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RESEARCH ARTICLE

CSMA/SCA: AN IMPROVED CSMA/CA PROTOCOL TO BETTER ADDRESS THE FAIRNESS PROBLEM

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ABSTRACT

CSMA/CA (Carrier Sensing Multiple Access with collision avoidance) is used in wireless local area networks (WLANs). The above-mentioned protocol brings down the number of collisions and improves performance of the network. To alleviate problems of fairness that comes with CSMA/CA ab altered version of the protocol, termed CSMA with synchronised collision avoidance (CSMA/SCA). It differentiates itself from CSMA/CA by the fact that it synchronises the waiting window size via the header of an overhead frame and then updates its backoff counter utilizing the new waiting window size.

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INTRODUCTION

In a wireless local area network (WLAN) the media access control (MAC) protocol is the major governing element that decides the efficiency of utilisation of the often limited bandwidth of the underlying wireless channel. It is of the utmost importance that the MAC protocol is robust and fair for all the users. Thus, this paper looks at a solution to enhance the performance of the CSMA/CA (Carrier Sense Multiple Access with Collision Avoidance) that is in dependence of the BEB (Binary Exponential Backoff) algorithm. Statistical analysis has shown that stations get fair chances to access the common channel. However, when not all the stations have frames to transmit, simultaneously while the network is congested, the stations experience unfairness. These fairness problems arises from the fact that an individual station has to depend on its own calculations of congestion, more often than not leading to skewed views. To avoid this situation a simple solution is being proposed – to find a way to convey the calculations of one station to the others thus improving fairness. The aim of this paper is modify the CSMA/CA to better address the fairness problem without the requirement of extensive changes to prevalent hardware. The idea is to synchronise the window size for contenting stations. Thus, the resulting protocol is called CSMA with synchronised collision avoidance (CSMA/SCA).

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It works in the same way as CSMA in the beginning but after a station senses that the channel is empty and ready for transfer, the station sends its waiting window size as a part of the data frame. By this technique, we can assume that the stations can compete with equivalent statistical opportunity.

Current Scenario of CSMA/CA: The CSMA/CA protocol station that want to send a MAC frame senses the channel. The station can only begin transmitting once the channel is inactive for the DIFS period. Else, the station waits and continues surveying the channel until an inactive DIFS is sensed. Before sending, a random backoff counter is generated by the station. The counter runs during periods of inactivity and halts when the channel becomes busy. Only when the counter's value equals zero will the station be allowed to transmit. For conflict resolution the CSMA/CA protocol depends on the BEB algorithm to control the waiting size of each station in its initial state.

The CSMA/SCA Protocol: This proposed protocol operates under the assumption that all the links in WLAN have similar priorities. The principal difference between the original and proposed protocol is the inclusion of synchronisation of waiting window sizes to deal with the fairness problem. In this technique, synchronising procedures are developed alongside an altered BEB algorithm along with which a rest is included.

Waiting Window Size Synchronising Procedures: The synchronising procedure consists of a piggyback procedure, a sync procedure and an update procedure. Just as in the CSMA/CA protocol, the stations compete for the channel with a backoff prior to transmission in the CSMA/SCA protocol too. After a successful transmission, the station proceeds with the piggyback procedure by adding the waiting window size to the data frame. Then the rest of the stations duplicate the window sizes in the frame via the sync procedure. Then, the stations perform the update procedure to change their present backoff counters according to the new size.

The Piggyback Procedure: Transmitting the waiting window size can be accomplished by incorporating it into the header of certain frames, i.e. piggybacking. The waiting window size is only circulated on the completed on a successful transmission.

Update Procedure: After the waiting window size has been received by the other suspended stations, those stations still have to update their backoff counter in accordance to the received value of the waiting window size. A size alteration factor is defined as the ratio of the updated window size and the previous window size.

Altered BEB Algorithm: The altered BEB algorithm is used to manage the waiting window size in the proposed protocol. Unlike regular BEB where the size is set to minimum after one successful transmission, in the altered version does not set it to minimum. In this method, the window size is doubled after every failed attempt to transmit, until a maximum value is reached. But unlike the regular BEB, after a particular number of failures, this system has a reset function that resets the window size to the minimum value.

Size Decrease Algorithm: In the CSMA/CA protocol the waiting window size of the premier station is reset to the minimum value after a successful transmission. If we choose to proceed with this tactic, at the conclusion of ever successful transmission we will end up back to square one where all the initial stations in between a certain range would have the minimal value of waiting window size. To prevent this disadvantageous and preposterous oscillation we utilize a protocol that is built upon the total channel traffic instead of the discrete station's contention history. Each station has a counter that has an initial value of 0. There are many ways through which the counter is updated. Whenever a station concludes a successful transmission, it increments the counter by 1 and if the station fails in transmitting, it resets the counter to 0. If the waiting window size received over the overhead is the same value as the current one then the counter is incremented by one and in other cases the counter is set to 1. Prior to sending a data frame after being victorious in the contention, the station compares the counter value with a predetermined threshold value and if it turns out that the counter is greater than or equal to the threshold value then the counter is reset to zero and the station reduces its waiting widow size to half of what it previously was. Therefore, the proposed alternate version size decrease algorithm prevents the quick and concurrent decrease of all the initial stations' waiting window sizes.

Waiting Window Size Reset Function: During the standard operation of CSMA/CA, upon collision, the size of the window doubles. This ideology is also adopted in the alternate version of the proposed BEB algorithm. From the perspective of a single station, the waiting window size adjustment process would look like a rapid increase gentle decrease procedure. This has the potential to effectuate the shadow-receiver conundrum. The possible lack of a backoff function won't bring about the failure of the proposed protocol as it has inherited a capable backoff procedure. To better address the problem, a waiting window size resetting function is designed. A failure counter is introduced in all the stations and has an initial value of zero. It increments the counter every time it fails to transmit a frame owing to the other stations utilizing the channel at that particular instant of time. The counter is reset to zero once the station completes a successful transmission. If the number of failures is below the predetermined limit, then the waiting window size is doubled as always. Else, the waiting window size is reset to its minimum value.

The functioning of CSMA/SCA: The steps involved in the functioning of the proposed Carrier sensing multiple access with synchronised collision avoidance protocol involves a waiting window size, a success counter and a failure counter with both values having predetermined threshold values that has to be determined by trials. The steps are as follows.

- **Standby:** The station does not have any data to transmit and is in fact waiting for receiving data.
- **Synchronisation:** The station is synchronising its waiting window size in accordance to the proposed protocol.
- **Competition:** The station is competing in the channel by periodically decrementing its backoff counter.
- **Backoff:** The station is backing off owing to a busy channel.
- **Consensus:** The station is trying to get approval for transmission.
- **Transmission:** The station transmits the data frames.

The crux of this protocol lies in the synchronisation state. This state is majorly controlled by the proposed SCA protocol. This state is through which fairness of access is intended to be achieved all the while resolving conflicts. The operation of a station at the MAC layer under the newly proposed protocol is as follows.

Standby-synchronisation: A backoff counter value is randomly generated after the channel is sensed to be inactive for a predetermined period of time and the station simultaneously transitions from the standby stage to the synchronisation stage.

Synchronisation-Competition: Once there are data frames to be sent in the transmission queue, the backoff counter is calculated and the station either commences the counter or continues the counter from before. As long as the channel remains idle, the counter keeps on decrementing periodically.

Competition-Backoff: Before the counter has a chance of reaching zero, if the channel is sensed to be active, then the station transitions from contenting to backing off. The failure counter is reset to zero and the back off counter is paused.

Backoff-Consensus: If it has been sensed that the channel has been inactive for the predetermined time then the station transitions from the Backing off stage to the consensus stage.
The synchronisation stage is activated after the successful sensing of a data frame and it is checked if it is required to

copy the values of the waiting window size. It is only necessary to copy the values if the waiting window sizes are different in the data frame overhead. If a different waiting window size is detected, then the update procedure is initiated to recalculate its present backoff counters. Consensus-Transmission: When the counter reaches zero, the station sends out the request to transmit and awaits for conformation.

Transmission-Synchronisation: In the situation the request-approval exchange fails, the state moves from the Transmission to the Synchronisation stage. The failure counter is incremented by one and the success counter is reinitialised to zero. As long as the number of failures is less than the predefined limit, the waiting window size keeps on doubling, and on reaching the threshold, it is reset to the minimum value with a randomly generated as the counter value.

Transmission-Completion: The station moves from the transmission to the completion stage once the transmission request has been approved and the actual data transmission begins. The number of failures is set to zero and the number of success is incremented by one.

Completion-Synchronisation: After the data exchange takes place the station goes back into the synchronisation stage. On the event of a successful data frame transfer, the data frame is removed from the transmission buffer. Or else, it is retained for retransmissions.

Synchronisation-Standby: After all the frames are transferred, the station changes state from the synchronisation to the standby state and the cycle repeats again.

Conclusion

This paper looks into the refinement of the pre-existing CSMA/CA to better address the fairness problem by synchronising the waiting window sizes and choosing similar sizes so as to make sure that all stations get a fair chance to transmit or receive data. The new protocol has been named CSMA/SCA which stands for carrier sensing multiple access with synchronised collision avoidance. The advantage of the proposed protocol is that it can be easily implemented in the existing hardware solutions. Thus, prototypes can be devised and tested to thoroughly scrutinize the competence of the proposed protocol.

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