A History-Based Backoff Algorithm for Mobile Ad Hoc Networks

S. Manaseer Ph.D.
Department of Computer Science,
University of Jordan
Amman, Jordan
saher@ju.edu.jo

M. Bani Yassein Ph.D.
Department of Computer Science,
Jordan University of Science
and Technology,
Irbid, Jordan
masadeh@just.edu.jo

A. Momani M.Sc
Department of Computer Science,
Jordan University of Science
and Technology,
Irbid, Jordan
ahmed_cs2004@yahoo.com

Abstract—**the standard IEEE 802.11 Medium Access Control protocol uses the Binary Exponential Backoff algorithm. The Binary Exponential Backoff makes exponential increments to contention window sizes. This work has studied the effect of choosing a combination between linear, exponential and logarithmic increments to contention windows. Results have shown that choosing the right increment based on network status enhances the data delivery ratio up to 37% compared to the Binary Exponential Backoff, and up to 38 % compared to the Pessimistic Linear Exponential Backoff algorithms.**

Keywords- MANETs, MAC, CW, Backoff algorithms

I. INTRODUCTION

The first appearance of wireless networks was in 1970s. Since that time, these networks are being developed so fast. It has been shown that in the last decade all trends moved toward wireless technology. Furthermore, the mobile wireless networks which is also called mobile ad hoc networks (MANETs) has become the new age of wireless networks. As discussed before, we can distinguish two types of networks; infrastructure and ad hoc networks [1, 13, 14].

In infrastructure wireless networks, communication between nodes is managed via a base station or a central access point. Each base station has a limited transmission range; therefore each node in the network connects to the nearest base station within its transmission range [14].

On the other hand, A MANET is a set of mobile nodes that communicate through wireless links. Each node acts as a host and router. Since nodes are mobile, the network topology can change rapidly and unpredictably over time [1]. In other words, a MANET does not have a base station, so communication between nodes is managed by the nodes themselves. Moreover, nodes are not expected to be fully-connected, hence nodes in a MANET must use multihop path for data transfer when needed [15].

Recently, most interests were focused on MANETs due to potential applications provided by this type of networks such as military operation, disaster recovery, and temporary conference meetings…etc.

Features and Characteristics of MANETs

Despite a MANET has many features shared with infrastructure networks, it also has its own features (i.e. additional features). This is true since nodes in MANETs have different capabilities which lead to new features. Some of these features are:

- ***Dynamic network topology:*** nodes in the network are free to move unpredictably over time. Thus, the network topology may change rapidly and unpredictably. This change may lead to some serious issues, such as increasing the number of transmitted messages between nodes of the network to keep routing information table up-to-date, and this will increase the network overhead [17].

- ***Distributed operations:*** in MANET there is no centralized management to control the network operations like security and routing, therefore, the nodes must collaborate to implement such functions. In other words, the control management is distributed among nodes of the network [13].

- ***Limited resources:*** in MANETs nodes are mobile, so they suffer constrained resources compared to wired networks. For example, nodes in a MANET depend on batteries for communication and computation, so we should take in to account how to optimize energy consumption [16, 17, 18].

MANETs are deployed in different environments due to their valuable features of mobility, no base stations, etc... Some of these applications are **Military Operations, Emergency Operations and Mobile Conferencing.**

This research paper is structured as follows. Section 2 discusses related work. Section 3 presents the simulation model and the parameters used in the experiments. Section 4 concludes the results.

II. RELATED WORK

S. Manaseer and M. Masadeh [1] proposed the Pessimistic Linear Exponential Backoff (PLEB). This algorithm is composed of two increment behaviors for the backoff value; the exponential and linear increments. When a transmission failure occurs, the algorithm starts working by increasing the contention window size exponentially. And after incrementing the backoff value for a number of times, it starts increasing the contention window size linearly. PLEB works the best when implemented in large network sizes.

H. Ki, Choi, S. Choi, M. Chung and T. Lee [8] proposed the binary negative-exponential backoff (BNEB) algorithm. This algorithm uses exponential increments to contention window size during collisions (transmission failures), and reduces the contention window size by half after a successful transmission of a frame. The analytical model and simulation results in [8, 9] showed that the BNEB outperforms the BEB implemented in standard IEEE 802.11 MAC protocol.

V. Bharghavan, A. Demers, S. Shenker, and L. Zhang [12] proposed Multiplicative Increase and Linear Decrease (MILD) backoff algorithm. This algorithm uses multiplication by a factor when failed transmission occurs (due to collision or transmission failure). On the other hand and after a success transmission occur the contention window CW is decremented by a factor in order to reduce the probability of successful users to access the channel all the time. This decrement helps solving the unfairness problem which might occur to other users who have collisions and send failures [10, 11, 12].

S. Manaseer, M. Ould-Khaoua and L. Mackenzie [2] proposed Fibonacci Increment Backoff (FIB). This algorithm uses the Fibonacci series formula which is defined by:

$$F(n) = F(n-1) + F(n-2). \quad F(0)=0 , F(1)=1, \; n>=0.$$

FIB algorithm aims to reduce the difference between contention widow sizes generated, resulting a higher network throughput than the standard IEEE 802.11.

III. THE SMART ADAPTIVE BACKOFF ALGORITHM (SABA)

The Smart Adaptive Backoff Algorithm SABA is a new algorithm which aims to select the most adequate increment type based on the network status. SABA uses three increment types: Exponential, logarithmic and linear increments. Moreover, SABA uses a history of last five contention window (CW) values used whenever a transmission is successful.

SABA makes essential modifications to the standard Binary Exponential Backoff (BEB) algorithm used in IEEE 802.11 MAC protocol. In the first step, SABA does an exponential increment whenever a transmission failure occurs. During this step, each CW is saved if a transmission is successful. This increment type is repeated for five successes and CW is saved in an array at each success. After that, the algorithm calculates the average of the array in order to be used as a start point to another type of increment. If the new CW is still very high, SABA will use a linear increment. Otherwise, it will use logarithmic.

IV. SIMULATION RESULTS

The comparison made between SABA, BEB, and PLEB backoff algorithms is evaluated through the GloMoSim simulator. This paper applies 10 scenarios for each node speed over the routing protocol Ad hoc On Demand Distance Vector (AODV) [19]. This study uses a variation of speeds and number of nodes in a fixed area. Table 1 explores the simulation parameters used in these experiments.

The metric used in the evaluation is the data delivery ratio which presents the data packets delivered to a destination. The following figures (1, 2, 3, 4) show the effect of mobility on 10, 20, 50, 100 nodes according to evaluation metric mentioned before.

The mobility speed has been varied between 1 m/s and 4 m/s. in comparison to human movements, 4 m/s is considered to be a high value. Therefore, node speed has been kept less than or equal to 4 m/s in order obtain more realistic values.

TABLE I.

Parameter	**Value**
Area	1000 X 1000 m^2
Nodes	10, 20, 50, 100
Maximum Speed	(1, 2, 3, 4) m/s
Simulation Time	900 sec.
Traffic type	CBR
packet size	512
Pause Time	0

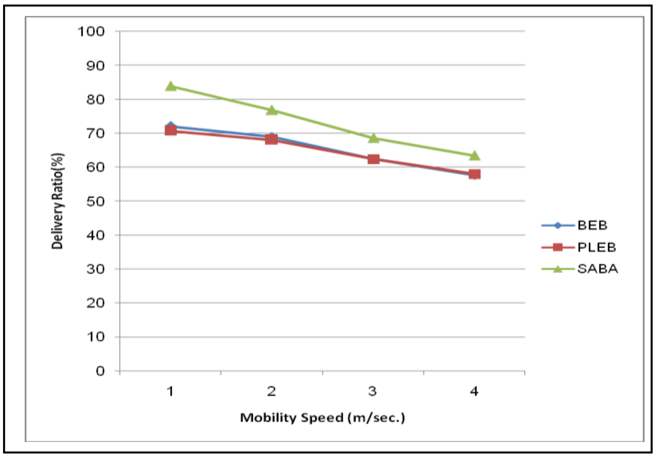

Figure 1. Mobility speed vs. Delivery ratio in SABA, BEB and PLEB for 10 Nodes

Figure 1 displays the delivery ratio of the BEB, PLEB and SABA backoff algorithms for 10 nodes when the number of sources is 5 and the transmission rate is 20 packets per second. Figure 1 shows that SABA outperforms BEB and PLEB backoff algorithms for all maximum speed values. When the mobility is low (maximum speed = 1), SABA outperforms BEB and PLEB by 11.88% and 13.26%, respectively. At high mobility (maximum speed = 4), SABA outperforms BEB and PLEB by 5.75% and 5.47%, respectively.

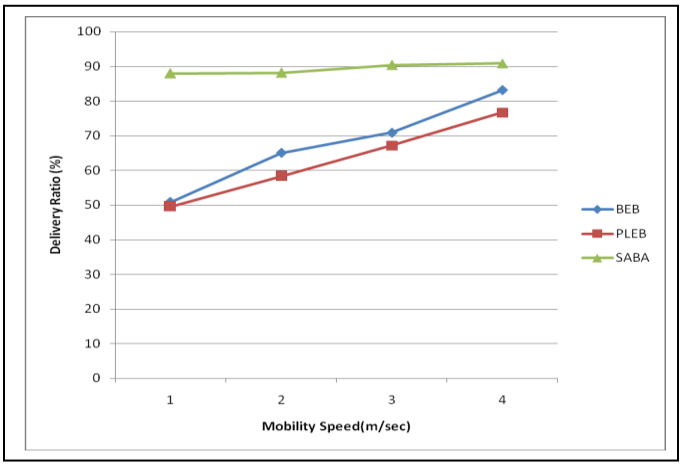

Figure 2. Mobility speed vs. Delivery ratio in SABA, BEB and PLEB for 20 Nodes.

Figure 2 displays the delivery ratio of the BEB, PLEB and SABA backoff algorithms for 20 nodes when the number of sources is 5 and the transmission rate is 20 packets per second. Figure 2 shows that SABA outperforms BEB and PLEB backoff algorithms for all maximum speed values. When the mobility is low (maximum speed = 1), SABA outperforms BEB and PLEB by 37.11% and 38.45%, respectively. At high mobility (maximum speed = 4), SABA outperforms BEB and PLEB by 7.74% and 14.13%, respectively.

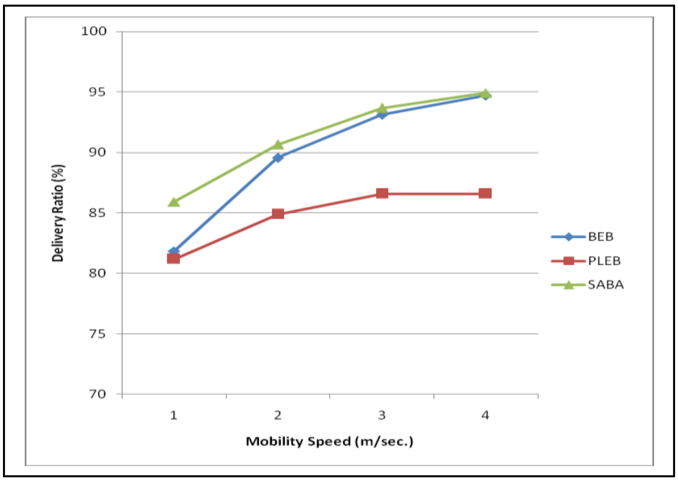

Figure 3. Mobility speed vs. Delivery ratio in SABA, BEB and PLEB for 50 Nodes

Figure 3 displays the delivery ratio of the BEB, PLEB and SABA backoff algorithms for 50 nodes when the number of sources is 5 and the transmission rate is 20 packets per second. Figure 3 shows that SABA outperforms BEB and PLEB backoff algorithms for all maximum speed values. When the mobility is low (maximum speed = 1), SABA outperforms BEB and PLEB by 4.07% and 4.72%, respectively. At high mobility (maximum speed = 4), SABA outperforms BEB and PLEB by 0.21% and 8.32%, respectively.

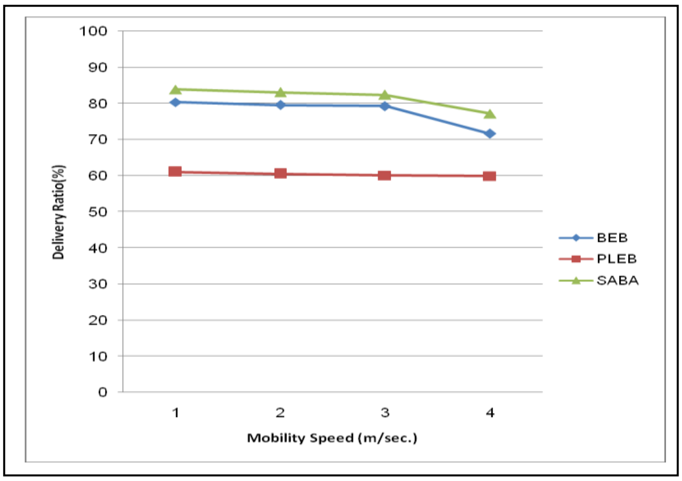

Figure 4. Mobility speed vs. Delivery ratio in SABA, BEB and PLEB for 100 Nodes

Figure 4 displays the delivery ratio of the BEB, PLEB and SABA backoff algorithms for 100 nodes when the number of sources is 5 and the transmission rate is 20 packets per second. Figure 4 shows that SABA outperforms BEB and PLEB backoff algorithms for all maximum speed values. When the mobility is low (maximum speed = 1), SABA outperforms BEB and PLEB by 3.48% and 22.83%, respectively. At high mobility (maximum speed = 4), SABA outperforms BEB and PLEB by 5.58% and 17.31%, respectively.

V. CONCLUSIONS

In this paper, further scenarios have been studied in order to compare a new backoff algorithm to other existing ones. The backoff algorithms introduced in this paper were the Smart Adaptive Backoff Algorithm (SABA), the Binary Exponential Backoff (BEB) and the Pessimistic Linear Exponential Backoff (PLEB). The results extracted from simulations show that the SABA backoff algorithm improves the data delivery ratio up to 37% compared to BEB, and up to 38 % compared to PLEB backoff algorithms in mobile ad hoc networks. Therefore, the adaptive increments in SABA based on network status increases the overall performance of the network.

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