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An Insight of Backoff Algorithms in Wireless Networks

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Abstract: . The IEEE 802.11 MAC is liable for the scheme of channel accessing. It decides the performance of the WLAN and DCF is the central strategy. Stations that need to get to the divert may partake in a disseminated manner by means of CSMA/CA in the MAC layer. Packet collision can't be totally avoided because of the nodes which are in scattered manner. MAC layer uses a BEB scheme for CA (collision avoidance).. Nodes are experiencing a collision in common channel in IEEE 802.11 and must have to backoff for a arbitrary time and selected consistently from CW. The contention window is maintained dynamically by BO algorithms. Network performance is decreased due to a sudden change in window size. Different existing algorithms for backoff and comparision among the algorithms are shown in the manuscript.

Keywords: - DCF, Backoff algorithm, Contention window

I. INTRODUCTION

In recent years the development in technology, WLAN got widespread.. The IEEE 802.11 standard gives Physical layer, MAC layer for WLAN with different frequencies 2.4 Hz, 5 Hz, 60 Hz and so forth. Most of the home, office networks are with laptops, printers, and smart phones, household devices to talk to each other and access the Internet without connecting wires. In 1997 the base version of the IEEE standard was released, followed by subsequent amendments.

The IEEE 802.11, MAC characterized two strategies, which are contention based, contention free i.e., Distributed Co-ordination Function (DCF), Point Co-ordination Function (PCF). Every IEEE802.11 station should support DCF whereas PCF is optional. The main aim of coordination and scheduling of transmission is is ultimate channel usage , fairness amid the contending stations with least of the interference.

The fundamental access strategies are three. . The basic function of DCF is to provide effective packet delivery. It uses two-way handshaking mechanism. The source node will wait until the medium is idle and allow transmitting the packet. As the destination node receives the packet acknowledgment is transmitted to the source for successful packet delivery.

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In wireless station there is problem of hidden nodes, to resolve hidden terminal problems four ways handshaking is applied. The communication process generates request to send (RTS) at source node to destination nodes. At receiver node Clear to send message (CTS) is sent as positive response. After receiving the CTS the source node transmits the packet data and after receiving the packet data at destination ACK message is generated to ensure the successful communication

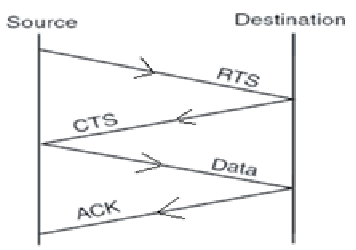


Figure 1: Four Way Handshaking (DCF)

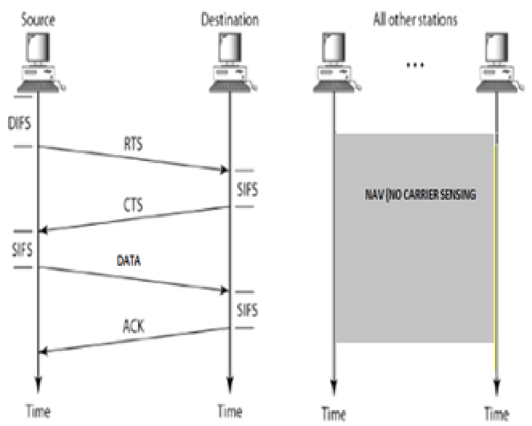


Figure 2: CSMA/CA and NAV

CSMA/CA is another communication mechanism to ensure communication reliability is based on listen before talk. According to this scheme, before packet transmission the channel sensing is performed to identify the idle channel stage so that the specified DCF interframe space duration is analyzed. In the event that the medium is occupied, at that point the station needs to hold back to turn into the channel medium inactive for the inter-frame space duration. In such case some random backoff counter is considered to identify the actual time count for which the node has to wait until the transmission is not initiated.

During IS interval the medium stay idle and the nodes decreases the backoff counter.

The process is repeated till the counter not reaches to zero and as it reaches zero the medium is identified as ready for packet transmission backoff timer is randomly uniformly chosen interval (0, CW-1). In wireless network, when 2 or additional wireless nodes decrease to zero at an identical time, there's collision in packets transmission [19] [20]

Now during the communication, as the collision is identified, the CW size is doubled and this process is repeated till the CW size not reaches to CWMax. As the successful communication is performed, the CW size resets to initial value called CWMin. The communicating packet is discarded if after specific number of retries, no successful transmission is obtained. Today, the communication network faces number of challenges and lot of improvement is done in terms of communication channel, transmission media etc. The objectives of this improvement are to achieve the communication QoS in real time. But IEEE 802.11 DCF does not ensure the QoS instead it provides the best effort service. Because of this, to obtain the QoS requirements, the improvement to the standard is performed. One of the improved forms is 802.11e that has improved the function called EDCF (Enhanced Distribution Coordination Function). The improvement is here made in terms of prioritization on traffic categories (TC). This contention window is here defined by CWNew (TC)>=CWOld (TC)*2. [18]

In this manuscript, the distinctive contention window algorithms for optimization has been presented. In this section, the basic handshaking communication mechanism is defined along with the exploration of CSMA/CA mechanism. The remainder of the paper is composed as: the investigation to backoff system in second segment, the outline of numerous backoff algorithms in third segment, and conclusion in fourth segment.

II. LITERATURE STUDY

Backoff is a mechanism accustomed to avoid collision in wireless networks during sharing a common channel by more nodes at once. Avoidance of Collision is done at which only 1 node gets access to channel and different contended channel area unit suspended into backoff state for a few amounts of time before failure of transmission while accessing a common channel.

Backoff (BO) is utilized to relegate satisfactory waiting-time to clear contention issues amid stations that are ready to the transmission of packed data at constant time.BO algorithms are accomplished in the three following cases:

(a) Whenever a station detects the engaged channel even before first packet transmission (b) after each retransmission (c) after each winning transmission.

When a station goes into a BO state, it must wait for an additional random number of timeperiods. It must be in between 0 and CW_{max} [0, CWmax].

Throughout all this , the medium is interminably being sensed by the station whether it would remain free or a new transmission starts.

In wireless network to perform communication the medium analysis is performed under busy time and idle time analysis by backoff timer which counts slot time to estimate the overall slot using random backoff timer is estimated. The back off timer depends on sot time

Backofftimer=random()*slottime

Random () produces an arbitrary value lies from (0 to CW). CW is calculated by 2^m-1.CW lies between (CW_{min}, CW_{max}). The CW Size adjustment is as per the following

initially set the cw size to cwmin for all stations

perform the transmission success and retry limit estimation.

if no collision identified

set cw=cw_{min}

if the collision identified during transmission

set cw=min(2*(cw+1)-1,cw_{max})

and set cw=min(2m*(cw+1)-1,cw_{max})

where m represents number of retries

N.Marek and others [1] presented a random BO procedure to avert collisions. When stations start packet transmission, they select random CW (Contention Window). The stations transmits the frames randomly. Thus, the possibility of collision decreased. The parameter selection for backoff has a very huge effect on network performance. The inaccurate choice of the contention window parameters create deterioration of output and hence mean packet-delay will increase several times.

G.Bianchi and others [2] bestowed a straight forward model for computing the performance of saturation throughput of IEEE 802.11's DCF. It predicts a limited terminals, idle conditions of the channel. This model was fit to all access themes used. This model was absolutely accurate in predicting the system throughput.

H.Wu and others [3] bestowed a technique for throughput upgrade of DCF by altering CW resetting plan and just incase of the collisions, contention window size will be doubled. Markov chain model was utilized to analyze new backoff scheme effect. It may be utilized by every essential access methodology, four way access strategy i.e., RTS/CTS. It was absolutely correct in performance prediction and has proven the effectiveness of BO algorithm.

X.Yang and others[4] bestowed mechanism packet transmission by pipeline collision resolution detection and then that the period of time reduced during which channel was in idle or collision. By pipelining conception the each channel idle time and colliding time had been reduced. In an exceedingly extremely loaded network the consumption of channel information measure is on the point of peak performance.

III. RELATED WORK

Different BO Algorithms BEB, Modified BEB, EIED, MILD, LMLD, DIDD, logarithmic backoff , modified logarithmic backoff, ,PLEB, EBA, EFB, EBEB, BBA, WTB, SABA, IPBA, BBA,TABA, CWC are discussed.

A. Binary Exponential Backoff (BEB)

The algorithm BEB exponentially expands contention

window size on transmission failure. If any node want to send packets it starts channel sensing Node will start transmission of data-packets immediately if an idle channel's found. If not, the back off technique is activated. Moreover, a back off timer will be selected at random out of current contention window size; this backoff timer will be decremented only whenever an idle time slot is found.
At the point when timer arrives at zero, data-packets are transmitted by node. The CW is reinitialized to minimum when node gets acknowledgement from destination node. Otherwise CW is exponentially incremented when acknowledgement is not received .by the node. See figure 3
Back_off time = (Rand () mod CW) * a_Slot_Time

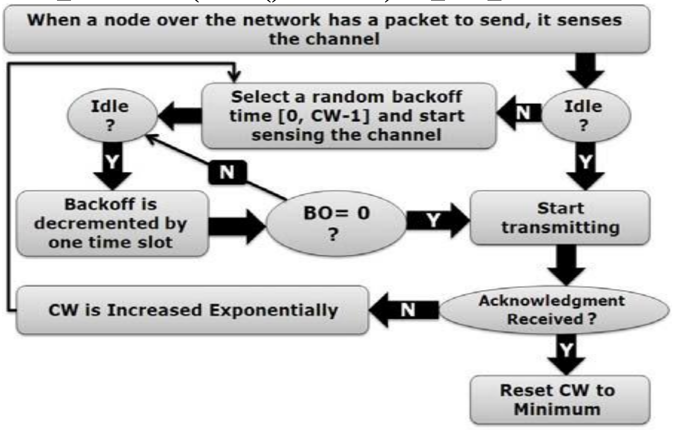
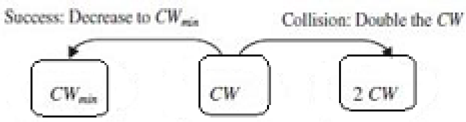


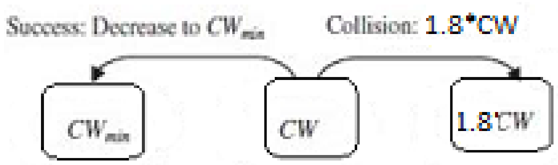
Figure 3: BEB algorithm description
The BEB BO algorithms is as follows

- at failed transmission i.e.,, collision
  cw (new) = 2*cw
- at transmission successful
  cw = cwmin



B. Modified BEB

As in BEB the back off time is inflated exponentially,however in MBEB base value is reduced by constant factor (< 2) when every collision transmission until a specified high value i.e (cw_{max}) is arrived. When node successfully transmits a packet, it's back off time will be decreased to some prescribed min value i.e (cw_{min}).Base value which is equals to 1.8 offers higher performance as compared to different potential base value.



The MBEB backoff algorithm can therefore be expressed as,

• At transmission failed i.e.,, collision
*CW = min [1.8*CW, CWmax]*
• At transmission successful
CW = CWmin

C. Exponential Increase Exponential Decrease (EIED)

N.Song and others [5] in 2003 Exponential increase Exponential decrease (EIED)BO algorithm ,the contention window resetting method causes an awfully massive deviation of size of CW and the performance is degraded in case of heavily loaded networks as a result of every brand-new packet begins with the cw_{min} which can be very little in case of significant network-load. In BEB it doesn't maintain collision history of earlier packets & quick decrease in CW which is not appropriate for significant loaded networks.

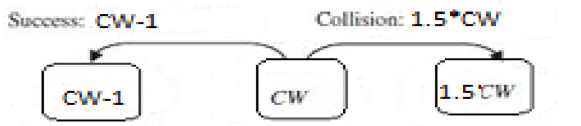
IN EIED CW is expanded exponentially because of a BO factor rI>1 in a transmission impact and is exponentially diminished by a backoff factor rD>1 in fruitful transmission.

The EIED BO is as follows,

- at transmission failed i.e.,, collision
  $cw = min[ri \cdot cw, cw_{max}]$
- at transmission successful
  $cw = max\ [cw/rd, cw_{min}]$

D. Multiplicative Increase and Linear Decrease (MILD)

In MILD BO algorithm CW increased to CW*1.5 when transmission fizzled, CW is decremented to CW-1 When fruitful transmission .



The MILD backoff algorithm can therefore be expressed as,

- at Collision
  CW (new) = CW * 1.5
- at Transmission success
  CW = CW -1

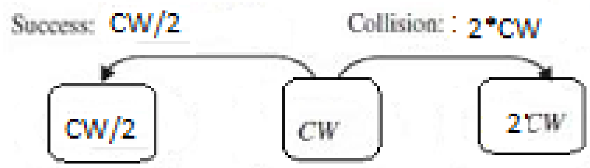
E. Linear Multiplicative Increase & Linear Decrease (LMILD) backoff algorithm

J.Deng. and others [6] in 2004 bestowed a backoff algorithm, known as the Linear MILD (LMILD). In this CW is increased in multiplicative fashion when nodes collided, CW increased linearly when overhearing of collision, CW decreases linearly on transmission success.
The LMILD backoff algorithm can therefore be expressed as,

- at collisions :
  $cw \leftarrow min(mc \cdot cw, cw_{max})$
- at collision overhearing
  $cw \leftarrow min(cw + \grave{}c, cw_{max})$
- at experiencing or success overhearing
  $cw \leftarrow max(cw - \grave{}s, cw_{min})$

F. Double Increment and Double Decrement

Chatzimisios.P et al. [8] in 2005 conferred a backoff algorithm known as DIDD. In this, after the packet collision CW is doubled, after successful transmission it halves the CW



The DIDD backoff algorithm can therefore be expressed as,

- In case of Collision
  cw (new) = 2 * cw
- At Transmission success
  cw = cw / 2

G. Logarithmic Backoff Algorithm (LOG)

The LOG algorithm utilizes logarithmic increments rather than exponential increments for MANETS. The cw_{new} is calculated as follows

$(cw)_{new} = (\log (cw)_{old}) * (cw)_{old} * a\_slot\_time.$

When a collision occurred the CW increased to Min (BO * log (N), CWmax). On the contrary, after each transmission success CW decreased to CWmin * log (N).

The LOG backoff algorithm can therefore be expressed as,

- In case of Collision
  $CW (new) = Min(BO * \log(N), CW_{max})$
- In case of Successful Transmission
  $CW = CW_{min} * \log(N)$

H. Modified Logarithmic Backoff Algorithm

Manaseer.S.S et al. [11] in 2005 Modified logarithmic backoff algorithm (MLOG) which used increment in logarithmic manner in place exponential expansion of the size of window to take off derogatory effect of the random num distribution. In larger networks it achieves higher throughput.

I. Pessimistic Linear Exponential Backoff (PLEB).

Manaseer.S et al., [13] in 2009 conferred PLEB. PLEB is combinational behaviors i.e. the linear & exponential increment of back off value. Once a transmission failure occurs the contention window size increased exponentially for multiple times and contention window size increased linearly. It is best suitable for huge networks

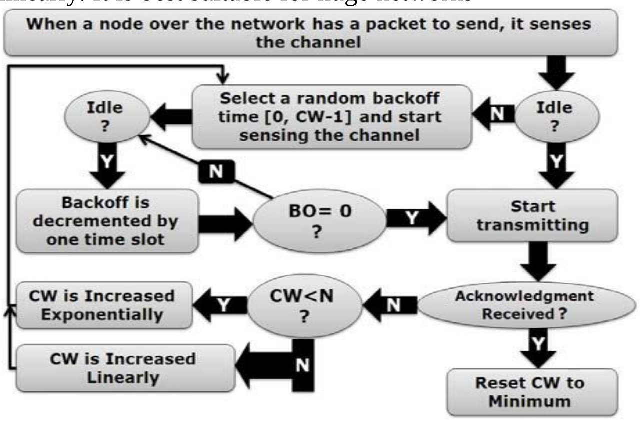


Figure 3: PLEB

J. Estimation-based Backoff Algorithm (EBA)

In EBA comprises 2 main functions 1) to gauge count of stations which are active 2) to choose which CW is best for present case. The best CW is acquired by estimation funtion which uses the mean of slots which are idle during the backoff time.

Step 1: estimation of the energetic nodes count

At backoff time when a channel is engaged

Busy count= busycount+1

Calculate the parameters

*Busyslotcount=busycount*α*

α=(datapacketsize/transmission data rate)(1/slotsize)*

total backoff period=idleslotcount+busyslotcount

$\alpha_0(N,n)=idleslotcount$

get estimated count of active nodes

$n_{est}=\log(\alpha 0(N,n)-\log(totalbackoffperiod)/(\log(totalbackoffperiod-1)-\log(totalbackoffperiod)$

step 2 : finalizing the optimal contention window

obatain the contention window optimal

$cw_{optimal} = n_{est}$

K. Enhanced Fibonacci Backoff (EFB)

Al Oqaily et al., 2010 gave an EFB; it utilizes Fibonacci technique to choose the ideal CW. The successive Fibonacci number is chosen for current CW once collision happened, (Fibonacci number <=CWmax). Else CW is balanced ancestor Fibonacci number it must be ≥ CWmin. By the attributes of Fibonacci series, EFB gives minor raise in bigger CW

L. Enhanced BEB (EBEB)

Mohd. Al-hubaishi et al proposed EBEB, depending on number of successful transmission which enhances or diminishes cw to yields greater fairness of while accessing the channel by that greater throughput when compared to BEB and improved BEB. CW will becomes double like as in BEB if the collision takes place. The flag count is increased whenever the transmission succeeds, by that value , new contention window value can be computed in the following way

- *at transmission failed i.e.,, collision*
  $cw (new) = \min(bo * \log(n), cw_{max})$
- *at transmission successful*
  $cw <(1/\sqrt{(cw_{min})} * cwmin)$ *or*
  $cw = cw +((cw_{max}/cw)*cw_{min})$

M. Balanced BackOff Algorithm (BBA)

Kadhim.D.J et. Al [22] in2012 proposed the Balanced BackOff Algorithm (BBA) is proposed. This mechanism increases the CW linearly for N transmission failures. For N+1 to M transmission failures, CW increases exponentially. After Mth transmission failure, it again increases CW linearly. Upon successful transmission, CW is reduced by half. But linear increase in CW, may not give the optimum waiting time under high traffic scenarios. Therefore, it increases collision rate and number of retransmissions

N. Waiting Time based BackOff (WTB)

Alekya.T et., al [23] in 2012 conferred Waiting Time based BackOff (WTB) is developed for calculating the CW using Waiting time of the nodes. The algorithm assumes ideal channel condition, no hidden terminal effect, same mean arrival rate of packets for total stations finite number of stations. In this technique, In case of engaged channel, the value of BO is chosen by node from default CW value from default CW. If the node encounters any transmission failure, it calculates the Waiting time (Wt). Wt is calculated using three parameters i) on transmission success the busy time of the channel , ii) status of packets collision of entire stations and iii) waiting time of backoff timer while decrementing. Wt is then compared with Maximum Waiting time (Wtmax) in order to determine retry limit (a) of the node. CW is calculated using retry limit (a) and CWmin value. If waiting time of a node is less than one third of Wtmax then CW increases 4 times, it exhibits huge delay in the low traffic scenario.

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O. Smart Adaptive BackOff Algorithm (SABA)
Muneer.O et al. [24] 2012 conferred a BO algorithm is SABA for MANETs. By the previous algorithms results obtained that the changes made to the accretion and depletion of the cw size which straightly influences metrics of the network performance i.e, ratio of data delivery and the overhead.

In this method, CW is increased exponentially for the successful transmissions and stores CW for last 5 successes in the history array. If the transmission fails, the node enters the BO strategy. In this, if the history array has 5 elements and it is used for the first time, then the average of those elements is taken as new CW. If the second transmission failure occurs, it should either take logarithmic increase or linear increase depending on threshold value N. For a set of continuous successes, CW increases exponentially hence there will be a chance for choosing large BO leading to high end-to-end delay

P. Intelligent Paging BackOff Algorithm (IPBA)

Ahmad Momani etal [29] in 2012 proposed IPBA, it is one more BO algorithm to choose adequate backoff clock it slide the conflict window esteem. IPBA compels the BO value ranges in between the last CW value and incremented new CW value. If the transmission fails it uses the quintuplet increments. By this it increases the delivery ratio of the data packets significantly and total end-to-end delay of packets. It's normal , since the value of cw is bounded, the algorithm prevents the selection of small backoff values (min value =value of last cw when failure of transmission occurs cwf) contrary to the BEB algorithm which will allow the selection of ,backoff value which ranges between(0 ,cw-1)

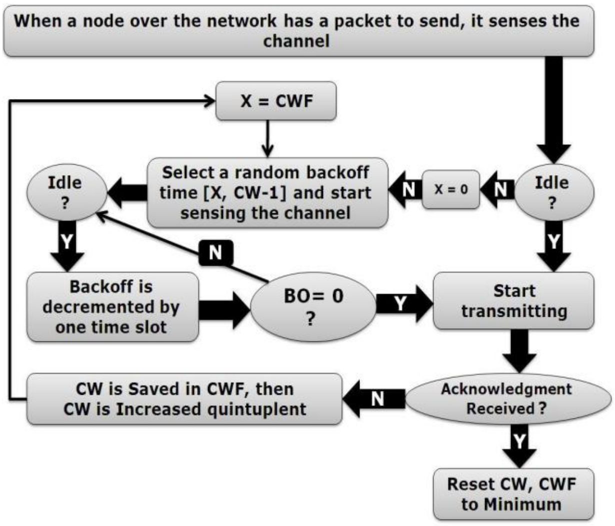

Figure 5: IPBA algorithm

Q. Binomial BackOff Algorithm (BiBA)

C.-Y. Kuo etal in 2012 [26] proposed Binomial BackOff Algorithm (BiBA), is introduced. It assumes nodes under saturated condition, error free channel and no hidden terminal. In BiBA, Binomial distribution gives different probability for different slots. If CW is 31, there is 100% probability to choose same channel i.e., (0mod31, 31mod31=0). If CW is 63, there is 50% probability to choose same channel (0mod31) and 50% chance to choose next channel (63mod31=1). If CW is 127, there is 50% chances to choose the same channel and 50% chance to choose next 3 channels (127mod31), same procedure is followed until the CW value becomes1023. The efficiency of this protocol relies on the ability of the ability of radios to switch between the channels quickly to increase network throughput without a central coordinator.

R. Traffic Adaptive BackOff Algorithm (TABA)

Y. Lee, etal In2012 [25] proposed Traffic Adaptive BackOff Algorithm (TABA) is introduced as a new CW Scheme. In this algorithm, error free channel, negligible propagation delay, no interference from nearby Basic Service Set (BSS) are assumed. A Channel of 16Mbps and slot time of 50 ms is used. Considering centralized WLAN, it will have a monitoring period (T) of 8 to 1023 slots to monitor the collision/s count. Depending upon the collision's count, T increased, U be the total slots used to carry data and collided slots in the monitoring period. Using U & T, TABA calculates CW value (CWTABA). T is doubled. if T <CWTABA, T remains as such if T _CWTABA. Here CWTABA extends from 7 slots to 7796 slots. Increasing the CW to 7796 leads to channel being idle for longer time. In low traffic condition, even 7 Slots for CWmin may lead to collision. In the formula, the term log (T-U) may become indefinite when T and U become equal.

$CW_{TABA} = (log(T\text{-}U)\text{-}log(2T)) / (log(T\text{-}1)\text{-}log(T))$

BT=random (0,CW_{TABA}-1)
If collision occur and (T<CW_{TABA})
BE=BE+1
T=2^{BE}-1
Else collision occur and (T>=CW_{TABA})
T=T
End if

S. Contention Window Control (CWC)

Balador.A etal in 2012 [27], proposed Contention Window Control (CWC). In this algorithm, BO range is divided into sub ranges and assigned to particular collision resolution level. Both lower and upper bounds of BO range are increased during collision CS history array stores the network plight which is considered for optimization of CW. In CS array, 0 is stored when the channel's idle and 1 is stored when the channel's engaged.

The algorithm uses different transitions (CW assignment) for both successful transmission and collisions. Since the lower bound (lb) of CW is also increased, this scheme reduces the number of slots. This may be feasible if the interval between Lower bound (lb) and Upper bound (ub) value is large, otherwise the possibility of the collision is high if different nodes have same back off sub range. It increases contention window twice or 1.7 times whenever channel is busy. If successfully transmitted, CWub = CWub _ 0:57 and CWlb = CWub-32. If the interval between lb and ub is less, it can cause collision in the high traffic scenario.

Table1 : contention window for collision ,success [21][28]

BO Algorithm	CW size after Collision	CW size after Successful transmission
BEB	CW (new) = 2*CW	$CW = CW_{min}$
Modified BEB	$CW = \min [1.8*CW, CW_{max}]$	$CW = CW_{min}$
EIED	$CW = \min[rI \cdot CW, CW_{max}]$	$CW = \max[CW/rD, CW_{min}]$
MILD	CW (new) =1.5 * CW	CW = CW -1
LMILD	$CW=\min(mc.CW,CW_{max})$ $CW= \min(CW+lc,CW_{max})$	$CW =\max(CW-ls,CW_{min})$
DIDD	CW = 2 CW	CW = ½ CW
LOG	$CW (new) = Min(BO * \log(N),CW_{max})$	$CW = CW_{min} * \log(N)$
EFB	CWj+1 = Fibonacci(i)	CWj+1= Fibonacci(j-1)
Enhanced BEB	CW = 2CW	$CW <(1/sqrt(CW_{min})* CW_{min})$ OR $CW = CW +((CW_{max}/CW)*CW_{min})$

BBA	if(collision count < N)
	CW = CW+l;
	if(collision count > N & < M)
	CW = CW * 2;
	if (collision count > M)
	CW = CW + l;
		CW=CW/2

WTB	$CW = CW_{min} * 2^{a-1}$; b = (float)rand() / RANDMAX; BO value = (int)(CW * b);	$CW=CW_{min}* 2^{a-1}$ B=(float)rand()/RANDMIX; BO value=(int)(CW*b)

SABA	if(failure) then
	if(history array contains all 5 values for succesful transmission)
	if(array used 1st time) then CW = average (array elements); else if(CW > N) Linear Increment;
	else Logarithmic Increment;
		Exponential increment if success , it saves history in array

TABA	CWTABA = [log(T-U)-log(2T)] / [log(T-1)-log T];	CWtaba=[log(T-U)-log(@T)]/[log(T-1)-logT]
BiBA	Upon failure it increments the slot by (+1 or +3 or +5) depending on the CW mod CWminvalue. CW increases exponentially during failure. slot value is chosen using Binomial distribution.	It remain in default CWmin as BEB. Inorder to choosea slot value , it uses binomialdistribution
CWC	CWub(i) = CWub(i-1)*Z; CWlb(i) = CWub(i)-size; i be contention level, Z be a number, size be CW range for every level.	CWub(i)=CWub(i-I)*Z CWib(i)=CWub(i)-size I be contention level Z be a number ,size be CW range for every level

IV. CONCLUSION

In remote systems, stations are encountering impacts on the basic channel which is essential to be backed off for an irregular discretionary time span , regularly chosen from the CW .The backoff algorithms controls the CW dynamically. This survey manuscript explores many existing backoff algorithms. From this analysis, it's been comprehended that the size of CW consolidates a great effect on the performance of the network.

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