Performance Analysis of Collision using IEEE802.11

Meghana Solanki, Sandhya Sharma, Ashish Sharma

***Abstract*— *In this paper*, An IEEE 802.11 primarily based mobile ad hoc network (MANET), a network node is accessed by a standard wireless channel through the distributed coordinate function(DCF),that is provided at the medium access control (MAC) layer of the IEEE 802.11 standard. This paper Based on the developed mathematical model, the back off probability distribution of a node, the probability of collision with reference to variety of nodes state is calculated. With the variation of various value of increasing factor (α).**

***Index Terms*— IEEE 802.11 standard, History based adaptive back off (HBAB), Mobile ad hoc networks**

I. INTRODUCTION

WirelessLAN's became additional standard since they will satisfy the necessities like quality, relocation of user, ad-hoc networking and coverage of locations that are quite tough to wire. Earlier, the wireless LAN's were expensive, a license was needed, may support solely low information rates. Due to of these factors, there have been limitations on the sensible utility of wireless LAN's. However, of these issue are addressed currently that is day by day increasing the recognition of wireless LAN's. Wireless local area network may be a latest example of wireless communication. Devices like as laptop, computers, workstations portable computer, conductor telephones and different communication appliances share the wireless medium.

Smart phones and laptops has recently Wireless network access of mobile devices, become additional possible and standard due to the unimaginable developments in wireless technologies, Wireless native space Networks being one in all the foremost enforced standards with IEEE 802.11. Since the wireless medium is shared by all transmitting stations in vary, among competitor stations IEEE 802.11 should control medium access therefore on minimize the impact of collisions on the performance of the network.

In wireless computer network, transmitter and receiver to permit communication between every computer and note book computer is provided with a short range. The IEEE committee standardized the wireless computer network and also the standard was 802.11. Actually, this standard had to work in following 2 completely different methods:

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1) Within the presence of a base station
2) Within the absence of a base station

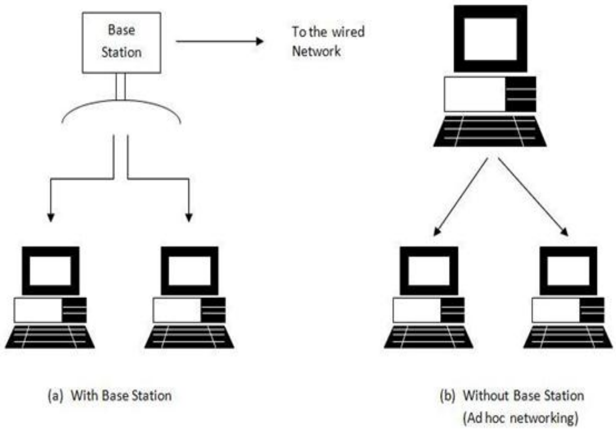

Fig 1: illustration of wireless networks (with or without base station)

In the network with the base station, all the communication passes through the base station that's also referred to as the access purpose in 802.11 terminologies. Within the network, the computers shall communicate between one another without base station. This mode is also referred to as ad hoc networking [2].

The IEEE 802.11 standard has physical layer and medium access control layer of a wireless area space network. At the medium access control (MAC) layer, positive acknowledge (ACK) is used to achieve reliable delivery of data packets between network nodes. The receiver of a data packet has to transmit an acknowledgement (ACK) to the sender of the packet if it receives the packet successfully. To achieve that, 802.11 adopts a binary exponential back off (BEB) algorithmic rule that exponentially will increase a station's waiting time if the random is busy and after a successful after a successful transmission, resets to a minimum value right. The BEB algorithmic rule is considered "memory-less" since it resets window the contention window(CW) value to the minimum right after a successful transmission. The packet considered lost and therefore the sender has got to retransmit the packet if the sender doesn't receive the ACK before the retransmission timer of the transmitted packet times out. The Mac layer provides the distributed coordinate function (DCF) and therefore the purpose coordinate function (PCF) to support and control access to the transmission channel.

II. HISTORY BASED ADAPTIVE BACK OFF

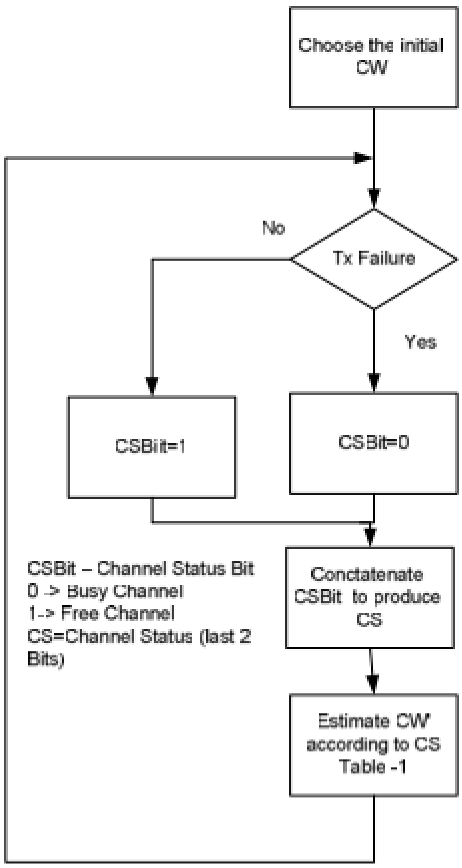

Fig2: Flowchart of History based Adaptive back off

In which the history of the past trials for transmission is consider in History based Adaptive Back off (HBAB) algorithm, The last N states of the medium checks by The HBAB algorithm and decides whether or not to increment or decrement the contention window size value based on the channel's tendency to being free or busy. In different words, if the channel tends to be free (the most recent state(s) indicate(s) a free channel), then the contention window value is decreased; if the channel tends to be busy (the most recent state(s) indicate(s) a busy channel), then the Contention Window value is increased. The HBAB algorithm have fix parameter, that which used to increase or decrease the new CW based on the old CW value(that will automatically increase or decrease the back off time) is known as multiplicative factor(α) [3].

III. DISTRIBUTED COORDINATE FUNCTION

In the 802.11 protocol, the elemental mechanism to access the medium is known as distributed coordination function(DCF).Carrier sense multiple access with collision avoidance(CSMA/CA) protocol these is a random access scheme. According to binary exponential back off rules, Retransmission of collided packets is managed an optional point coordination function (PCF) is additionally defines by the standard, that is a centralized Mac protocol ready to support time bounded and collision free services according to the DCF mechanism, the frame spacing time (DIFS) defines as, whenever a station has a packet to send it ought to defer its transmission for a guard period during which the channel should be detected idle. This can be followed by a random back off interval. Back off intervals are slotted, and stations are only allowable to start their transmissions at the beginning of slots. A random number back off time is chosen from the vary [0; CW− 1] with a homogenous distribution, once back off is initiated wherever CW may be a contention window [10].

As the first transmission attempt, Contention window is set equal to CWmin, the minimum contention window. The back off time counter is decremented as long as the channel is detected idle. It's frozen when activities (i.e. packet transmissions)are detected on the channel, and reactivated once the channel is detected idle again for a guard period. This guard period is equal to a DIFS if the transmitted packet was error free and equal to the extended inter frame spacing time if there was a collision. When the back off time counter reaches zero, the station transmits its packet. When the counters of two or more stations reach zero within the same slot happens Collision [8].

The binary exponential back off (BEB) algorithm and therefore the carrier sensing multiple access/collision avoidance(CSMA/CA) protocol area unit two key DCF components that are used to avoid packet collisions. A contention window is split into a series of time slots of equal length, With the BEB algorithm that are numbered in 0,1,2,....CW. Here, Contention Window is that the maximum number of contention window size, that is initialized to a constant.

To reduce the probability that a packet collision happens,a range in [0, CW] at random picks by node to set its back off timer and starts to transmit its data in the corresponding slot once two or more nodes pick a similar back off slot, collision could occur.

To avoid this problem, each every time a node encounters packet collisions, the size of contention window is increased or changed via some factor until it reaches its maximum value. For its next transmission, the node at random picks a back off slot in the increased contention window. As a result, the packet collision probability is often reduced at the expense of increasing the delay of the node to access the channel as a result of the probability that the node picks a larger back off slot is hyperbolic. Contention window size reset to its initial value i.e. CWmin when node has successful transmission.

In addition to the fundamental access, AN extra four approach handshake technique, referred to as request-to-send/clear-to-send (RTS/CTS) mechanism has been standardized. A station in operation in RTS/CTS mode reserves" the channel by causing a special Request-To-Send short frame before transmission a packet. The destination station acknowledges the receipt of AN RTS frame by sending back a Clear-To-Send frame, once that normal packet transmission and ACK response happens. Since solely on the RTS frame collision might occur, and it's detected by the lack of CTS response, the RTS/CTS mechanism permits increasing the system performance by reducing the duration of a collision once long messages are transmitted [4].

IV. MATHEMATICAL ANAYLSIS

To improve quality of service (QoS) ,an adaptive IEEE 802.11 History Based Adaptive Back off (HBAB) algorithm is used. The protocol modifies the IEEE 802.11 back off algorithm, which is used to control the contention window in the case of collisions, in order to provide a better QoS performance according to the network status and condition.

Let 0 and CW are minimum and maximum slot numbers in a contention window, respectively, and then the size of a contention window will be equal to CW+1. Let Li be the size of the contention window after it is doubled i times. Lm is the maximum contention window size, and i.e.= CWmax+1, where Lo is the minimum contention window size, i.e.=CWmin+1 . Also assumes that there are n nodes in the network and use V to denote the set of nodes in the network.

Under CSMA/CA, a node has to sense the wireless channel before its transmission [1].

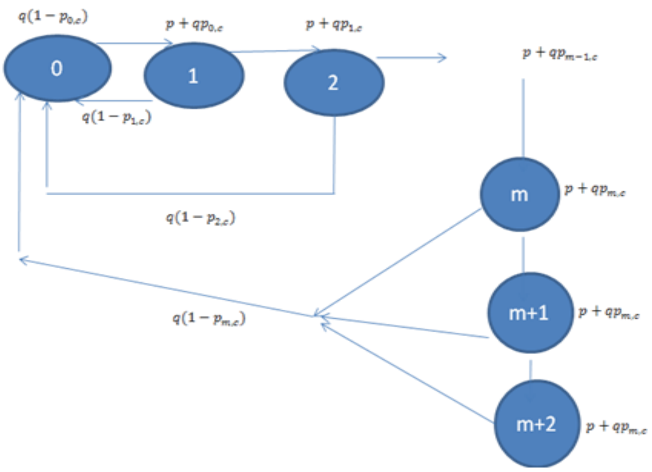

Fig2: State transition diagram of nodes

The following diagram showing the different back off slots

Let $p_{i,nc}$ is the probability that node (i) transmits without a collision such that $p_{i,c} = 1 - p_{i,nc}$ i.e. none of the other nodes in the network picks the same backoff slot as the one node(i) picks.

Here the state diagram shows that at state '0', there is no collision so probability of non-collision i.e. $p_{0,nc} = 1 - p_{0,c}$ is used at 0th state. At the same time there is no loss of packet so the probability that packet does not loss i.e. $q = 1 - p$ is used. So indirectly at 0th node mutual prabability is $q(1-p_{0,c})$.

At 1st state, some portion of packet is loss, so probability p is used and it is added to mutual probabilty of packet that does not loss (q) and probability of collision at 0th state, i.e. $p_{0,c}$ towards 0th to 1st node but simultaneously if at 1st node no packet does loss and if there is no collision then probability $1-p_{1,c}$ is used towards 1st to 0th state. So final probability at 1st node is calculated by $q(1-p_{1,c})$.

Similarly at 2nd state, if some portion of packet is loss, so probability p is used and it is added to mutual probabilty of packet that does not loss (q) and probability of collision at 1st state, i.e. $p_{1,c}$ towards 1st to 2nd node/state but simultaneously if at 2nd node no packet does loss and if there is no collision then probability $1-p_{2,c}$ is used towards 2nd to 0th state. So final probability at 1st node is calculated by $q(1-p_{1,c})$.

This will repeat for $i \le m$ (i.e. number of nodes should be less or equal to integar which represent the value that doubles itself to reach maximum contetion window) But for $i > m$, i.e. at $m, m+1, m+2 \ldots$ state,, mth state will raech at 0th position if and only if they have probability equal to $q(1-p_{m,c})$, due to $L_i = L_m$. Similarly mth state will move to next if and only if they have probability $p + qp_{m,c}$. The same will be continue for all the states having indexes greater than m.The probability of a node is in 1st state can be written as following:

$$P_1 = P_0[p + (1-p)p_{0,c}]$$

The above equations define that the probability is in node 1 in terms of packet loss probability and packet colloision probability at 0th state. i.e. when a node moves from 0th state to 1st state, it has probability $P_0[p + qp_{0,c}]$. Similarly moving from 1st to 2nd state, probability will be $P_1[p + qp_{1,c}]$, and so on.

$$P_m = P_{m-1}[p + (1-p)p_{m-1,c}]$$

$$P_{m+1} = P_m[p + (1-p)p_{m,c}]$$

$$P_i = P_0 \prod_{j=0}^{i-1} [p + (1-p)p_{j,c}]$$

$$P_{m+i} = P_0[p + (1-p)p_{m,c}]^i \prod_{j=0}^{m-1} [p + (1-p)p_{j,c}]$$

$$\sum_{i=0}^{inf} P_{m+i} = P_0 \prod_{j=0}^{m-1} [p + (1-p)p_{j,c}] \sum_{i=0}^{inf} [p + (1-p)p_{m,c}]^i$$

V. PERFORMANCE ANALYSIS

In this analysis, we have assumed some following assumptions that the minimum and maximum contention window size is let 16 and 1024 respectively. Also simultaneously we are assuming the value of probability of packet transfer per node state.

Usually, a real network has several tens of nodes. However, if the number of nodes in a network is too small, it does not easy to visualize the performance of the variable back off exponent algorithm. This is because in that case the probability that two or more nodes pick the same time slot that leads to a packet collision would be very small and as a result the contention window size of a node could rarely be alpha times to reach the maximum i.e. CWmax [7].

Under all assumptions, we obtain the different graphs for different value of multiplicative factor over 1000 runs with each random probability.

The graphs with different values of multiplicative factor (i.e. α=1.5, α=1.7and α=2.2) of packet collision probability showing the probability of packet collision with respect to number of nodes.

The following figure represents that the packet collision probability decreases as a node moves from the state with a smaller contention window size to the one with a larger size. i.e. the packet collision probability decreases as the size of the contention window becomes alpha (mulitiplicative times).

For the multiplicative factor α = 1.5, the number of nodes increses upto 10 and the probability of collision decreases when nodes moves from smaller contention window CW_{min} to larger contention window CW_{max}.

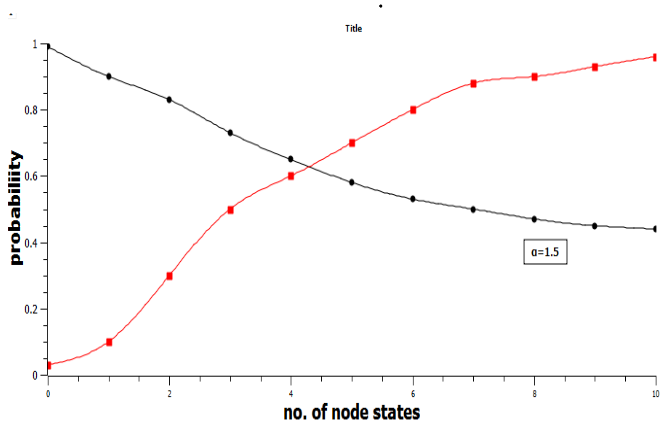

Fig 4 : packet collision probabilty v/s node state (when α=1.5)

TABLE 1

Number of node state M	Probability of collision P	Probabbility of packet transfer p
0	0.99	0.001
1	0.90	0.1
2	0.83	0.3
3	0.73	0.5
4	0.65	0.6
5	0.58	0.7
6	0.53	0.8
7	0.50	0.88
8	0.47	0.9
9	0.45	0.93
10	0.44	0.99

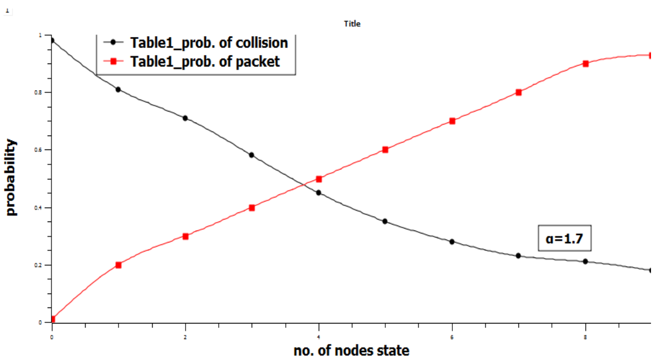

Fig 5: packet collision probabilty v/s node state (when α=1.7)

When the multiplicative factor $\alpha = 1.7$, this is the special case of this algorithm, known as binary back off exponential algorithm. In this case number of node are 9 (from $log_2(\frac{1024}{16})$,) according to our assumptions, that means the size of contention window doubled to reaches the maximum contention window.

TABLE 2

Number of node state M	Probability of collision P	Probability of packet transfer P
0	1	0.001
1	0.81	0.2
2	0.71	0.3
3	0.58	0.4
4	0.45	0.5
5	0.35	0.6
6	0.28	0.7
7	0.23	0.8
8	0.21	0.9
9	0.11	0.99

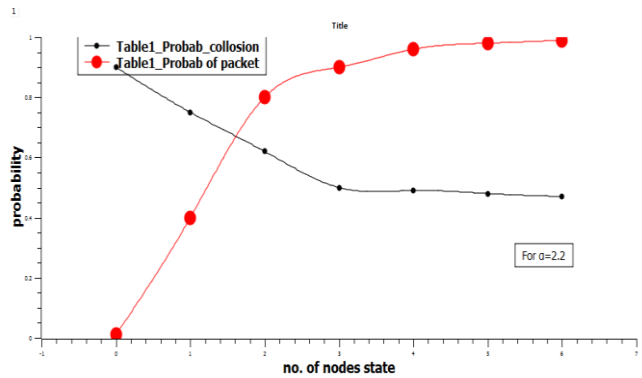

Fig 6: packet collision probabilty v/s node state (when α=2.2)

TABLE 3

Number of node state M	Probability of collision P	Probability of packet transfer P
0	0.9	0.001
1	0.75	0.4
2	0.62	0.8
3	0.5	0.9
4	0.49	0.96
5	0.48	0.98
6	0.47	0.99

For the multiplicative factor α = 2.2, the number of nodes reduced to 4 and the probability of collision decreases when nodes moves from smaller contention window CW_{min} to larger contention window CW_{max}. Since the size of frame can be less than maximum contention window size.Now we cans see that the probability of collision when α=2.2 is less as compared to when when α=1.7 and α=1.5.when comparing Table (a) and Table (b)and Table(c).

VI. RESULT

In mobile ad hoc networks, a node transmits it packet length on the basis of contention window size, probability of packet collision and the probability that a node present in n^{th} state for capturing the a wireless channel. The variable backoff exponential algorithm in the IEEE 802.11 plays an important role thorugh which packet collision can be avoided and a improved channel or utilized channel can be achieved.

We have used three different value of multiplicative factor (α) $i.e$ $1.5, 2$ & 2.4 and analysed different plots of packet collision probability with respect to node state and found that all these parameters like number of nodes while the packet collision probability decreases with node states. This is because on moving to a higher state or larger contention window size, the probability that a packet has lost is decreased. Simulation experiment is performed by using SCDAVAS.

VII. CONCLUSION

In this analysis, a variable backoff exponent is used to improve the performance of IEEE 802.11 that can be used in mobile Ad hoc networks to achieve the lower delay and low packet collision probability i.e. better packet delievery fraction. On observing all the graphs, we can conclude that the when the network congestion increases, the contention window size corresponding to network size simultaneously increases.

In addition, we can also conclude that as the number of nodes increases, the packet collision probability of a node decreases as the size of contention window is multiplicative times changed. In this algorithm each packet collides with constant and independent probability at the each transmission of packet and regardless of the number of nodes the retransmission of collided packets occurs. But this is not true for small number of nodes, as packet collides, it increased its collision probability or average contention window size value multiplicative factor (α) times to achieve the maximum contention window size. Or in other words, this is not true because probability that the two or more nodes pick the same backoff time slot, is very small that causes the widow size approximate doubled.

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