Modified *EDCA*Appraoch to Improve Quality of Service in *WLAN*

Parminder Kaur[1], Singara Singh[2]
School of Mathematics and Computer Applications
Thapar University, Patiala, INDIA
[1]minidadhwal43@gmail.com, [2]singara@thapar.edu

AbstractIn 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 withconventional *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.

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

1 Introduction

Although Ethernet is widely used, Wireless *LAN*s (*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 islikelytoplayamajorroleinthenext generation wirelesscommunication networks.*IEEE*802.11*WLAN*s havetwobasicco-ordination functions atMedium Access Control (*MAC*)layer: DistributedCoordination Function (*DCF*) andPoint CoordinationFunction (*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 *WLAN*s standard is composed of both Physical Layer (*PHY*) and *MAC*specifications for *WLAN*s. 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 multimediaapplicationsand traditional dataapplicationsinthesame*WLAN*is likelyto becommonin manyscenarios,suchasinahome network oracafedeployinga*WLAN*hotspot.However, withoutanytrafficprioritization mechanism in*MAC*, highdataratealonemaynotbesufficient tomeetQuality ofService(*QoS*)requirements imposedbycertain applicationssuchasrealtimevoice,audioand video. Therefore, *QoS*for*WLANMAC*hasreceivedmuch 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*

TheBasicServiceSet(*BSS*)isthefundamental buildingblockof*IEEE*802.11architecture.*IEEE*802.11supports boththeAd-hoc network and infrastructure networkarchitecture. In Ad-hoc network, DCF is used whichisbasedon *CSMA/CA*anditonlyprovidesasynchronousaccessfor best effortdata transmission, as shown in Fig. 1.*DCF*consistsofbothabasic accessmethodandanoptional channel accessmethod using*RTS*/*CTS*exchanges [1].

In802.11,priority accesstothewirelessmedium is controlled bytheuseofinter-framespace(*IFS*)time betweenthetransmissions offrames.TotalthreeIFS intervalshavebeenspecifiedby802.11standard:Short *IFS*(*SIFS*),PointCoordination Function *IFS*(*PIFS*),and *DCF*-*IFS*(*DIFS*).The*SIFS*isthesmallestandtheDIFS is thelargest.Thestation may proceedwithits transmission ifthemediumissensedtobeidleforan intervallarger thantheDistributedInterFrameSpace (*DIFS*).Ifthemedium isbusy,thestation defersuntila *DIFS*isdetectedandthengeneratearandom back-off periodbeforetransmitting. Theback-offtimercounteris decreased aslongasthechannelissensedidle [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 stationcaninitiate atransmissionwhen theback-offtimer reacheszero.Theback-offtimeisuniformlychoseninthe range (0,*w*-1).Also(*w*-1)isknown as*CW*,whichisanintegerwiththerange determined by thePHYcharacteristics*CWmin*and*CWmax*. Aftereachunsuccessfultransmission,*w*isdoubled,upto amaximumvalue2*m'W*,where*W*equalsto(*CWmin*+1) and2*m'W*equalsto (*CWmax*+1).

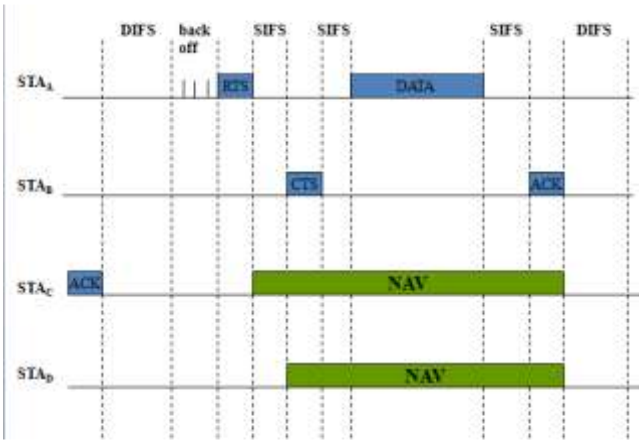

Fig. 1: *DCF* Protocol with *RTS/CTS*

*DCF*alsoprovides anoptionalwayof transmitting dataframesthatinvolvetransmission of special shortRequest to send (*RTS)*and clear to send(*CTS)*framespriortothe transmission ofactualdataframe.AsshowninFig.3,an *RTS*frameistransmitted byastation,whichneedsto transmitapacket.Whenthedestination receivesthe*RTS*frame,itwilltransmit a*CTS*frame after*SIFS*interval immediately followingthereceptionofthe*RTS*frame. Thesourcestationisallowedtotransmititspacket onlyif itreceivesthe*CTS*correctly. Notethatalltheother stations arecapable ofupdatingthe Network Allocation Vectors(*NAVs)* basedonthe *RTS*from thesourcestation andthe*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 - IEEE802.11QoSLimitations

2.1.3.1 -QoSLimitationofDCF

*DCF*supports only thebesteffortserviceanddoesnot provideany*QoS*guarantees. Typically,time-bounded servicessuchas voice over *IP*or audio/video conferencing require specified bandwidth, delay, and jitter,cantoleratesomelosses.

In*DCF*mode, allthe*STA's*inone*BSS* competeforthe resources andchannelwithsameprioritieswhereasprioritiesshouldbeassigneddependingonthetypeof dataflow. Thereisnodifferentiationtoguaranteebandwidth,packet delay andjitter forhighpriority*STAs*ormultimedia flows.

2.1.3.2 - QoSLimitationofPCF

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 backoffparameters[6][9].

Priority	User priority (UP - Same as 802.1D User Priority)	802.1D Designation	Access Category (AC)	Designation (Informative)
lowest	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
highest	6	VO	AC_VO	Voice
	7	NC	AC_VO	Voice

Fig. 2: EDCA Traffic Categories

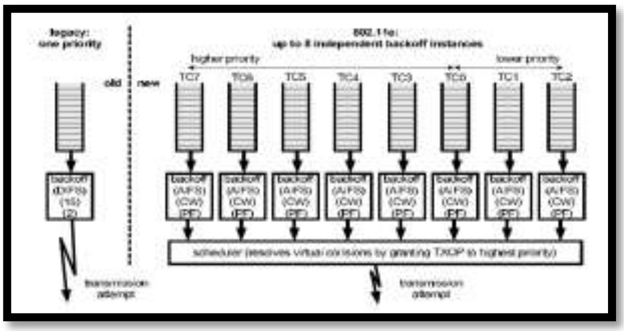

Fig. 3: *EDCA* Access Categories

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*× 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 *AC*s

Access Category	CWMin	CWMax
AC_BK	aCWmin	ACWmax
AC_BE	aCWmin	ACWmax
AC_VI	(CWmin+1)/2-1	ACWmin
AC_VO	(CWmin+1)/4-1	(CWmin+1)/2-1

Table 2: Default *EDCA* parameters

ccess Category	Wmin	Vmax	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 *CWmin*, then its *CW* is incremented linearly till it reaches twice the *CWmin*. Beyond the twice of *CWmin* 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; *CWmin*is minimum Contention Window size; *CWmax*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*] ×*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 voicetraffic 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.

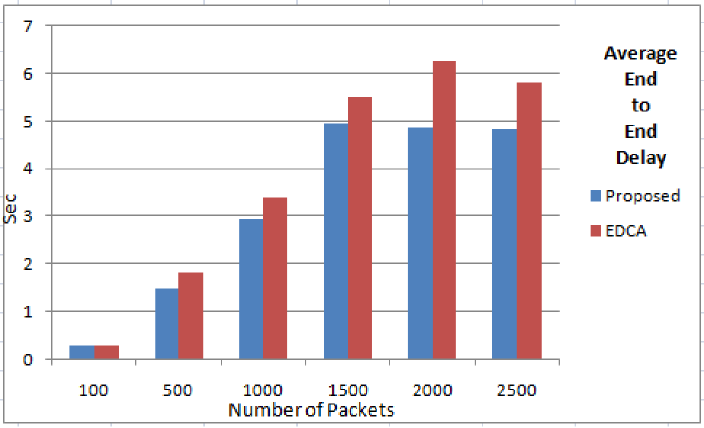

Fig. 4: Average End to End Delay

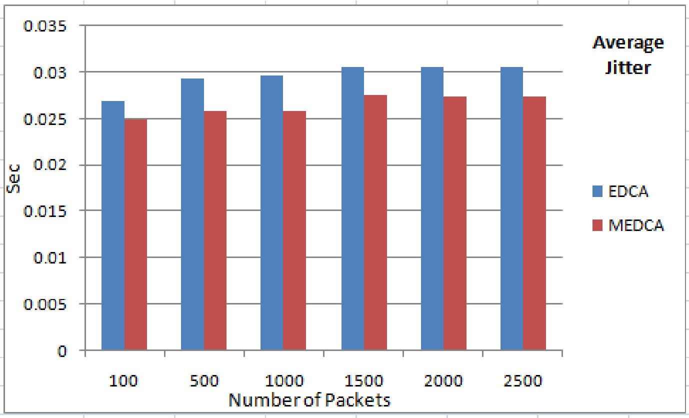

Fig. 5: Average Jitter

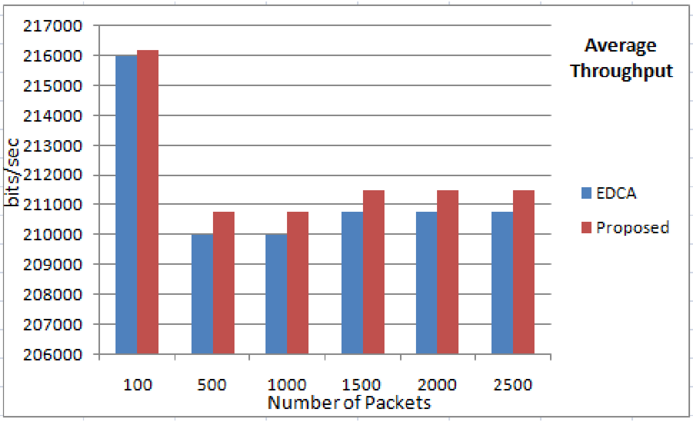

Fig. 6: Average Throughput

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	→1, 3→7, 12→3, 5→2, 2→8, 25→27, 8→25, 17→18, 22→23, 20→24

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.

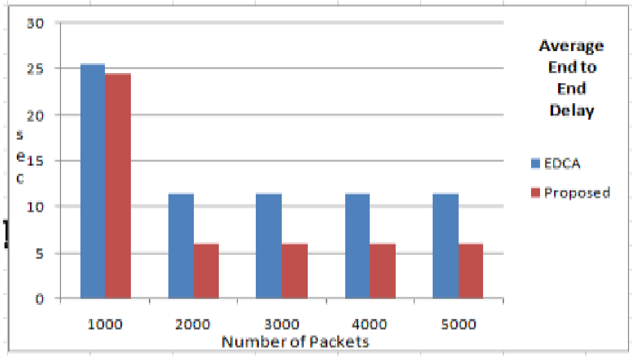

Fig. 7: Average End to End Delay

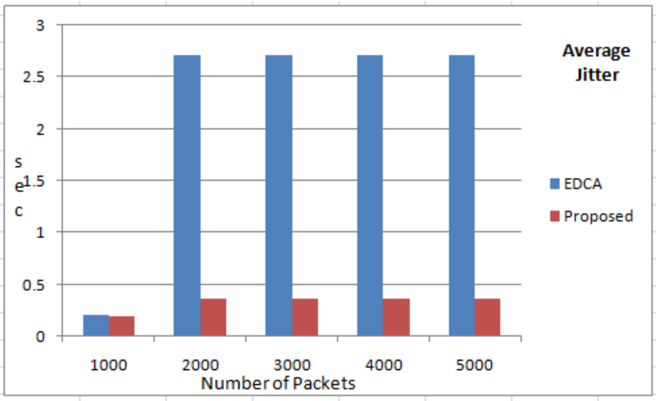

Fig. 8: Average Jitter

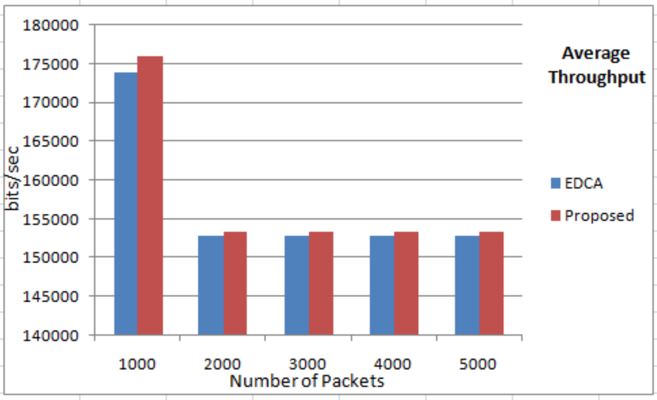

Fig. 9: Average Throughput

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.

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