Thresholds Determination for new Backoff Algorithm in MANETs

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Abstract - **Backoff algorithms are one class of collision resolution algorithms used in the medium access control protocols in mobile ad hoc networks. When there are different nodes competing to access a shared channel at the same time, the possibility of collision is highly probable, especially in high traffic load networks. This study aims to study the possibility of using different values for increments and decrements in the contention windows in order to improve the performance.**

Keywords - Medium Access Control protocols; Backoff Algorithm; Ad hoc network; network performance.

I. INTRODUCTION

Mobile Ad hoc Networks (MANETs) [1, 2] work without requiring any preexisting communication infrastructure. These types of networks gain a high importance and attract attention due to the need of rapid deployment in emergency cases such as military operations, search and rescue operations and disaster recovery that do not have enough time to build an infrastructure. A MANET is an autonomous system of wireless nodes connected by wireless links. Each node not only acts as a sender or receiver but also as a router in order to convey the packet via intermediate nodes until it reaches the desired destination (multi-hop technique). These nodes have mobility characteristic that allow forming a dynamic network topology which is highly changeable and random.

Collision is considered as the major problem in wireless networks, so the backoff mechanism should be applied in order to decrease the collision and to achieve an efficient use of the shared channel. IEEE 802.11 DCF, the most widely used standard in MAC protocol, uses a Binary Exponential Backoff (BEB) algorithm which uniformly chooses the backoff value from the Contention Window (CW).

The main idea of using the backoff algorithm is to reduce collision and resolve contention among different nodes. Once the collision has occurred, the collided nodes are needed to defer for a period time known as retransmission delay (or backoff) which is usually selected randomly from bounded contention window that has a predetermined lower and upper values. These values are based on the number of active nodes and traffic load in the network. As an example CWmin and CWmax are usually set to 31 and 1023 respectively in IEEE 802.11 DCF, and set to 2 and 1024 respectively in Ethernet [3, 4, 5, 6].

Researchers have proposed many backoff algorithms in order to utilize the performance for IEEE 802.11 DCF MAC protocol. Some of these algorithms will be mentioned in the following section.

II. BACKGROUND AND RELATED WORK

Many backoff algorithms have been proposed in order to decrease the collision and to achieve an efficient use of the shared channel.

In [7], Bharghavan, et al. have proposed Medium Access with Collision Avoidance-Wireless (MACAW) protocol which used a Multiplicative Increase Linear Decrease (MILD) Backoff algorithm. In the MILD algorithm, the nodes increase their contention window multiplicatively upon collision or failure in transmission and decrease their contention window linearly upon success. This algorithm introduced to address unfairness problem in Binary Exponential Backoff (BEB) algorithm.

Manaseer and Masadeh [8] have proposed a Pessimistic Linear Exponential Backoff (PLEB) algorithm. This algorithm based on assumption that the failure in transmission process is caused by the congestion in network. It is considered as a result of combination between linear and exponential increment methods. Using these two increment methods will help to achieve the aim of this algorithm in improving the performance of a MANET in terms of network throughput and average packet delay. By using the linear increment, this algorithm will improve the performance by reducing network delay. On the other hand, using the exponential increment will improve network throughput.

Manaseer, et al. [9,10] have proposed Fibonacci Increment Backoff (FIB) algorithm and Logarithmic (LOG) Backoff algorithm, respectively. The former algorithm uses a famous math series called Fibonacci Series, which aims to reduce the differences between successive contention window sizes, this algorithm achieves a higher throughput when compared with (BEB) algorithm, the later algorithm uses Logarithmic increments in order to utilize the distribution of random numbers. It achieves a higher throughput and less packet loss. It also achieves stability of network throughput over various speeds of nodes.

In [4], Haas and Deng have proposed the Sensing Backoff Algorithm (SBA) in order to utilize the network

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throughput and fairness issues. This algorithm based on sensing mechanism (overhearing the channel to get the needed information). So, each node changes its backoff interval based on the results of the sensed channel status.

Deng, et al. [11] have proposed linear Multiplicative Increase Linear Decrease (LMILD) Backoff algorithm; in this algorithm, the collided nodes mutiplicatively increase their contention windows, while other nodes overhearing the collision increase their contention window in linear way. Upon a success, all nodes decrease their contention windows in a linear way.

In [12], Exponential Increase Exponential Decrease (EIED) backoff algorithm was proposed to improve the performance of the IEEE 802.11 DCF. Upon a collision or Failure, nodes exponentially increase their contention window and upon a success all nodes exponentially decrease their contention windows. This algorithm surpasses BEB in terms of throughput and delay.

Choi, et al. [13] have proposed Predictive DCF (P-DCF) Backoff algorithm to be used in IEEE 802.11 DCF. This algorithm enables nodes to choose their next backoff times by listening to the channel continuously. It reduces the collision probability and outperforms the BEB algorithm in terms of throughput and delay.

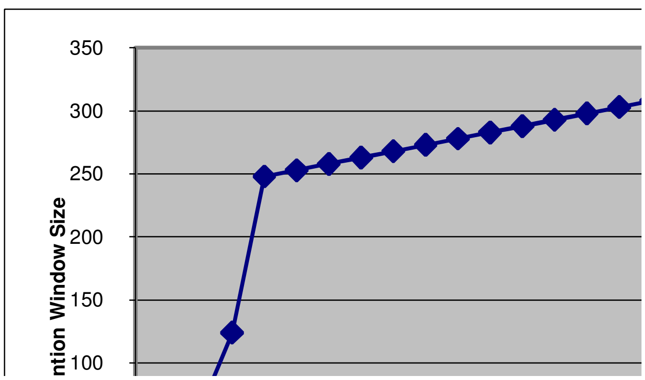

Figure 1. Exponential and linear increase of CW in PLEB.

Figure 1 shows the increment behavior of PLEB. In this paper, we study the impact of using different values of this exponential and linear increment. We also study the impact of having repeating this process in multiple phases.

When the backoff mechanism is applied, the contention window size needs to be increased as a response to a failure or collision. As the first response to a failure, we study increasing the CW size in an exponential way. Increasing by using exponential will improve network throughput by producing enough length of backoff times, so the new Contention Window (CW) is calculated using the following formula:

$$CW_{new} = CW * K \qquad (1)$$

where K is an exponential increase factor.

Then, after a number of exponential increments, we study the impact of linearly increases the CW in order to avoid the rapid growth of CW size that causes a high increase of the backoff value and thus results in reducing network delay, so the new contention window is changed using the following formula:

$$CW_{new} = CW + T \qquad (2)$$

where T is a linear increase factor.

Upon a success in transmission, we want to decreases the CW in a linear way instead of resetting the CW to its minimum value as in BEB. We use a linear decrease mechanism to solve the fairness problem (avoid channel domination of only one node) due to that resetting mechanism in BEB takes only one successful transmission to reach CW_{min} which causes a huge variation of the contention window size and degrades the performance in heavy loaded network since each new packet starts with the minimum contention window value which is considered as a small value in heavy loaded network, so in our algorithm the new contention window is changed using the following formula:

$$CW_{new} = CW - Y \qquad (3)$$

where Y is a linear decrease factor.

As justified later in the following section, based on experimental results, we choose the value of Y to be 2.

III. SIMULATION RESULTS AND ANALYSIS

We use Glomosim (version 2.03) simulator [14, 15] to study the impact of different values in order to choose a suitable values and compare them with Pessimistic Linear/Exponential Backoff (PLEB) Algorithm.

The network consists of 100 nodes randomly placed in a 2200m × 600m rectangular field. We use the Random Waypoint as the mobility model. Constant bit rate (CBR) with 512 byte data packets is used. The MAC layer protocol is 802.11.The main parameters used in the simulations are summarized in Table 1.

TABLE 1: SIMULATION PARAMETERS

Parameter	Value
Network area	2200m × 600 m
Transmission range	250 m
Number of nodes	100 nodes
Nodes speed	1, 4, 10 m/s
Pause time	0 s
Bandwidth	2 MHz
Traffic type	CBR
Packet rate	4
Packet size	512 B
Simulation time	500 s

The metrics used to compare the performance are the following:

1. **Throughput**: the total amount of data packets successfully received at the destination.
2. **Packet Delivery Ratio (PDR)**: the ratio of total amount of data packets received by the destination to the total amount of data packets sent by the CBR sources.
3. **Average End-to-End delay (EED)**: is the average delay taken for a data packet that is originated at the source to be received at the destination. All possible delays caused by buffering during route discovery latency, retransmission delays at the MAC, queuing at the interface queue and propagation delay are included.

Many experiments are conducted to study the effect of our proposed algorithm in terms of throughput, packet delivery ratio and end to end delay in order to justify our selected values. Figures 2-4 show the impact of number of increments of linear and exponential on throughput, packet delivery ratio and end to end delay respectively with keeping the resetting mechanism as in BEB and PLEB.

Experiment 1 to experiment 4 display 3 increments of exponential in the two phases within increase factors k and u equal 1.5 and varying the number of linear increments in phase 1 to 5, 10, 15, 20 respectively within increase factors t and v equal 5.

Experiment 5 to experiment 8 display 2 increments of exponential in the two phases within increase factors k and u equal 1.5 and varying the number of linear increments in phase 1 to 5, 10, 15, 20 respectively within increase factors t and v equal 5.

Results show that experiment 1 has a better prformance in terms of throughput and packet delivery ratio as compared to PLEB with no improvement in delay metric.

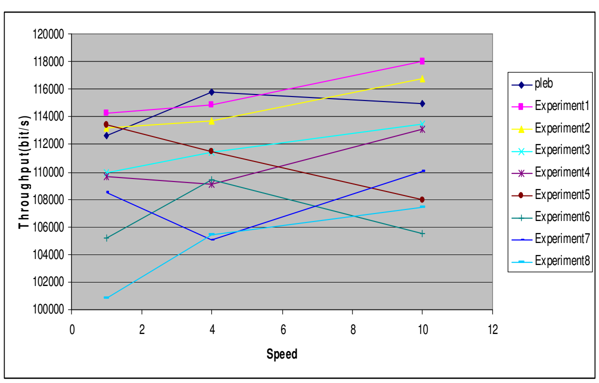

Figure 2. Impact of number of increments of linear and exponential on throughput for K= 1.5, T= 5, U= 1.5, V= 5.

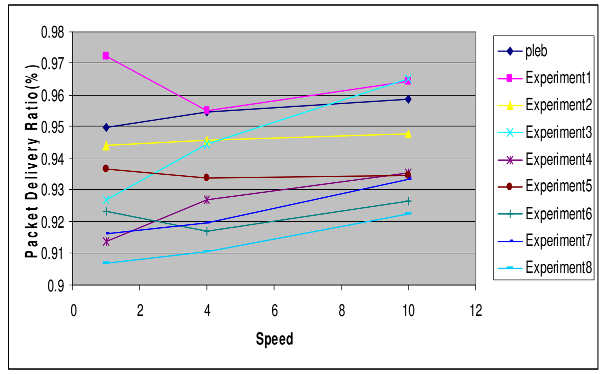

Figure 3. Impact of number of increments of linear and exponential on PDF for K= 1.5, T= 5, U= 1.5, V= 5.

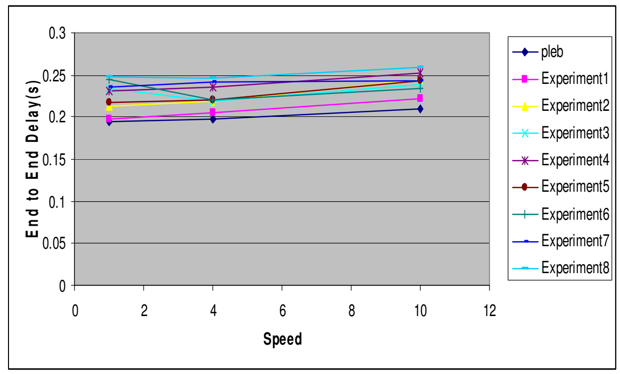

Figure 4 Impact of number of increments of linear and exponential on delay for K= 1.5, T= 5, U= 1.5, V= 5.

Depending on the results of previous figures, another type of experiments were held related to experiment 1. Figure 5, Figure 6 and Figure 7 show the impact of number of increments of linear and exponential on throughput, packet delivery ratio and end to end delay respectively.

Experiment 1 to experiment 3 display 3 increments of exponential with k=u=1.5 but varying the decrease process of CW upon successful transmission as exponentially decrease with y=1.5, resseting to CW_{min} and linearly decrease with y= 2 respectively.

Experiment 4 to experiment 6 display 3 increments of exponential at phase 1 and 2 increments at phase 2 with k=u= 1.8 but varying the decrease process of CW upon successful transmission as exponentially decrease with y=1.8 , resseting to CW_{min} and linearly decrease with y= 2 respectively.

Experiment 7 to experiment 9 display 3 increments of exponential at phase 1 and 1 increment at phase 2 with k=u= 2 but varying the decrease process of CW upon successful transmission as exponentially decrease with y=2 , resseting to CW_{min} and linearly decrease with y= 2 respectively.

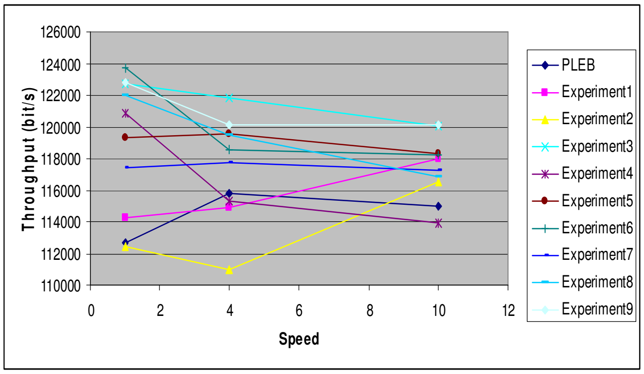

Figure 5. Impact of varying exponential increase factor and resetting mechanism of linear on throughput.

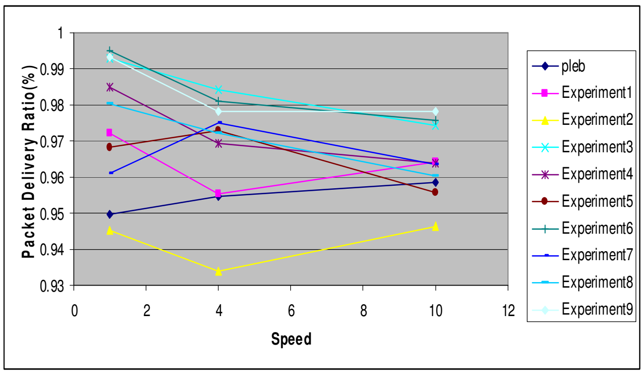

Figure 6. Impact of varying exponential increase factor and resetting mechanism of linear on PDF.

Results show that experiment 3 has a better prformance in terms of throughput and packet delivery ratio as compared to PLEB and the delay is approximately the same.

Based on the results of the above figures, in this study our suitable thresholds are K= 1.5, T= 5, U= 1.5, V= 5, Y= 2 as they offer better performance as compared to other possible values, based on these values W equal 69.75.

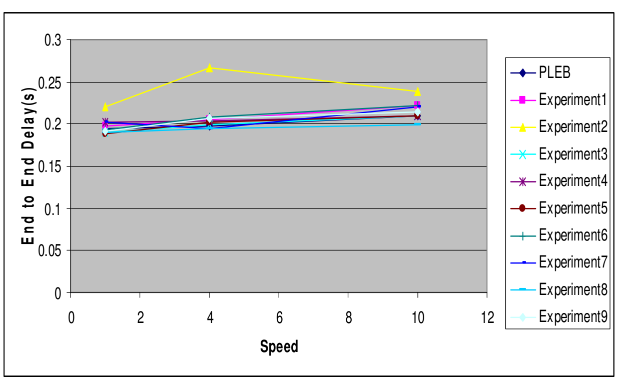

Figure 7. Impact of varying exponential increase factor and resetting mechanism of linear on delay.

IV. CONCLUSION

This research presented an experimental study of using different values in a backoff algorithm with different criteria (e.g., number of increments) to select suitable thresholds to be used in new algorithms and compared them with PLEB. The results show that when thresholds are K= 1.5, T= 5, U= 1.5, V= 5, Y= 2 this will offer better performance as compared to other possible values in terms of throughput, packet delivery ratio and delay which is approximately the same compared to PLEB.

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