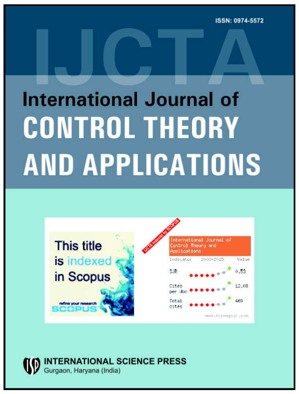

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Development of Efficient Back off Algorithm for Multi hop AD HOC Network

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Abstract: In Mobile Ad Hoc Network (MANET), mobile nodes are allowed to access the medium by IEEE 802.11 DCF protocol. Here, channel access mechanism outperforms in low traffic and node density. The performance of IEEE 802.11 DCF function affected in high density and high traffic. Here, increase of transmitting nodes cause the fairness of medium access that is handled by the use of binary exponential backoff algorithm. We know that traditional backoff algorithms works better in specific scenario like as less traffic in dense network. In this paper we aimed to cover the reason of packet drop due to improper adjustment of contention window. Selection of large range contention window effectively works for high traffic in low density network. Here, analysis of existing analytical and traditional back off algorithms is required to improve their utility. In our study we have considered following most used back off algorithms such as; Slow Start Back off Algorithm (SSB), Fibonacci Increment Back off Algorithm and State based back off. These algorithms are used to adjust their contention window with actual network traffic. We have proposed a new back off algorithm which is the combination of bit shift and linear increment to adjust the contention window of active nodes. It improves the channel access fairness while maintaining the channel throughput and also improves the selection process of the contention window (CW) that is based on successful and unsuccessful transmissions.

Keywords: Back off , Contention window , Distributed Coordination Function , Moving average

1. INTRODUCTION

An ad hoc network is simply a decentralized wireless network where decentralized term mandates that there is no particular node that is governing the wireless transmission. The network is ad hoc because it does not depend on pre-existing infrastructure, such as routers in wired networks or access point in wireless networks. In ad hoc networks, distributed coordination function (DCF) algorithm is employed for better affinity with the changing conditions in the network, based on the carrier sense multiple access with collision avoidance (CSMA/CA) protocol.

Carrier sense multiple access with collision avoidance (CSMA/CA) in networking, is a multiple channel access method in which channel sensing is done, and with that nodes seek to avoid collisions by transmitting data packets only when the channel is sensed as "redundant". Wireless networks, need this setup as the collision detection of the CSMA/CD is unreliable due to the hidden node problem. By CSMA/CA, every node senses the channel for another node wanting to communicate with the same destination node. Now these source nodes may not be able to sense each other's presence as they may not lie in the range of the other. Because of this, both sense the channel as empty and thus send their data packets to the destination node thus causing collection of data packets. To avoid the Hidden Node Problem, a variety of back off algorithms are implemented which specify as to after each collision for how long does a node have to packet before sending the data packet again.

2. BACKGROUND AND RELATED WORK

2.1. Slow Start Back off algorithm [1]

Table 1
Notations and Variables Used in Implementation [1]

Notations	*Meaning and Explanation*
CW	Current Back off Window Size
CW_{min}	Minimum Back off Window Size
CW_{max}	Maximum Back off Window size
W_m	Threshold
W_n	Initial Backoff Window Size
W_o	Maximum Backoff Window Size
L	Data size of each frame
A	Amount of Data
α	smoothing factor (0 to 1)
D_i	Value of time period i
E_i	EWMA value at time period i

Slow start backoff (SSB) algorithm [1] is basically a hybrid algorithm which combines the predominantly used binary exponential backoff algorithm and linear increase linear decrease (LILD) algorithm. The problem of high collision rate, throughput degradation and unfair channel access caused in binary exponential backoff (BEB) algorithm and less support for varying network conditions in linear increase linear decrease (LILD) algorithm[1] is handled by slow start backoff (SSB) algorithm.

Slow Start Backoff (SSB) algorithm [1] is much more flexible as it incorporates the features of both BEB and LILD algorithm. It is a smarted algorithm which takes into account the current window size and decides whether to increase or deacrease and the rate at which to do so using the concept of a threshold value.

When it comes to a adhoc networks, channel collision rate is proportional to the number of competing stations, so small number of competing stations signifies low collision rate. Hence for better results, short contention windows should be set. But successive collisions indicate that there are a multitude of competing stations in the system. So here large enough sized backoff window should be set to reduce the risk of collisions in further transmissions. In case of SSB algorithm, every active station undergoes computations for a threshold of backoff window size Wm. Once the threshold contention backoff window size is determined on the very onset, the backoff window size is increased exponentially so as to rapidly adapt to the current channel status. Once the backoff window size reaches the threshold value Wm, the backoff window size grows in a linear fashion until frame transmission is successful. Below is the flowchart explaining the implementation of SSB algorithm [1] in C++ .

But, Let us take a scenario in which we consider 3 nodes and map 3 packets over the wireless network.

A and C both have to send the data, but if they do so at the same time or their packet reaches B at the same time, it will result into collision pertaining to Hidden Node Problem.

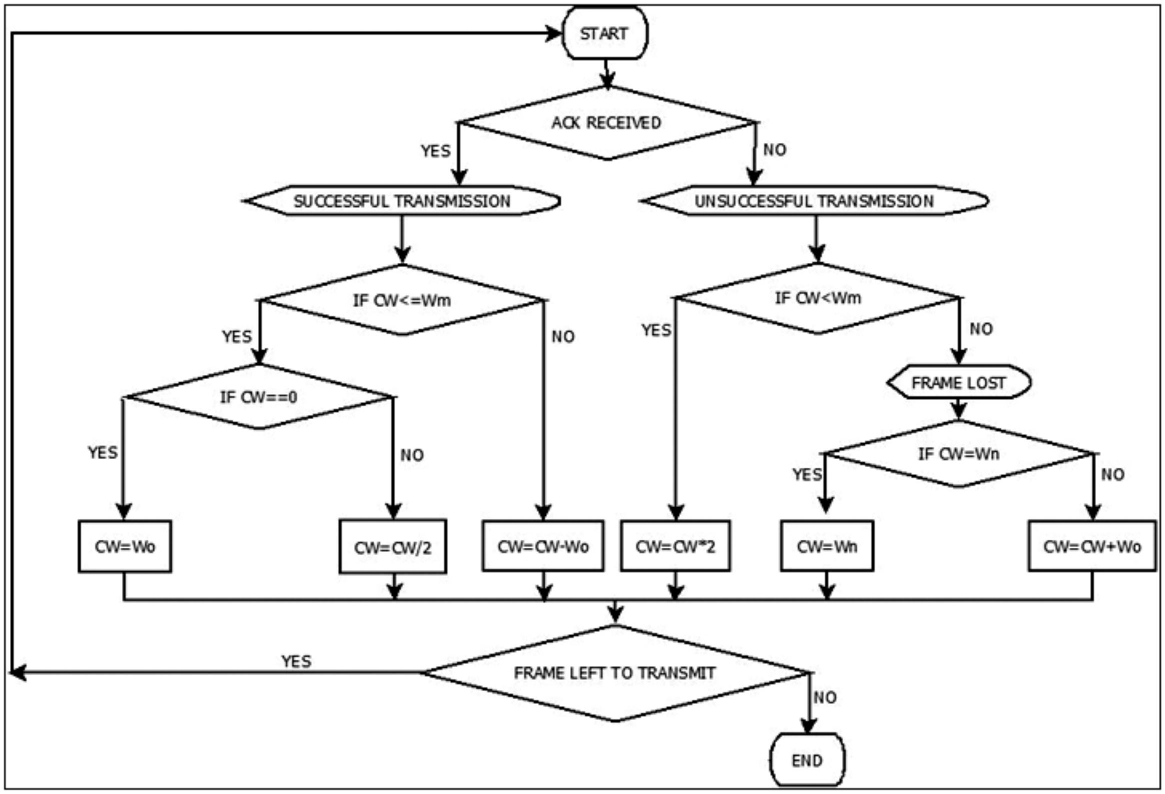

Figure 1: Slow Start Back off Algorithm [1]

In MACAW layer protocol based on RTS and CTS A sensing clear channel sends its packet which then collide with packets from C thus sending negative acknowledge to C.

In A implements the SSB algorithm for setting the contention window. Here as the contention window was very large, again there is collision between the second packet of C and the first packet of A.

In Figure 2, A sets its contention window to small so whenever C tries to sense the channel, it finds it busy.

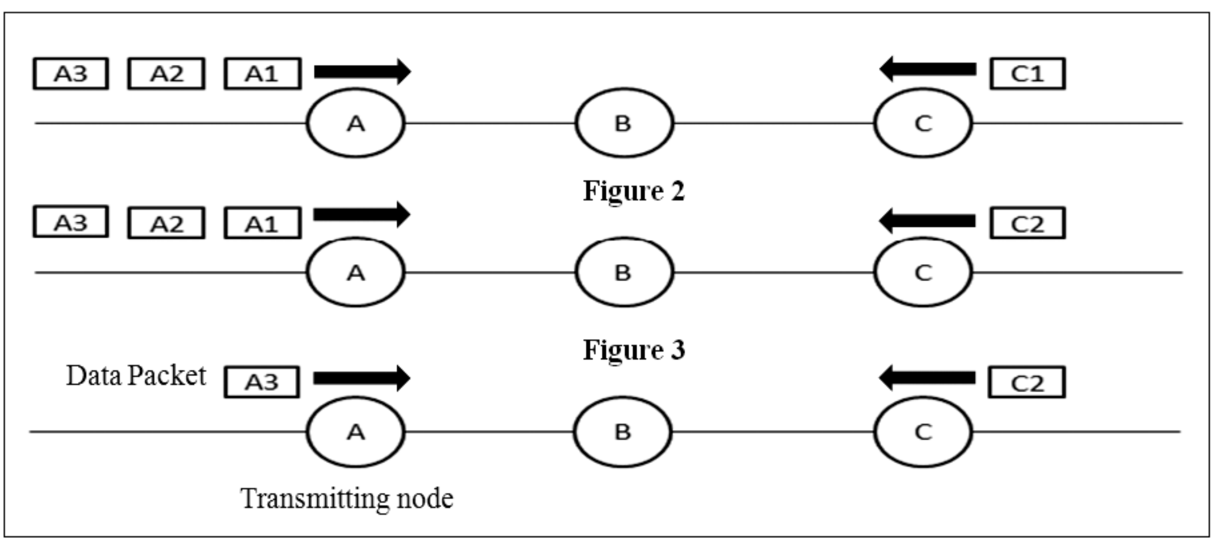

Figure 2:

So finally based on the working of algorithm and the results obtained , when implemented on NS-2, following drawbacks came out.

1. There is no specific algorithm or basis that defines the initial value of threshold contention window size. According to SSB algorithm, the threshold contention window is taken at random due to which throughput of the overall network suffers due to increased collision rate. Also as seen from the above example and Figure 3, the way in which contention window is increased or decreased about the threshold value is very extreme which leads to throughput degradation.

2. The second drawback is, the contention window is decided for each node in a vast multi hop network. In a vast network with thousands and millions of nodes, it is difficult to control the working of algorithm for each and every node. There might be failures in a network, but the SSB algorithm does not look into that. Thus the algorithm isn't network flexible.

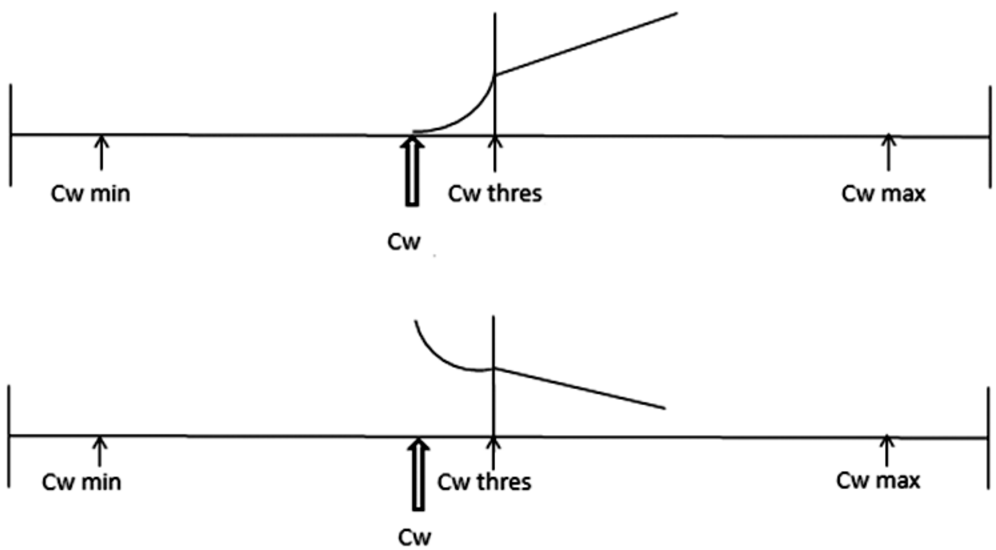

Figure 3: SSB contention window size variation graph

2.2. EWMA filter [2]

EWMA (Exponentially Weighted Moving Average) [2] is a technique which averages the previous 'n' number of values, based on the dataset, and exponentially decreases the weightage given to each preceding value. Thus it is also referred to as "exponential smoothing". The last value is given the highest weightage/precedence as it defines the current state of the system. It is referred to ass moving average because the range of values for which the average is being taken keeps moving or shifting with every iteration.

The current EWMA value Ei is calculated as follows:

$$E_1 = D_1$$
$$E_i = \alpha * D_i + (1 - \alpha) * E_{i-1}$$

The application of EWMA [2] technique along with the traditional SSB [1] algorithm can help improvise the determination of threshold CW-$_{th}$ value as per the need of the network as the technique gives higher weightage to the previous value so the CW is set according to the current requirement of the CW value in the network.

But, this filter is based on a dynamic learning method to set the same threshold for Slow Start Back off algorithm but as learning is a slow process and still start fundamentally with an arbitrary threshold thus proves less efficient.

2.3. Fibonacci Incremental Back off Algorithm [3]

Major drawback of most back off algorithms exists due to the intrinsic operations performed within the node. In case of failure, increasing the contention window size by large amount tends to restrict the possibility of gaining access to the channel thereby increasing the channel idle time. This leads to wastage of shared, limited channel for communication. Motivated by this observation, a new back off algorithm to improve the performance of the back off algorithm was proposed [3]. One of the most famous series in math is the Fibonacci series defined by the following rule :

$$F(n) = F(n-1) + F(n-2).\ F(0) = 0,\ F(1) = 1,\ n >= 0. \tag{3}$$

3. PROPOSED ALGORITHM

In the proposed method for contention resolution , whenever there is a success in packet delivery, a reset in the contention window value is done by setting the previous CW value to 1 and current CW value to CWmin. In the case of failure, the CW value is modified by setting the previous CW value to the current CW value and doubling the current CW value. If this value exceeds the CWmax value, it is set to CWmax value. And if the previous and current CW has the same value, then the previous value is set to half of the current CW value so as to provide a range for the back off timer to pick a random CW value, otherwise it will pick the same value all the time.

The proposed algorithm is as shown in the flow chart :

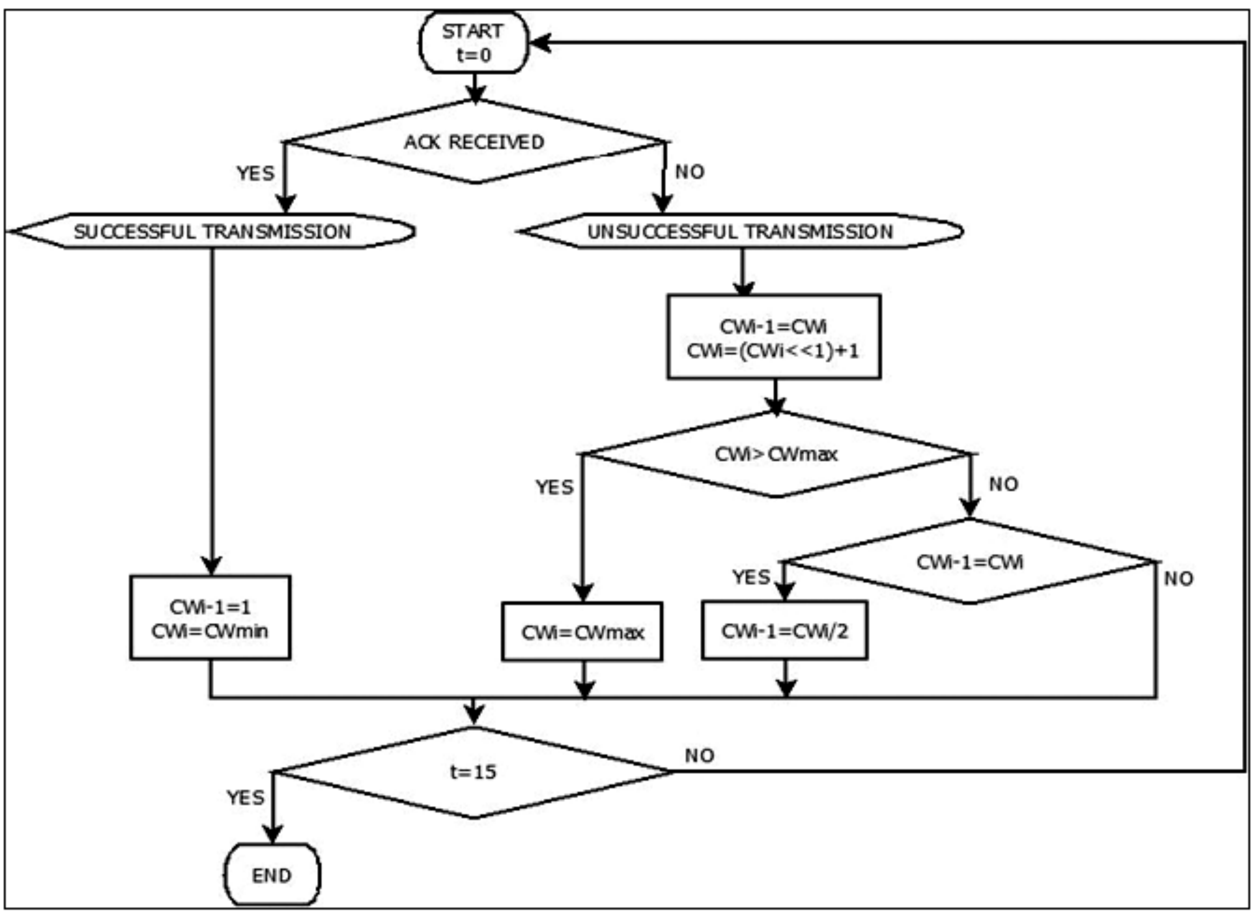

Figure 4: Proposed algorithm flowchart

4. SIMULATIONS AND PERFORMANCE EVALUATION

In this section, we evaluate the performance of the proposed scheme. We have used a simulation program which was runs both in NS-2 and C++ environment. The following parameters have been maintained for all simulations:

Number of Nodes	:	100
Data Rate	:	2 Mbps
Packet Size	:	512 bytes
Cwmin	:	31
Cwmax	:	1023
Topology	:	Grid
Network Range per Node	:	250m
Simulation Time	:	600s

Throughput : One of the major parameters for determining the performance of the wireless network is the throughput. For a dense, heavy traffic network, improvement in the throughput brings about a better utilization of channel bandwidth. Figure compares the throughput obtained from the proposed scheme with other algorithms, namely, legacy BEB protocol, slow start back-off. We can see that there is a **16.8 %** improvement in the values of the performance measures when traffic load is heavy.

Table 1
Throughput Comparison

Number of CBR Applications	*BEB*	*SSB*	*Proposed*
5	570.02	558.22	566.67
10	904.09	891.43	909.94
15	1,152.01	1,149.5	1,341.53
20	1,084.14	1,023.82	1,141.22
25	1,222.19	1,082.15	1,264.26

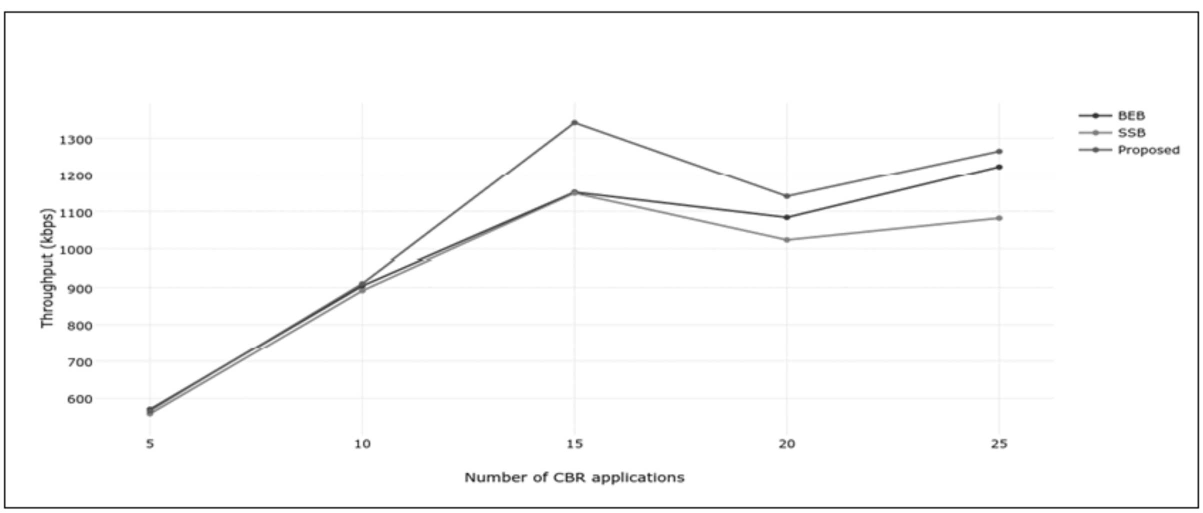

Figure 5: Throughput Comparison

Packet Drop: Another important parameter which affects the channel performance is the packet drop. Decrement in packet drop can substantially increase the channel efficiency. Figure depicts the Packet loss which occurs when one or more packets of data travelling across a computer network fail to reach their destination, typically caused by network congestion. As we can see, there is comparatively lesser packet drops as compared to SSB.

Table 2
Packet Drop Comparison

Number of CBR Applications	*BEB*	*SSB*	*Proposed*
5	42,736	32,162	35,017
10	85,599	68,824	95,916
15	121,649	130,598	81,825
20	212,366	215,559	200,744
25	196,658	234,558	221,129

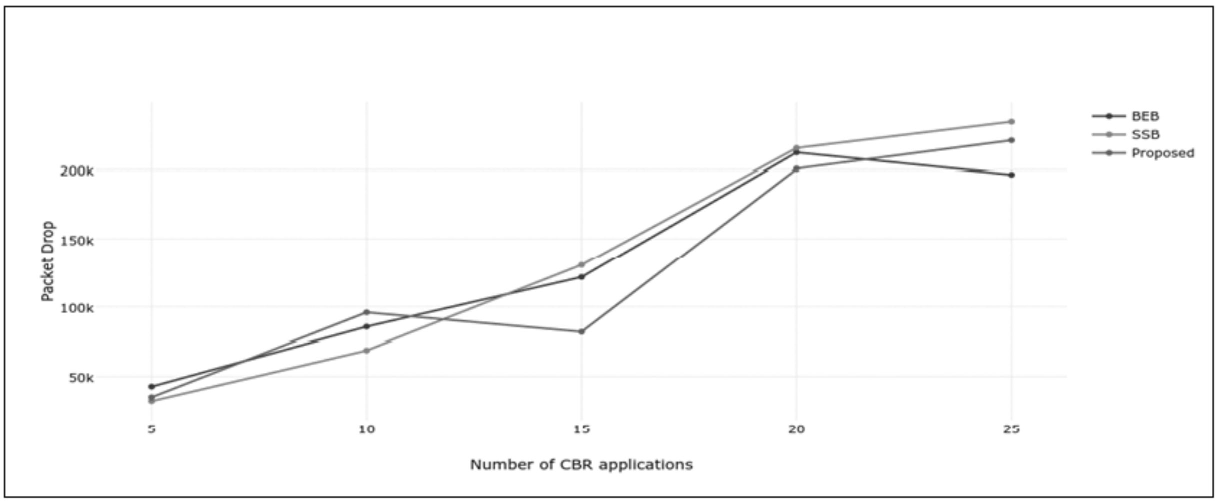

Figure 6: Packet Drop Comparison

5. CONCLUSION

In the IEEE 802.11 WLANs, even after the utilization of RTS/CTS scheme, the packet collisions cannot be completely eliminated. Still the active nodes need to backoff randomly for avoiding repeated collisions. In this paper, we have proposed a new algorithm to be used with IEEE 802.11 DCF scheme. Through this algorithm, we were able to achieve better throughput and lesser packet drops by increasing the channel fairness index for each node. This feature differentiates this algorithm from other schemes.

Our study shows that through this algorithm, with proper network parameter settings, the performace parameters out-performs the SSB scheme in every respect employed in the IEEE 802.11 DCF scheme over a dense wireless active nodes network. The resulting performance is even stable and consistent with changing density. There is a scope for further analysis on the basis of other parameters and possible improvement chances.

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