ABSTRACT

In wireless ad hoc networks, designing a backoff (BO) algorithm is crucial to avoid collision and to enhance the network throughput. The majority of current MAC protocols have altered the Binary Exponential Backoff (BEB) algorithm to provide relative priority among multiple traffic classes. But the BO interval should be adaptively altered depending on the residual energy and traffic load of contending nodes. Hence this paper designs a priority based optimized BO (PBOB) algorithm for collision avoidance. This algorithm works in standard IEEE 802.11 MAC protocol in which the contending nodes are prioritized based on their residual energy, load and traffic type. Then during contention period, the backoff interval is adaptively adjusted based on the priority of each contending node. By simulation results, it has been shown that the PBOB algorithm has better packet delivery ratio and throughput with reduced energy consumption.

Keywords: Binary Exponential Backoff (BEB), Inter Frame Space (IFS), Contention Window (CW), Distributed Coordination Function (DCF), MAC Protocol, Residual Energy.

INTRODUCTION

Wireless ad hoc network (WANET) is a group of active, automated and radio fortified nodes deprived of any substructure. Ad hoc networks need every single intermediary node to perform as forwards, getting and advancing data to every another node. This sort of network is commonly positioned in numerous situations in which immediate connectivity turns out to be the on-going need, either in alternative circumstances such as a calamitous emptying condition or in an unplanned gathering for performances [1]. IEEE 802.11 is the regularly used familiar standard for wireless networks. In a communal medium, only one of the locations is able to communicate at any provided instant of period. If two or more locations try to direct data packages simultaneously, impact will occur and the package is lost. IEEE 802.11 standard describes the Distributed Coordination Function (DCF) [2]. A MAC procedure must offer active contrivances for collision avoidance (CA) and unbiased dispute steadfastness. The difficulty of impacts is poorer in a multi-hop setting than in a single-hop atmosphere [3]. Because of distribution of wireless bandwidth amongst ad hoc nodes, MAC procedures may depend on IEEE 802.11 DCF access contrivance [4].

The DCF access contrivance commands that all the nodes ought to arbitrarily access networks by means of the transporter sense manifold access/impact evasion contrivance. If an ACK retort is not acknowledged, nodes will wait for an inter frame space (IFS), and then, they will appeal BEB procedure that makes use of an unwavering arbitrary supply known as contention window (CW) magnitude to produce an arbitrary back-off value [5]. One of disadvantages of the IEEE 802.11 dispute contrivance is because of the circumstance that the conflict window is diminished after every effective broadcast. As this approach is legal even in a crowded system, the system practices great impact possibility when a broadcast happens after an effective broadcast. To resolve this difficulty, adaptive conflict window systems are planned [6][7].

Problem Identification

Back off algorithm is essentially needed for the enhancement of network performance in ad hoc networks [19]. A good MAC protocol should maximize the fairness and throughput through interference reduction and rate adaptation techniques. [20][21]. There are lot interference reduction and mitigation techniques available in literature [22].

The Binary Exponential BO (BEB) algorithm provides relative priority among multiple traffic classes [4]. However, the method of decrementing the CW was not addressed and assumed to be static. In [1], the BO interval is dynamically altered using Fuzzy logic using queue size and queue waiting time, ignoring the throughput. Moreover, nodes with high remaining energy should be granted shorter back-off time. CWMIDB [4] ignores the residual energy of nodes and priority of various traffic flows for back off interval adjustment. The improved backoff algorithm [8] modifies the CW updating factor based on the current network status. But it ignores the residual energy of nodes and priority of various traffic flows. In [10], traffic rate and remaining energy are used for altering the CW. But the priority of various flows was not taken into account. Hence the objective of this work is to design an enhanced BO algorithm based on traffic priority and energy.

RELATED WORKS

Hui-Hsin Chin et al [9] have suggested a modest, effectual, significance facility, and well achieved conflict resolve procedure known as enhanced BEB (E-BEB) procedure. They also gave a modest and precise investigative prototypet to study the system inundation output of the planned system. Donghong Xu et al [10] have suggested an EA-MAC procedure on the basis of SMAC procedure. In EA-MAC, node association investigation procedure and traffic adaptive liability cycle contrivance are included. In the node association procedure, the entire network nodes are split into numerous zones by calculating node association based on the gathered data. In traffic based liability cycle contrivance, the liability cycle is controlled vigorously.

PRIORITY BASED OPTIMIZED BACKOFF ALGORITHM FOR COLLISION AVOIDANCE IN WIRELESS AD HOC NETWORKS

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to decline indolent heeding by relating the verge group with the flow value got from the expected flow exemplary. Besides, nodes with more battery power have importance to access the network and have smaller back-off period, which can retain the stability of the entire system energy ingestion and extend system lifespan.

Yangcha o Huang et al [11] have suggested a new harmonized dispute windows-based BO procedure, i.e., SCW. In SCW procedure, every single location (STA) energetically trails the broadcast circumstances of the system and when the network state is altered, the CW of each location that partakes in the contention is harmonised by rearranging the CW, which creates each location acquire the medium access grant with the similar possibility in subsequent network dispute.

Marek Natkniec et al [12] have offered an extensive indication of investigation of QoS provisioning at the MAC protocol. Rather than defining each procedure separately we are certain to offer a new taxonomic cataloguing of QoS mechanisms, then sketch the mechanisms in sequence, and lastly define their protocol-specific executions. This method not only makes the theme at ease to comprehend, but it also displays the numerous methods in which every mechanism can be used. Besides, this method is paired to the plan and execution of upcoming prefabricated designs.

Mahdieh Ghazvini et al [13] have suggested a game theory oriented technique to regulate the customers’ dispute window in refining the system output, suspension and package drop proportion under hefty traffic load situations. The system presentation, assessed by replicates, displays certain dominances of the suggested technique over 802.11-DCF (Distribute Coordinate Function).

Ibrahim Sayed Ahmad et al [14] have strained to curtail the period broadcast cycle of the data amid mobiles moving altering the BEB procedure. This procedure handles access to the physical network by executing an adjudication based on period. What they have prepared display that the procedure by means of CSMA / CA access period alleged quickly. If the locations and / or network load upsurges or additional conditions disturbs the system.

Rong Geng et al [15] have suggested an Adaptive MAC Procedure (AMP). In AMP, they announced the idea of broadcast permit, where only the node which grips broadcast permit can partake in the network dispute for altering the amount of permits based on the load of the system adaptively, governing the amount of the nodules that partake in the network dispute, and confirming the nodules with permits segment the networks via dispute. Besides, AMP allots dissimilar significant classes for diverse traffic based on the distinct features and enactment sorts of the diverse systems, and it fixes the dissimilar dispute factors for the diverse primacies services for ensuring these services enactments to have benefits in the network dispute.

Xiaoying Zhang et al [16] have suggested the finest enterprise collection procedure that profits vitality ingestion into concern for choice of the ideal supportive aid to link in the broadcast. By swapping control packages, the ideal broadcast power is allotted for dispatchers to transfer data packages to recipients. Replication outcomes display that EECO-MAC ingests not as much of energy and extends the system lifespan.

PRIORITY BASED OPTIMIZED BACKOFF (PBBO) ALGORITHM

Overview
This paper extends our previous works done [17][18] by designing an enhanced BO algorithm for collision avoidance, based on traffic priority and energy.

This algorithm is implemented in static nodes scenario. This algorithm is based on the standard DCF mechanism. In this algorithm, the contending nodes are prioritized based on their residual energy, overload or traffic type (real-time, non-real time or best effort). Then during contention period, the contention window or BO interval is adaptively adjusted based on the priority of each contending node.

Estimation of Metrics

Traffic Load
The traffic load of each intermediate node is estimated from its queue length. Then the traffic load L of node Ni at time interval t is given by

\[ L(t) = \frac{N_{p}}{Q_{L}} \]  

Where \( N_{p} \) denotes the number packets stored at the queue Qi at time t and \( Q_{L} \) denotes the queue length of Qi.

Predicted Residual Energy
The total energy consumption of a node Ni at time is then given by

\[ E_{R}(t) = E_{C}(t) \cdot E_{C} \]  

Where \( E_{C} \) is the energy needed to transmit a single packet, which is given by

\[ E_{C} = \frac{E_{p} + E_{n}}{E_{t}} \]  

Where, \( E_{p} \) is the energy utilized for transmitting a packet \( E_{n} \) is the energy utilized for receiving a packet

Then the residual energy of Ni after transmitting n packets can be computed by

\[ E_{R}(t) = E_{p} - n \cdot E_{C}(t) \]  

Where \( E_{R}(t) \) is the current residual energy of Ni at time t.

3.2.3 Classification of Traffic type
The following table illustrates the various types of traffic services and their service ids (service priority) considered in this work.

| Traffic requirements | Traffic type | Examples | Service id |
|----------------------|-------------|----------|------------|
| High Data Rate and High latency | RT | Video streaming | 1 |
| Low Data Rate and High latency | NRT | FTP | 3 |
| Low Data Rate and Low latency | NRT | HTTP | 4 |

As it can be seen from the table, Video streaming application has the highest service id followed by VoIP, FTP and HTTP.

Priority of contending nodes
Each contending nodes are assigned priority depending on the predicted residual energy, traffic load and the service id of the requested traffic type.

Let CN, CN2,.....CNm be the number of contenders for transmission, during the contention period.

Let \( L_{i} \), \( E_{res} \), and \( S_{r} \) be the load, residual energy and service id of the node CNi.

Then the priority \( P_{i} \) of CNi is given by

\[ P_{i} = (\alpha \cdot L_{i} + \beta \cdot E_{res}) / S_{r} \]  

Where \( \alpha \) and \( \beta \) are weighted constants.

IEEE 802.11 based Back off algorithm
In DCF method, every time a BO process happens, the BO timer T is carefully chosen from a constant sharing over the interim [0, CW-1]. T can be split into numerous time periods. The location retains heeding to the network. If the network is indolent for a period, the BO timer will be reduced by one period. If the network is hectic, the timer will be constant, till the network is detected to be indolent again. When T attains zero, the location tries to transfer data in elementary or RTS/CTS method. If the broadcast flops, CW will be multiplied by 2. Else, it will be rearranged to the least.

The CW is updated as...
\[ CW_{\text{new}} = \begin{cases} CW_{\text{min}}, & \text{if success} \\ \min(CW_{\text{max}}, 2.CW_{\text{old}}), & \text{if collision} \end{cases} \]  

Where \( CW_{\text{max}} \) and \( CW_{\text{min}} \) are the maximum and minimum values of \( CW \)

**Optimized BO Algorithm**

This section proposes an optimized BO algorithm to reduce the energy consumption due to contentions. The nodes with high traffic load need to wait more time and the nodes with less remaining energy needs to send the data immediately. At the same time, the traffic services with higher priority should not wait for longer time.

The BEB algorithm in the MAC layer is modified as follows. Let \( CW_{\text{min}} \) and \( CW_{\text{max}} \) denote the minimum and maximum of \( CW \).

Here, \( 0 \leq CW_{\text{min}} \leq CW \leq CW_{\text{max}} \)

The optimized back-off algorithm with adaptive CW (ACW) is given below:

**Algorithm: Optimized BO with ACW**

1. If \( CW \) be the initial contention window of node \( N_i \)
2. If collision occurs, then
3. // Adaptive CW adjustment
4. \( CW_i = CW_i \times P_j, \) NCC
5. If \( \text{RE}(N_i) < \text{RE}_{\text{min}} \), then
6. \( \delta = \delta / 2 \)
7. End if
8. End if
9. If transmission is success full, then
10. // Modified BO
11. If \( CW > CW_{\text{th}} \)
12. \( CW_i = \max(CW_i / 2, CW_{\text{th}}) \)
13. Else
14. \( CW_i = \max(CW_i / 2, CW_{\text{min}}) \)
15. End if
16. Else
17. \( CW_i = \min(2 \cdot \max(CW_i, CW_{\text{th}}), CW_{\text{max}}) \)
18. End if

**EXPERIMENTAL RESULTS**

**Experimental settings**

The Priority based Optimized Backoff (PBOB) algorithm is implemented in NS2 and compared with CWMIDB algorithm \([4]\) based on the metrics End-to-End Delay (E2D), Packet Delivery Ratio (PDR), Residual Energy and Throughput. The experimental settings are shown in Table 1.

| Number of Nodes | 25, 50, 75, 100 and 125 |
|-----------------|-------------------------|
| Simulation Topology | 1250m X 1250m |
| MAC Protocol | IEEE 802.11 |
| Traffic type | Constant Bit Rate (CBR) |
| Number of Contenders | 4, 6, 8, 10 and 12 |
| Propagation type | Two Ray Ground |
| Antenna type | Omni Antenna |
| Initial Energy | 20 Joules |
| Transmission Power | 0.8 watts |
| Receiving Power | 0.5 watts |

**Varying the Contenders**

This section presents the results of varying the number of contenders from 4 to 12.
CWMIDB ranges from 0.50 to 0.74. Ultimately, the throughput of PBOB is 24% high when compared to CWMIDB.

**Based on Network Size**

This section presents the results of varying the network size (nodes) from 25 to 125.

The graph showing the results of E2D for varying the nodes is shown in Figure 5. The figure depicts that the E2D of PBOB ranges from 1.5 to 4.2 seconds and E2D of CWMIDB ranges from 2.2 to 5.4 seconds. Ultimately, the E2D of PBOB is 16% less when compared to CWMIDB.

**Figure 5: E2D for various nodes**

The graph showing the results of D2R for varying the nodes is shown in Figure 6. The figure depicts that the PDR of PBOB ranges from 0.84 to 0.73 and PDR of CWMIDB ranges from 0.75 to 0.63. Ultimately, the PDR of PBOB is 9% high when compared to CWMIDB.

**Figure 6: PDR for various nodes**

The graph showing the results of residual energy for various nodes is shown in Figure 7. The figure depicts that the residual energy of PBOB ranges from 14.4 to 12.6 joules and residual energy of CWMIDB ranges from 13.2 to 11.2 joules. Ultimately, the residual energy of PBOB is 8% higher than CWMIDB.

**Figure 7: Residual energy for various nodes**

The graph showing the results of throughput for varying the nodes is shown in Figure 8. The figure depicts that the throughput of PBOB ranges from 0.36 to 0.84 and throughput of CWMIDB ranges from 0.22 to 0.72. Ultimately, the throughput of PBOB is 30% high when compared to CWMIDB.

**Figure 8: Throughput for various nodes**

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