Performance Analysis of EIED Backoff Algorithm of the IEEE 802.11 MAC under Fading Channel Errors

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Abstract— **Binary Exponential Backoff (BEB) is the most popular backoff algorithm that is used to compare the numerical results of saturated throughput with other alternative backoff algorithms. In spite of the fact that backoff algorithm under fading channel errors lead to practical application that has higher accurate and better performance, its numerical result of saturated throughput is lower than BEB. In this research, we propose a new discrete time Markov chain model of Exponential Increased Exponential Decreased (EIED) backoff algorithm under fading channel errors, and its numerical result of saturated throughput is better than BEB under fading channel errors. The transmission probabilities are derived in the fixed backoff stage and fixed contention window technique. Our numerical results show that the saturated throughput of EIED under fading channel errors is better and more stable than BEB under fading channel errors when the number of contending station is increased.**

Keywords-Backoff algorithm, BEB, EIED, FBFC, discrete time Markov chain model, fading channel errors

I. INTRODUCTION

The Wireless Local Area Network (WLAN) is becoming increasingly important and the IEEE802.11 is one of the most popular standards [1] in WLAN systems. A serious problem of WLAN system occurs when the network has a high number of contending stations and get the effect from fading channel errors. These problems are the cause of degrading saturated throughput. The popular model for performance analysis of backoff algorithm is Bianchi's model [2]. It used two-dimension discrete Markov chain model to solve the collision problem, and it is called binary exponential backoff. Many researches have extended BEB to a design new backoff algorithm. Researches [4]-[6] proposed a new backoff algorithm that its contention window size was increased exponentially on a collision transmission and was decreased exponentially on a successful transmission. This technique is called Exponential Increased Exponential Decreased backoff algorithm (EIED). The performance of EIED scheme was better than BEB, but it was not considered under fading channel errors cases and freezing of backoff counters. Research [3] proposed a new model that considered keys practical issues such as fading channel errors and freezing of backoff counters. It led to more accurate and practical Markov chain model but its numerical results of saturated through were lower than BEB. Generally, the transmission probability (τ) is the most common and important parameter because it is derived in the discrete time Markov chain model in the general case (unlimited backoff stages and unlimited contention window size). Consequently, the key of this research introduces a new technique to derive the transmission probability by using the fixed backoff stage and fixed contention window technique [7] and [8]. This research proposes the use of EIED backoff algorithm along with fixed backoff stage and fixed contention technique while also considering under fading channel errors and freezing of backoff counter cases

This paper is organized as follows. In section II, we derive the transmission probability of BEB algorithm under fading channel by using the fixed backoff stage and fixed contention window technique. In section III, we derive the transmission probability of EIED under fading channels by using the fixed backoff stage and fixed contention window technique. In section IV, we describe the theory and the method of saturated throughput calculation under fading channels errors case. In section V, we show and compare the numerical results between BEB and EIED backoff algorithm under fading channel errors. Finally, the conclusion is explained in section VI.

II. BEB ALGORITHM UNDER FADING CHANNEL ERRORS MODEL

In this section, we propose Bianchi's model that takes fading channel errors into consideration and apply the fixed backoff stage and fixed contention technique to derive transmission probability (τ). The contention window size equals $2^i \times W_{min}$ where i is backoff stage or the number of retransmission. In this research, the backoff stage i can be increased up to 7 stage (i=0, 1, 2,…,7). Thereby, the maximum contention window size is 1,024 timeslot (0 to 1,023) and the minimum contention window size is 8 timeslot (0 to 7). At the first transmission, the contention window size is selected equal to a minimum contention window size (W_{min}). Afterward, the contention window size is decreased from slot by slot during the idle period more than the Distributed Inter Frame Space (DIFS) time. A contending station can send a data frame through wireless channel when the contention window size is counted down to zero. If the transmission is unsuccessful or the collision happens, the contention window size is doubled for every transmission failure until it reaches the maximum contention window size (W_{max}). In fixed backoff stage and fixed contention model, the state probability of each backoff stage and contention window size is denoted $b_{i,k}$ where i is the

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backoff stage, and k is the contention window size. The backoff stage i varies from 0 to 7 stage and the contention window size k varies from 0 to 1,023 timeslot. P_F is the probability that a contending station suspends its countdown process in backoff mode until the wireless channel is sensed idle more than DIFS period, then the contention window size is counted down again. P_c is collision probability of a data packet to transmission through wireless channel. P_e is fading channel error probability. A proposed model can be shown in Fig.1. We use the global balance equation concept in fixed backoff stage and fixed contention window scheme to derive the transmission probability (τ) parameter for calculating the saturated throughput of BEB algorithm under fading channels errors.

From Fig.1, in retransmission process, before a data packet is transmitted through WLAN channel, the contention window size must be counted down to zero. Firstly, when the backoff stage i is 0 and contention window size k is 7 timeslot, the state probability of $b_{0,7}$ is given by

$$\frac{(1-P_c)(1-P_e)}{7}b_{0,0}+P_F b_{0,7}=(1-P_F)b_{0,7}$$

$$b_{0,7}=\frac{(1-P_c)(1-P_e)}{7(1-2P_F)}b_{0,0} \tag{1}$$

When the backoff stage i is 0 and contention window size k is 6 timeslots, and we let $P_{ce}=(1-P_c)(1-P_e)$ *and* $P_{cce}=P_c+(1-Pc)P_e$, the state probability of $b_{0,6}$ is given by

$$\frac{P_{ce}}{7}b_{0,0}+P_F b_{0,6}+(1-P_F)b_{0,7}=(1-P_F)b_{0,6}$$

$$b_{0,6}=\frac{P_{ce}}{7(1-2P_F)}b_{0,0}+\frac{(1-P_F)}{(1-2P_F)}b_{0,7} \tag{2}$$

Substituting (1) into (2), we get

$$b_{0,6}=\frac{P_{ce}}{7(1-2P_F)}\frac{(1-P_F)}{(1-2P_F)}b_{0,0}+\frac{P_{ce}}{7(1-2P_F)}\frac{(1-P_F)^2}{(1-2P_F)^2}b_{0,0} \tag{3}$$

From (3), we let $B=\frac{1-P_F}{1-2P_F}$, then equation (3) can be rewritten by

$$b_{0,6}=\frac{P_{ce}}{7(1-2P_F)}Bb_{0,0}+\frac{P_{ce}}{7(1-2P_F)}B^2b_{0,0}=\frac{P_{ce}}{7(1-P_F)}\sum_{L=1}^{2}B^Lb_{0,0} \tag{4}$$

We use a similar method (1) to (4) to calculate the state probability at backoff stage i=0 and contention window size k=1. The stage probability is given by

$$b_{0,1}=\frac{P_{ce}}{7(1-P_F)}\sum_{L=1}^{7}B^Lb_{0,0} \tag{5}$$

Next, when backoff state i=0, and contention window size k=0, the stage probability fo $b_{0,0}$ is given by

$$b_{0,0}=(1-P_F)b_{0,1} \tag{6}$$

Substituting (5) into (6), the state probability of $b_{0,0}$ can be rewritten by

$$b_{0,0}=\frac{P_{ce}}{7}\sum_{L=1}^{7}B^Lb_{0,0} \tag{7}$$

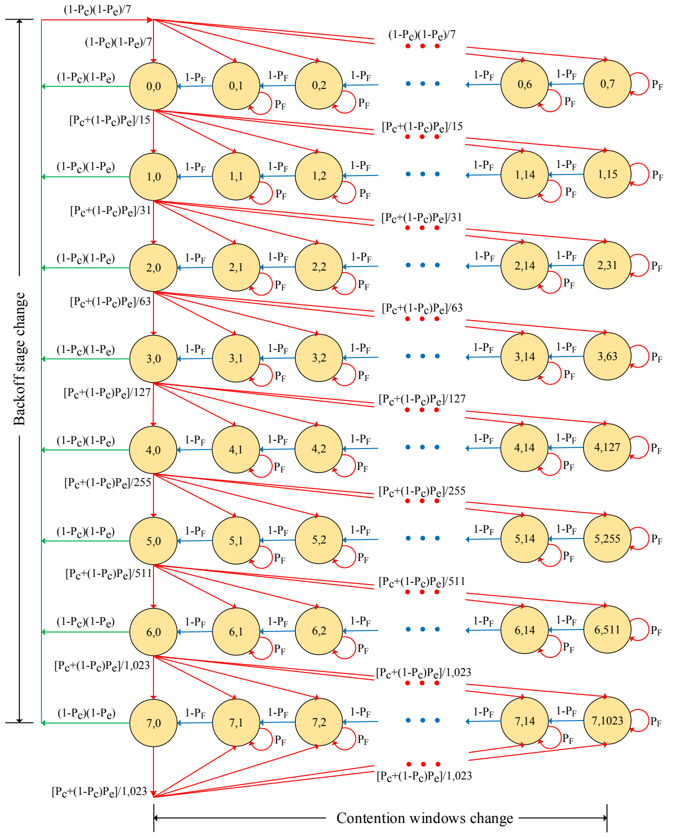

Fig. 1. The binary exponential backoff algorithm model under fading channel in fixed backoff stage and fixed contention window size

Similarly, we use the same method of (1) to (7) to derive the state probability of $b_{1,0}$, $b_{2,0}$, $b_{3,0}$, $b_{4,0}$, $b_{5,0}$, $b_{6,0}$ *and* $b_{7,0}$ which are expressed by

$$b_{1,0}=A=\frac{217P_{cce}}{465P_{ce}+105P_{cce}}\sum_{L=1}^{15}B^Lb_{0,0} \tag{8}$$

$$b_{2,0}=C=\frac{441P_{cce}}{1{,}953P_{ce}+217P_{cce}}\sum_{L=1}^{31}B^Lb_{1,0} \tag{9}$$

$$b_{3,0}=D=\frac{889P_{cce}}{8{,}001P_{ce}+441P_{cce}}\sum_{L=1}^{63}B^Lb_{2,0} \tag{10}$$

$$b_{4,0}=E=\frac{1{,}785P_{cce}}{32{,}385P_{ce}+889P_{cce}}\sum_{L=1}^{127}B^Lb_{3,0} \tag{11}$$

$$b_{5,0}=F=\frac{3{,}577P_{cce}}{130{,}305P_{ce}+1{,}785P_{cce}}\sum_{L=1}^{255}B^Lb_{4,0} \tag{12}$$

$$b_{6,0}=G=\frac{7{,}161P_{cce}}{552{,}753P_{ce}+3577P_{cce}}\sum_{L=1}^{255}B^Lb_{5,0} \tag{13}$$

$$b_{7,0}=H=\frac{7{,}161P_{cce}}{1{,}046{,}529P_{ce}+7{,}161P_{cce}}\sum_{L=1}^{1{,}023}B^Lb_{6,0}+\frac{7{,}161P_{cce}}{1{,}046{,}529P_{ce}+7{,}161P_{cce}}\sum_{L=1}^{1{,}023}B^Lb_{7,0} \tag{14}$$

Before a data packet is transmitted through WLAN channel, the contention window in backoff process must be counted down to zero (k=0). Similarly in [2], the transmission probability of BEB under fading channel ($\tau_{BEB\ fading}$) is given by

$$\tau_{BEB\ Fading} = \frac{1}{\sum_{i=0}^{7} b_{i,0}} = \frac{1}{\left[b_{0,0}+b_{1,0}+b_{2,0}+b_{3,0}+b_{4,0}+b_{5,0}+b_{6,0}+b_{7,0}\right]} \tag{15}$$

Substituting (7) to (14) into (15), the transmission probability is simplified by

$$\tau_{BEB\ Fading} = \frac{1}{\left[1+A+AC+ACD+ACDE+ACDEF+ACDEFG+\left[\frac{H}{1-H}\right]ACDEFG\right]} \tag{16}$$

This technique is the same concept to derive the transmission probability of EIED backoff algorithm that is detailed next sections.

III. EIED Backoff Algorithm under Fading Channel Errors Model

In this section, we propose a new discrete time Markov chain model of Exponential Increased Exponential Decreased (EIED) backoff algorithm under fading channel errors. In fixed backoff stage and fixed contention window size scheme, the EIED backoff algorithm under fading channel errors is shown in Fig.2. Significantly, the EIED backoff algorithm under fading channel errors is differenced from BEB algorithm under fading channel errors when the transmission is successful. After collision transmission, the contention window size is doubled of the current contention window size (EI: Exponential Increment) until the contention window reaches the maximum contention window size. In a subsequent successful transmission, the contention window size is not reset to the initial value (W_{min}), but the contention window size of EIED algorithm is set to initial contention window size of the previous backoff stage (ED: Exponential Decrement).The global balance equation concept in discrete time Markov chain is used to derive the transmission probability (τ) of EIED backoff algorithm. The transmission probability of $b_{0,0}$, $b_{1,0}$, $b_{2,0}$, $b_{3,0}$, $b_{4,0}$, $b_{5,0}$, $b_{6,0}$ *and* $b_{7,0}$ is defined by

$$b_{0,0} = \frac{105P_{ce}}{105P_{ce}+49P_{cce}}\sum_{L=1}^{7} B^{L} b_{0,0} + \frac{105P_{ce}}{105P_{ce}+49P_{cce}}\sum_{L=1}^{7} B^{L} b_{1,0} \tag{17}$$

$$b_{1,0} = \frac{217P_{cce}}{465P_{ce}+105P_{cce}}\sum_{L=1}^{15} B^{L} b_{0,0} + \frac{217P_{ce}}{465P_{ce}+105P_{cce}}\sum_{L=1}^{15} B^{L} b_{2,0} \tag{18}$$

$$b_{2,0} = \frac{945P_{cce}}{1{,}953P_{ce}+465P_{cce}}\sum_{L=1}^{31} B^{L} b_{1,0} + \frac{945P_{ce}}{1{,}953P_{ce}+465P_{cce}}\sum_{L=1}^{31} B^{L} b_{3,0} \tag{19}$$

$$b_{3,0} = \frac{3{,}937P_{cce}}{8{,}001P_{ce}+1{,}953P_{cce}}\sum_{L=1}^{63} B^{L} b_{2,0} + \frac{3{,}937P_{ce}}{8{,}001P_{ce}+1{,}953P_{cce}}\sum_{L=1}^{63} B^{L} b_{4,0} \tag{20}$$

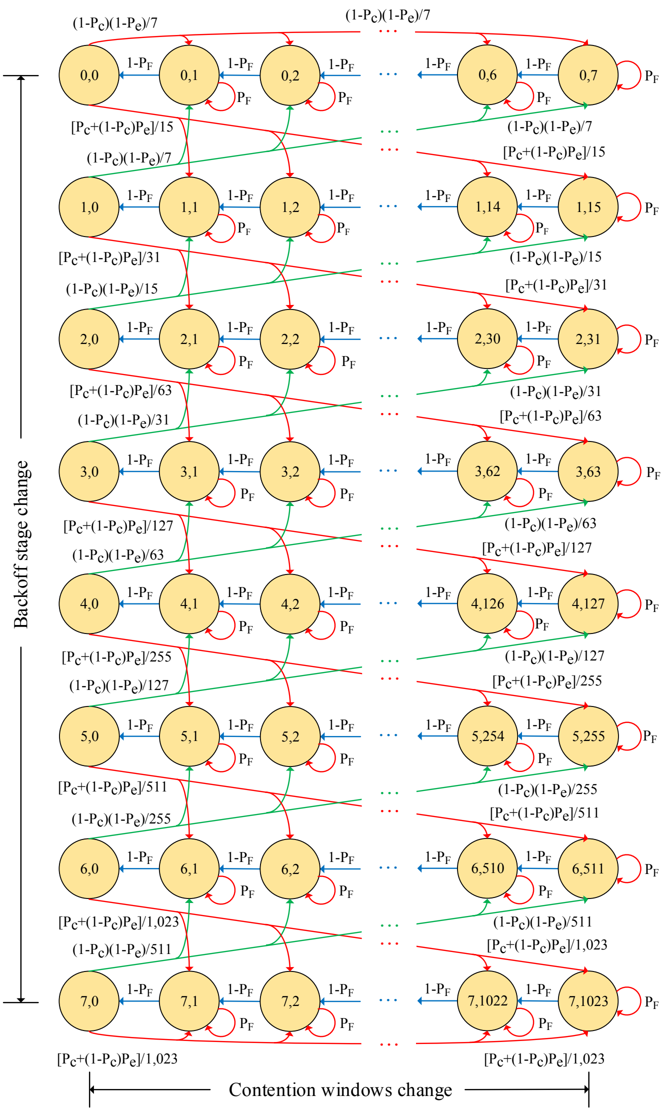

Fig. 2. Exponential Increment Exponential Decrement Backoff algorithm model under fading channel errors in fixed backoff stage and fixed contention window size

$$b_{4,0} = \frac{16{,}065P_{cce}}{32{,}385P_{ce}+8{,}001P_{cce}}\sum_{L=1}^{127} B^{L} b_{3,0} + \frac{16{,}065P_{ce}}{32{,}385P_{ce}+8{,}001P_{cce}}\sum_{L=1}^{127} B^{L} b_{5,0} \tag{21}$$

$$b_{5,0} = \frac{64{,}897P_{cce}}{130{,}305P_{ce}+32{,}385P_{cce}}\sum_{L=1}^{255} B^{L} b_{4,0} + \frac{64{,}897P_{ce}}{130{,}305P_{ce}+32{,}385P_{cce}}\sum_{L=1}^{255} B^{L} b_{6,0} \tag{22}$$

$$b_{6,0} = \frac{260{,}865P_{cce}}{522{,}753P_{ce}+130{,}305P_{cce}}\sum_{L=1}^{511} B^{L} b_{5,0} + \frac{260{,}865P_{ce}}{522{,}753P_{ce}+130{,}305P_{cce}}\sum_{L=1}^{511} B^{L} b_{7,0} \tag{23}$$

$$b_{7,0}=\frac{522{,}753P_{cce}}{1{,}046{,}539P_{ce}+522{,}753P_{cce}}\sum_{L=1}^{1{,}023}B^{L}b_{6,0}+\frac{522{,}753P_{cce}}{1{,}046{,}539P_{ce}+522{,}753P_{cce}}\sum_{L=1}^{1{,}023}B^{L}b_{7,0} \tag{24}$$

The transmission probability of EIED under fading channel errors ($\tau_{EIED\ fading}$) is given by

$$\tau_{EIED\ Fading}=\frac{1}{\sum_{i=0}^{7}b_{i,0}}=\frac{1}{\left[b_{0,0}+b_{1,0}+b_{2,0}+b_{3,0}+b_{4,0}+b_{5,0}+b_{6,0}+b_{7,0}\right]} \tag{25}$$

Substituting (17) to (24) into (25), the transmission probability is simplified by

$$\tau_{EIED\ Fading}=1/\left(1+1/C_3+D_3+E_3+F_3+G_3+H_3+J_3\right) \tag{26}$$

Where by

$$C_1=\frac{105P_{ce}}{105P_{ce}+49P_{cce}}\sum_{L=1}^{7}B^{L},\quad C_2=\frac{105P_{ce}}{105P_{ce}+49P_{cce}}\sum_{L=1}^{7}B^{L},$$

$$C_3=\frac{C_2}{1-C_1},\quad D_1=\frac{217P_{cce}}{465P_{ce}+105P_{cce}}\sum_{L=1}^{15}B^{L},$$

$$D_2=\frac{217P_{ce}}{465P_{ce}+105P_{cce}}\sum_{L=1}^{15}B^{L},\ D_3=\left(\frac{1-C_3D_1}{C_3D_2}\right),$$

$$E_1=\frac{945P_{cce}}{1{,}953P_{ce}+465P_{cce}}\sum_{L=1}^{31}B^{L},\ E_2=\frac{945P_{ce}}{1{,}953P_{ce}+465P_{cce}}\sum_{L=1}^{31}B^{L},$$

$$E_3=\left(\frac{C_3D_3+E_1}{E_2C_3}\right),\quad F_1=\frac{3{,}937P_{cce}}{8{,}001P_{ce}+1{,}953P_{cce}}\sum_{L=1}^{63}B^{L},$$

$$F_2=\frac{3{,}937P_{ce}}{8{,}001P_{ce}+1{,}953P_{cce}}\sum_{L=1}^{63}B^{L},\quad F_3=\frac{E_3-D_3F_1}{F_2},$$

$$G_1=\frac{16{,}065P_{cce}}{32{,}385P_{ce}+8{,}001P_{cce}}\sum_{L=1}^{127}B^{L},$$

$$G_2=\frac{16{,}065P_{ce}}{32{,}385P_{ce}+8{,}001P_{cce}}\sum_{L=1}^{127}B^{L},\quad G_3=\frac{F_3-G_1E_3}{G_2},$$

$$H_1=\frac{64{,}897P_{cce}}{130{,}305P_{ce}+32{,}385P_{cce}}\sum_{L=1}^{255}B^{L},$$

$$H_2=\frac{64{,}897P_{ce}}{130{,}305P_{ce}+32{,}385P_{cce}}\sum_{L=1}^{255}B^{L},\quad H_3=\frac{G_3-H_1F_3}{H_2},$$

$$I_1=\frac{260{,}865P_{cce}}{522{,}753P_{ce}+130{,}305P_{cce}}\sum_{L=1}^{511}B^{L},$$

$$I_2=\frac{260{,}865P_{ce}}{522{,}753P_{ce}+130{,}305P_{cce}}\sum_{L=1}^{511}B^{L},\quad I_3=\frac{H_3-I_1G_3}{I_2},$$

$$J_1=\frac{522{,}753P_{cce}}{1{,}046{,}529P_{ce}+522{,}753P_{cce}}\sum_{L=1}^{1023}B^{L},$$

$$J_2=\frac{522{,}753P_{cce}}{1{,}046{,}529P_{ce}+522{,}753P_{cce}}\sum_{L=1}^{1023}B^{L},\quad J_3=\frac{I_3-J_1H_3}{J_2}$$

IV. Throughput Calculation

Bianchi's model [2] evaluated the performance of the DCF under error-free channel. Each transmission ignored number of retransmissions and the packet collides with a constant probability (p). Let τ be the transmission probability that depends on the collision windows determined by the Physical layer characteristics. From Bianchi's model, we have

$$\tau=\frac{2(1-2p)(1-p)^{m+1}}{(1-2p)+W\left[(1-2p)+p\left(1-(2p)^{m}\right)\right]} \tag{27}$$

Parameter P_c is the collision probability that, in the same time slot, at least one of n-1 remaining stations transmit. If we assume that all stations see the system at steady state and transmission with probability τ. The collision probability P_c is given by

$$P_c=1-(1-\tau)^{n-1} \tag{28}$$

Hence, P_{tr} is the probability that in a slot time here is at least one transmission

$$P_{tr}=1-(1-\tau)^{n} \tag{29}$$

Then we can write the probability of successful transmission (P_s) as the following equation

$$P_s=\frac{n\tau(1-\tau)^{n-1}}{1-(1-\tau)^{n}} \tag{30}$$

Binary exponential backoff under fading channel errors was proposed by Song Ci. This model took the probability of fading channel errors into consideration. The transition probability of the time discrete Markov chain model is described as follow.

1) The backoff time counter decreases if the station senses that the channel is idle or there is no transmitting.

$$P\{i,k\,|\,i,k+1\}=1-P_F \tag{31}$$

2) The backoff counter suspends its contention window countdown process when WLAN is busy, or the another node has been transmitting a data packet.

$$P\{i,k\,|\,i,k\}=P_F \tag{32}$$

$$k\in(1,W_i-1);i(0,m)$$

3) After a successful transmission, the contention window size is reset to initial Value (W_{min}) or initial backoff stage i=0.

$$P\{i,k\,|\,i,0\}=\frac{(1-P_c)(1-P_e)}{W_0} \tag{33}$$

$$k\in(1,W_0-1);\ i\in(0,m-1)$$

4) When an unsuccessful transmission occurs, backoff stage increases and new initial backoff value is chosen contention window in the range $(0,W_i)$.

$$p\{i,k\,|\,i-1,0\}=\frac{\left[P_c-(1-P_c)P_e\right]}{W_i} \tag{34}$$

$$k\in(0,W_i-1);\ i\in(1,m)$$

$$S_{Fading} = \frac{P_{tr}P_s(1-P_e)E[1-P_e]}{(1-P_{tr})\delta + P_{tr}P_sT_s(1-P_e) + P_{tr}(1-P_s)T_c + P_{tr}P_s\left(P_e^{rts}T_e^{rts} + P_e^{cts}T_e^{cts} + P_e^{data}T_e^{data} + P_e^{ack}T_e^{ack}\right)} \quad (39)$$

5) If the system is in the maximum backoff stage and another retransmission is needed, a backoff counter is chosen in maximum backoff stage again.

$$P\{0,k \mid m,0\} = \frac{1}{W_0} \quad (35)$$
$$k \in (0, W_0 - 1)$$

Bianchi's model has represented the saturation throughput for a finite number of contending station condition. The saturated throughput can be calculated by dividing the time utilized for transmitting a data packet (payload information) in a slot time by the average duration of a slot time. If we consider ideal channel condition without errors, the saturation throughput equation is given by

$$S = \frac{P_{tr}P_sE[P]}{(1-P_{tr})\sigma + P_{tr}P_sT_s + P_{tr}(1-P_s)T_c} \quad (36)$$

E[P] is the average packet payload size. Let packet header be $H=PHY_{hdr}+MAC_{hdr}$ and let propagation be δ. Consideration system in which each packet is transmission by mean of the RTS/CTS access mechanism, we have

$$T_s^{rts/cts} = DIFS + RTS + CTS + H + E[P] + 4\delta + SIFS + ACK \quad (37)$$

$$T_c^{rts/cts} = DIFS + RTS + \delta \quad (38)$$

In research [3], Song Ci extended (36) into fading channel errors situation and made the throughput under fading channel errors that is shown in (39).

From the equation (39), the expression of probability of frame errors can be calculated from

$$P_e = 1-(1-P_b)^{L_{rts}+L_{cts}+L_{data}+L_{ack}} \quad (40)$$

$$P_e^{rts} = 1-(P_b)^{L_{rts}} \quad (41)$$

$$P_e^{cts} = (1-P_b)^{L_{rts}}\left(1-(1-P_b)^{L_{rts}}\right) \quad (42)$$

$$P_e^{data} = (1-P_b)^{L_{rts}+L_{cts}}\left(1-(1-P_b)^{L_{data}}\right) \quad (43)$$

$$P_e^{ack} = (1-P_b)^{L_{rts}+L_{cts}+L_{data}}\left(1-(1-P_b)^{L_{ack}}\right) \quad (44)$$

In the length of different type of frame can calculate the overhead caused by the frame error of each the frame type as follow

$$T_e^{rts} = T_{rts} + T_{cts}^{timeout} + DIFS + \delta \quad (45)$$

$$T_e^{cts} = T_{rts} + SIFS + DIFS + 2\delta \quad (46)$$

$$T_e^{data} = T_{rts} + T_{cts} + DIFS + 2SIFS + H + E[P] + T_{cts}^{timeout} + 3\delta \quad (47)$$

An algorithm 1 is used to calculate the saturated throughput.

Algorithm 1: Throughput calculation

Begin

Step: 1 fixed parameter, n=1, 2, 3,…, 40, P_F:=0.05, P_b:=10^{-6}, RTS:=352 bits, CTS=ACK:=304 bits, *E[P]*:=8,192 bits

Step: 2 calculated P_{tr}, P_s, T_s and T_c by applying equation (29), (30), (37), and (38)

Step: 3 calculated throughput under error-free channel and throughput under fading channel errors by applying equation (36) and (39)

End

TABLE I
THE SYSTEM PARAMETERS ARE USE IN THE SIMULATION AND PLOT

T_{SIFS}	$10\mu S$
T_{DIFS}	$50\mu S$
$T_{SlotTime}$	$20\mu S$
T_{delay}	$1\mu S$
T_{RTS}	$352\mu S$
T_{CTS}	$304\mu S$
T_{ACK}	$304\mu S$
MAC Header	272 bits
PHY Header	128 bits
RTS Packet	160 bits
CTS Packet	112 bits
ACK Packet	112 bits
Packet Payload	8,192 bits

V. NUMERICAL RESULTS

In this section, we show and compare our numerical results of a proposal about a new discrete time Markov chain model. Figure 3 compares the saturated throughput performance between BEB and BEB under fading channel errors. Figure 3 shows when the contending station is increased, the saturated throughput of BEB appears to reduce quickly as BEB under fading channel errors. However, the throughput of BEB is higher than BEB under fading channel errors. Figure 4 compares the saturated throughput performance between EIED and EIED under fading channel errors. Figure 4 shows when contending stations vary from 1 to 8 stations, the saturated throughput of EIED appears to increase quickly. When contending stations vary from 9 to 40 stations, the saturated throughput of EIED appears to be stable as EIED under fading channel errors. However, the throughput of EIED is higher than EIED under fading channel errors. Figure 5 displays and compares all of the numerical results of a proposal about a new discrete time Markov chain model. The throughput of backoff algorithm which is under fading channel errors is lower than backoff algorithm which is under error-free channel. Even though, EIED under fading channel errors in contending stations which vary from 5 to 40 is still higher and more stable than BEB under error-free channel.

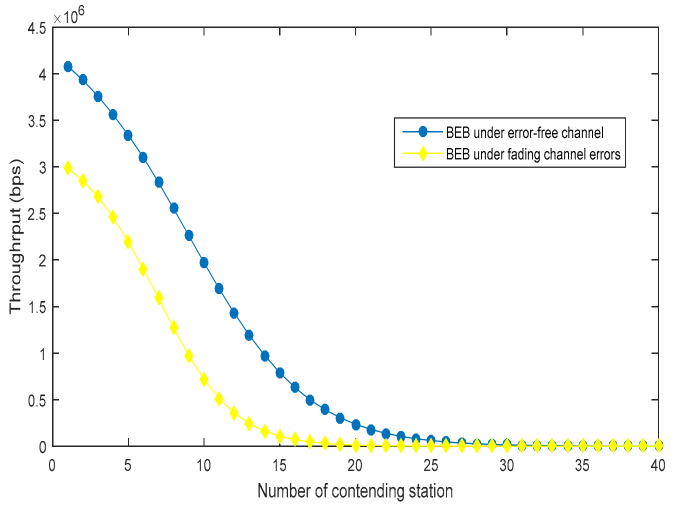

Fig. 3. Saturated throughput of BEB under error-free channel and BEB under fading channel errors

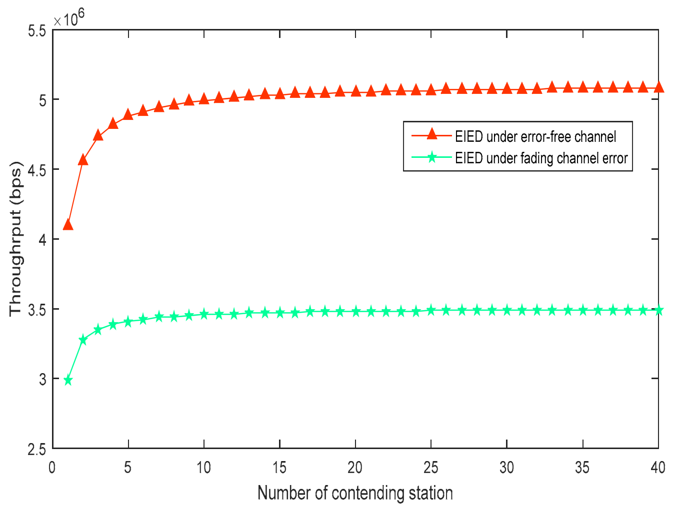

Fig. 4. Saturated throughput of EIED under error-free channel and EIED under fading channel errors

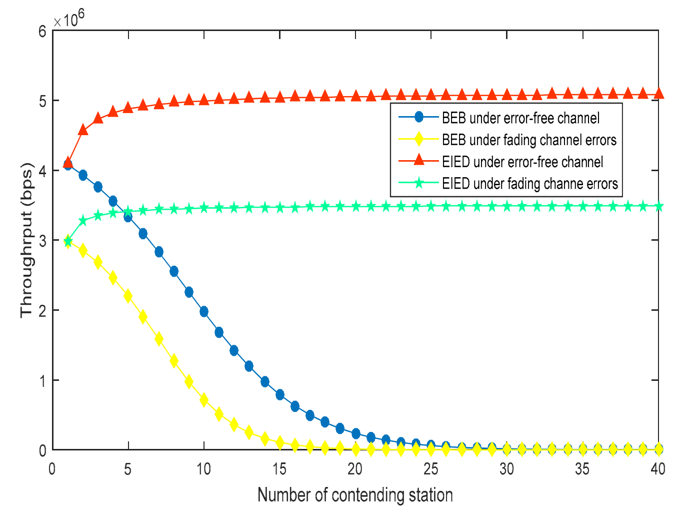

Fig. 5. Saturated throughput of BEB under error-free channel, BEB under fading channel errors, EIED under error-free channel and EIED under fading channel errors

VI. CONCLUSION

Although BEB algorithm under fading channel errors leads to more accurate practical and application and better performance, its numerical results of saturated throughput is lower than those of BEB. In this research, we propose a new discrete time Markov chain model which although it is under fading channel errors case, its numerical results of the saturated throughput are better than BEB algorithm. The proposed backoff is called EIED under fading channel errors. The accuracy of throughput results is compared by using new discrete time Markov chain model that its maximum backoff stage and contention window size are fixed at 8 stage and 1,024 timeslots respectively. The numerical results have clearly shown that the saturated throughput of EIED backoff algorithm under fading channel errors is higher and more stable than BEB algorithm which is under error-free channel when the contending stations are increased.

In future work, we plan to evaluate the performance of EIED under fading channel in non-saturated WLAN channel and use Network Simulator 2 (NS-2) in order to achieve more accurate result and better performance in realistic network simulation based on recent standard (IEEE802.11 ac)

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