# Adaptive Wireless Networks QoS Evaluation Analysis Through Enhanced Parameters Tuning Algorithms

BEN-BIN CHEN[1], HUA-CHING CHEN[1,2], DONG-HUI GUO[1]
[1]Department of Electronic Engineering
Xiamen University
Xiamen Fujian 361005, China
[2]Department of Computer Science and Information Engineering
National Quemoy University
No. 1 University, Rd., Kin-Ning Vallage Kinmen, 892, Taiwan
chenbenbin@163.com, galaxy.km@gmail.com, dhguo@xmu.edu.cn

*Abstract:* - The enhanced parameters tuning (EPT) algorithm is applied to adjust the parameters of 802.11e, i.e. arbitration inter frame space (AIFS), Contention window minimum (CWmin) and Contention window maximum (CWmax). The EPT tuning algorithm is proposed with the simple and effective adjustment in the priority combinations strategy to achieve the high quality of service (QoS). The internal competition of business analysis methods are determined to detect the channel busy probability. The EPT tunes the conflict probability by the variant setting of AIFS, CWmin and CWmax to approach the performance analysis while the traffic business is retreating into the idle and zero state. Three simulations results in the four businesses of wireless networks applications are applied to present the better adapt parameters regulation machines.

*Key-Words:* - Wireless Network, 802.11e, EDCA, EPT, QoS, Access Categories

## 1 Introduction

Several real-time business based on the data transformation services require the higher Quality of Service (QoS) permissions. The main functions in the wireless network platforms not only provide a simple connectivity network but also offer the higher QoS to support the complex and unexpected problems. The traditional IEEE 802.11 standard doesn't provide the better guarantee of heavy traffic loads to assure the real-time business model. The improvement of accessing mechanisms for the IEEE 802.11e protocol provides several voice and video applications in the WLAN (Wireless Local Area Network) [20]. The appropriate wireless LAN offers a high-speed accessing rate to provide transmitted ability for both non-real-time and real-time dataset. For example, WWW, FTP, HTTP is a non-real-time services data, but videoconference, remote education, remote medical care, Voice are considered as the real-time multimedia applications services.

The agreements of IEEE802.11e standard distinguish the priority of various type's applications by the evaluation of AIFS, minimum contention window, maximum contention window and internal collision mechanism. It provides the preliminary support for multimedia applications. However, the standard of IEEE802.11e doesn't guarantee the traffic service to achieve the maximum channel utilization [4]. This study presents the performance analysis of saturated throughput by the three various parameters combinations. Bianchi [2, 3] proposed a Markov chain model to find the solution of the Markov equilibrium probability for packet transmission chain within a generic slot time. The ultimately re-analysis is applied to approach the suitable saturation throughput within a generic time slot. Many researchers devoted themselves to improve these wireless studys in the recent years. The mathematical model of the average replace is proposed by Tay [13], it is used to calculate the probability of the divided packet collisions and solve the maximum collision probability problem of the traffic throughput. Wu et al. applied the modified Bianchi model to give further consideration in the retry limit testing problem [14]. Choi, and others searches [5, 9] described in detail of the IEEE 802.11e EDCA mechanisms to give more performance simulation and methods evaluation in the literature. Xiao and Li [15] proposed the EDCA priority study to obtain the effects of transferring delay conditions when changing the queue buffer size. The paper of the Xiao Yang [17] is developed based on the basis of

Ziouva [19] study. It offers the EDCA learning-based network analysis of 802.11e model when AC is divided into four grades and applies the machine of priority channel competition.

## 2 EDCA Model and QoS Evaluation

The EDCA (Enhanced Distributed Channel Access) has been approved in many analytical WLAN modes [16-17]. The hybrid coordination function (HCF) is developed in 802.11 e by the isolation of various traffic business to offer the higher QoS requirements in the WLAN system. The HCF Controlled Channel Access(HCCA) and EDCA methods are proposed by the basis of the improvement of the distributed coordination function (DCF) and PCF in the 802.11 e machine [1, 12-13]. In study experiments, voice and image data are assigned to obtain the higher priority for reducing the package collision in the traffic flow channel. The EDCA competition of the network accessing channel is similar to the DCF way. In the EDCA transmission model, it first waits for the fixed IFS (Inter-frame Space) at the default interval and goes into the chaotic-backoff timer cycle when the idle state of wireless medium is detected. It is noted that the transmitted frames will start to resend the package when the countdown cycle is completed. The traffic businesses are divided into four access categories (AC), they includes voice (AC_VO), video (AC_VI), best effort (AC_BE), and background (AC_BK) in the EDCA machine. These categories contain various priorities in the competed buffer of network channel. Traffic orders of various data types from high to low are declared as voice (*AC[3]*), video (*AC[2]*), best effort (*AC[1]*) and background (*AC[0]*). The proposed model analysis is divided into two stages in this research. The algorithm makes sure the analysis of the internal events within the network site. Calculate the sending and conflicting probability through the levels of traffic data access priority in differential time slot. Evaluate the accessing levels of traffic channel based on the computation of throughput and time delay in the next stage.

Assume that there are n sites located in a community, and each site's traffic is divided into *N* (*i = 0,1,2,…, N-1*) grades, where 0 is the highest priority for easily comparing the results. Each site for each traffic data queues are always ready to send. This means the network is in a saturated state.

The term b(*i*, *t*) represents the *i*-th class of traffic for backoff counters, and *s*(*i*, *t*) is the back series number for the *i*-th class of traffic. According to Bianchi [21], {*b* (*i*, *t*), s (*i*, *t*)} can be considered as the *i*-th class of traffic in a 2D discrete Markov chain. Fig. 1 shows the state transition diagram of the Markov chain model for *AC*[*i*].

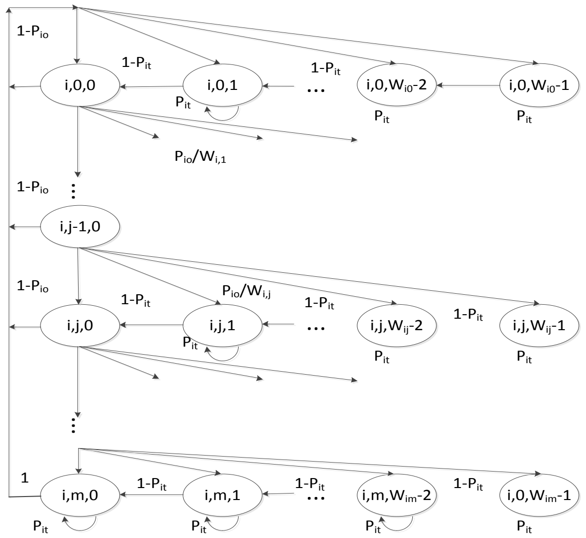


**Fig. 1**. Transition diagram of Markov chain model for *AC*[*i*].

Let $\tau_i$ represent the steady-state probability of a traffic flow i for any time gap. $p_i$ is the conditional probability of the conflict in traffic *i*. The conflict includes the real and the virtual conflict conditions. Static probability for *i*-th traffic flow in variant website within one time-gap is considered as $\tau_i$. The calculation of $\tau_i$ is introduced in [1], its calculation is determined by

$$\tau_i = \frac{1}{\sum_{j=0}^{R} \frac{1-p_i}{1-p_i^{R+1}} P_i^j (1+E[b_j]} \tag{1}$$

Here $E[b_i]$ denotes the average content window size and its range is in the interval of $[0, W_{ij}]$. The $p_i$ denotes the conditional probability of the conflict for the *i*-th traffic flow. Conflict condition includes real and virtual states. Where $W_{ij}$ denotes the *i*-th traffic business in the *j*-th backoff cycle. $E[b_i]$ equals to the $W_{i,j}/2$ and will be approached by the division operation 2 in the next backoff cycle. Therefore,

$$W_{i,j} = \begin{cases} 2^j W_{i,0}, & j \in [0, m'] \\ 2^{m'} W_{i,0}, & j \in [m', m] \end{cases} \tag{2}$$

Here m is the maximal retransmission number and $m'$ is the maximal backoff time number. In addition, $W_{i0} = CW_{\min}[i]$ and $CW_{\max}[i] = 2^{m'} CW_{\min}[i]$.

Let $\tau_i$ be the probability of *i*-th class to send data frames within a given time slot. $\tau_b$ is the probability to send information in the website within the time interval. $p_{it}$ is the detection probability of busy channel for the *i*-th traffic class during the backoff time cycle. The $p_{io}$ indicates as the conflict probability in sending data when the backoff timer is countering to 0.

The next step transition probability in the Markov chain mode is formulated as following:

$$\begin{cases} p\{i,j,k \mid i,j,k+1\} = 1 - p_{it}, & k \in [0, W_{i,j}-2],\ j \in [0,m] \\ p\{i,j,k \mid i,j,k\} = p_{it}, & k \in [0, W_{i,j}-1],\ j \in [0,m] \\ p\{i,j,k \mid i,j-1,0\} = p_{io} / W_{i,j}, & k \in [0, W_{i,j}-1],\ j \in [1,m] \\ p\{i,0,k \mid i,j,0\} = (1-p_{io}) / W_{i,0}, & k \in [0, W_{i,0}-1],\ j \in [0,m-1] \\ p\{i,0,k \mid i,m,0\} = 1 / W_{i,0}, & k \in [0, W_{i,0}-1] \end{cases} \quad (3)$$

This equation displays five possible conditions. $1\text{-}p_{it}$ denotes the probability of the countdown timer in the current traffic state. It keeps in certain level of countdown probability while not detecting the data flow in the network channel. $p_{it}$ is the original probability of countdown timer, which begins to gradually decrease in the uniform interval of idle time. From 3-subequation, the original probability of the *i+1*-th countdown timer is randomly selected in the range of $[0, W_{i,j}-1]$ when the collision is happen at the *i*-th transition state. It presents in the above description of 4-subequation. After the data frame is successfully transformed, the probability of countdown timer for new frame is randomly selected in the range of $[0, W_{i,0}-1]$. If the network channel reaches the maximum count downing number, all traffic flames will be withdrawn. New frames retransmit in the transmission probability of $1 - W_{i,0}$. Based on the internal scheduling algorithm of the EDCA machine in the traffic channel, the delivering probability of the packets is described as formulas:

$$\tau_b = \tau_0 + \tau_1 (1-\tau_0) + \ldots + \tau_{N-1} \prod_{j=0}^{N-2} (1-\tau) \quad (4)$$

The probability formulas of Markov chain model is discussed in the previous formulas. It is shown that the traffic flow in the countdown is idle. The $1\text{-}p_{it}$ is the probability that the other different sites of networks does not send to the traffic flow in this website. The probability $p_{it}$ presents that

$$P_{it} = 1 - (1-t_b)^{n-1} \prod_{h=0, h \neq i}^{N-1} (1-\tau_h) \quad (5)$$

A primary traffic service successfully transmits the network packet when the timer is counting down to 0. The unsuccessful transmission probability is $p_{io}$

$$P_{io} = 1 - (1-t^b)^{n-1} \prod_{h=0}^{i-1} (1-\tau_h) \quad (6)$$

Suppose that

$b_{i,j,k} = \lim_{t \to \infty} P\{s(i,t) = j, b(i,t) = k\}$, it denotes the distributed steady state of the Markov chain model.

Thus,

$$b_{i,j,0} = p_{io}^j b_{i,0,0},\ j \in [0,m] \quad (7)$$

And

$$b_{i,j,k} = \begin{cases} \dfrac{W_{i,j}-k}{W_{i,j}} \dfrac{1}{1-p_{it}} b_{i,j,0}, & k \in [1, W_{i,j}-1] \\ p_{io}^j b_{i,0,0}, & k = 0 \end{cases} \quad (8)$$

The stationary condition is satisfied by

$$\sum_{j=0}^{m} \sum_{k=0}^{W_{i,j}-1} b_{i,j,k} = 1 \quad (9)$$

Therefore, the calculation of $b_{i,0,0}$ denotes as formulas (10),

$$b_{i,0,0} = \begin{cases} \dfrac{2(1-2p_{io})(1-p_{io})(1-p_{it})}{2(1-p_{io}^{m+1})(1-2p_{io})(1-p_{it}) + W_{i0}(1-(2p_{io})^{m'+1})(1-p_{io}) - (1-p_{io}^{m'+1})(1-2p_{io})} \\ \quad + \dfrac{2(1-2p_{io})(1-p_{io})(1-p_{it})}{(1-2p_{io})(2^{m'}W-1)(p_{io}^{m'+1} - p_{io}^{m+1})}, \quad m > m' \\ \dfrac{2(1-2p_{io})(1-p_{io})(1-p_{it})}{2(1-p_{io}^{m+1})(1-2p_{io})(1-p_{it}) + W_{i0}(1-(2p_{io})^{m+1})(1-p_{io})} \\ \quad - \dfrac{2(1-2p_{io})(1-p_{io})(1-p_{it})}{(1-p_{io}^{m+1})(1-2p_{io})}, \quad m \le m' \end{cases} \quad (10)$$

Let the *i*-th class of traffic sending data for a given time slot of the probability ($\tau_i$) presents in the formula (11)

$$b_{i,j,0} = p_{io}^j b_{i,0,0},\ j \in [0,m] \quad (11)$$

$$\tau_i = \sum_{j=0}^{m} b_{i,j,k} = \frac{1-p_{io}^{m+1}}{1-p_{io}} b_{i,0,0} \quad (12)$$

Nonlinear united equations (4), (5), (6), (9) and (10) can be solve to obtain the transmission probability of *i*-th class business $\tau_i$ and the conflict probability $p_{io}$ at the counter zero state**.**

The throughput and time delay analysis is the main evaluated issues in the QoS evaluation module. The definition of throughput means that it is the average transmit rate in the active data for specific traffic business in every time unit. The considered index of throughput for the related *i*-th business is the idle time, successful time and conflict time. The formulas of the throughput are concluded by the following equations in this article:

$$S_i = \frac{P_{si} T_{E(L)}}{\left[\frac{1}{p_b} - 1\right]\delta + \sum_{i=0}^{N-1} p_{si} T_{s,i} + (p_b - p_s) T_c} \tag{13}$$

Here $p_{si}$ is the total successful probability for the i-th business transferring task. $\delta$ denotes the duration time unit. $T_c$ is the largest conflict time. $T_E(L)$ is the transmission duration of valid data. $T_{si}$ is the successful transmission time for the data frames. $T_{c,i}$ is the duration time at the conflict occurrence. $p_s$ is the successful probability of frame transformation. The other parameters are calculated by the following formulas:

$$P_{si} = n\tau_i (1 - P_{io}) = n\tau_i (1 - \tau_b)^{n-1} \prod_{k=0}^{i-1} (1 - \tau_k) \tag{14}$$

$$P_S = \prod_{i=0}^{n-1} P_{si} \tag{15}$$

$$\tau_b = \tau_0 + \tau_1 (1 - \tau_0) + \ldots + \tau_{N-1} \prod_{j=0}^{N-2} (1 - \tau) \tag{16}$$

$$P_b = 1 - (1 - \tau_b)^n \tag{17}$$

$$T_{s,i} = T_H + T_{E(L)} + SIFS + \gamma + T_{ACK} \tag{18}$$

$$T_{c,i} = T_H + T_{E(L^*)} + AIFS[i] + \gamma \tag{19}$$

$T_H$, $T_{E(L)}$ and $T_{ACK}$ are the required time interval of sending header, validated data and acknowledged procedure, respectively.

In the analysis of delay, its definition is the total interval between the starting and confirming state while the data is being delivering at the medium-access-control (MAC) layer.

The package deliver and collision probability is determined by the priority of the same station (STA) incident within the time slot. It can obtain the throughput and time delay within different access level. Based on the study of high priority frame delay by Ziegenhain [18], the time delay analysis of the network traffic is presented in the following formulas [8],

$$E(N_i)(E(X)\delta + E(B_i)(P_s T_{s,i} + (1 - P_s) T_{c,i})) + E(X)\delta + T_{s,i} \tag{20}$$

Where $X_i$ denotes as the sending period for the *i*-th level frame in the network channel. The $E(X_i)$ is the average period of $X_i$. $B_i$ denotes the paused time number within the delivering interval. $N_i$ is the number of retransmission cycle time. *E*(.) is the average function, and $B_i$ denotes the pausing number within the transfer process. $N_i$ is the period number of return cycle. The average of $X_i$ is calculated by

$$E(X_{i)} = \sum_{j=0}^{m} \sum_{k=0}^{W_{i,j}-1} kb_{i,j,k} = \begin{cases} \frac{b_{i,0,0}(W_{i0}^2(1-(4p_{io})^{m'+1}(1-p_{io}) - (1-4p_{io})(1-p_{io}^{m'+1})}{6(1-p_{it})(1-4p_{io})(1-p_{io})} \\ \quad + \frac{(4^{m'}W_{i0}^2 - 1)(1-4p_{io})(p_{io}^{m'+1} - p_{io}^{m+1}))}{6(1-p_{it})(1-4p_{io})(1-p_{io})}, m \geq m'; \\ \frac{b_{i,0,0}(W_{i0}^2(1-(4p_{io})^{m+1}(1-p_{io}) - (1-4p_{io})(1-p_{io}^{m+1}))}{6(1-p_{it})(1-4p_{io})(1-p_{io})}, m < m' \end{cases} \tag{21}$$

where

$$E(B_i) = \frac{E(X_i) p_{it}}{1 - p_{it}}, \tag{22}$$

$$E(N_i) = \sum_{j=0}^{m} j\, p_{io}^j (1 - p_{io}) \tag{23}$$

## 3 Enhanced Parameters Tuning Algorithms

To approach the real-time application service, each type of *ACs* contains its own buffer queue to act as the independent backoff entities and then dynamically regulate three parameters (*CWmin*, *CWmax* and *AIFS*)[4]. Due to the big change of *ACs* number within the variant business in the traffic occupation of the network channel, the adapt parameters tuning algorithm is proposed to reduce the collision probability and achieve the higher QoS even in sending various network topologies. Each internal STA adopts a virtual queue to realize four kinds of ACs before sending the packet data. The STA is assigned to obtain varied *CW's* parameters to simulate its related priority in the competing channel. If two or more queues arrived at the same time, it will possibly generate a collision, which is called a virtual collision. Collusion is always caused the time delay conditions.

The objective of the proposed learning algorithm allows the higher priority of ACs to hold the more opportunities to grab channel's transmission rights. Each category has its own exclusive right of getting data frame within the delivering interval by the appropriate parameters tuning machine. Therefore, each category has its own exclusive right of getting data frame by the randomly generated backoff time parameters, i.e. *CWmin* and *CWmax*. In the EDCA modes, it is listened to the channel conditions before sending the packets to the network. The packages are directly delivered to the network channel if the traffic flow is empty. Otherwise, the process enters the backoff time cycle. The backoff time slots will be randomly chosen within the range of interval [*0*, *CW-1*]. The *CW's* initial default value is *CWmin*, the next *CW's* value is doubled until *CWmax* at every occurrence of a collision. The number of Backoff timer is discounted by 1 time slot while detecting an idle state. Packages engage the channel bandwidth if backoff countering time is equal to 0. The higher priority packets can take the superior sending right if two or more AC backoff timer counts into 0 at the same time. If the channel is detected idle for a period of time that is equal to the arbitration inter frame space (AIFS), the STA transmits to start the backoff time cycle. Otherwise, the network flow is busy in the channel to be continuously monitored the traffic flow until the idle time is equal to the length of *AIFS*. The *AIFS* of *AC* is denotes as *AIFS*[*AC*]. Similarly, *CWmin* and *CWmax* are indicated as *CWmin*[*AC*] and *CWmax*[*AC*] for the discussed *ACs* samples, respectively. In general, different STAs present various admitted time (AT) based on the topology of network type. In some command sense, the shortest backoff time of *ACs* can get the great media accessing right. Chio introduces the regulating number of AIFS (AISFN) to improve the transmission rate [18]. The AIFS is determined by Eq. (24)

$$AIFS = SIFS + AIFSN[AC] * aSlotTime \quad (24)$$

The *AIFS* can be dynamically adjusted based on the AT value to reduce the collision probability.

The network transmission model of Xiao [19-20] doesn't consider the impact of internal scheduling scheme. Thus, its disadvantage is not giving the detailed EDCA function of the 802.11e. In the EDCA mode of Fig.2, each category has its own exclusive right of getting data frame in the interval time with the adjustable time parameters, i.e. *CWmin* and *CWmax*. In this case, *CW's* initial value is setting as *CWmin*, and the next *CW's* value is increased one unit until arriving the *CWmax* when it meets the collision.

An appropriate parameter tuning machine acts an important role for approaching the great WLAN global system performance. In general, the smaller *AIFSN* value gets higher probability to obtain the transmission rights.

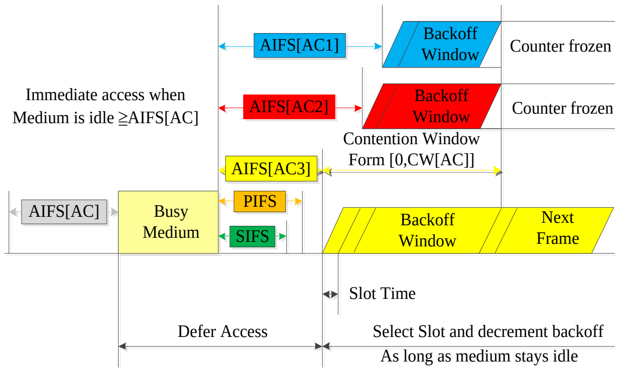


**Fig. 2.** IEEE802.11e EDCA operations

The concept of the enhanced parameters tuning (EPT) algorithm is proposed to randomly generate some intervals of time window (TW) with the following formula:

$$BackoffTime = Random(CW_{min}[ACi], CW_{max}[ACi]) * aSlotTime \quad (25)$$

Where $CW[ACi]$ is the adjustable contention window size, *aSlotTime* denotes as the time slot size and $Random(CW_{min}[ACi], CW_{max}[ACi]) * aSlotTime$ are the range of minimal and maximal time window size in the random generation. If the package transmission fails, the size of TW is required to be modified to avoid the recurrent probability of collision. The *CW's* parameters are proposed to be regulated based on the variant *AC* channel of occupancy rate. A suitable parameter adjustment of *CW* and the appropriate $CW[ACi]_{min}$ and $CW[ACi]_{max}$ selections are proposed to ensure the high-priority priority of business flow, which can improve the efficiency of accessing to the network channels.

The concept of sustainable factor (Per-sistence Factor, PF) is applied in this cross-layer regulation algorithm. The regulation of available window size is related to the variant of Traffic Categories (TC) value. Based on the priority regulating mechanism, the small $PF[TC]$ and $CW[ACi]$ values contain the high accessing priority. In a word, the smaller regulation algorithm index results the higher priority in accessing the network channel. The new *CW* is updated by the respective output value of $PF[TC]$ function in the following equation:

$$CW_{new} = (CW_{old} + 1) * PF[TC] - 1 \quad (26)$$

When the $CW$ values of traffic business is countering down 0 at the same network channel, the probability of traffic collision is happen. The scheme of transmission opportunity (TXOP) is proposed in the article to avoid this problem. The queue holds the higher level TXOP can achieve the better priority to send and receive the data package. The TXOP scheduler of each queue is adjusted by the specific priority theory to allocate and tune the token right in several applications [1, 8].

This paper presents a mathematical probability procedure by the Markov model chain analyses to simulate the package travelling behaviours. The study proposed a cross-layer based enhanced parameters tuning (ECP) algorithm by tuning three parameters of *CWmin*, *CWmax* and AIFS to achieve the appropriate performance models. The objective of ECP algorithm determines to adjust the parameters sizes in stabilizing the network channel load of the traffic business. Traffic flows of the business load are evaluated from all the access points (AP) in the disposing topology of the wireless network. An appropriate $CW[ACi]$ size can be selected by the ECP and then the information of $CW[ACi]$ is broadcasted into the internal points in the network channel. The competitive length of the packages by the mean of $CW[ACi]$ can be adapted to fairly balance the flow utilization in the heavy wireless network channel. The proposed algorithm monitors the network throughput by the evaluation of load change from the dynamic routing environments. Due to the increasing probability of network collision problem, the initial length of delivering queue is not directly resetting as *CWmin* after the frame is successfully completed in the package transmitted cycle. The queue length is gradually decreased by the steps of $CW[ACi]/3$.

The ECP algorithm with the on-line regulation machine of $CW[ACi]$ to determine the variance of network flow. Their learning steps are described as follows:

1st) Set each initial queue length of the related i-th CW[ACi] as $CW_{\min}[ACi]$.

2nd) Increase the CW[ACi] value when detecting the collision in network channel until the maximal value ($CW_{\max}[ACi]$), the new $CW[ACi]$ is modified by the following formula:

$$CW_{new}[ACi] = \min(CW_{\max}[ACi], (CW[ACi]+1)*2-1 \quad (27)$$

3rd) Regulate the next $CW[ACi]$ with the linear reducing scaling factor (0.5) by the following formula when the traffic flow is successfully transmitted,

$$CW_{new}[ACi] = \max(CW_{\min}[ACi], 0.5*(CW[ACi]+1)) \quad (28)$$

In the concept of learning algorithm, the adopted random early detection (RED) scheme presents to make a great congestion control method to efficiently avoid the condition of queue collision. The optimal queue managed algorithm is by

$$qlen(AC[i]) = (1-Wi)qlen(AC[i]-1) + Wi * Qt(n) \quad (29)$$

Where $qlen(AC[i])$ and $qlen(AC[i])-1$ are average queue length. The $Wi$ is denoted as the average weight factor. $Qt(n)$ is the current amount of queue size. The flow probability of the best data sending type calculates as follows:

$$\Pr ob_{AC[i]}\_Best = \begin{cases} 0; & qlen(AC[i]) < Threshold_{low} \\ 1; & qlen(AC[i]) > Threshold_{high} \\ \dfrac{qlen(AC[i]) - Threshold\_{low}}{Threshold_{high} - Threshold_{low}} Threshold_{p}; & \\ \quad \text{where } Threshold_{low} \le qlen(AC[i]) \le Threshold_{high} & \end{cases} \quad (30)$$

where $Threshold_{low}$ and $Threshold_{high}$ are been assigned as the threshold for the minimal and maximal sizes of queue length. The $Threshold_{p}$ is the possible extensive probability of falling down action. Based on the previous probability of the obtained value, the new probability for the next sending media of $AC[3]$ is mapped by the next formula,

$$\Pr ob_{AC[3]}\_New = \Pr ob\_TYPE * \frac{qlen(AC[3]) - Threshold\_low}{Threshold\_high - Threshold\_low} \quad (31)$$

In this case, the $AC[3]$ type data set is directly acquired the token right to be sent to.

## 4 Simulations Results

All the performance analysis and network simulation of the proposed implementation is based on the network assumption. The network channel is setting at the ideal environment and also keeping in the saturated state, i.e. no hidden nodes, no third-party interception of ideal channel conditions, without reference to the channel bit error rate, signal attenuation and other factors. The general characteristics are suitable for the IEEE 802 standard. Any agreement body of the IEEE 802.11 ensures the deployment in the MAC and PHY layers. Parameter settings are shown in Table 1.

Table1: MAC/PHY parameters

| Parameters | Values | Parameters | Values |
|---|---|---|---|
| $PHY_{header}$/byte | 24 | ACK/*byte* | 14 |
| $MAC_{header}$/byte | 34 | CWmin | 32 |
| Slot_time/µs | 20 | CWmax | 1024 |
| SIFS/µs | 10 | Short Retry Limit | 7 |
| DIFS/µs | 50 | Long Retry Limit | 4 |
| RTS/byte | 20 | Packet size/byte | 1500 |
| CTS/byte | 14 | | |

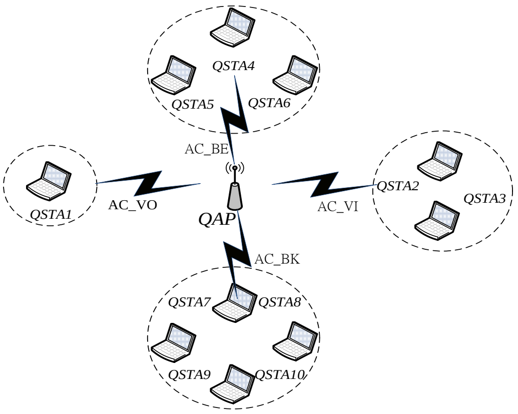


**Fig. 3.** Simulation environments.

In our simulated environments of Fig. 3, a QAP with 10 wireless stations are present in the Fig.2. Detail experiments settings are described in the others searches [7, 10, 12]. Total 10 stations support four business streams, AC_VO * 1, AC_VI * 2, AC_BE * 3 and AC_BK * 4, in this experiment. Ten transferred scenes, no.1 to no.10, are continuously delivering in the duration of 300 seconds.

In case one study, all parameters are setting by the default standard of 802.11e. Three illustrated examples are proposed to demonstrate the variance of traffic flow by various parameters settings of AIFS, *CWmin* and *CWmax*. Detail parameters settings are described in Table2.

Table2: Parameters settings for AIFS, CWmin and CWmax in various parameters setting Case.

| **Examp.** | **Paramenter** | **AC_BK** | **AC_BE** | **AC_VI** | **AC_VO** |
|---|---|---|---|---|---|
| **No.1** | AIFS | 7 | 3 | 2 | 2 |
| | CWmin | 31 | 31 | 15 | 7 |
| | CWmax | 1023 | 1023 | 31 | 15 |
| **No.2** | AIFS | 8 | 6 | 4 | 2 |
| | CWmin | 31 | 31 | 31 | 31 |
| | CWmax | 1023 | 1023 | 1023 | 1023 |
| **No.3** | AIFS | 2 | 2 | 2 | 2 |
| | CWmin | 31 | 31 | 15 | 7 |
| | CWmax | 1023 | 1023 | 31 | 15 |

The parameters selections of this case are the IEEE 802.11 standard. Fig.4a. shows the simulated throughputs rate of the AC_VO, AC_VI, AC_BE and AC_BK in this example 1. It presents that the AC_VO is the highest-priority service point to obtain the large throughputs. The AC_BK contains the lowest throughputs in this case. The throughput response for this selected parameters model is gradually decreased with respect to the increasing station number. The system saturation of total throughputs is approaching to 80% when the station is 10. Fig.4b. shows the simulated accessing delay in the same case 1. The result presents that the higher priority service point determine the lower accessing delay. This experiment proves that the proposed simulation model conform the condition of IEEE 802.11 standard.

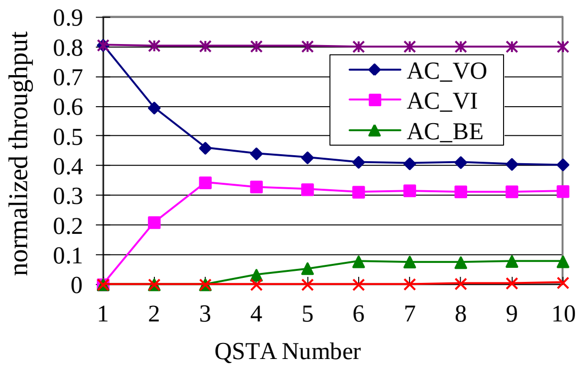


**Fig. 4a.** Throughputs vis. station number in example 1.

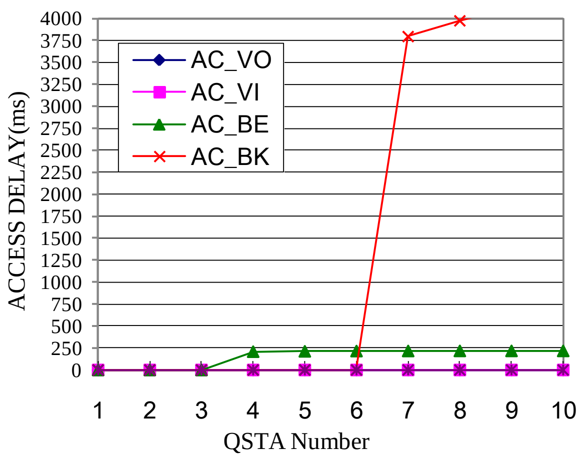


**Fig. 4b**. Access time delay vis. station number in example 1.

In the results of example 2, New parameters settings of AIFS, *CWmin* and *CWmax* illustrate that we select the same *CWmin* and *CWmax* parameters values and compare the effect of various AIFS values. The new *CW* values is adjusted the AC_VI and AC_VO setting, which can avoid the collision probability of AC_BK and AC_BE. From the simulation of Fig.5a, the throughputs of the AC_VI and AC_VO are rapidly decreased with the increasing number of wireless station. Fig.5b is the related time delay response to show the loss advtangeous of AC_VI and AC_VO. This affection shows that the parameters settings of the AC_VI and AC_VO obtain the shrinking performance in the throughputs rate. Therefore, the access time delay is gradually raised due to the large wireless station number.

In the experiment of example 3, system selects the small and same AIFS value for such different AC-types businesses. The combination of *CWmin* and *CWmax* parameters are proposed to show their simulations in traffic flow comparison of four businesses. The smaller AIFS value is better for AC_BK type data even in the higher wireless station. The plotted responses for the AC_VI is determined a conclusion that the large *CWmin* and *CWmax* values for the AC_VI business lead to the lower throughputs in Fig.6a.

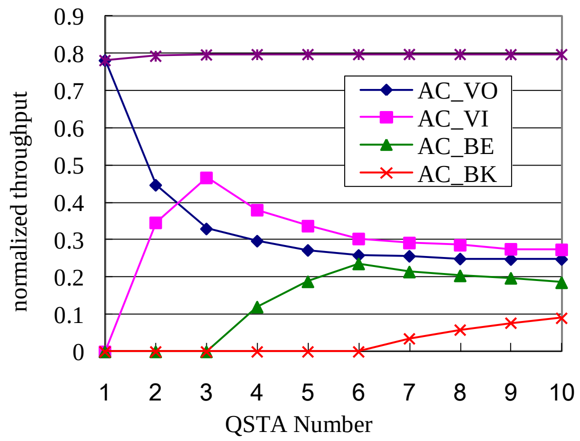


**Fig. 5a**. Throughputs vis. station number in example 2.

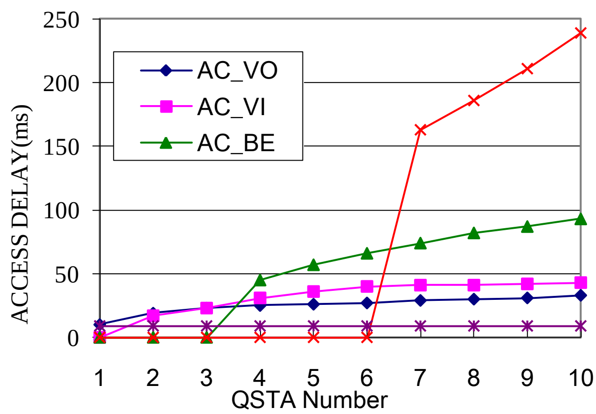


**Fig. 5b**. Access time delay vis. station number in example 2.

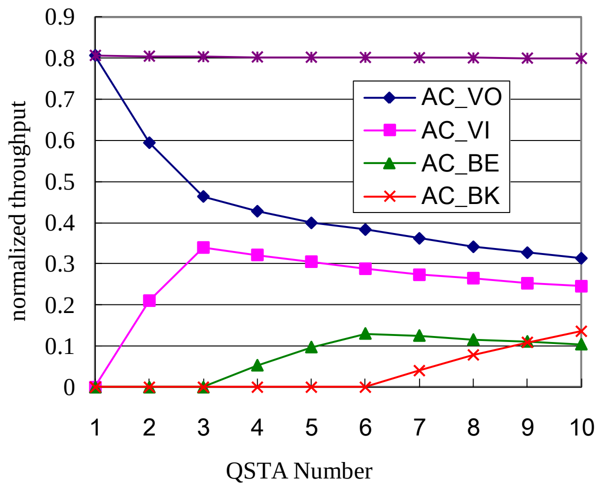


**Fig. 6a**. Throughputs vis. station number in example 3.

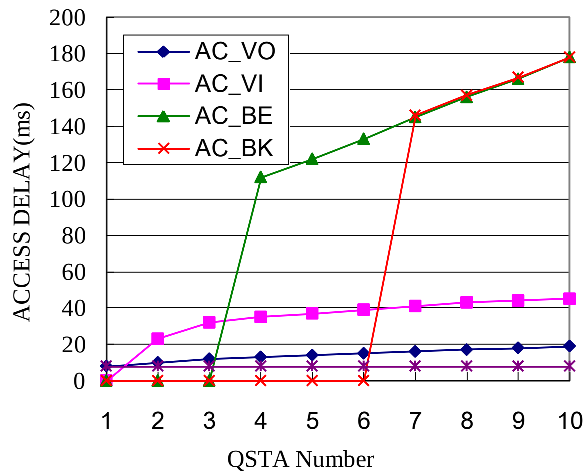


**Fig. 6b.** Access time delay vis. station number in example 3.

In the plot of Fig. 6b, it shows the detail response for the accessing time delay vis. station number. The smaller AIFS value causes the AC_BE business obtains a large accessing time delay when the number of wireless station is becoming a bigger one. The simulations show that parameter AIFS can make a large variance in the performance affection than the parameters *CWmin* and *CWmax*.

Example 4 is the study of case two, the *CWmin* and *CWmax* are constant values of 31 and 1023, respectively. The variant variable of AIFS is selected by the testing procedure in this experiment. The AIFS is being a constant 2 for AC_VO, variant tuning values for AC_VI are (2. 4… 20), (2, 5... 29) are selected for AC_BE and (2, 6, …, 38) for AC_BK. The plot of Fig.7a shows the simulated throughputs of the AC_VO, AC_VI, AC_BE and AC_BK in case 1. The AC_VO holds the smallest AIFS to approach the highest-priority service with the large throughputs. The AC_BK stream obtains the biggest AIFS to cause the lowest throughputs. The related simulations of time delay are present in the Fig.7b. The simulated graphic trace presents that the flow stream has the higher priority to achieve the lower time delay.

Table3: Parameters settings for AIFS, CWmin and CWmax in differential settings.

| Examp. | Parameter | AC_BK | AC_BE | AC_VI | AC_VO |
|---|---|---|---|---|---|
| No. 4 | AIFS<br>CWmin<br>CWmax | 7<br>31<br>1023 | 3<br>31<br>1023 | 2<br>15<br>31 | 2<br>7<br>15 |
| No. 5 | AIFS<br>CWmin<br>CWmax | 8<br>31<br>1023 | 6<br>31<br>1023 | 4<br>31<br>1023 | 2<br>31<br>1023 |
| No.6 | AIFS<br>CWmin<br>CWmax | 2<br>31<br>1023 | 2<br>31<br>1023 | 2<br>15<br>31 | 2<br>7<br>15 |

In the simulation of example 4 study, various parameters settings of AIFS, *CWmin* and *CWmax* illustrate that the AIFS is constant 2 and *CWmax*=1023. The vary *CWmin* parameters are proposed to show the effect of business traffic. The AC_VO setting of *CWmin* is the small 31 value. The *CWmin* setting of AC_VI is (31, 33, …, 49), AC_BE is (31, 34, …, 58) and AC_BK is (31,35, …, 67). In the illustration of Fig.8a, the variant *CWmin* let the throughputs of the AC_VI, AC_BE and AC_BK go down with the related increment of *CWmin*. The AC_VO present the better throughput in opposition to the smaller *CWmin*. The simulated time delays responses of AC_VO, AC_VI, AC_BE and AC_BK are shown in Fig.8b. This simulation also presents that the affection of bigger *CWmin* let AC_BK causes the large time delays when meets the big number of wireless station.

In the experiment of example 6, AC_VO obtain the small and same AIFS and *CWmin* values. Set three different AC-types businesses of AC_VI, AC_BE and AC_BK with the gradual increased steps of 2, 3, and 4. This experiment can be considered as the combination of example 4 and example 5. Simulation for throughputs and time delays response are presented in Fig.9a and Fig.9b, respectively. Simulations of the throughputs and time delays shows that example 6 and example 4 contain the most similar trends. This result demonstrates that AIFS can give more effects in performance of traffic flow. The simulations show that parameter AIFS can make a large variance in the performance affection than the parameters *CWmin* and *CWmax*.

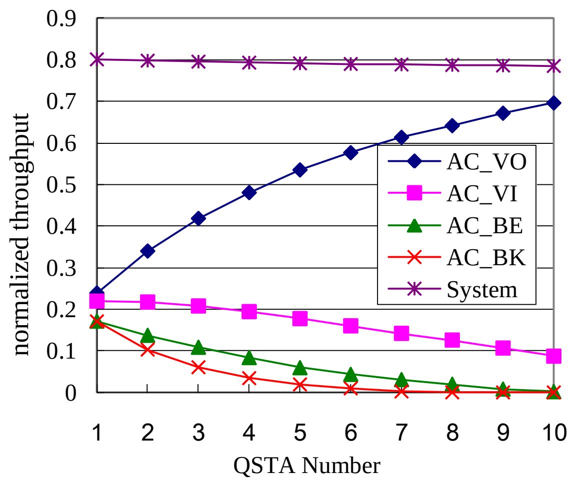


**Fig. 7a.** Throughputs vis. station number in example 4.

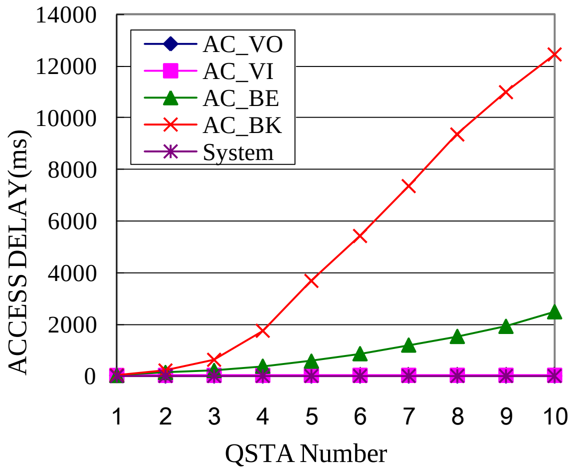


**Fig. 7b.** Access time delay vis. station number in example 4.

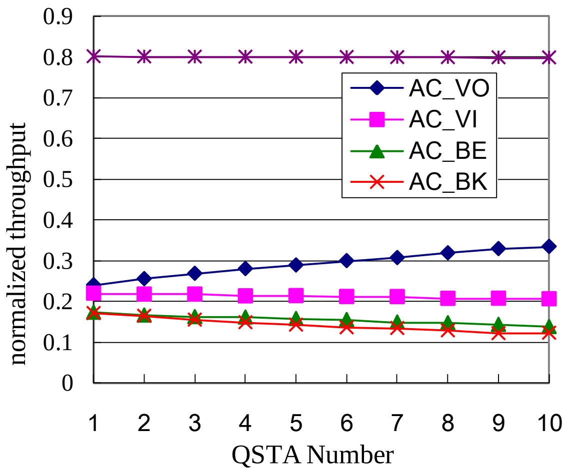


**Fig. 8a.** Throughputs vis. station number in example 5.

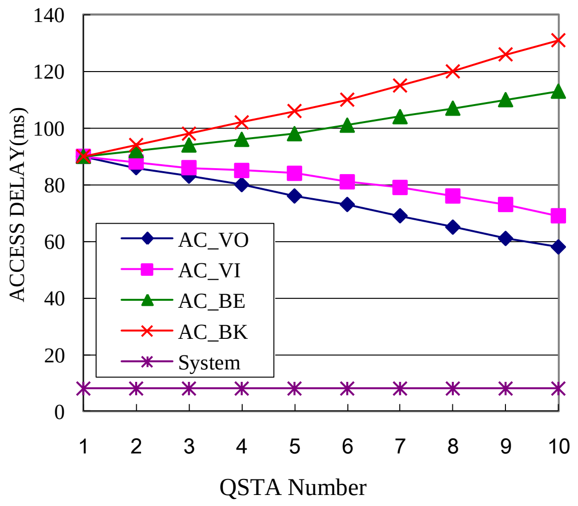


**Fig. 8b.** Access time delay vis. station number in example 5.

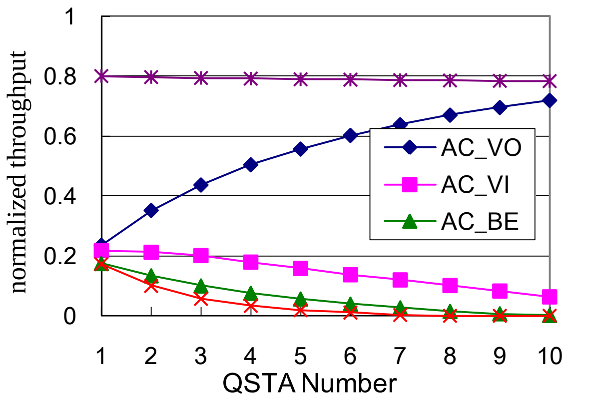


**Fig. 9a.** Throughputs vis. station number in example 6.

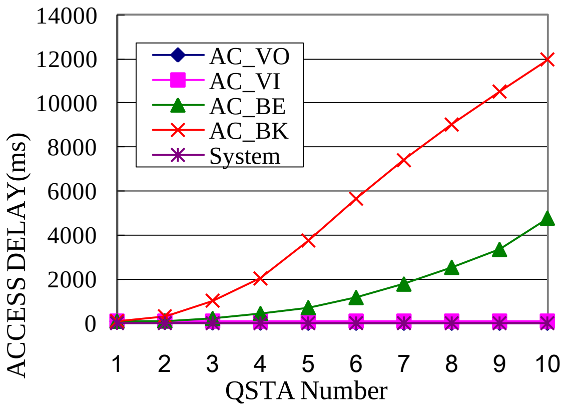


**Fig. 9b.** Access time delay vis. station number in example 6.

In the last parameter tanning simulation, the EPT algorithm compared the EDCA model by the regulation of three available parameters in the same environment. Simulations results for throughput and time delay are separately illustrated in Fig.10a and Fig.10b. The EPT algorithm can obviously approach the better throughputs for the related businesses channels of AC_VO and AC_VI, respectively. Total throughputs in the summation of AC_BK, AC_BE, AC_VI and AC_VO for ATFT and EDCA also present that the EPT algorithm achieves the better throughput than the EDCA mode in the separated traffic flows of business.

Time delay experiments of four traffic flows (AC_BK, AC_BE, AC_VI and AC_VO) are illustrated in Fig.11. In the Fig.11a, the delay response for AC_VO type package show the proposed EPT learning scheme can approach the great performance in keeping the lower time delay even meeting the more accessing station conditions. The EPT method offers the smaller time delay in the testing of AC_VI traffic flow by the left down response of Fig.11b. Simulation shows that the EPT algorithm with the adaptive tuning ability can solve the complicated large accessing connection problems and satisfy the real-time image and voice transferring services. The AC_BK and AC_BE data type delivering experiments are shown in Fig.11c and Fig.11d, respectively. The EPT algorithm also obtains the higher performance than EDCA mode due to the lower time delay response is our experiments.

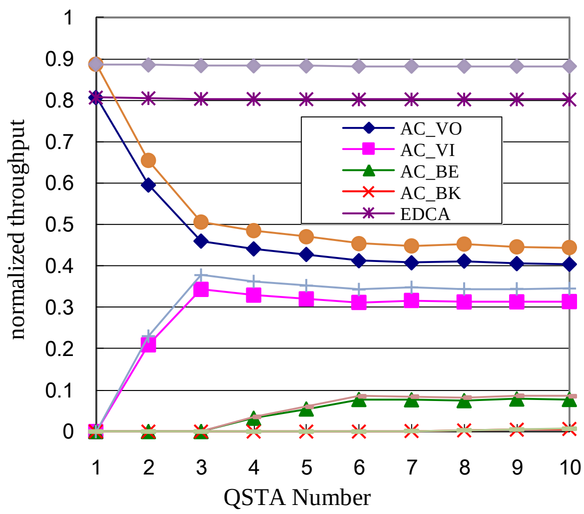


**Fig. 10a.** performance analysis of throughput by EPT and EDCA

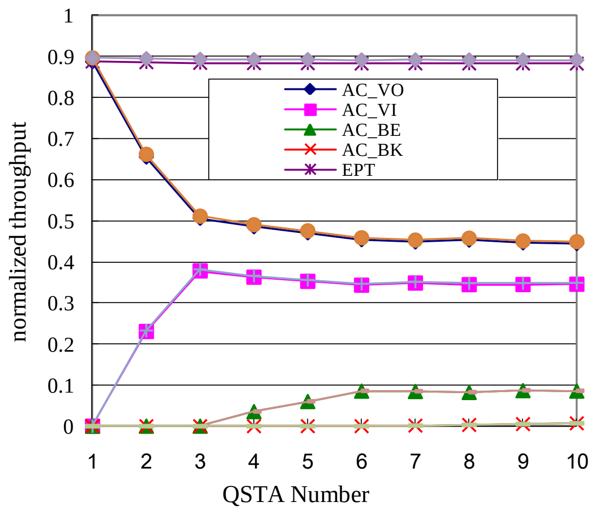


**Fig. 10b.** performance analysis of delay by EPT and EDCA

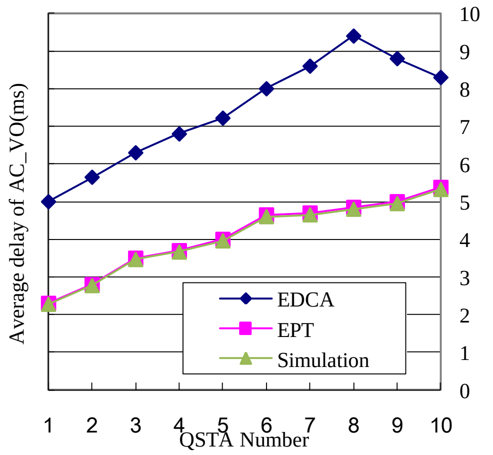


Fig. 11(a)

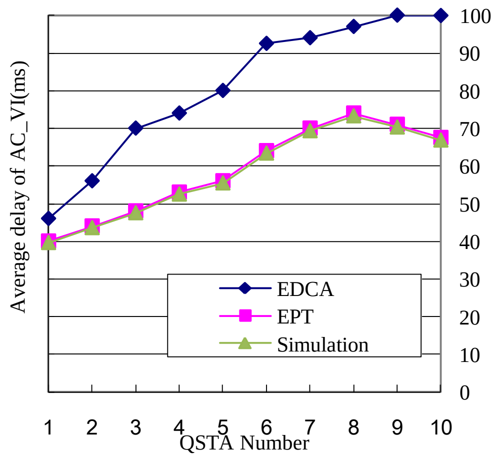


Fig. 11(b)

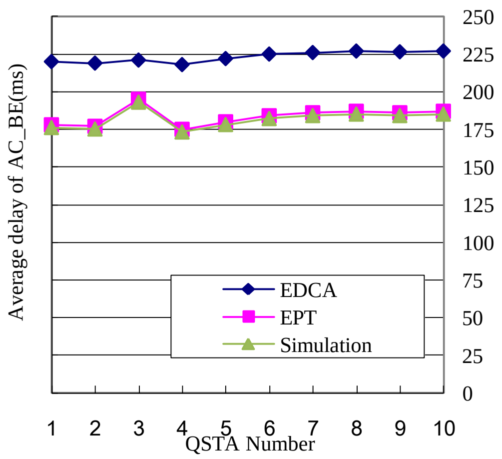


Fig. 11(c)

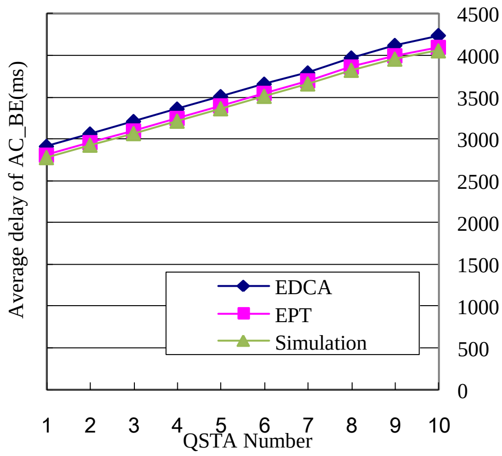


Fig.11(d)

**Fig. 11.** Performance analysis of delay in four businesses AC_VO AC_VI, AC_BE, and AC_BK.

In this study, the proposed EPT algorithm is adapted to regulate these available parameters to approach the better performance of throughputs and time delay in the four traffic channel of AC_BK, AC_BE, AC_VI and AC_VO business. The simulations show that the improved EPT algorithm achieves the better stability results in the large amount of AC_VI and AC_VO data delivering applications.

## 5 Conclusions

In this study, the EPT tuning algorithm is proposed with the simple and effective adjustment in the priority combinations strategy to achieve the high quality of service (QoS). The algorithm performs the adapt regulation machine by the isolation of different business flows. This experiment is based on the EDCA model to simulate the network connection and traffic flow response in several differential conditions. Simulations also present the great transmitted performance in the large amount of data delivering type applications. The proposed EPT is proposed to dynamically regulate the CWs size and *ACs* number based on the evaluation of the network flow loading. The contribution of the design EPT algorithm is proposed to reduce the collision problem in the delivering channel to improve throughput in differential priority which can approach the global QoS performance in the EDCA module.

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