

# Modified *EDCA* Approach to Improve Quality of Service in *WLAN*

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**Abstract** In this paper, we have proposed modified Enhanced Distributed Coordination Access (*EDCA*) in order to improve Quality of Service in Wireless *LAN*. In this approach, we have changed the Contention Window (*CW*) for backoff procedure and method for calculation of Arbitration Inter Frame Spacing (*AIFS*). The proposed approach is implemented in Qualnet 5.2 Simulator and compared the results with conventional *EDCA*. The simulation shows that Modified *EDCA* produces less average jitter, less average end to end delay and improvements in throughput as compared to conventional *EDCA* mechanism.

**Keywords** Access Category, Quality of Service, Wireless LAN's, *EDCA*.

## 1 Introduction

Although Ethernet is widely used, Wireless *LANs* (*WLAN*) is increasingly popular. Wireless Local Area Network links two or more devices using some wireless distribution method and provides mobility to move in the local coverage area without disconnected from network. Wireless networks can be seen as superior over wired networks as they are easy to install and flexible.

*IEEE* 802.11 *WLAN* standard is gaining a lot of popularity in recent years because of its role in building wireless broadband computing environment. It is likely to play a major role in the next generation wireless communication networks. *IEEE* 802.11 *WLANs* have two basic co-ordination functions at Medium Access Control (*MAC*) layer: Distributed Coordination Function (*DCF*) and Point Coordination Function (*PCF*). The ability of *WLAN*

to come with real time applications and maintaining quality of service was not sufficient as 802.11 does not provide differentiation and prioritization based on the traffic type. To enhance Quality of Service in *WLAN*, 802.11e *IEEE* standard was introduced. *EDCA* mechanism prioritizes the traffic by using four access categories.

The *IEEE* 802.11 *WLANs* standard is composed of both Physical Layer (*PHY*) and *MAC* specifications for *WLANs*. The primary function of a *MAC* protocol is to define a set of rules and give the stations a fair access to the channel for successful communication. *DCF* is the basic medium access mechanism for both ad hoc and infrastructure mode. *DCF* is based on carrier sense multiple accesses with time thus relies on *CSMA/CA* as access method.

Various task groups under the *IEEE* 802.11 Working Groups are also developing revisions of the standard. New *PHY* specifications now allow much higher data rates to be used (e.g., up to 11Mbps in 802.11b and 54Mbps in 802.11a), as compared to the 1Mbps and 2Mbps in the initial version. Higher data rates have paved the way for incorporation of a larger variety of new applications including multimedia applications in *WLAN* environment. Use of both multimedia applications and traditional data applications in the same *WLAN* is likely to be common in many scenarios, such as in a home network or a cafe deploying a *WLAN* hotspot. However, without any traffic prioritization mechanism in *MAC*, high data rate alone may not be sufficient to meet Quality of Service (*QoS*) requirements imposed by certain

applications such as real time voice, audio and video. Therefore, *QoS* for *WLAN MAC* has received much attention.

The IEEE 802.11e standard introduces the hybrid coordination function (*HCF*) as the medium access control (*MAC*) scheme. It is combination of two aspects Contention –based and Contention-free access methods. Enhanced Distributed Channel Access (*EDCA*) is contention based access method and it is an extension of *DCF* to provide *QoS* Services. On other side, *HCF* Controlled Channel Access (*HCCA*) is contention free period and it is an extension of *PCF*. In 802.11e, *EDCA* is mandatory mechanism where as *HCCA* is optional and requires centralized polling and scheduling algorithms to allocate the resources.

*HCF* supports Service Differentiation by using different *MAC* Parameters for different applications to provide Quality of Service. The conventional Protocols provide fixed parameters which lacks in achieving the optimal performance, however it is still an open area of research.

In this paper we have modified the conventional *EDCA* method in order to improve the *QoS* for *WLAN*.

## 2 - IEEE 802.11 Contention Based Access Methods

### 2.1.1 - 802.11 DCF

The Basic Service Set (*BSS*) is the fundamental building block of *IEEE 802.11* architecture. *IEEE 802.11* supports both the Ad-hoc network and infrastructure network architecture. In Ad-hoc network, *DCF* is used which is based on *CSMA/CA* and it only provides asynchronous access for best effort data transmission, as shown in Fig. 1. *DCF* consists of both a basic access method and an optional channel access method using *RTS/CTS* exchanges [1].

In 802.11, priority access to the wireless medium is controlled by the use of inter-frame space (*IFS*) time between the transmissions of frames. Total three *IFS* intervals have been specified by 802.11 standard: Short *IFS* (*SIFS*), Point Coordination Function *IFS*

(*PIFS*), and *DCF-IFS* (*DIFS*). The *SIFS* is the smallest and the *DIFS* is the largest. The station may proceed with its transmission if the medium is sensed to be idle for an interval larger than the Distributed Inter Frame Space (*DIFS*). If the medium is busy, the station defers until a *DIFS* is detected and then generate a random back-off period before transmitting. The back-off timer counter is decreased as long as the channel is sensed idle [2].

The counter will stop when transmission is detected on the channel and reactivated again when the channel is sensed idle for more than *DIFS* period [10]. A station can initiate a transmission when the back-off timer reaches zero. The back-off time is uniformly chosen in the range  $(0, w-1)$ . Also  $(w-1)$  is known as *CW*, which is an integer with the range determined by the PHY characteristics *CW<sub>min</sub>* and *CW<sub>max</sub>*. After each unsuccessful transmission, *w* is doubled, up to a maximum value  $2^m W$ , where *W* equals to  $(CW_{min}+1)$  and  $2^m W$  equals to  $(CW_{max}+1)$ .

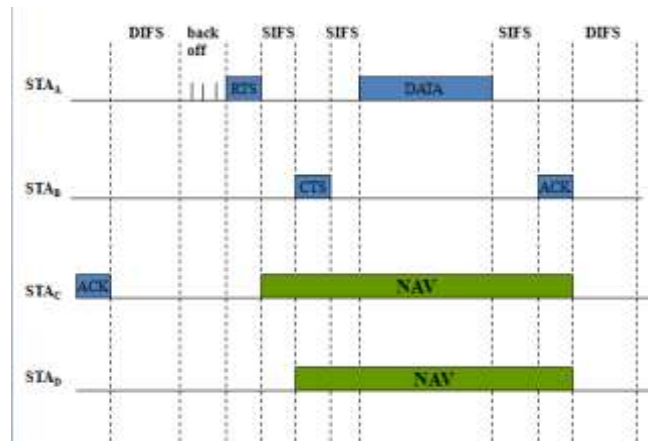


Fig. 1: *DCF* Protocol with *RTS/CTS*

*DCF* also provides an optional way of transmitting data frames that involve transmission of special short Request to send (*RTS*) and clear to send (*CTS*) frames prior to the transmission of actual data frame. As shown in Fig.3, an *RTS* frame is transmitted by a station, which needs to transmit a packet. When the destination receives the *RTS* frame, it will transmit a *CTS* frame after *SIFS* interval immediately following the reception of the *RTS* frame. The source station is allowed to transmit its packet only if it receives the

*CTS* correctly. Note that all the other stations are capable of updating the Network Allocation Vectors (*NAVs*) based on the *RTS* from the source station and the *CTS* from the destination station. Other Stations defer their data sending if one station acquires the access on medium. To overcome the hidden node problem *RTS/CTS* scheme has been devised.

### 2.1.2 - Point Coordination Function

*PCF* uses a centralized polling method, which requires the *AP* as a Point Coordinator (*PC*). The stations request the *PCF* mode, to get associated with the Point Coordinator during the Contention Period (*CP*).

The *PCF* provides synchronous service that basically implements polling based access. It has a higher priority than the *DCF*, because the period during which the *PCF* is used protected from the *DCF* contention via, the Network Allocation Vector (*NAV*) set. If at same time station wants to use *DCF* and *AP* wants to use *PCF*, the *AP* has higher priority. This is an optional access method, implemented in infrastructure network. It is mostly used in time sensitive transmission.

During repetition interval *PC* (point controller) can send poll frame, receive or send, data or *ACK*. At the end, *PC* sends *CF* (contention free end) end frame to allow contention based station to use medium. A super frame is formed by the *CP* and *CFP* together. A beacon frame is generated at regular beacon frame intervals called target beacon transmission time (*TBTT*) by the access point. The value of the *TBTT* is announced in the beacon frame. The beacon frame, which is used to maintain synchronization among local timers in the stations and to deliver protocol related parameters, is used to indicate the beginning of the super frame.

### 2.1.3 - IEEE 802.11 QoS Limitations

#### 2.1.3.1 - QoS Limitation of DCF

*DCF* supports only the best effort service and does not provide any *QoS* guarantees. Typically, time-bounded services such as voice over *IP* or audio/video conferencing require specified

bandwidth, delay, and jitter, can tolerate some losses.

In *DCF* mode, all the *STA*'s in one *BSS* compete for the resources and channel with same priorities where as priorities should be assigned depending on the type of data flow.

There is no differentiation to guarantee bandwidth, packet delay and jitter for high priority *STAs* or multimedia flows.

#### 2.1.3.2 - QoS Limitation of PCF

Although *PCF* has been designed to support time bounded multimedia applications, this mode has some problems that lead to poor *QoS* performances.

Central polling scheme. All the communication between two *STAs* in the same *BSS* has to go through the Access Point (*AP*), thus some of the channel bandwidth is wasted. As traffic increases a lot of channel resources are wasted.

The cooperation between *CP* and *CFP* modes may lead to unpredictable beacon delays.

No mechanisms for the stations to communicate their *QoS* requirements to the *AP*.

### 2.2 - 802.11e Quality of Service Method

#### 2.2.1- EDCA

*EDCA* provides differentiated and distributed access to the Wireless medium. Each frame received from upper layers is assigned with its user priority (*UP*). After receiving each frame the *MAC* layer maps the frame into an Access Category (*AC*) depending on its user priority it carries. The levels of priority in *EDCA* are called *AC* [3]. Each *AC* has a different priority or preference of access. One or more *Ups* can be assigned to one *AC*. *AC* for *EDCA* are shown in Fig. 2. *EDCA* specifies up to eight *ACs* to support the user Priorities, as shown in Fig. 3. Each *QoS*-enhanced *STA* (*QSTA*) has 4 queues (*ACs*), to support 8 *Ups* as given in Table 2. Each *AC* queue works as an independent *DCF STA* and uses its own backoff parameters [6][9].

Priority	User priority (UP - Same as 802.1D User Priority)	802.1D Designation	Access Category (AC)	Designation (Informative)
lowest ↓ highest	1	BK	AC_BK	Background
	2	-	AC_BK	Background
	0	BE	AC_BE	Best Effort
	3	EE	AC_BE	Best Effort
	4	CL	AC_VI	Video
	5	VI	AC_VI	Video
	6	VO	AC_VO	Voice
7	NC	AC_VO	Voice	

Fig. 2: EDCA Traffic Categories

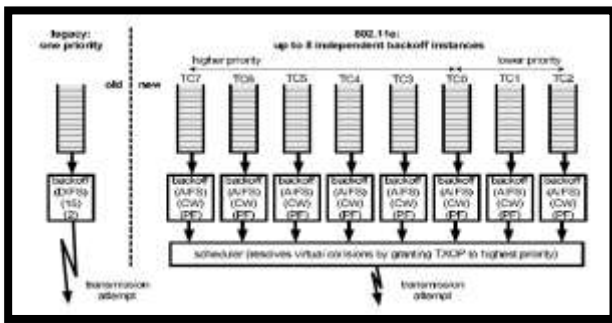


Fig. 3: EDCA Access Categories

In *DCF*, Backoff slot begins after *DIFS* from the end of the last indicated busy medium, where as in *EDCA*, backoff slots begin at different intervals according to the *AC* of the traffic queue.

The Duration of Inter Frame space is given by:

$$AIFSN[i] = SIFS + AIFSN \times \text{Slot Time}$$

*EDCA* ensures better services to higher priority classes while offering a minimum best effort for low priority traffic.

The Default *EDCA* Parameters for Access Categories are given below [7]:

Table 1: CW for different ACs

Access Category	CW <sub>Min</sub>	CW <sub>Max</sub>
AC_BK	aCW <sub>min</sub>	ACW <sub>max</sub>
AC_BE	aCW <sub>min</sub>	ACW <sub>max</sub>
AC_VI	CW <sub>min</sub> +1/2-1	ACW <sub>min</sub>
AC_VO	(CW <sub>min</sub> +1)/4-1	(CW <sub>min</sub> +1)/2-1

Table 2: Default *EDCA* parameters

Access Category	CW <sub>min</sub>	CW <sub>max</sub>	IFSN
AC_BK	15	1023	7
AC_BE	15	1023	3
AC_VI	7	15	2
AC_VO	3	7	2

### 2.2.2 - HCF Controlled Channel Access

The Hybrid Coordination Function (*HCF*) controlled channel access (*HCCA*) works a lot like *PCF*. However, in contrast to *PCF*, in which the interval between two beacon frames is divided into two periods of *CFP* and *CP*, the *HCCA* allows for *CFPs* being initiated at almost any time during a *CP*. A *CFP* is initiated by the *AP* whenever it wants to send a frame to a station or receive a frame from a station in a contention-free manner [11]. During a *CFP*, the Hybrid Controller (*HC*) which is also the *AP*, controls the access to the medium. During the *CP*, all stations function in *EDCA*. The other difference with the *PCF* is that Traffic Class (*TC*) and Traffic Streams (*TS*) are defined. This means that the *HC* is not limited to per-station queuing and can provide a kind of per-session service [10]. Also, the *HC* can coordinate these streams or sessions in any fashion it chooses (not just round-robin). Moreover, the stations give info about the lengths of their queues for each *TC* [8]. The *HC* can use this info to give priority to one station over another, or better adjust its scheduling mechanism. Another difference is that stations are given a *TXOP*: they may send multiple packets in a row, for a given time period selected by the *HC*. During the *CP*, the *HC* allows stations to send data by sending *CF-Poll* frames [4][5].

### 3. Proposed Method

In *IEEE 802.11 Wireless LAN* when a collision occurs, there is the need of a backoff time, which is randomly selected from the Contention Window (*CW*). The commonly used backoff algorithm is

Binary Exponential Backoff Algorithm (*BEB*). In *BEB* algorithm, the value of the *CW* is doubled every time a node experiences an unsuccessful transmission. If there is a successful transmission, *CW* is reset to minimum value. We have proposed an algorithm in which we have modified the procedure of increasing the *CW* in case of transmission failure occurs in order to decrease the average end to end delay and average jitter. There are two modules in the proposed algorithm, which are explained below.

### Algorithm 3.1:

The manner in which contention window vary depends on the traffic category. When collision occurs, for high priority traffic the contention window varies linearly till it reaches certain value after which it increases at faster rate whereas the contention window with lower priority traffic increases at faster rate.

Whenever there is unsuccessful transmission occurs first of all *AC* of the traffic flow will be checked. If it is high priority traffic i.e. video or voice then its current value of its *CW* will be checked, if this value is less than twice of its *CW<sub>min</sub>*, then its *CW* is incremented linearly till it reaches twice the *CW<sub>min</sub>*. Beyond the twice of *CW<sub>min</sub>* value is increased by multiplying with the factor of 1.5. For the low priority traffic *CW* value is increased consistently by multiplying with the factor of 1.5.

### Increase Contention Window Function:

#### Begin:

```

If (AC >= 2) //for video and voice traffic
If (CW[AC] < 2 × CWmin[AC])
CW[AC] = MIN (CW [AC]+1, 2 × CWmin[AC])
Else
CW[AC] = MIN (CW [AC] × 1.5, CWmax[AC])
Endif
Elseif (AC >= 0 and AC < 2) //for Best effort and background traffic
CW[AC] = MIN (CW[AC] × 1.5, CWmax[AC])
Endif

```

where *AC* is the Access Category; *MIN* is function to calculate the minimum value of its parameters; *CW<sub>min</sub>* is minimum Contention Window size; *CW<sub>max</sub>* is maximum Contention Window size; *CW*[*AC*] means Contention Window for particular Access Category.

### Algorithm 3.2:

Another modification we have done in our algorithm is changing parameters of *AIFS* according to the priority of Traffic Category. In case of *EDCA* the value of *AIFS* parameter for every Access category is chosen in same way as given below:

$$AIFS = SIFS + AIFS [AC] \times SLOTTIME$$

Where *AIFS* [*AC*] is the *AIFS* for particular *AC*; *SLOTTIME* depends on Physical layer. For 802.11b it is defined as 20 microseconds.

In order to provide the priority to higher traffic categories we have modified the *AIFS* by lowering the *AIFS* value for Traffic categories 2 and 3. *AIFS* value for Traffic category 2 and 3 has been reduced to *SIFS* only. Whereas *AIFS* value calculation function for Traffic categories 0 and 1 are same as original *EDCA* function. By using algorithm the *AIFS* value has been decreased for Access categories having high priority. This leads to reduce Average End to End Delay and Average Jitter significantly.

### AIFS Calculation Functions

```

If (AC >= 2) //for voice or video traffic
AIFS = SIFS;
Else (AC >= 0 and AC < 2) //for Best effort and background traffic
AIFS = SIFS + AIFS [AC] × SLOTTIME
Endif

```

## 4. Simulations and Results

### 4.1 Experiment 1:

In this experiment, we have 6 nodes in 1000 × 1000 areas, which are configured under 802.11e Ad-hoc wireless network. A Random Distribution model has been followed. Nodes are fully independent i.e.

without any Access Point to coordinate the channel access and are operating in a distributed environment. Constant bit rate connections have been used between every node. For best effort traffic 64 byte packets are sent at an interval of 20 milliseconds by giving data rate of 25.6 Kbps. For the voice traffic 512 byte data packets are sent at an interval of 16 milliseconds giving data rate of 256 Kbps. Table 3 shows the properties of best effort traffic Constant Bit Rate (CBR).

Table 3: Properties of scenario 1

Property	Value
Terrain Size	1000 x 1000
Simulation Time	30s
Number of Nodes	6
Item Size	512 bytes having priority 7 and 64 bytes having priority 0
CBR Applications having priority 7	1→6, 6→7, 3→5, 4→2
CBR Applications having priority 0	6→1, 1→3, 4→5, 6→2

We have simulated the experiment firstly for 100 packets and then 500 till 2500 packets. The experiments were performed once for existing EDCA model then for proposed method. Then QoS parameters are compared of both experiments.

Fig. 4, 5, 6 have shown the detailed comparison graph for both EDCA and proposed approach.

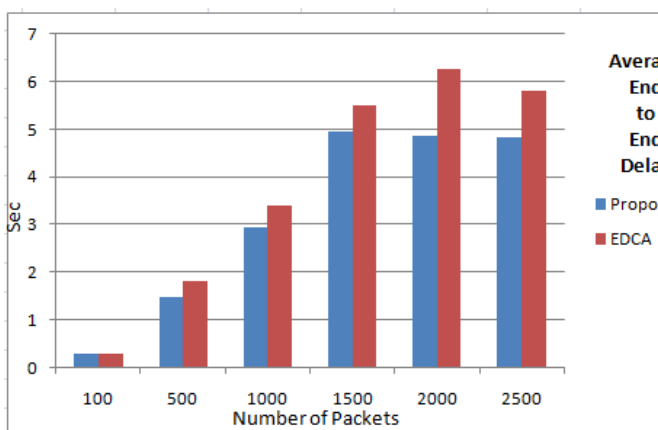


Fig. 4: Average End to End Delay

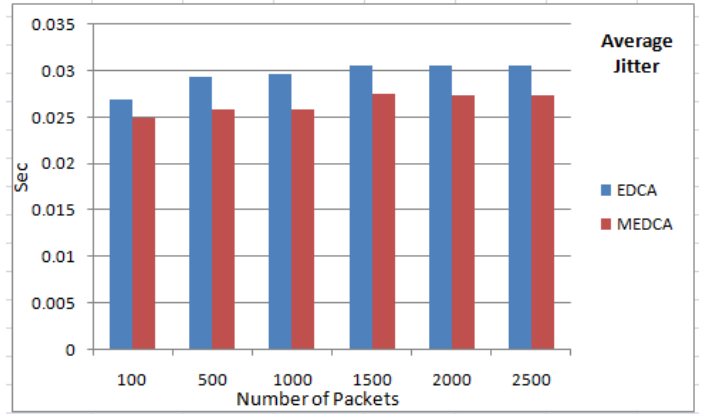


Fig. 5: Average Jitter

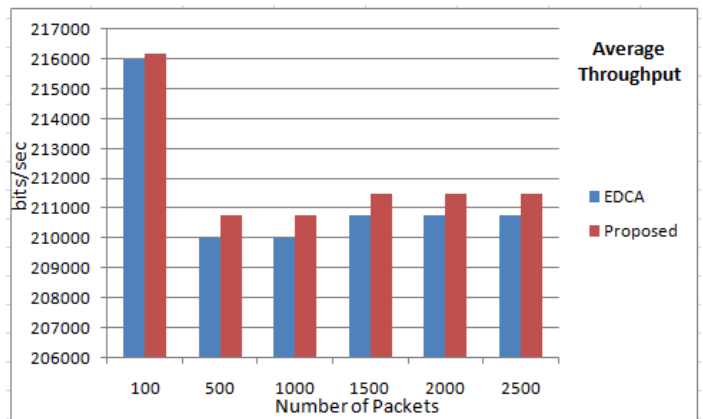


Fig. 6: Average Throughput

## 4.2 Experiment 2

Second experiment is performed with increasing the number of nodes in network and number of packets. In this scenario simulation is carried with 30 nodes on 1000 x 1000 area. Again a random distribution model has been chosen with fully independent nodes. Nodes are operating in an Ad-hoc mode without a central access point. Constant bit rate connections have been used between nodes. For best effort traffic 64 byte packets are sent at an interval of 20 milliseconds by giving data rate of 25.6 Kbps. For the voice traffic 512 byte data packets are sent at an interval of 16 milliseconds giving data rate of 256 Kbps. Now in this simulation number of packets increased from 1000 to 5000 for both traffics. Priorities of CBR links are as given in Table 4.

Table 4: Properties for Scenario 2

Property	Value
Terrain Size	1000 x 1000
Simulation Time	30s
Number of Nodes	30
Item Size	512 bytes having priority 7 and 64 bytes having priority 0
CBR Applications having priority 7	6→5, 3→1, 12→28, 5→28, 2→30, 25→16, 8→3, 17→9, 23→19, 20→21
CBR Applications having priority 0	5→1, 3→7, 12→3, 5→2, 2→8, 25→27, 8→25, 17→18, 22→23, 20→24

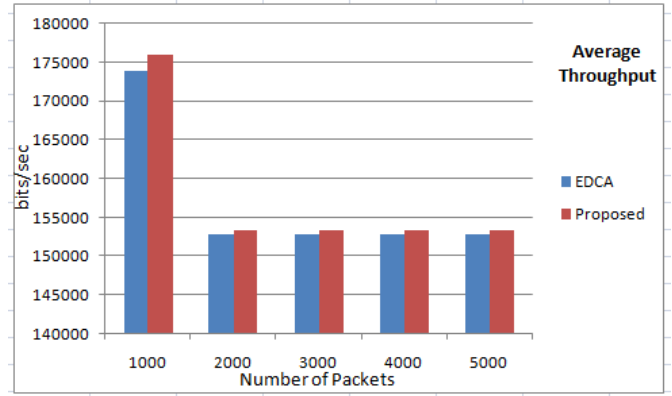


Fig. 9: Average Throughput

These Graphs given in Fig. 7, 8, 9 shows the impact on Quality of Service parameters Average End to End Delay, Average Jitter and Average Throughput of proposed algorithm in comparison with conventional EDCA algorithm.

### 5. Conclusion and Future Work

The modified method provides less end to end delay and jitter and high throughput as compared to the conventional EDCA method. We can achieve the optimal performance by considering other parameters such as TXOP. In proposed Algorithm we have consider only two priorities (less than 2 and greater or equal to 2). But further more combinations of priorities can be considered. The implementation of modified algorithm has done in Ad-hoc Network in this paper. In future same modified procedure can implement on infrastructure based network as well to improve End to End delay and jitter parameters.

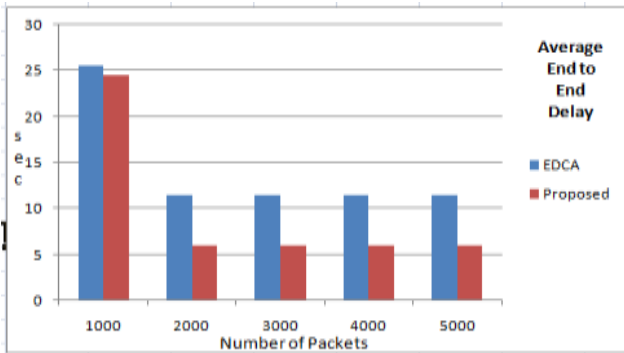


Fig. 7: Average End to End Delay

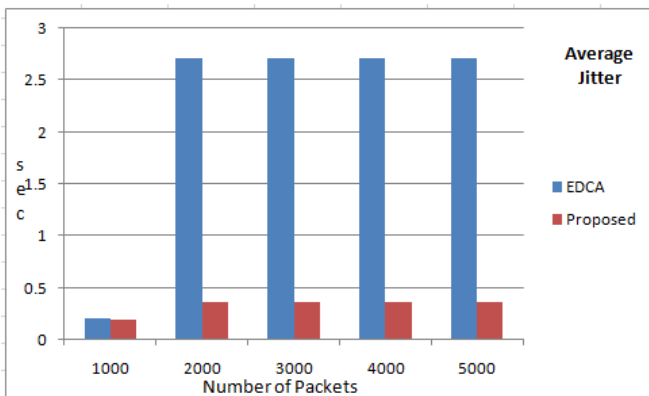


Fig. 8: Average Jitter

### References

1. VANSI/IEEE Std. 802.11e, "Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications: Amendment 8: Medium Access Control (MAC) Quality of Service Enhancement", 2<sup>nd</sup> Ed, November 2005.
2. IEEE 802.11 WG. Draft Supplement to Standard 802.11-1999, "Medium Access Control (MAC) Enhancement for Quality of Service (QoS)", Vol. 1, pp. 128-136, November 2001.
3. A. Banchs, X. Perez-Costa and D. Qiao, "Providing throughput guarantees in IEEE802.11e wireless LANs", 18<sup>th</sup> International Telegraphic Conference, September 2003.

4. P. Ferre, A. Doufexi, A. Nix and D. Bull, "Throughput analysis of IEEE 802.11 and 802.11e MAC", Wireless Communication and Networking Conference, pp. 783-788, 2004.
5. S. Sherawat, R. P. Bora, and D. Harihar, "Performance Analysis of QoS supported by Enhanced Distributed Channel Access (EDCA) mechanism in IEEE 802.11e", IAENG International Journal of Computer Science, 33:1, April 2006.
6. D. Wu and R. Negi, "Effective capacity-based quality of service measures for wireless networks," ACM Mob. Netw. Appl., Vol. 11, No. 1, pp. 91-99, Feb. 2006.
7. E. C. Park, D. Y. Kim, C. H. Choi, and J. So, "Improving Quality of Service and Assuring Fairness in WLAN Access Networks", IEEE Transactions on Mobile Computing, Vol. 6, No. 4, April 2007
8. S. Zhalehpour, H. S. Shahhoseini and S. Zhalehpour, "Performance Evaluation of Adaptive Backoff Algorithms in Ad Hoc Networks", International Conference on Computer Technology and Development, DOI 10.1109/ICCTD. 238. 2009.
9. H. W. Ferng, and H. Y. Liao, "Design of Fair Scheduling Schemes for the QoS-Oriented Wireless LAN", IEEE Transactions on Mobile Computing, Vol. 8, No. 7, July 2009
10. R. Acharya, V. Vityanathan, and P. R. Chellai "WLAN QoS Issues and IEEE 802.11e QoS Enhancement", International Journal of Computer Theory and Engineering, Vol. 2, No. 1, pp. 143-149, February 2010
11. P. Serrano, A. Banchs, P. Patras and A. Azcorra, "Optimal Configuration of 802.11e EDCA for Real-Time and Data Traffic", IEEE Transactions on Vehicular Technology, Vol. 59, No. 5, June 2010.