# Analysis of Internal Collision and Dropping Packets Characteristics of EDCA IEEE802.11e Using NS-2.34 Simulator

A. S. M. Tariq and K. Perveen

*Abstract*— **Enhanced Distributed Channel Access (EDCA) is designed to provide quality of service (QoS) support enhanced on conventional IEEE 802.11 wireless local area network (WLAN). However, One of the main challenge is to proper tuning of EDCA medium access control(MAC) parameters for QoS requirements, namely arbitration inter frame space (AIFS), contention window (CW) and transmission opportunity (TXOP). Fundamentally, queue mapping of Access Categories (AC) are divided into four. As a result, an unsuccessful transmission (in other words, a collision) is experienced due to same independent backoff value within the station or with other stations. To reduce the probability of the stations colliding again, apposite tuning of EDCA MAC parameters and analysis of dropping packets is presented in this paper. The NS-2 based simulation results show firstly, the service differentiation and prioritization of EDCA. Secondly, we analyze the internal collision possibilities among access categories with dropping packets characterization.**

*Index Terms*— **Access categories, enhanced distributed channel access, fairness, quality of Service, 802.11e.**

## I. INTRODUCTION

Wireless local area network is now highly acceptable at home and office due to high speed and guarantee of successful transmission. User applications and multimedia transmission is vastly demandable such voice, video streaming. High bandwidth intensive applications are not extensively supported in IEEE802.11 standard MAC and physical layer, which uses Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA) as the main MAC protocol. In term of qualitative and quantitative characteristics Quality of Service (QoS), a new extension of the IEEE 802.11 distributed coordination function (DCF) mechanism, enhanced version IEEE 802.11e standard is recently published, which is based on service differentiation and supports QoS requirements for user perspective.

The paper is organized as follows: we first give an overview of the access mechanism of EDCA as well as transmission procedures. We present collision problems among ACs and analyzed the characteristics of dropping packets using NS-2.34 simulator. Finally, we simulate the performance of EDCA IEEE802.11e including modification of EDCA parameters compare to standard one. External collision is not considered in this simulation scenario.

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## II. IEEE802.11E EDCA

EDCA (Enhanced Distributed Channel Access) is specified to provide Service Differentiation and Prioritization Mechanism. Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA) and slotted Binary Exponential Back-off (BEB) mechanism are the basic access method of IEEE802.11e EDCA. Standard differentiation of Access Categories (AC's) are best effort (AC_3), background (AC_2), video (AC_1) and voice (AC_0). AC based traffic prioritization is implemented by using a combination of AC specific parameters, which include contention window (CW) size, arbitration interframe space(AIFS), and transmission opportunity (TXOP) limit differentiations. Contention window size defined as minimum contention window size ($CW_{min}$), the maximum contention window size ($CW_{max}$). Stations that use smaller $CW_{min}$ and $CW_{max}$ receive higher QoS than the lower one. In EDCA, AIFS is used instead of DIFS, where AIFS≥DIFS. AIFSN refers to length of the AIFS. Stations that use lower AIFS encounter fewer collisions and countdown the backoff counter faster than the other stations; hence, they receive better QoS. In addition, a Transmit Opportunity (TXOP) limit supports MAC-level QoS and prioritization [1].

### A. *Description of EDCAF*

An EDCAF (Enhanced Distributed Channel Access Function) contends for medium based on the following parameters associated to an AC: AIFS - The time period the medium is sensed idle before the transmission or backoff is started. $CW_{min}$, $CW_{max}$ - Size of Contention Window used for backoff. TXOPLimit - The maximum duration of the transmission after the medium is acquired. Fig. 1 represents each individual AC queues. Each queue has own different $CW_{min}$, $CW_{max}$, and AIFS. To achieve differentiation, instead of using fixed DIFS (Distributed Interframe Space), AIFS used to influence the successful transmission probability (statistically) in favor of high-priority ACs [3]. The AC with the smallest AIFS has the highest priority, and a station needs to defer for its corresponding AIFS interval. The smaller the parameter values (AIFS, $CW_{min}$ and $CW_{max}$) the greater the probability of gaining access to the medium [2]. Individual virtual station contends for access to the medium and

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independently starts its back-off procedure after detecting the channel being idle for at least an AIFS period. The back-off procedure of each AC is the same as that of DCF.

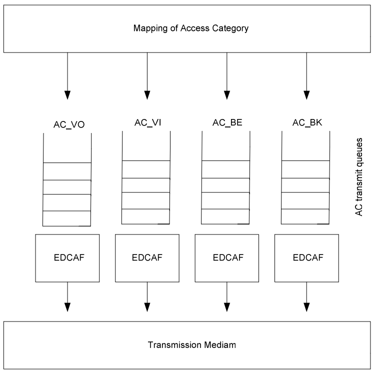


Figure 1: EDCA AC transmit queues

Moreover, IEEE 802.11e EDCA defines a time interval in which a particular station can initiate transmissions called transmission opportunity limit (TXOPlimit) [8]. During this period, stations are allowed to transmit multiple data frames from the same access categories (ACs) continuously within the time limit defined by TXOPlimit. In 802.11e EDCA the higher priority ACs have a longer TXOPlimit, while lower priority ACs have a shorter TXOPlimit.

## III. EDCA COLLISIONS

Higher priority ACs has small contention window that is the reason they suffer from higher collisions. Two types of collision can be experienced [1].

### *A. Internal collision*

Every AC in the single station can act as a virtual station and transmit whenever channel is idle. When more than one EDCAF in the same station count their back-off timers to zero and try to transmit at the same time, it leads to a situation referred to as internal collision or virtual collision. In such situation, the access to the medium is granted to the EDCAF for the highest priority AC among the colliding EDCAFs, and the lower priority colliding EDCAF doubles its Contention Window and back-off, similar to an external collision.

### *B. External collision*

An external collision occurs if back-off timers of the EDCAFs at two or more stations reach zero at the same time and win access to the medium. After the external collision the colliding EDCAFs double their Contention Windows as original standard and choose new back-off values, and the rest of the EDCAFs retain their paused back-off timers.

## IV. SIMULATION TOPOLOGY

To evaluate the performance of IEEE 802.11e, a widely adopted Network Simulator NS-2.34 is used. This simulation package includes IEEE802.11e patch [7] and MPEG4 patch [6]. There are two simulation scenario is presented here. First one is standard EDCA parameters and second one is modified version concerning the impact of using different AIFSs and different CW sizes on network performance. The common topology consist adhoc wireless network with number of stations as illustrated in Fig.2. The common platform for both scenarios is, received traffic quality at node 1 and dropping packets at node 0 where node 0 is sending packets with different priority queue. Traffic flows is randomly generated and transmitted over the entire simulation environment. Four ACs are used in the simulation and their parameters are consistent. The AODV (Adhoc On Demand Vector) protocol, available in NS2.34, uses dynamic routing in order to deliver packets to any destination in an adhoc mode. However, transmission power is set such that stations are within each other's transmission range. In these simulation, Stations placement static, RTS/CTS disabled, fragmentation of frame is disabled, Two-Ray propagation path loss model is used, traffic/application types are configured as AC_VO(RealAudio, which is built-in in NS-2.34 package[13]), AC_VI (MPEG4, which is patch file), AC_BE (CBR), and AC_BK (FTP). UDP is implemented as the Transport layer protocol for all traffic except AC_BK. The size of each AC transmit queue is 50 frames. The CFB (common frame burst) functionality is disabled, i.e., only one data frame is allowed to be transmitted after the medium is acquired.

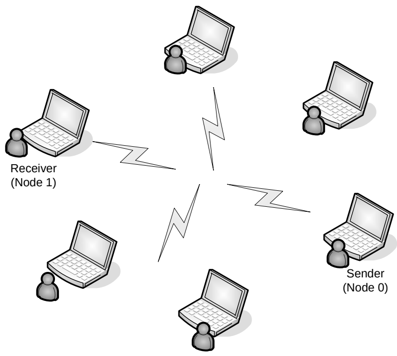


Figure 2: Wireless simulation scenario

### *A. Simulation Parameters for Scenario 1*

In the first scenario, four ACs, i.e., voice, video, best effort and background are used. The simulation parameter is designed to investigate the effect of using different CW sizes are used by ACs respectively (see Table I). Each AC has its own buffered queue and behaves as an independent backoff entity. The priority among ACs is then determined by AC-specific parameters. For RealAudio traffic, packet size 160 byte, idle time 1800ms and burst time 0.05ms is used. For MPEG4, video traffic is being transmitted as rate factor 1 and initial seed 0.5 where rate factor is how much we need to scale up or down of video and initial seed is start generating the first frame during simulation(see Table II). IEEE802.11e

TABLE I
IEEE802.11E STANDARD EDCA PARAMETERS

| Priority | Traffic | AIFS | CWmin | CWmax | TXOPlimit |
|---|---|---|---|---|---|
| 0 | Voice | 2 | 7 | 15 | 0.003008 |
| 1 | Video | 2 | 15 | 31 | 0.006016 |
| 2 | Best Effort | 3 | 31 | 1023 | 0 |
| 3 | Background | 7 | 31 | 1023 | 0 |

EDCA standard parameters are selected for simulation scenario 1. Traffics are used Real Audio, MPEG4[a], CBR[a], TCP[a] according to priority level.

[a]Different traffics ; MPEG4 = Moving Picture Experts Group, CBR = constant bit rat, TCP = Transmission Control Protocol.

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basic transmission data rate is 1Mbps considered as default bandwidth of wireless link.

TABLE II
SIMULATION PARAMETERS FOR NS-2.34

| Priority | Traffic | Packet size(byte) | Data Rate |
|---|---|---|---|
| 0 | RealAudio | 160 | 2Kbps |
| 1 | MPEG4 | 21-1020 | 30 frame/sec |
| 2 | CBR | 200 | 125Kbps |
| 3 | TCP | 40-1040 | Default |

### *B. Simulation Parameters for Scenario 2*

In the scenario 2, the MAC parameters of IEEE802.11e has been changed considering more prioritization of higher priority access category such as voice and less prioritized of data oriented access category such as TCP. The modified service differentiation and prioritization parameters have been set for each queue (see Table III). However, less TXOP means less channel access opportunity. Moreover, static backoff value 7 is set for RealAudio which gives high priority than others (see Table III). More intention is to analysis of dropping packets of the simulation scenario.

TABLE III
MODIFIED IEEE802.11E EDCA PARAMETERS

| Priority | Traffic | AIFS | CWmin | CWmax | TXOPlimit |
|---|---|---|---|---|---|
| 0 | RealAudio | 2 | 7 | 7 | 0 |
| 1 | MPEG4 | 4 | 10 | 31 | 0 |
| 2 | CBR | 7 | 15 | 255 | 0 |
| 3 | TCP | 7 | 31 | 1023 | 0 |

## V. SIMULATION RESULT

We run experiments with two stations, where station 0 is sending packets with different queuing parameters. Fig. 2 shows the average, max, and min throughput of each queue considering scenario 1. Our simulations follow the assumptions as described above in section IV. In addition, the arrival model for the simulations is Poisson process and each station can keep only one data frame in its local MAC buffer. The figure also shows service differentiations while different traffic such as Audio, Video, CBR, and TCP are transmitted. Fig 3 also shows the average, max, and min throughput of each queue considering scenario 2 considering other parameters like transmission rate, fragmentation threshold as default.

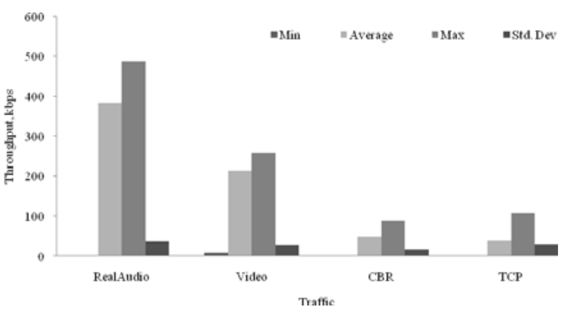


Figure 3: Simulation result of scenario 1

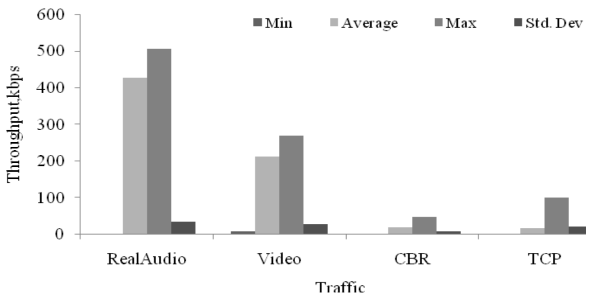


Figure 4: Simulation result of scenario 2

## VI. SIMULATION ANALYSIS

As described above, internal collusion occurs when more than one EDCAF count their backoff timers to zero within the same station. After internal collision among categories, the highest priority traffic can get immediate channel access. Lower priority traffic use following approach

$$CW_{new}^{i} = 2 \times CW_{max}^{i} \text{ where } i \text{ is } 0 \ldots 3$$

Then it starts new backoff value in order to avoid further collisions [3]. This means that dropping packets of lower priority will be retransmitted. Consequently, traffics will be highly dropped with low CW size. Another problem we can introduce, all queues of the same station must have equal channel access probability. As a result, lower priority traffic is mostly affected by higher traffic after internal collision described in EDCA's internal collision management.

The first scenario presents the average throughput results for all four ACs, and the effectiveness of QoS scheme realized by introducing different ACs for data traffic of different priorities. We conclude that the EDCA is able to provide service differentiation between different types of traffic flows. Moreover, the higher priority traffic streams are better served than lower priority traffic streams as well as the high priority stations have larger bandwidth share. As a result, the throughput of the RealAudio much higher than low priority access category (BE and BK) in a context of reducing its contention window size. A number of packets are dropped in case of RealAudio which decreases real-time performance and increase its delay compare to lower priority streams.

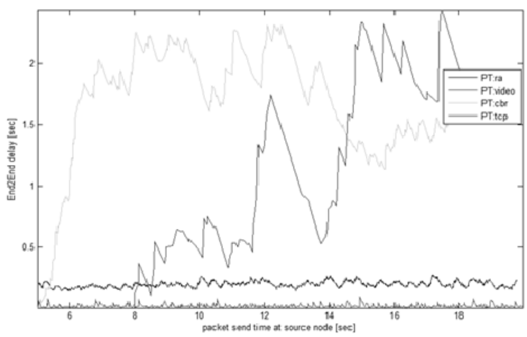


Figure 5: End2End delay of Scenario 1

Fig. 5 shows end to end delay for all four ACs. This figure shows the evidence of delay differentiation capability of

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EDCA mechanism. The delay differentiation is observed at high priority traffic, which is low. Therefore, high priority stations such as RealAudio and Video can transmit after shorter waiting period caused by lower contention window with the expense of high delay for the low priority.

The second approach also provides throughput differentiation. The average throughput of higher priority traffic such as RealAudio in the context of reducing contention window size shown in Fig.4.This figure also shows collision probabilities among ACs become affected. In other words, throughput of BE (CBR) decreases and increases dropping packets, caused by internal collision probability. This is due to increase the collision probability, by reducing the size of its contention window (min and max) and increasing AIFS. So, this modified scheme introduces collision probability dependency with contention window size. Fig. 6 also shows delay differentiation capability of modified EDCA mechanism. Low priority is more effected using this scheme. Moreover, end to end delay increases rapidly due to their high contention window size.

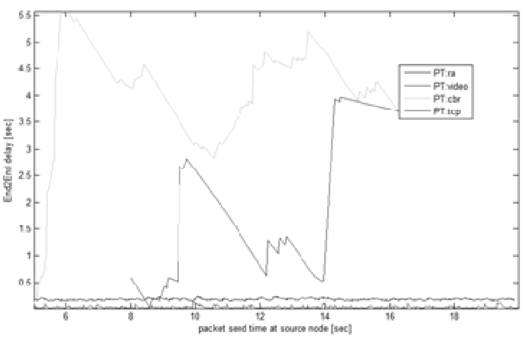


Figure 6: End2End delay of Scenario 2

### A. *Observations*

As it is observed that, the number of dropping packets is very high for RealAudio traffic, which is mainly due the fact of the internal collisions; this is due to their small Contention Window sizes. As a result, the fact of collision rate (or rate of unsuccessful transmissions) which give us a contrary on EDCA real time performance. Note that, a packet is dropped after the number of retransmissions reaches to the retry limit. Therefore, packet dropping probability increases. The higher number of packet drops for AC_VO and AC_VI does not question the effectiveness of the service differentiation scheme, the packet drop rate as well as the End2End delay is dependent on the number of retransmissions, which is bounded by the retry limits. The higher the number of retransmissions, the larger the packet drop rate shown in Fig. 8. End2End delay for BestEffort/CBR is significantly changed in scenario 2 due to fact that CW range is 15 to 255 which is less compared to scenario 1.

### B. *Comparison*

The effects of AIFS and CW size on traffic prioritization observed in the both simulation scenario results shown in Fig. 7. Use of different AIFSs introduces the contention window specific transmission probability. Lower priority station may be excluded for transmission in some contention window, which results in the possibility that some higher priority stations monopolize transmission opportunities and bandwidth. However, use of different CW sizes will only result in longer delay for lower priority stations and lower priority stations can still get the opportunity to transmit shown in Fig. 8.

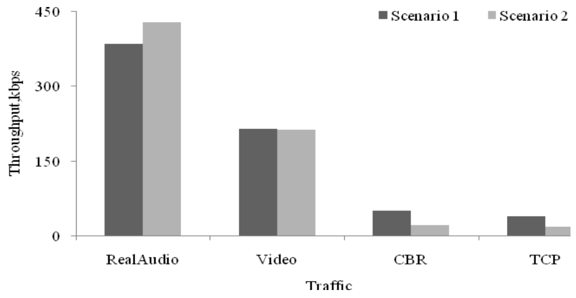


Figure 7: Average throughput of each category

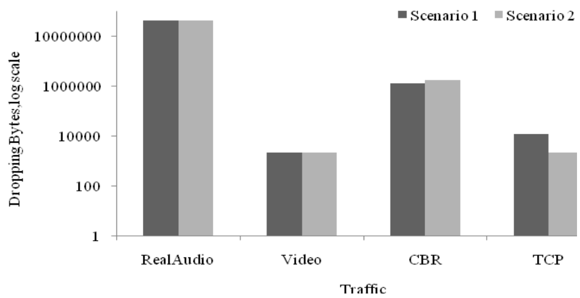


Figure 8: Dropping packets of each category

## VII. Conclusion

In light of these above results, it can be seen that the performance of EDCA IEEE802.11e affected by contention window size. Moreover, we observe that the reason is both RealAudio and Voice have small AIFS and CW values. This enables stations to have a high transmission probability at a time slot, and accordingly their transmission will suffer a high collision probability if the number of stations is large. Therefore the majority of the available bandwidth is wasted on collision instead of successful transmission.

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