# Collision mitigating Sliding DCF Backoff Algorithm (SDBA) for Multi-hop wireless networks

B.Nithya*, Nikita Sivakumar and Arvindmani Satyanarayan
Department of Computer Science and Engineering, National Institute of Technology Tiruchirappalli - 620015,Tamil Nadu, India
{bnithyanitt, nikita.siva, arvindmani.satya}@ gmail.com

***Abstract*— In the IEEE 802.11 based wireless networks, an adjustment of the Contention Window (CW) is indispensable in order to provide a differentiated quality of service. Distributed Coordination Function (DCF) is a contention-based MAC method which allows to mutually share the common wireless channel. DCF backoff algorithm regulates the size of CW range upon successful transmissions and collisions. Due to wireless medium characteristics and node mobility, estimating pertinent CW range is a very crucial task. This paper proposes Sliding DCF Backoff Algorithm (SDBA) that predicts current medium status using Backoff Success Ratio (BSR). According to this, SDBA slides both CW lower and upper boundaries. To investigate the behavior and capability of the proposed SDBA, extensive NS2 simulations are carried out with varying mobility speed under random topology. It is perceived from the simulation results that the proposed algorithm attains better throughput and significantly reduces collisions, routing control overhead and energy consumption, thereby extending network lifetime.**

***Index Terms*— IEEE 802.11, Medium Access, Backoff, Contention Window, Multi-hop, Simulation.**

## I. INTRODUCTION

A multi-hop network is a wireless network where the data is transmitted between two nodes via two or more wireless hops. The close interaction between the multi-hop wireless paths [1] with MAC and physical layer properties helps to acquire several benefits in terms of performance. Also, in case of wireless systems, clients require mechanisms to access the wired architecture. Consequently, the ultimate aim of the access infrastructure is to build suitable paths, whether single-hop or multi-hop, to the closest AP (Access Point) of a WLAN. The drawbacks of multi-hop networks is that the forwarding nodes have to expend energy for transmitting as well as receiving packets. Even though several MAC- schemes have been developed to decrease the amount of overhearing as well as frivolous idle listening, the amount of energy taken to receive packets (receive energy) and the amount of energy to transmit packets (transmit energy) creates overhead during communication [2]. Moreover, a decreased network lifetime could be caused by nodes in close proximity to the base station which have to handle greater amounts of traffic, causing a system with poor energy balance. Therefore, data transmission using multiple hops may be worse than for the single-hop case in terms of the overall energy consumption.

The basis for the IEEE 802.11 DCF is the CSMA/CA Carrier Sense Multiple Access with Collision Avoidance [3]. It specifies the BEB(Binary Exponential Backoff) Algorithm where back off time is measured as the additional random deferral time measured in slot time before transmitting data. The duration of a backoff period is a pseudo-random integer picked from the uniform distribution over [0,CW], which then serves as CW size. After each collision this value is doubled ($CW_{new} = 2 (CW_{old} + 1)$). This solution is unfair and inefficient. An increase in the number of active neighbours directly increases the number of collisions as well. Although the CW size is doubled after each collision, multiple nodes may backoff with similar CW. This could lead to a greater chance of an unsuccessful transmission. Moreover, the successful receiving of a packet does not say much about the contention level. It only delineates on picking (randomly) a convenient CW value by luck.

Picking a period of time from the range [0, CW] randomly has several disadvantages [4]. For instance, despite the fact that the CW size is increased by doubling it after each collision, nodes may still back off from using the medium for a short period. This happens by picking a number from beginning of the [0,CW] interval, thus creating shorter backoff periods, which might in turn lead to more collision. Moreover, in the case of heavy traffic, after the interval has been changed to the upper limit of [0,1023], changing it back to [0,31] upon successful transmission will not prove fruitful as this will lead to more collision. Moreover, in the scenario of a fewer stations with lesser traffic, if CW increases exponentially, the medium remains free for a longer time period, thus wasting the bandwidth of the channel. Lastly, in BEB, the newer stations and stations which have recent successful transmissions will be given priority over the stations that have been waiting for a longer time. As a result, service starvation and unfairness among stations are inexorable.

Moreover, upon receiving a packet, nodes in wireless network have to perform routing, forwarding (switching) and encapsulation. When a node receives a packet, it gets rid of the L2 information on the header present on the packet, checks for destination address and checks for routes for that destination prefix. Once a match is found, it then attaches the exit address assigned to it as source and the

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devices connected to it as the destination and sends it out through the exit interface. If however, there are no routes found in the table, nodes initiate route discovery process. Due to node mobility in a highly dynamic multi-hop network, the frequent route discovery process is unavoidable. However, by transmitting only the minimum required number of control packets at correct time during discovery process, it is possible to minimize control overhead. But BEB and other algorithms fail to curtail control overhead as they blindly perform i-increase and j-decrease on CW without considering current medium condition. So multiple retransmissions lead to high probability of collisions. Thereby consuming more energy are inevitable. To alleviate these problems, the proposed SDBA focuses on arriving at a better way to select the lower and upper bounds of CW. This is selected after considering current medium condition also. The proposed algorithm helps the stations to successfully transmit or forces the stations to defer from accessing the busy medium. This is the key factor for minimizing unsafe transmissions thereby reducing collisions and retransmissions.

The paper is organized in the following manner: In Section II, related works are discussed along with their demerits. Section III proposes Sliding DCF Backoff Algorithm (SDBA). Section IV provides the detailed analysis of simulation results obtained from NS2 simulations. Finally, the paper ends with conclusion.

## I. Related Works

In this section, several existing algorithms which are related to the proposed algorithm are discussed. Multiple Backoff algorithms were proposed [5-9] to get rid of the faults in the BEB mechanism. Multiple Increase Linear Decrease MILD [5], Linear Increase Linear Decrease LILD [5], Exponential Increase Exponential Decrease EIED [6,9] and Double Increment Double Decrement DIDD [7] are algorithms which were devised to solve the fairness problem of BEB. MILD [5] increments CW by 1.5 during collisions and decreases CW by number of RTS packet transmission time after successful transmissions. However, header size of a packet increases due to embedding of current CW in each packet that is transmitted. Just like the MILD algorithm, the Linear/Multiplicative Increase and Linear Decrease LMILD [8] employs a special method after a correct packet transmission where a linear decrease mechanism is used. These algorithms however, retain the lower bound of CW at 0 no matter what the upper bound of CW is. In this section, our primary concern is the algorithms [10-16], which alter both lower and upper bounds of CW. These algorithms are delineated below in this section.

Bounds Selection - Dynamic Reset Protocol for Wireless Ad Hoc LANs (SB-DRA) algorithm [10] is for both adhoc and infrastructure network configurations. The amount of one jump active nodes present as neighbours is what determines the selection of the lower and upper bounds of the CW (sb). Also, it is based on the number of attempts to transmit the packets when the recovery mechanism has begun. The backoff timer is randomly picked from the range [lB,uB]. Better throughput and significant reduction in the collision rate and loss of packets is prevalent in sB-DRA protocol. However, the algorithm is lacking in the sense that it is difficult to find the number of one hop neighbours due to the changes in mobility.

In the Contention-based congestion control in wireless ad hoc networks algorithm proposed in [11], the multi-hop ad hoc network is considered. BSR (Backoff State Ratio) was introduced to measure the congestion at a node and is a term used to identify the fraction of nodes which enter backoff state after failing a transmission to the total number of nodes. This paper successfully establishes a congestion metric which is a more precise parameter to characterize the status of the network congestion by monitoring the number of one node entry the backoff algorithm. Achievements of the algorithm involve superior performance in terms of delay, packet delivery ratio, throughput and congestion at MAC layer. This algorithm is yet to be tested against various network topologies in terms of its fairness.

An algorithm called, Novel Dynamic Tuning of the Contention Window (CW) for IEEE 802.11 Enhanced Distributed Control Function proposed in [12] for wireless ad hoc networks performs a novel and dynamic tuning of the contention window. In order to reduce the collision rate fluctuation, the busy rate parameter is used as the smoothing factor of the collision rate. The main contribution of the algorithm is to smoothen out the collision by altering the window. The algorithm does so by taking into account, the flow priority and nodes density. The performance of the network in terms of collision, throughput and delay are improved greatly. However, only the ring structure has been analyzed in this paper.

In the algorithm Distributed Optimal Contention Window Control for Elastic Traffic in Single-Cell Wireless LANs ([13]), a theoretical study has been presented on CW control algorithms for gaining efficient utilization of channel and various bandwidth allocating protocols. An algorithm, General Contention window Adaptation (GCA) was designed whereby the optimal stable point to identify maximum channel utilization was found. The backoff mechanism employed in this paper uses the concept of a virtual slot, which is the period for a backoff station to reduce its backoff timer by 1. A virtual slot can be two things. One, a Slot Time period during the idle time of the channel. Second, it could include a busy period (a DIFS and a Slot Time) if the channel is occupied. Multiple drawbacks were found to exist in this method. For instance, the channel access used in this paper was probabilistic in nature. Also, the asynchronous updates among nodes wasn't considered. For these two reasons, there exists a gap to be bridged between reality and the model proposed.

Sliding Contention Window (SCW) [14] uses a parameter called sliding contention window provides QoS differentiation between different classes and fairness between flows of the same class, while still maximizing network utilization for each network flow. Here, to calculate backoff time, a number is selected from [1,1+CW[AC]], where AC stands for Access Category and is 0,1,2,3 corresponding to Best Effort, Video Probe, Video, Voice respectively. However, the algorithm relies on the assumption that the network has adequate resources to service all accepted multimedia flows; which is not always true. Despite the fact that SCW is better fit to accommodate the variations in the network load for each class, further work is required in order to be able to acknowledge any given network.

The paper on Dynamic Sliding Contention Window after Successful Transmission introduced in [15] provides a methodology to reduce or avoid further collisions by introducing a sliding CW approach. Ratio of contention for the channel and the utilization of it are two parameters used to measure the channel condition at any point of time for the dynamic updation of CW boundaries upon successful transmissions. This algorithm adopts exponential CW increments during collision as in BEB. The NS2 Simulator results show that it performs better than the Double Increment Double Decrement (DIDD) and the conventional Binary Exponential Back off (BEB) algorithms in terms of delay, throughput and packet loss. However, based on channel condition, adjustment on CW boundaries upon unsuccessful transmissions is highly recommended to further enhance the network performance.

Dynamic Control Backoff Time Algorithm (DCBTA) is proposed in [16] to improve the performance of IEEE 802.11 under unsaturated traffic loads. It distinguishes light and heavy traffic based on CW size. If the $CW_{i-1}$ is lesser than or equal to $CW_{threshold}$ (which has been taken as $CW_{max}/2$ in this algorithm), the traffic is designated as low. If greater, traffic is high. In case of low (light) traffic, there are two cases. First, in case of a successful transmission, the algorithm reduces the $CW_i$ to $CW_{i-1} - 1$. Second, in case of a collision, the $CW_i$ is increased to $CW_{i-1}\ 2$. On the other hand, in case of high (heavy) traffic, the two cases occur again. First, in case of a successful transmission, the algorithm reduces the $CW_i$ to $CW_{i-1} - 2$. Second, in case of a collision, the $CW_i$ is increased to $CW_{i-1}\ 2 + 2$. (In both cases, the algorithm takes into consideration that a heavy traffic medium would require a slightly longer waiting time compared to its lighter counterpart. But there is no much difference between $CW_{i-1} - 1$ and $CW_{i-1} - 2$ values selected after successful transmission. The same fact holds true for the values $CW_{i-1}\ 2$ and $CW_{i-1}\ 2 + 2$ selected upon collisions. So the algorithm fails to minimize collisions specially in a highly dynamic and congested network. All these algorithms are summarized in Table 1.

In order to overcome the aforementioned drawbacks, this paper brings forth an algorithm called the Sliding DCF Back- off Algorithm (SDBA) for multi hop wireless networks. The proposed SDBA algorithm alters both, the lower and upper bounds of CW in order to get new contention window after every transmission. The parameter used is BSR, which has a lesser computational cost. As a result, distinct differentiated CW boundaries for each of the stations at different BO (backoff) stages is obtained.

## II. PROPOSED SLIDING DCF BACKOFF ALGORITHM (SDBA)

The proposed SDBA algorithm seeks to re-adjust contention window to improve goodput by minimizing collisions, control overhead and energy consumption over BEB and DCBTA. To address the problems mentioned in the previous sections, the following corrective measures are incorporated into the proposed SDBA algorithm.

1) The upper as well as lower bounds of CW interval are re-adjusted. The reason for changing lower bound is that if the random number is chosen between 0 and CW, it is likely that the chosen number is from the initial range itself, irrespective of the CW value. This small random value yields shorter backoff time and hence, immediate transmission occurs without considering channel status. Since the lower bound is also dynamically adjusted, unnecessary transmissions and collisions can be avoided.

2) Lower and upper boundaries are adjusted after every failed as well as successful transmission. Because, it is important to change the contention window prior to every transmission in order to minimize the chances of collision.

3) The network traffic condition, in terms of Backoff State Ratio (BSR), is taken into account before transmitting a packet. This ensures maximum chance of successful transmission because nodes either sends a packet successfully or defers from sending the packet through a busy medium.

Nodes utilize BSR to measure the congestion in the network. It can be calculated by dividing the value of the $BSR_{fail}$ by the total value of BSR, obtained by adding $BSR_{fail}$ and $BSR_{success}$ where $BSR_{success}$ refers to the number of times a node enters the backoff state after finishing successful transmissions and $BSR_{fail}$ refers to the number of times a node enters the backoff state after it has failed a transmission. BSR is expressed in the following equation:

$$BSR = \frac{BSR\text{fail}}{\text{BSR fail} + \text{BSR Successful}}$$

Table 1: COMPARISON OF BACKOFF ALGORITHMS

| BO Algorithms | Decision Parameters | Advantages | Disadvantages | Topology and no. of nodes |
|---|---|---|---|---|
| LILD [5] | Transmission Event | CW is dynamically adjusted, slots are not unnecessarily wasted, improves on slow linear change for medium number of nodes | Resetting the lower bound to 0 might cause the network to pick a small CW. This will cause col- lisions | Upto 100 nodes & Random topology. |
| EIED [6] | Transmission Event | Better saturated throughput and lesser saturated delay | Since the current CW is embed- ded in each transmitted packet, header size is increased | Upto 50 nodes & Tested with RTS/CTS and Basic Access method. |
| DIDD [7] | Transmission Event | Outperforms BEB in a highly congested network | Does not take current channel status into account when per- forming CW augments | Upto 70 nodes & Tested with RTS-CTS and Basic Access method. |
| LMILD [8] | Transmission Event | Better saturated throughput than BEB and MILD | Station needs to report the col- lisions when it senses the busy medium but no packet header is detected | Upto 100 nodes &Static Topology. |
| sb-DRA [10] | Number of transmission attempts and number of 1-hop active neighbours | Better throughput and significant reduction in the number of colli- sions and packet loss | It is difficult to find the number of one hop neighbours due to mobility | Upto 50 nodes &Random Topology. |
| Contention-based congestion control [11] | BSR (backoff state ratio) | Better performance in terms of delay, packet delivery ratio, and throughput. | Tested only for lesser number of stations | upto 9 nodes & Chain Topology. |
| A Novel Dynamic Tuning of CW [12] | Average collision rate | Smooth the collision by altering the contention window | Only the ring structure has been analyzed | upto 40 nodes & Ring Topology. |
| Distributed Optimal CW Control [13] | Idle and Busy Time | Achieved efficient channel uti- lization and arbitrary bandwidth allocation policies | The channel access was prob- abilistic in nature, restricted to single-cell wireless LANs only | 50 Flows |
| SCW [14] | a threshold value for the maximum tolerated loss rate | Provides QoS differentiation be- tween different classes, maxi- mizing network utilization for each network flow | Network needs to have sufficient resources to service all accepted multimedia flows | upto 10 nodes & Central- ized Network. |
| DSCW-ST [15] | CWThreshold | Reduces or avoids further col- lisions by introducing a sliding CW approach | Exponential Increments upon collisions | upto 50 nodes &Linear and Random topology. |
| DCBTA [16] | CWThreshold | Better performance for varying traffic load conditions | Different frame sizes have not been considered. Also, only for unsaturated network | Upto 100 nodes &Static Topology. |

After every successful and failed transmission, nodes enter into a backoff state for calculating the next contention window. During this time, the new value of BSR needs to be calculated to mimic the current network status. Using this run time measurement, CW lower and upper boundaries are accustomed as stated by Algorithm 1. Instead of increment- ing or decrementing CW size based on a strict number as in BEB, it is increased or decreased proportionally with the current status of channel.

*Case 1 (BSR < threshold):*

This is the case where the fraction of nodes entering backoff state after failing a transmission to the total number of nodes is lesser than threshold. Since, this case depicts a network with relatively lesser congestion/ medium traffic, it would prove fruitful to transmit after a short waiting time to minimize idle time. Thus, by reducing upper bound and the lower bounds, the interval shifts to the left in the number line. Now, the range of values chosen from this interval is relatively smaller leading to lesser backoff time. Consequently, the channel access probability is increased, thereby enhancing goodput.

*Case 2 (BSR threshold):*
This is the case where the fraction of nodes entering backoff state after failing a transmission to the total number of nodes is greater than or equal to threshold. Since this casedepicts a network with severe congestion/heavy traffic, it would prove fruitful to transmit only after elapsing decent length of time. If time of backoff is low, it might lead to further collision. Hence, the upper bound and the lower bounds are increased drastically, shifting the interval to the right in the number line. Thus, the range of values selected from this interval are relatively higher, thereby causing the medium to pause, instead of transmitting packets. This fast increment reduces chances of collision. In BEB, a group of stations have to pick a random value between [0,CW]. Often, multiple stations pick the same/similar value and there exists a high chance of collision. The main reason behind this is that the lower bound is always set as zero. So there is a possibility of having tight intersection among CW intervals at different BO stages. This causes the stations at different backoff stages to select more or less similar values, thus leading to high probability of collisions. However, according to the proposed algorithm, an adjustment is made in the lower as well as the upper bound according to the current traffic in the network. The intersection among CW intervals at various backoff stage is reduced. Therefore, the chance of selecting the same or similar backoff value is minimized. For example, consider a network with medium congestion.

**Algorithm 1: SDBA**
**Arguments involved in SDBA Algorithm**
CW Lower and CW Upper Bound ($CW_{UB}$ and $CW_{LB}$),avg, a

**Initialization**:
$CW_{UB}^{max} = 1023$ , $CW_{LB}^{max} = 7$
avg = ( $CW_{UB}$ + $CW_{LB}$ )/2, a = 0.25

**Backoff procedure after each transmission:**
In case of medium congestion:
**if (BSR < threshold)**
$CW_{UB}^{i} = \min(CW_{UB}^{i-1} - avg*a, CW_{UB}^{max})$
$CW_{LB}^{i} = \max( CW_{UB}^{i}/4, CW_{LB}^{max})$

In case of heavy congestion:
**if (BSR ≥ threshold)**
$CW_{UB}^{i} = \min( CW_{UB}^{i-1} + avg*a, CW_{UB}^{max})$
$CW_{LB}^{i} = \max( CW_{UB}^{i}/2, CW_{LB}^{max})$

If a node A is currently picking a backoff number from the interval [0,47], it is possible that it picks the random number as 6. Similarly, if another node B also picks the same backoff time, there is a 100 percent chance of collision. However, in the proposed algorithm, the upper bound reduces to 47 - avg*a which translates to 47 - [(0+47)/2]*0.25 which is similarly, the lower bound (instead of staying at 0) will be increased to 47/4 which is 12. Therefore, the node will now pick the backoff time from the interval [12,42]. The range of intersection between [0,47] and [12,42] is lesser. This reduces the chance of the two nodes picking the same number, hence reducing chances of collision.

## III. Simulation Results and Analysis

In this section, performance of the proposed SDBA is analyzed and compared with BEB and DCBTA under random topology with varying mobility speed. NS-2 is used to simulate SDBA, BEB and DCBTA with a random topology, which consists of 50 nodes. The mobility model used is the random way point mobility model and is considered with different mobility speed varying from 4 m/s to 24 m/s. Table 2 gives other simulation parameters used in the simulation. The performance metrics, Goodput ratio, Collision frequency, Delay, Routing control overhead and Energy consumption, are measured for SDBA, BEB and DCBTA and analyzed in the following subsections.

TABLE II: Values of Simulation Parameters

| Parameters | Values |
|---|---|
| Propagation Model | Two Ray Ground |
| Link Bandwidth | 2 Mbps |
| Transmission Range | 250 m |
| IFQ length | 32 |
| Routing protocol | AODV protocol |
| TCP window size | 32 |
| TCP Packet size | 512 bytes |
| Traffic Pattern | FTP |
| Access Method | RTS-CTS-DATA- ACK |
| Simulation Time | 200 sec |
| Simulation Area | 1000 X 1000 meters |
| Number of nodes | 10 to 50 |
| Mobility Speed | 4 to 24 m/sec |
| Mobility Model | Random Way Point |
| Slot time | 20 $\mu$ se |

### A. Goodput Ratio

The ratio of the successful TCP data packets transmission is the goodput ratio. The goodput ratio of the algorithms

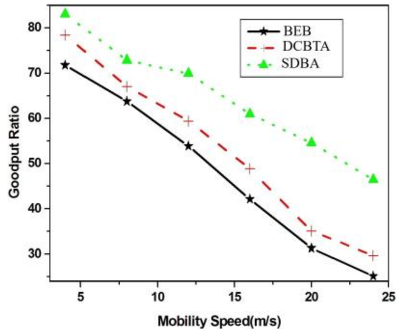


Fig. 1. Goodput Ratio

compared against each other is depicted in a random topology in Fig. 1. In BEB, the channel condition is not checked. In case of a collision, there is an exponential increment in the upper bound of the contention window. This in turn leads to the possibility of an increase in the channel access delay in case a large number is picked as the contention window. Also, it leads to a fewer number of transmissions. Moreover, in BEB and DCBTA, the lower bound gets reset to zero. This is not suitable in the case of high mobility nodes and a highly congested medium. This is because there is a possibility of zero or any relatively small number being picked as the lower bound. Due to this reason, the waiting time before sending the next packet may be reduced, leading to further collisions and hence, further congestion in the network. However, in the SDBA, the CW boundary is altered after comparing the BSR with the threshold. So the current status of the channel medium is taken into account. Also, since the upper bound is not exponentially incremented, and the lower bound isn't reset to zero, the waiting time is ideal before transmission. This leads to lesser chance of collision and hence a better goodput because either the node safely transmits the packet through an idle medium or defers from sending in a busy medium. Thus SDBA has a better goodput than BEB and DCBTA.

*B. Collision frequency*

The Collision frequency is defined as the number of collisions per second in a network. From the Fig.2, it is observed that SDBA has a reduced collision frequency as compared to BEB and DCBTA.

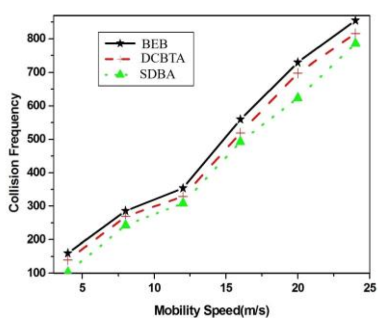


Fig. 2. Collision Frequency

In BEB, after every successful transmission, the CW resets to its minimum value. For instance, assume that the station A achieved successful transmission after its 6th backoff stage (in that CW range is [0 1023]). So for the next retransmission, station A will use CW range as [0 31]. Also assume that Station B is about to transmit for the first time. Now these two stations are having same CW range for the subsequent transmission. Thus, there is a chance that A and B might pick the same or similar CW values, leading to collisions. Similarly, for the DCBTA algorithm, station at backoff stage 1 will have a window [0,31]. A station at backoff stage 2 will have a window [0,63]. Similarly, station at backoff stage 6 will have a window [0,1023]. Therefore, even in the worst case, there exists an overlap of 31 possible numbers. Due to the overlap of window, there is a chance of the two stations picking a similar CW just like the BEB situation. If multiple stations have overlapping windows, more stations might pick similar CW's and hence, may have to wait the same time. This might lead to them transmitting together after the interval and hence,leads to a collision. In the case of SDBA, each node has a distinct CW boundary. Therefore, there is a reduced chance of selecting the same CW value. This translates to no simultaneous transmissions and hence, a decreased number of collisions. It is possible that two nodes may have the same BSR value and the same CW boundaries. However, the probability of such a case is low and hence, this is a significant improvement over BEB and DCBTA.

*C. End-to-End Delay*

Fig.3. depicts the three algorithms, BEB, DCBTA and the proposed SDBA in a random topology with varying mobility speed, compared in terms of end-to-end delay.

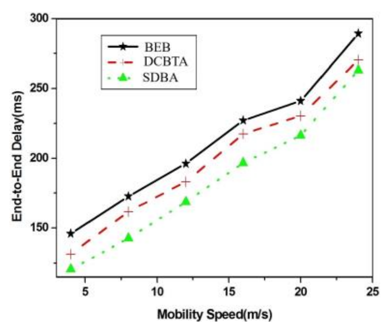


Fig. 3. End-to-End Delay

In the BEB algorithm, during a collision, the upper bound is increased exponentially without accounting for the current traffic con- ditions in the network. Thus,in an idle medium, this leads to unnecessary delay. In the BEB and DCBTA algorithms, the CW lower bound is always fixed as zero which might cause a node to pick a small number as its backoff time. As a consequence, immediate transmissions are imminent thereby causing too many collisions and retransmissions in a congested network. Each of the intermediate node may have to carry out multiple such retransmissions and thus, the time taken by the packet to reach the destination from the source via the intermediate routers is greatly increased. Thus, the end-to-end delay in case of BEB and DCBTA is high. However, on the other hand, in the case of SDBA, the unique setting of the CW window boundaries helps each station pick a distinct backoff time, thus reducing the chance of collision. This leads to lesser retransmissions and hence, a faster transport of the packets from the source to the destination via the routers. This is the reason for the reduced end-to-end delay as compared to BEB and DCBTA algorithms.

### D. Routing Control Overhead

Overhead refers to meta-data and network routing in- formation which occupies space in the bandwidth of a communications protocol. According to the Fig.4, the degree of overhead faced by SDBA is much lesser than BEB and DCBTA. Due to the high mobility, the routing path is not stable in multi hop wireless network. Therefore, the nodes are frequently required to perform route discovery process. This requires a large number of control packets to be broad- casted by nodes. Consider an example with two nodes A and
B. B wants to send RTS packet to A but A has to defer from accessing the medium due to some ongoing transmissions in its range. Consequently, A will not acknowledge B's RTS with a CTS. After 6 retransmissions (maximum for RTS), B will assume that A has shifted its position, even though A is in the same position as before. Now B conducts a route discovery by broadcasting control packets, thus increasing the number of control packets in the network. To curtail routing control overhead, these unnecessary transmissions of control packets need to be minimized. But BEB and DCBTA fail to minimize control overhead as they followed *i*-increase and *j*-decrease CW adjustments without bothering about current channel condition. On the contrary, SDBA checks the status of medium with the guidance of BSR factor and accordingly picks CW from the window with changing lower and upper bounds. So, the stations thus either transmit with success or defer from transmitting through the busy medium. This reduces the number of superfluous control packets thereby reducing collisions among these control packets.

### E. Energy Consumption

The average energy (which is the energy dissipated by the network while performing transmissions) consumed for each of the algorithms is different for the various mobility speeds. According to Fig.5, SDBA consumes much lesser energy than that of other two algorithms.

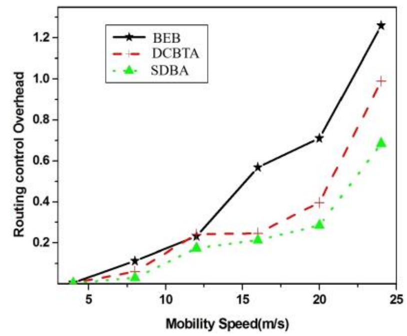


Fig. 4. Routing Overhead

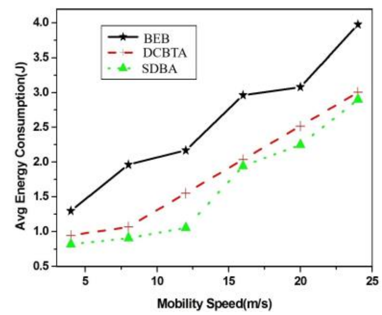


Fig. 5. Energy consumption

In the case of BEB and DCBTA, the increased number of collisions (as mentioned in section IV.B) leads to more number of retransmissions. Moreover, the increased routing control overhead (as men- tioned in section IV.D) of BEB and DCBTA has escalated the amount of energy expenditure made by the network. However, in SDBA, number of collisions is reduced, which in turn reduces number of retransmissions and number of control packets in the network (as mentioned in section IV.B). Also, as seen in the previous section, mobility reduc- tion causes the number of control packets transmitted to be lower. Since packet loss and mobility are both high energy consuming activities, SDBA significantly reduces the energy consumption in the network.

## I. CONCLUSIONS

The congestion and contention control in TCP causes severe performance degradation in Ad Hoc networks. It is therefore critical to introduce algorithms that reduce the routing control overhead and other critical performance metrics. The novel BSR metric has proven to be an accurate metric to characterize the network status as congested or not. Thus, by using the BSR metric in this paper, an algorithm Sliding DCF Backoff Algorithm (SDBA) is proposed for the adjustment of contention window size by changing both lower and upper bounds effectively under random topology with varying mobility speed. It is observed from the simulation results that the proposed SDBA outperforms IEEE 802.11 DCF standard and

DCBTA in terms of Goodput ratio, collision frequency, delay, routing control overhead and energy consumption. The value of *a* used in the proposed algorithm has been derived intuitively after a number of simulation experiments. It is possible to however, derive a mathematical model or an analytical model to prove the correctness of the value of a. This value also has scope for further optimization.

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