against the number of the stations for various backoff algorithms. From Fig. 6, it can be seen that with the increase of the number of stations, the fairness index of the proposed SCW algorithm is the most stable and always close to 1. Meanwhile, we can seen that the fairness index of the EIED algorithm and MILD algorithm are far lower than the conventional BEB backoff algorithm, which indicates that the throughput gain of the EIED and the MILD is obtained through sacrificing the network fairness, although the network throughput is increased, but the network fairness of the EIED and the MILD are reduced. In fact, the SCW algorithm inherits the EIED algorithm to change the size of the contention windows, but in SCW algorithm, the contention windows of the all stations are synchronized so that each station can get the same probability to send packet on channel.

IV. CONCLUSION

Focused on the issue that the conventional BEB algorithm has characteristics of excessive collisions and poor fairness when the number of stations is large. To improve the fair-ness of network, while respectively increasing and reducing the throughput and delay, a new synchronous competition window-based backoff algorithm is proposed. In this algorith-m, according to track the transmission situation of the current channel, when the channel state changes, all participated stations will synchronously reset their contention windows and keep the same size of the contention windows each other, which lead to that each station has the same probability of the channel access in each competition. Simulation results show that SCW algorithm effectively improve the fairness of network, and has the superiority in respect of throughput and delay. In the future, we will configure an experimental equipment to further verify the performance of the SCW algorithm.

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