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Achieving MAC Fairness Using Binary Exponential Backoff (BEB) Algorithm in Wireless Adhoc Network

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Abstract: ***The Medium Access Control (MAC) protocol is the main constituent which determines the system throughput using IEEE 802.11 protocol in Wireless Networks. The MAC Layer system of the IEEE 802.11 protocol is also referenced as Distributed Coordination Function (DCF). In DCF mode, source nodes contend for the use of the channel in dispersed manner via the use of the Carrier Sensing Multiple Access with Collision Avoidance (CSMA/CA) procedure. Using the CSMA/CA procedure, each source nodes sets up a Backoff time according to a randomly selected interval from zero to the Contention Window (CW) size for an extra delay time before transmitting the data packets. Binary Exponential Backoff (BEB) algorithm is used to randomize moments at which source nodes try to access the wireless medium. Additionally, in the Backoff mechanism, data packet collisions are not totally eliminated, and the system throughput is decreased when the number of source nodes is large, and there is no fairness between source nodes. The BEB algorithm occupies number of disadvantages; one vital disadvantage is the problem of fairness. This research paper analyzes the behavior of the BEB algorithm used in IEEE 802.11 protocol. We have proposed a hybrid environment using IEEE802.11p protocol to enhance the fairness of the channel access for BEB algorithm. Hybrid approach adapts the way of increase or decrease of the contention window (CW) based on the number of the frame which is delivered successfully. NS-2 simulator is used to analyze the network's fairness of the channel access of the BEB algorithm in terms of throughput, end-to-end delay and packet dropping ratio. The result showed that comparing with IEEE 802.11 and BEB algorithm, hybrid approach with IEEE 802.11p improves the fairness of the channel access and increases the network's throughput capacity.***

Keywords: Ad-hoc Network, backoff algorithm, DCF, NS2**.**

1. Introduction

Wireless Ad-Hoc Networks have achieved a large amount of growth in recent years. IEEE 802.11 protocol was originally designed for wireless local area networks which has been invoked repeatedly in the context of wireless networks to provide better performances. Generally in such networks, wireless nodes use a shared channel and every node should compete for the channel before it can send its own data packet. IEEE 802.11 protocol provides detailed Medium Access Control (MAC) and physical layer (PHY) specification for wireless networks. IEEE 802.11 MAC consists two coordination functions,Point Coordination Function (PCF) and Distributed Coordination Function(DCF) which support the infrastructure and Ad-Hoc configuration.

Point Coordination Function (PCF) depends on a central coordinator to allocate channel resource and provide services without any competition. While Distributed Coordination Function (DCF) is a compulsory and contention-based protocol. In wireless networks, due to lack of access points, contention –based distributed channel access protocols are more efficient. Distributed contention-based shared algorithms in ad hoc network have been mainly focused on achieving fairness and increasing spatial channel reuse. However, most of these efforts focused on achieving fairness do not consider the problem of bottlenecks. However, the bottleneck nodes will be the key point to degrade the throughput performance in ad hoc network.

Through this research paper, introducing the new hybrid environment which coordinates between IEEE 802.11p protocol using BEB algorithm and IEEE 802.11 protocol. This approach gives MAC fairness in terms of throughput, End-to-End delay and Packet dropping Ratio.

2. Medium Access Control (MAC) Layer Challenges and Issues

While Wireless Ad-hoc Networks, exhibit unique advantages compared to wireless local area networks (WLANs), they do inflict several challenges and design issues on MAC protocol design. The first challenge is that centralized controlling is not available in such networks due to the lack of infrastructure support. Without ideal coordination, collisions could take place when several nodes simultaneously access the shared medium. Second, , a wireless node cannot instantly perceive collisions during the data transmission due to hardware constraints, which leads to ineffectiveness of the channel. Third, as every node in the network is mobile, the network topology may change from time to time. Accordingly, each node may experience different degree of channel contention and collision. At the same time, the attendant route changes also affect the interaction between the MAC layer and higher layers. At the end, some important issues like energy efficiency, fairness, or quality of service (QoS) prerequisite need to be carefully considered when designing MAC protocols for wireless networks. Summarizing some issues in MAC Design:

2.1 Collisions

Collisions may arise from two aspects in wireless ad-hoc networks. They may occur due to simultaneous transmissions by two or more source nodes in a certain range where their signals collide and interfere with each other. Apparently, the more the active nodes in the range of a sender- receiver pair, the more harsh the collisions seen. On the other hand, collisions can outcome from hidden terminal nodes. A hidden terminal node is the one which can neither sense the transmission of a sender node nor correctly receive the reservation packet from its corresponding receiver node. In the IEEE 802.11 MAC protocol, the reservation packet is a clear-to-send (CTS) packet, which advertises the reservation of the channel. A hidden terminal node can interfere with an ongoing transmission by transmitting data at the same time.

2.2 Fairness

Unfairness could arise from different conditions of channel access. In Wireless networks, there are two major sources for imbalanced channel access opportunities: the backoff mechanism and location mechanism. The backoff mechanism is widely used in MAC protocols for wireless networks to reduce collisions and achieve high channel efficiency, it always favors the node that just effectively detained the channel. As a result, different nodes may use different backoff time, leading to different transmission probabilities and consequently short-term unfairness as well as long term unfairness. Temporarily, since nodes location and traffic might not be uniformly distributed in such networks, a node's location also influence its channel access opportunity. Moreover, Nodes with less channel contention window from their neighboring nodes can seize the channel more likely than other nodes. It is to be noted that to achieve fairness among all nodes in a network, the network's aggregate throughput and efficiency, often has to be sacrificed.

2.3 Energy Efficiency

In wireless networks, energy efficiency is always a critical issue due to a limited battery life of wireless nodes. First thing is that MAC protocols should reduce the number of collided packets as many as possible, and hence reduce the power consumption wasted in collisions. Secondly, only presently enough power should be used to achieve a certain data rate for each packet transmission while maintaining good synchronization among all the nodes in a network.

2.4 Quality of Service (Qos)

With the proliferation of Internet multimedia services, such as voice over IP and streaming video, mobile devices in wireless networks are expected to support these multimedia services with QoS guarantee. In view of the fact that multimedia services typically have strict end-to-end delay and delay variation requirements, QoS provisioning will not be easy given that wireless networks are characterized by their distributed and bandwidth-limited channel access, where medium contention and collisions are common.

3. Backoff Algorithm

Binary Exponential Backoff (BEB) algorithm is commonly used in MAC protocol in distributed manner. The IEEE 802.11 MAC and DCF procedure (RTS-CTS Data-ACK frames) use to manage multiple access nodes. In order to give further space between succeeding transmissions, the value of CW gets doubled at each time of collision and thus fascinating the growing contending flows. Also, CW sets to CW(min) at each successful or unsuccessful transmission. To define the shortest and distributed inter frame spaces, the Backoff slot time is used and Backoff interval time is updated. This time create delays for accessing the channel to avoid a collision, at any time any node finds the medium busy, it gets a random value within a contention window for Backoff time interval.

In BEB algorithm, the node starts counting down its Backoff time only when the medium becomes free and it is no longer busy. If the medium is ideal for an interval of time longer than DIFS time, the node transmits the data packet immediately. Else, it selects a random Backoff time period to avoid collision. This Backoff time is different from one node to another or may they have the same amount of slot time within contention window size. Subsequently, after the expiration of the Backoff time, the nodes start sensing the medium [9], as long as the node senses the channel is busy; it loses its twist and selects another Backoff time period for next phase. The nodes select their Backoff time from interval between 0 to the CW size. The Backoff time calculated using the subsequent formula:

$$\text{Backoff Time} = \text{Random}[0, CW] * \text{SlotTime} \tag{1}$$

If a node transmission fails due to collision, the node will twice its Contention Window size exponentially. The new value of CW size is calculated by the given formula:

$$CW_{new} = \min(2 * CW_{old}, CW_{max}) \tag{2}$$

The node resets its Contention Window to CWmin after every successful or unsuccessful transmission using the following formula:

$$CW = CW_{min} \tag{3}$$

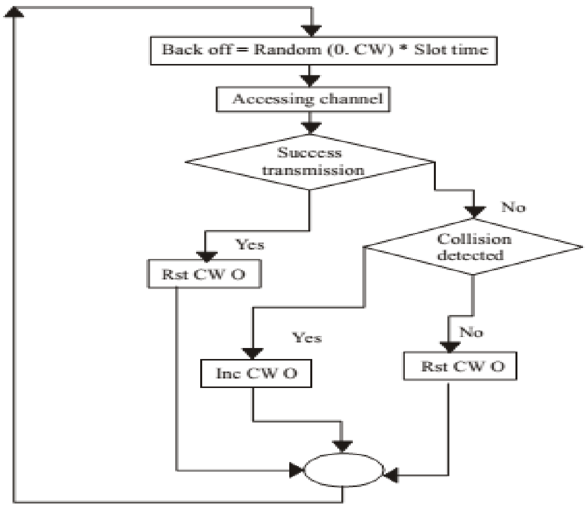

Figure 1: BEB ALGORITHM

The working flowchart of the BEB algorithm is shown in Figure 1.In general, the node starts selecting its random Backoff time using formula (1). When the node detects a collision of its data packet, it doubles its CW value using formula (2). When the transmitter node detects a successful transmission of its packet; it resets its Backoff time to CWmin using formula (3). In BEB algorithm, the last sender is unfairly compete the channel again as it has a low Backoff time for the next time cycle and thus leads to unfairness, especially when the offered load is high. Based on these aspects, we propose the hybrid environment for Backoff algorithm based on the fairness equality for Ad-Hoc networks to build a robust and fair enough wireless medium access protocol.

4. IEEE based MAC protocols

4.1 IEEE 802.11 standard

The IEEE 802.11 protocol includes the MAC layer and Physical layer of the OSI model. Actually, the MAC layer interacts with the three PHYSICALs :

- Frequency Hopping Spread Spectrum in the 2.4 GHz band
- Direct Sequence Spread Spectrum in the 2.4 GHz band
- Infrared

IEEE 802.11 standard operate two MAC function: The Point Coordination Function (PCF) and the Distributed Coordination Function (DCF). The PCF is responsible for time-bounded service and the DCF is responsible for asynchronous data service. Figure 2 shows the MAC layer of an IEEE standard.

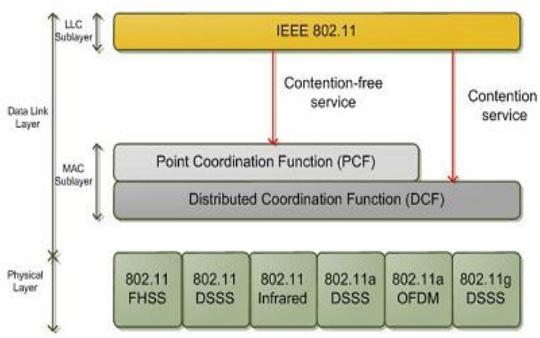

Figure 2: IEEE 802.11 standard in MAC Layer

4.2 IEEE 802.11p standard

The IEEE 802.11p protocol is an amendment of the IEEE 802.11 protocol for wireless network which focuses on the improvement of the performance of the CSMA/CA networks in high mobile ad-hoc networks. It is the proposed standard of the DSRC (Direct Short Range communications) in the vehicular environment by the IEEE organization. When taking into consideration the global success of IEEE 802.11 standard, the derived IEEE 802.11p version has the potential of becoming a single global standard for the communication in wireless ad-hoc networks. IEEE 802.11p main features are:

- Dedicated frequency band (5.850 to 5.925 GHz)
- The channel bandwidth differs : 10 MHz per channel instead of 20 MHz
- This implies the data rate is also halved, alongside the symbol and guard periods being doubled.
- Short Inter-frame Space (SIFS) time increased in order to prevent long range issues.
- Introduction of wave operation mode: allows fast communication setup when certain conditions are met.

5. 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.

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

$$f(n) = f(n-1) + f(n-2) \quad f(0) = 0, f(1) = 1, n \geq 0$$

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

H. Ki, Choi, S. Choi, M. Chung and T. Lee [3] 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 simulation results showed that the BNEB outperforms the BEB implemented in standard IEEE 802.11 MAC protocol.

S. Kang, J. Cha and J. Kim [4] proposed the Estimation-based Backoff Algorithm (EBA). This new algorithm has two main functions; the first one used to estimate the number of active nodes, and the second used to decide which contention window CW is optimal for the current case. The estimation function uses the average number of idle slots during backoff time to obtain the number of nodes which will be after the optimal CW for the current case.

EBA algorithm outperforms the binary exponential backoff (BEB), the exponential increase exponential decrease (EIED), the exponential increase linear decrease (EILD), the pause count backoff (PCB) and the history based adaptive backoff (HBAB) in network throughput and the mean packet delay.

S. Pudasaini, A. Thapa, M. Kang, and S. Shin [5] proposed an intelligent contention window control scheme for backoff based on Collision Resolution Algorithm (CRA). This algorithm keep a history for a success and failure access attempts in order to use this history to modify the contention window interval (CWmin, CWmax). This modification will cause a dynamic shifting for backoff interval to more suitable region. CRA algorithm made some improvements to channel efficiency in terms of packet end-to-end delay.

A. Balador, A. Movaghar, and S. Jabbehdari [6] proposed a new History Based Contention Window Control (HBCWC) algorithm for IEEE 802.11 MAC protocol. HBCWC prepared an optimization to the contention window values via saving the last three states of transmission. The main factor in this algorithm is the packet lost rate, if this factor increases due to collisions or channel errors then the CW size will increase. Otherwise it will decrease.

J. Deng, P. Varshney, and Z. Haas [7] proposed the linear multiplicative increase and linear decrease (LMILD) backoff algorithm. LMILD uses both linear and multiplicative increments in the case of send failure; that is when a collision occurs, the colliding nodes increase their contention window CW multiplicatively, and other nodes overhearing this collision make a linear increment to their CW. In the case of successful transmission, all nodes decrease their contention windows linearly. LMILD has shown a better performance than the standard IEEE 802.11 when used in large network sizes. It also outperforms the pessimistic linear exponential backoff (PLEB) in small networks, but PLEB achieves better performance than LMILD in large network sizes.

V. Bharghavan, A. Demers, S. Shenker, and L. Zhang [8] proposed Multiplicative Increase and Linear Decrease (MILD) backoff algorithm. MILD algorithm uses multiplication by a factor when failed transmission occurs (due to collision or transmission failure). After a success transmission occurs 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.

6. Research Methodology

The scope of Vehicular Ad Hoc Network (VANET) and its related research studies are still in progression phases to a major extend. The limited practical deployable options under different projects are purely simulation based before their actual implementations in the real scenarios. The collaboration of imminent research objectives and its related scope in this study are also collapsed into same influence of simulation environment for generating some authenticated outcomes. The adopted methodology for the results of this research work is based on simulations near to the real time packages before any actual implementation.

6.1 Simulations

The most reliable and authenticated tools used and preferred by most of the researchers for these kinds of simulations is Network Simulator, NS-2. The generic and experimental simulation runs of this methodology adoption are illustrated in Figure 3 below:

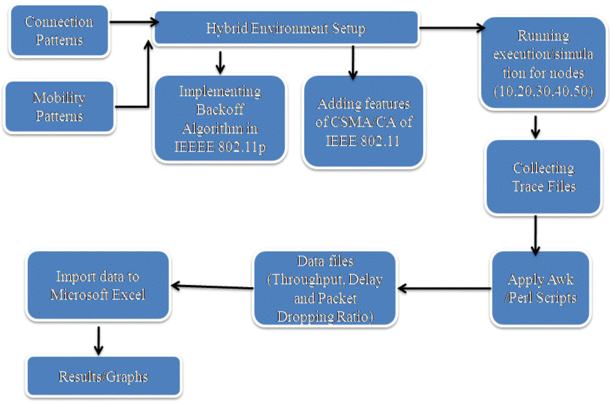

Figure 3: Adopted Methodology

7. Simulation and Result Evaluation

In this research paper the network performance is measured by three criteria: throughput, packet dropping ratio and average end-to-end delay. In this research paper, we present and evaluate the simulation results that were obtained for different scenarios. The proposed hybrid environment is implemented using binary exponential backoff algorithm using the NS-2 simulator to evaluate the performance of the new proposed method.

Our simulations were run using a network of 10, 20, 30, 40 and 50 nodes placed randomly within a 1000 meter × 1000 meter area. Each node has a radio propagation range of 250 meters, and the channel capacity is 2 Mb/s. Simulation run time is 60 seconds. We used the IEEE 802.11p as the MAC layer protocol. The Constant Bit Rate (CBR) node traffic is used in the simulations. We used the random waypoint model for node mobility.

Figure 4 shows the graph of throughput Vs number of mobile nodes.

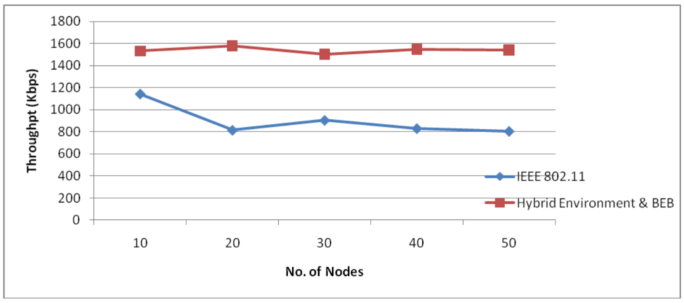

Figure 4: Throughput

The Graph clearly shows that throughput is higher, in case of hybrid environment & BEB. While in case of IEEE 802.11 standard there is decrease in the percentage of throughput because the no. of mobile nodes increases in the topology from 10 to 50. Therefore, analyzing throughput graph, it shows that Hybrid environment is much better than the alone IEEE 802.11 with BEB algorithm for all five scenarios.

Figure 5 shows the graph of packet dropping ratio Vs number of mobile nodes. The Graph clearly shows an increase in percentage of dropped packets in case of IEEE 802.11 standard. It is increasing because the no. of packets has to send over the network which is increasing the no. of mobile nodes with next scenario.

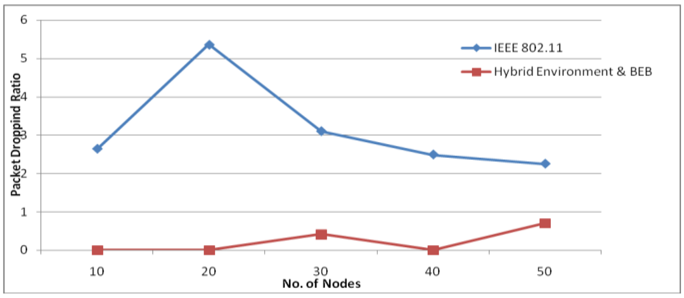

Figure 5: Packet Dropping Ratio

While in case of Hybrid environment there is slightly increase in the percentage of dropped packets because the no. of mobile nodes increases in the topology from 10 to 50 and shows the limitation of IEEE 802.11p protocol that its performance degrade as the nodes increases in the network .

Figure 6 shows the graph of average end-to-end delay Vs number of mobile nodes.

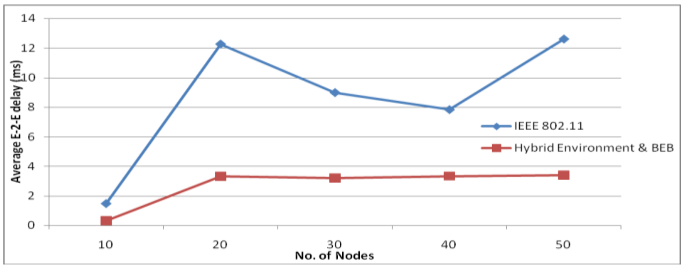

Figure 6: Average End-to-End Delay

The Graph clearly shows that delay is achieved better in case of hybrid environmnet than the IEEE 802.11 standard for all five scenarios.

8. Conclusion

Wireless Ad -Hoc Networks could be deployed anywhere as it does not require any centralized infrastructure. With the importance of such networks and its large application areas it has still many challenges to overcome. In this paper, we performed and analyzed the hybrid environment with IEEE 802.11p standard and BEB algorithm. The simulative results show that Hybrid environmnet performs better than alone IEEE 802.11 protocol for all parameters like network throughput,average end-to-end delay and packet dropping ratio.

References

[1] S. Manaseer and M. Masadeh. "Pessimistic Backoff for Mobile Ad hoc Networks". Al-Zaytoonah University, the International Conference on Information Technology (ICIT'09), Jordan, 2009.

[2] S. Manaseer, M. Ould-Khaoua, and L. Mackenzie. "Fibonacci Backoff Algorithm for Mobile Ad Hoc Networks". Liverpool John Moores University, the 7th Annual Postgraduate Symposium on the Convergence of Telecommunications, Networking and Broadcasting (PGNET 06), Liverpool, 2006.

[3] M. H. Ki, Choi, S. Choi, M. Chung,and T. Lee. "Performance evaluation of Binary Negative-Exponential Backoff Algorithm in IEEE 802.11 WLAN". Lecture Notes in Computer Science, Springer-Verlag Berlin Heidelberg, vol. 4325, pp. 294–303, and 2006.

[4] S. Kang, J. Cha, and J. Kim. "A Novel Estimation-Based Backoff Algorithm in the IEEE 802.11 Based Wireless Network". 7th Annual IEEE Consumer Communications & Networking Conference (CCNC), Las Vegas, Nevada, USA, 2010.

[5] S. Pudasaini, A. Thapa, M. Kang, and S. Shin. "An Intelligent Contention Window Control Scheme for Distributed Medium Access". 7th Annual IEEE Consumer Communications & NetworkingConference (CCNC), Las Vegas, Nevada, USA, 2010.

[6] A. Balador, A. Movaghar, and S. Jabbehdari. "History Based Contention Window Control in IEEE 802.11 MAC Protocol in Error Prone Channel". Journal of Computer Science, 6 (2), pp. 205-209, 2010.

[7] J. Deng, P. Varshney, and Z. Haas. "A New Backoff Algorithm for the IEEE 802.11 Distributed Coordination Function". Communication Networks and Distributed Systems Modeling and Simulation (CNDS'04), San Diego, California, 2004.

[8] V. Bharghavan et al, "MACAW: A Media Access Protocol for Wireless LAN's", in Proc. ACM SIGCOMM '94, pp. 212–225, 1994.

[9] Mohammed Al-Hubaishi, Tariq Abdullah, Raed Alsaqour and Amine Berqia "E-BEB Algorithm to Improve Quality of Service on Wireless Ad-Hoc Networks", Research Journal of Applied Sciences, Engineering and Technology 4(7): 807-812, 2012,ISSN: 2040-7467