Study of QoS Management In IEEE 802.11 and 802.11e MAC Layer Protocols

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Certificate

This is to certify that the work in the thesis entitled ***Study of QoS Management in IEEE 802.11 and 802.11e MAC layer wireless protocols,***, submitted by ***Sujeet Bhushan*** and ***Nirmalya Ganguly***, bearing roll numbers ***107CS002*** and ***107CS029*** respectively, is a record of the original research work carried out by them under my supervision and guidance in partial fulfillment of the requirements for the award of the degree of ***Bachelor of Technology*** in *Computer Science and Engineering* during the session 2007-2011 in the *Department of Computer Science and Engineering, National Institute of Technology Rourkela.* Neither this thesis nor any part of it has been submitted for any degree or academic award elsewhere.

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Sujeet Bhushan and Nirmalya Ganguly

Abstract

Wireless networks have become increasingly popular in recent times and it has become a pressing need to ensure that the various applications using it get the necessary Quality of service. Wireless networks being inherently different from wired networks and pose a unique set of challenges . Quality of Service(QoS) is defined as the performance offered by a network to its users in terms of providing resource assurance and service differentiation to different kinds of traffic flows .Due to scarcity of bandwidth and high rate of packet loss in wireless networks providing QoS to time critical applications is a challenging task .In this thesis we attempt to study the QoS management strategies applied by the wireless networks at the MAC layer .The most common QoS provisioning strategy is to prioritize the different classes of traffic and make sure that the high priority traffic gets preferential access to the channel .In this thesis ,a study of the binary exponential back-off algorithm which is used by the wireless MAC protocols has been done and an improvement has been proposed in which the Contention Window(CW) is varied in a non-uniform manner for different access categories with an aim to improve the performance parameters. The CW defines the range[0,CW] from which a random no of slots are chosen by a station in case of a failure in transmission for backing off before attempting to transmit again. To demonstrate the effect of the modified contention window variation scheme simulations have been carried out using the Qualnet Simulator designed by Scalable Network Technologies, Inc. After implementing the proposed modification a performance comparison has been carried out for parameters such as packet delivery ratio, throughput and jitter.

Table 1: **List of Acronyms**

Acronyms	**Description**
AC	Access Categories
ACK	Acknowledgement
AIFS	Arbitration Inter Frame Space
AP	Access Point
BC	Backoff Counter
BEB	Binary Exponential Backoff
BSS	Basic Service Set
CAP	Controlled Access Period
CBR	Constant Bit Rate
CP	Contention Period
CSMA/CA	Carrier Sense Multiple Access / Collision Avoidance
CTS	Clear to Send
CW	Contention Window
DCF	Distributed Coordination Function
DIFS	Distributed Inter Frame Space
EDCF	Enhanced Distributed Channel Function
FIFO	First In First Out
FTP	File Transmission Protocol
HC	Hybrid Coordinator
HCF	Hybrid Coordination Function
IBSS	Independent Basic Service Set
IEEE	Institute of Electrical and Electronics Engineers
IFS	Inter Frame Space
MAC	Medium Access Controller
NAV	Network Allocation Vector
PCF	Point Coordination Function
PHY	Physical Layer
PIFS	PCF Inter Frame Space
RTS	Request to Send
SD	Slow Contention Window Decrease

Acronyms	**Description**
SIFS	Short Interframe Space
TBTT	Target Beacon Transmission Time
TXOP	Transmission Opportunity
QAP	Quality Access Point
QBSS	Quality Basic Service Set
QoS	Quality of Service
WLAN	Wireless Local Area Network

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1 Chapter

Introduction

Nodes in an ad-hoc wireless network share a common broadcast radio channel. Since the radio spectrum is limited ,the bandwidth available for communication in such network is also limited .Access to the shared medium should be controlled in a manner that all the nodes get a fair share of the available bandwidth ,and that the bandwidth is utilized efficiently .Since the characteristics of the wireless medium are completely different from those of a wired medium ,and since ad-hoc wireless networks need to address unique issues such as node mobility ,limited bandwidth availability ,error prone broadcast channel ,hidden and exposed terminal problems and power constraints that are not applicable to wired networks ,a different set of protocols is required for controlling access to the shared medium in such networks[1] .The Wireless LAN(WLAN) has been standardized by the IEEE 802.11 specification[3] .The popularity of wireless LANs has grown very rapidly since its introduction mainly due to the rapid growth in the number of wireless devices such as mobile phones ,laptops etc .This has resulted in an increasing demand for quality of service for applications which run on these devices. Real time applications involving voice or video transmissions over a network have stringent requirements in terms of delay, bandwidth and other QoS parameters. Hence, QoS must be provided by the underlying network for proper functioning of those applications. One way to achieve this is to provide QoS at the MAC layer, which makes physical bandwidth usable. But IEEE 802.11, which is the most prevalent WLAN technology, does not have any inherent QoS support . The IEEE 802.11 MAC uses DCF (Distributed Coordination Function) for media access among the participating network nodes. But DCF alone is neither capable nor suitable for fulfilling the QoS requirements of real time applications like voice and video. It does not provide any priority and there is no service differentiation between different flows. Generally, the proposed QoS schemes which are based on IEEE 802.11 try to improve DCF functionality. There are primarily three ways in which QoS is provided by modifying DCF based MAC:

• Prioritization among different classes of traffic: Most of the techniques use different

Inter Frame Space(IFSs) or different Contention Window (CWs) or both [4][6][7][8][10].

• Resource allocation to prioritized classes of data: This is achieved by some distributed variant of Weighted Fair Queuing (WFQ).

• Admission control: QoS is provided by measurement and model based admission control[5].

1.1 Motivation

WLANs have made their way into numerous places and its popularity has been increasing at a tremendous pace .Popularly known as WiFi it has found its application in fields such as manufacturing ,health-care and academics and is being extensively used for wireless communication . These sectors have found it possible to make productivity gains by using hand-held terminals and notebook computers to transmit real-time information in an environment in which the devices are physically distributed. Wireless networks pose a different set of issues and challenges which have to be tackled in order to make it suitable for all kinds of traffic .Those kinds of traffic flows that demand timeliness and accuracy in communication have to be provided by the network. Wireless networks are extensively being used for transmission of real time data that are time critical and have stringent QoS needs .Examples are Video Conferencing ,multimedia streaming etc. The goal for the future is to enable all the sophisticated real time and multimedia applications to use a single wireless network infrastructure to communicate without having to compromise on quality.

1.2 Aspects of Qos Management

Quality of service (QoS) is the performance level of a service offered by the network to the user. The purpose of QoS provisioning is to achieve a more deterministic network behavior, so that information carried by the network can be better delivered and there can be better utilization of network resources. A network or a service provider can offer different kinds of services to the users. Here, a service can be characterized by a set of measurable pre specified service requirements such as minimum bandwidth, maximum delay, maximum delay variance (jitter), and maximum packet loss rate. After accepting a service request from the user, the network has to ensure that service requirements of the users flow are met, as per the agreement, throughout the duration of the flow (a packet stream from the source to the destination). In other words, the network has to guarantee certain services while transporting a flow. QoS provisioning often requires negotiation between host and network, call admission control ,resource reservation, and priority scheduling of packets[4].

1.3 Thesis Outline

Chapter 2 focuses on the Various protocols defined in the 802.11 the and their characteristics.

Chapter 3 focusses on the he QoS enhancements introduced in the 802.11e .

Chapter 4 deals with the proposals made to modify the EDCF in order to obtain a better performance .

Chapter 5 contains the simulations results and analysis of the proposed schemes.

2 Chapter

Scope of IEEE 802.11

The IEEE 802.11 is a set of standards pertaining to the MAC and PHY layers[3]. IEEE 802.11 refers to a family of specifications developed by the IEEE for wireless LAN technology .The protocols used in all the 802 variations ,including 802.3(Ethernet) have certain common features. The physical layer corresponds to the OSI physical layer fairly well .But the data link layer in all the 802 protocols are split into two sub-layers .It is upon the Media access control(MAC) sub-layer to determine how the channel is allocated or who gets to use the channel next. Above it is the Logical Link Control(LLC) sub-layer whose job is to make the 802 variants transparent to the network layer[2].

2.1 The 802.11 Physical Layer

The 802.11 standard specifies three transmission techniques allowed in the physical layer .The infrared method uses much the same technology as the television remote controls. The other two use short range radio using techniques called FHSS and DSSS .The original 802.11 can support upto 2 Mbps. The 802.11a uses a high speed connection that supports upto 54Mbps .The 802.11b operates at the unlicensed radio band and supports upto 11Mbps and uses DSSS. The 802.11g operates at the unlicensed band and provides upto 54Mbps using OFDM modulation scheme. The IEEE 802.11n significantly improves the network throughput in comparision previous standards, with an increase in the maximum (PHY) data rate from 54 Mbps to a maximum of 600 Mbps[2][3].

2.2 The 802.11 MAC Sublayer

The characteristics of the 802.11 MAC sub-layer protocols is completely different from that of traditional Ethernet mainly due to the complexity of the wireless environment

.With Ethernet sensing the medium and detecting collisions is far more easier. The wireless medium has certain inherent problems such as the hidden and exposed nodes problem. Since all stations are not within radio range of each other. In general, the wireless networking can be implemented in two different operating modes: infrastructure and ad hoc modes. The infrastructure mode consists of an access point (AP) co-ordinating the operation of the other nodes in the network with each client station communicating through it. The system can be extended by having a system with multiple access points. In the Ad-hoc mode essentially eliminates the need for an access point. In this mode, the mobile nodes can be connected in a dynamic topology in an arbitrary manner. All nodes of these networks behave as routers and take part in discovery and maintenance of routes to other nodes in the network. The 802.11 defines two modes of operation ,the first is the mandatory Distributed coordination function (DCF) and the second is the optional Point Coordination Function(PCF)[3].The DCF operates in the ad-hoc mode without any central coordination whereas the PCF uses a base station or Access Point to control the activities of its cell[1][2].

2.3 The 802.11 Distributed Coordination Function(DCF):

DCF using CSMA/CA:

The CSMA/CA protocol is designed to reduce the collision probability between multiple stations accessing a medium ,MAC works with a first-in-first-out single queue (FIFO)transmission mechanism and is shared by all the traffics .The CSMA/CA mechanism works as follows: when a packet arrives at the front of transmission queue ,with the channel being found idle for an interval of time than in excess of the distributed Inter frame Space (DIFS), the source station can transmit the packet immediately, mean while other stations defer their transmission while asserting their network allocation vector (NAVs)and the back-off process starts . In this process, the station chooses a random interval ,called back-off-timer, selected from the contention window (CW): rand [O,CW]* Slot-Time .If the channel is busy, the MAC waits until the medium becomes idle, then waits until the medium becomes idle, then defers for an extra time interval, called the DIFS[2][6] .For each idle slot time interval, the back-off counter is decremented. When the counter reaches zero, the packet is transmitted

.For each successful reception of a packet, the receiving queue station immediately acknowledges by sending an acknowledgement (ACK) packet. The ACK packet is transmitted after a short inter frame space (SIFS). If an ACK packet is not received after the data transmission, the packet is retransmitted after another random back-off. MAC parameters including, DIFS, SIFS, Slot Time , CWmin and CWmax are dependent on the underlying physical layer address (PHY) [2][6].

RTS/CTS mechanism:

In order to get over the hidden terminal problem the RTS/CTS scheme has been devised ,whenever a packet arrives it generates an RTS frame for destination station, which listens for an short inter frame space (SIFS), if it found to be idle then transmission of RTS, otherwise deferred until idle condition. Other stations defer their transmission with NAV. If CTS arrives then channel is reserved for transmission of data with a waiting for acknowledgment (ACK). If an ACK packet is not received after the data transmission, the packet is retransmitted after another random back-off. For each successful reception of a packet, the receiving station sends an ACK after SIFS. If ACK arrives then it goes to the starting state, otherwise after ACK timeout it goes for an exponential back-off .Once an error occurs, a packet has to be retransmitted by the attempting station. Errors may be caused by many possible situations. For example, the corresponding CTS frame may not be returned after an RTS frame is transmitted. This may occur due to: Collision with the transmission of another station. Interference in the channel during the transmission of other RTS/CTS frames. DCF only supports best-effort services but does not provide any QoS guarantee for time bounded applications such as real-time multimedia, video conferencing etc .So DCF does not support any differentiation mechanism to guarantee bandwidth ,packet delay and jitter for high-priority multimedia flows. These are the problem area in WLAN, which needs a greater attention for research. Some parameters of CW,Back-off Algorithm and Inter-frame spacing can be tunable to achieve the better service differentiation. Due to the lack of a centralized controller,it is challenging to achieve quality of service (QoS) in terms of delay, jitter ,and fairness in distributed channel access. To enhance the IEEE 802.11 MAC, IEEE 802.11e proposes new features with QoS provisioning to real-time applications [2][4][10].

2.4 The 802.11 Point Coordination Function(PCF)

The mandatory Point Coordinator Function is implemented by the Access point in an infrastructure based network[3]. The stations requesting the PCF mode of get associated with the Point Coordinator during the contention period (CP). With PCF, the channel access alternates between the contention free period (CFP) and the contention period (CP) for the PCF and DCF modes of operation respectively.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 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 a super frame.The channel access switches alternately between PCF mode and DCF mode, but the CFP may shrink due to stretching when DCF takes more time than expected. This happens when an MSDU is fragmented into several MPDUs, hence giving priority to these fragments over PCF mode of operation[4].

2.5 Inter Frame Spaces Defined In IEEE 802.11

The time interval between frames is called the IFS. A station shall determine that the medium is idle through the use of the carrier-sense function for the interval specified. Four different IFSs are defined to provide priority levels for access to the wireless media; they are listed in order, from the shortest to the longest:

SIFS(Short Inter frame space):It is the shortest inter frame space used to allow the parties in a single dialog a chance to attempt transmission .This includes allowing the receiver to send a CTS in response to a RTS or allowing the receiver to send an ACK in response to to a data frame.

PIFS(PCF Inter frame space):In the infrastructure mode the base station or access point may sent a beacon frame or poll frame The PIFS shall be used only by STAs operating under the PCF to gain priority access to the medium at the start of the Contention Free Period.

DIFS(DCF Inter frame space): A station using the DCF shall be allowed to transmit if its carrier-sense mechanism determines that the medium is idle at the DIFS as a correctly received frame, and its back-off time has expired.

EIFS(Extended inter frame space): The EIFS is used only by a station that has just received a bad or unknown frame to report a bad frame[2][3].

2.6 Services Offered by IEEE 802.11

Wireless LANs conforming to IEEE 802.11 must provide nine services divided into two categories :five distribution services and four station services. The five distribution services are provided by the base stations and deal with station mobility .They are as follows :

(i)Association: These are services used by mobile stations to connect themselves to the base stations .It is generally used just after a station moves within the radio range of the base station.

(ii)Disassociation: Either the base station or station can disassociate ,thus breaking the relationship.

(iii)Reassociation: The preferred base station can be changed by this service.

(iv)Distribution: The manner in which the route frames are sent to the base station is determined by this service.

(v)Integration: Translations from the 802.11 format to the format required by the destination network is handled by this service.

The four station services are as follows :

(i)Authentication: A station must authenticate itself before it is permitted to send data because wireless communication can easily be monitored by unauthorized stations .

(ii)Deauthentication: When a previously authenticated station wants to leave the network ,it is deauthenticated.

(iii)Privacy: For information sent over a wireless LAN to be kept confidential ,it must be encrypted.

(iv)Data delivery: It provides a way to transmit and receive data[2].

3 Chapter

QoS Enhancements proposed in 802.11e

The IEEE 802.11 Task Group e (TGe) was setup to enhance the current 802.11 MAC protocol such that it is able to support multimedia applications and overcome the shortcoming of the DCF and PCF in providing QoS to multimedia and real time traffic[4].

3.1 Enhanced distributed coordination function (EDCF):

Enhanced distributed coordination function (EDCF)[4][5][6][7][8][10]provides differentiated and distributed access to the wireless medium. Each frame from the higher layer carries its user priority (UP). After receiving each frame, the MAC layer maps a frame into an access category (AC) depending upon the user priority it carries. Each AC has a different priority or preference of access to the wireless medium. One or more UPs can be assigned to each AC. EDCF specifies upto eight ACs to support the user UPs. The EDCF has access parameters for controlling channel access such as Minimum and maximum Contention Window size(CWmin and CWmax) ,Arbitration inter frame space(AIFS) and Transmission opportunity limit(TXOP limit).The user priorities are generally mapped into four ACs ,the packets in each AC being treated identically. Each station contends for transmission opportunities (TXOPs) by means of a unique set of EDCF channel access parameters with respect to the AC of the packet to be transmitted. The TXOP is defined as an interval of time during which a station has the right to initiate transmissions. It is characterized by a starting time and a maximum duration called TXOP Limit. Depending on the duration of TXOP, the station may transmit one or more MSDUs.The lowest UP assigned to the Access category determines its priority. Whereas all DCF back-off slots begin after DIFS from the end of the last indicated busy medium, EDCF back-off slots begin at different intervals according to the AC of the traffic queue. The duration of the inter frame space (AIFS[AC]) is given by:

$AIFS[i] = SIFS + AIFSN*slottime$

Each queue is associated with a specific access category (AC) and contends for the channel independent of the others. Collisions among a single stations queues are resolved internally, permitting the higher priority queue to transmit and forcing the lower priority queue to perform a collision response. Different levels of service are provided to each AC through a combination of three service differentiation mechanisms as follows:

- Arbitrary Interframe Spaces (AIFS);
- Contention Window sizes;
- Medium occupancy limits[6].

Per priority differentiation used by EDCF ensures better services to high priority classes while offering a minimum best effort service for low priority traffic. Although this mechanism improves the quality of service of real-time traffic, the performance obtained are not optimal since EDCF parameters cannot be adapted to the network conditions[7].

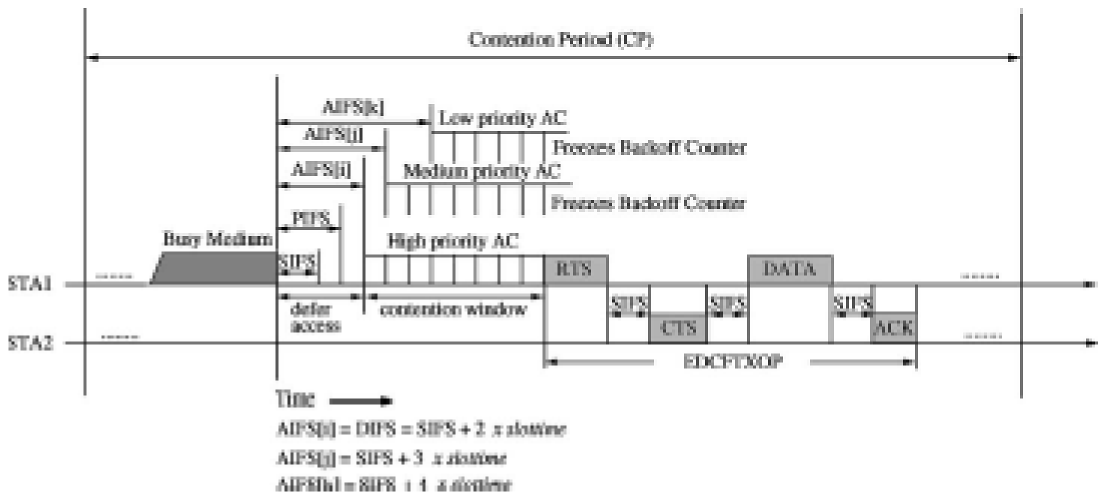

Figure 1: EDCF access Mechanism[4]

3.2 Hybrid coordination function(HCF):

The Hybrid coordination function (HCF) has features common to both EDCF and PCF in order to provide the capability of preferential handling of MAC service data units (MSDUs). It has upward compatibility with the both DCF and PCF. A common set of frame exchange sequences is carried out during both the Contention Period(CP) and the Contention Free Period (CFP). The HCF is usable only in infrastructure-based BSSs that provide QoS, i.e., QBSSs. The HCF uses a QoS-aware point coordinator, called HC, which is typically associated with a QAP. The HC or Hybrid Coordinator implements the frame exchange sequences and the MSDU handling rules defined in HCF, operating during both the CP and the CFP. It allocates TXOPs to stations and initiates controlled contention periods for the stations to send reservation requests. When the HC needs access to the wireless medium, it senses the medium.If the medium remains idle for a PIFS period MSDU services are initiated. After the medium is determined to be idle for at least one PIFS period the HC can start contention free controlled access periods called CAPs at any time during the CP. A CAP may include one or more TXOPs. During the CAP, the HC may transmit frames and issue polls to stations to grant them TXOPs. At the end of the TXOP or when the station has no more frames to transmit, the control of the medium is explicitly handed back to the HC. During CP, each TXOP begins either when the medium is determined to be available under the EDCF rules (EDCF-TXOP) or when the station receives a QoS CF-Poll frame from the HC (Polled-TXOP)[4][8][10].

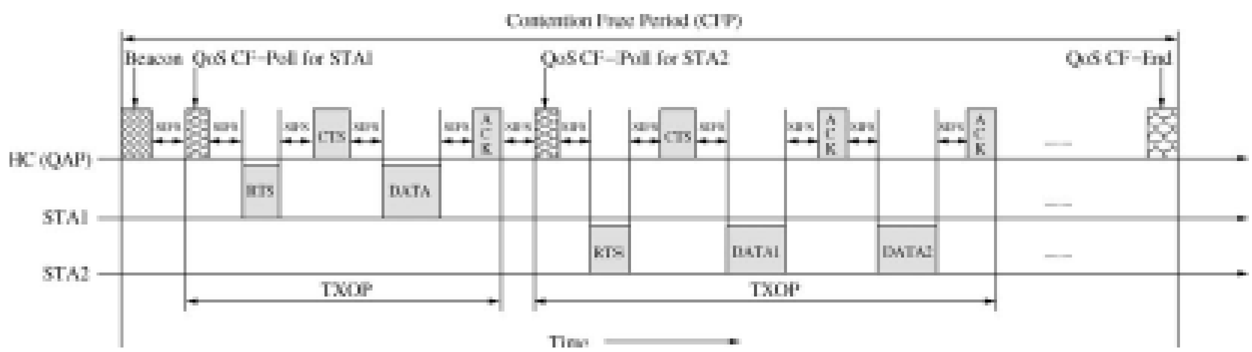

Figure 2: HCF access Mechanism[4]

4 Chapter

Further Proposals for QoS Improvement

4.1 Different back-off algorithms and Contention Window management schemes

In the IEEE 802.11 Wireless Local Area Networks (WLANs), network nodes share a common radio channel and hence face collisions .When a collision occurs they need to back-off for a period of time, which is randomly selected from the Contention Window (CW).The commonly used back-off scheme is the Binary Exponential Back-off algorithm .Since it has been seen in several studies that the BEB scheme lacks fairness some other back-off algorithms have also been proposed. In the IEEE 802.11 DCF scheme, the CW is dynamically controlled by the Binary Exponential Back-off (BEB). In the BEB algorithm, the value of the contention window is doubled every time a node experiences an unsuccessful packet transmission .If however there is a successful packet transmission the contention window is reset to the minimum value. In order to avoid the contention window from growing too large or shrinking too small, two bounds on CW are defined: the maximum contention window (CWmax) and the minimum contention window (CWmin). However, the BEB scheme is seen to fairness ; some nodes can achieve significantly larger throughput than others. The fairness problem can be attributed to the fact that the scheme resets the contention window of a successful sender to CWmin , while other nodes continue to retain larger contention windows, thus reducing their chances of getting hold of the channel and resulting in channel domination by the successful nodes .To address the issue of fairness in BEB the MILD(Multiplicative Increase and Linear decrease) algorithm was introduced which works as follows:

CW = min(1.5*CW;CWmax)   upon collision

CW = CW packet upon overhearing successful packets

CW = max(CW-1;CWmin) upon success

In the LMILD scheme, each node experiencing an RTS collision increases its CW by multiplying it by the factor mc. Any node overhearing a collision with the help of the above-mentioned technique increases its CW by lc units(slots). When a successful RTS transmission takes place, all nodes (including the sender, the receiver, and all overhearing neighbors) decrease their CWs by ls units. Thus, the operation of the LMILD algorithm can be summarized as follows:

CW= min(mc* CW; CWmax) upon collisions

CW= min(CW + lc; CWmax) upon overhearing collisions

CW= max(CW ls ;CWmin) upon experiencing or overhearing success

In the LMILD scheme, the failed senders increase theirCWs multiplicatively, while neighboring nodes increase their CWs linearly[9].

4.2 Characteristics of the original EDCF scheme

The EDCF scheme in 802.11e protocol differentiates the traffic and maps them into separate access category depending upon its priority. Each access category is allotted different channel access parameters such as contention window range[CWmax[i],CWmin[i]] and Arbitration Inter Frame Spaces(AIFS[i])for each access category denoted by AC[i].The CW range and AIFSN values are kept low for high priority traffic and high for low priority traffic such that the high priority traffic may have to wait less for getting a chance to transmit [5][8].

The values of the parameters for the different Access Categories are as follows:

AC[3]→ CWmin=3;CWmax=7;AIFSN=2;

AC[2]→ CWmin=7;CWmax=15;AIFSN=2;

AC[1]→ CWmin=15;CWmax=1023;AIFSN=7;

AC[0]→ CWmin=15;CWmax=1023;AIFSN=16;

Where; AC[0] refers to background traffic ,AC[1] refers to best effort traffic ,AC[2] refers to video traffic and AC[3] refers to voice traffic. By using different values of these parameters it is ensured that the high priority video and voice traffic have to wait less in order to access the medium. Since these are delay sensitive traffic it is essential that the delay and jitter are kept at minimum.

Predefined values of CWmin and CWmax and a binary exponential backoff is used for each access category is used.

CW[i] = max(2*CW[i],CWmax[i])   On collision;

CW[i] = CWmin[i];   On Successful Transmission;

Where ; AC[0] refers to background traffic ,AC[1] refers to best effort traffic ,AC[2] refers to video traffic and AC[3] refers to voice traffic. By using different values of these parameters it is ensured that the high priority video and voice traffic have to wait less in order to access the medium. Since these are delay sensitive traffic it is essential that the delay and jitter are kept at minimum.

The IEEE 802.11MAC layer DCF of and the 802.11e EDCF follow the binary exponential back-off algorithm in which the Contention Window for that particular Access Category(AC[i]) is is set to double its value whenever there is a transmission failure till it reaches the maximum value that is CWmax[i] . Whenever there is a successful transmission the CW[i] is reset to its minimum value CWmin[i]. It assumes that once a successful transmission occurs the factors causing failure of transmission no longer exist. This may not be the case always and it may result in a higher rate of collisions causing degeneration of performance .Further the BEB scheme suffers from fairness issues under high traffic load and low throughput problems when network size is large. The fairness problem occurs due to the fact that the scheme resets the contention window of a successful sender to CWmin , while other nodes continue to maintain larger contention windows[9].

4.3 Proposed Modification

We have proposed a scheme in which the increasing of the contention window in case of a transmission failure as well as its resetting is done in a gradual and non-uniform manner in the Contention Window range. The manner in which the Contention window is made to vary depends upon the kind of traffic .For high priority traffic the Contention Window is varied linearly in case of a collision till it reaches a certain value after which it is increased at a faster rate. Same is the case for resetting the contention window. Linear increase in contention window size helps reducing the delay difference between packets sent from different rounds of back-off, while reducing the probability of collision in subsequent rounds[5].

4.4 Module Description

In the above scheme the module Increase Contention Window which is called whenever there is a unsuccessful transmission occurs performs the following functions .First it checks the access category of the traffic flow .If it is high priority voice or video traffic it checks its current CW[i] value .If it is less than twice that of its CWmin[i] ,its CW is incremented linearly till it reaches twice the CWmin[i] .Beyond that the value of CW[i] is increased at a faster rate by multiplying with a factor of 1.5.The justification for this kind of modification is that the probability of three or more consecutive collisions is less [5] hence linear increase of the CW will not affect the overall performance .Moreover the CWmin[i] value of the high priority traffic is kept low .If there are too many collisions the CW starts to increase at a faster rate once CW[i] becomes greater than 2*CWmin[i]. for low priority traffic the CW[i] value is increased consistently by multiplying by a factor of 1.5.

Increase Contention Window(AC[i]):

```
Begin
        If(i≥2)        //For video and voice traffic
        If(CWi<2*CWmin)
             CW[i]=min(CW[i]+1,2*CWmin[i])
        Else
             CW[i]=min(CW[i]*1.5,CWmax[i])
        Endif
        Elseif(i≥0 and i<2 ) //For best effort and background traffic
             CW[i]=min(CW[i]*1.5,CWmax[i])
        Else (Display Invalid Access category)
        Endif
End
```

4.5 Module Description

The above module Reset Contention Window which is called whenever there is a successful transmission performs the following functions .Instead of immediately resetting the CW[i] value to CWmin[i] for a particular Access Category in case of a successful transmission it checks its priority .If it belongs to video or voice traffic the Contention window is linearly decremented if CW[i] is less than twice that of CWmin[i] otherwise it is decreased by a factor of 0.5 as in the slow decrease scheme mentioned in[7] .For all other traffics the CW[i] is decreased by 0.5 till it reaches the CWmin[i] .This slow decrease scheme includes linear decrease for high priority traffic[7][9].

Reset Contention Window(AC[i]):

```
Begin
        If(i≥2)          // For video and voice traffic
        If(CW[i]<2*CWmin[i])
             CW[i]=max(0.5*CW[i],2*CWmin[i])
        Else
             CW[i]=max(CW[i]-1,CWmin[i])
        Endif
        Else(i≥0and i<2) //For best effort and background traffic
             CW[i]=max(0.5*CW[i],CWmin[i]);
        Else(Display Invalid Access Category);
        Endif
End
```

5 Chapter

Simulations and Result

5.1 Simulations

We have implemented the above proposed modifications and compared the results to the existing EDCF. All the simulations have been done using the Qualnet network simulator designed by Scalable Networks Inc. For carrying out the simulation we have taken 50 nodes in a 1000mX1000m area. An uniform distribution model has been followed. The nodes are fully independent and are operating in a distributed environment. The nodes are operating in an ad-hoc mode or IBSS mode without any central Access Point to coordinate channel access, Ten nodes have been connected in a manner such that each node sends and receives a pair of high priority voice traffic and a low priority best effort traffic. Constant Bit Rate connections have been used for each of the connections. For the voice traffic 64 byte packets are sent at an interval of 20 millisecond giving a data rate of 25.6 kbps .For the best effort traffic 512 byte data packets are sent at an interval of 16 milliseconds giving a data rate of 256 kbps. The no of packets of each of the two traffic are increased from 20 to 160 and the scenario is executed. Finally graphs for the average value of the Throughput ,Packet Delivery Ratio ,and jitter of the high priority voice traffic in the presence of low priority best effort traffic are plotted against the no of packets sent. The performance of proposed modification can be compared with the existing EDCF scheme. Simulation have also been carried for mobile stations .For this a random waypoint mobility model is used with a pause time of 50 seconds.

SCENARIO SCREEN SHOT

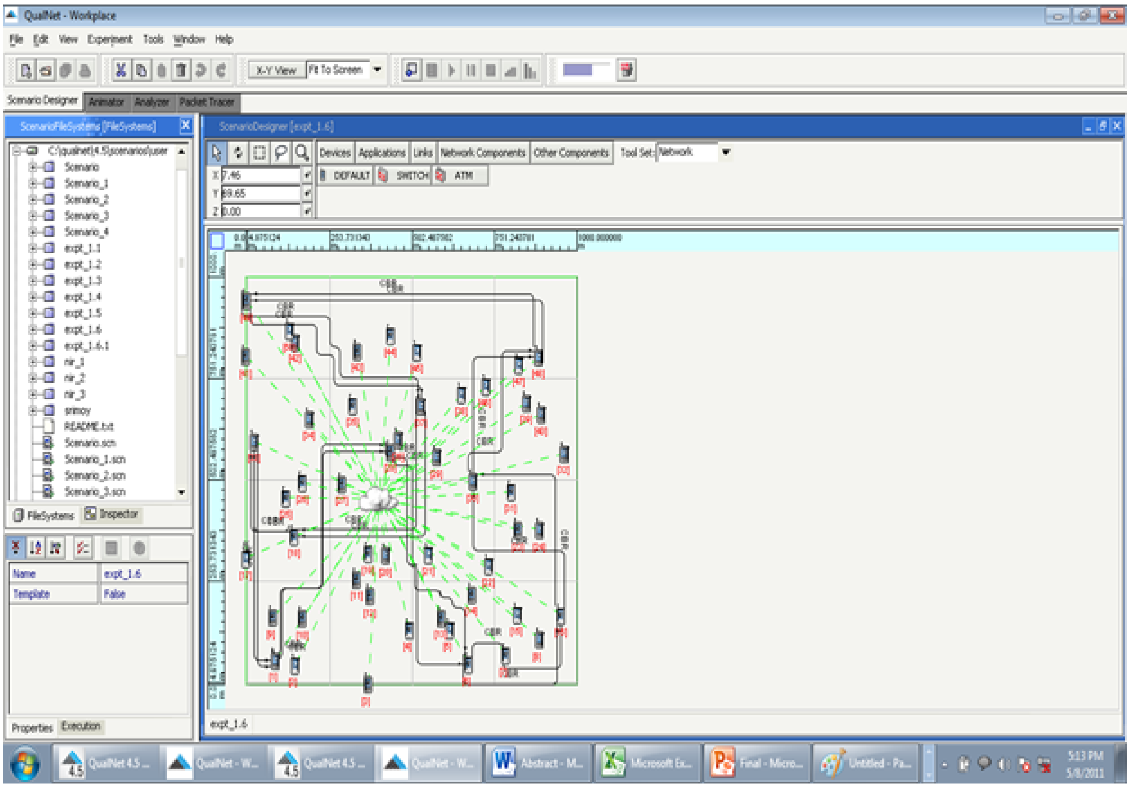

Figure 3: Screen Shot of Scenario

5.2 Results

The scenario described above was run for no of the packets varying from 20 to 160 Packets and the average value of the performance parameters are taken for the ten stations .The experiment is carried out once for the existing EDCF scheme and once for the proposed scheme. The performance parameters are then compared .

5.2.1 For Static Nodes

When the results are plotted for static nodes the following graphs have been obtained:

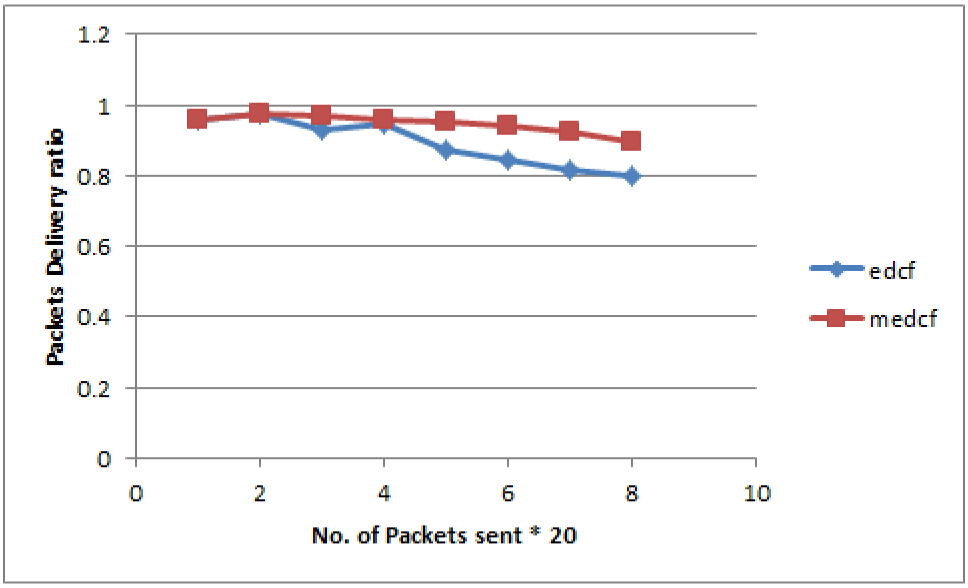

Figure 4: Packet Delivery Ratio VS No. of Packets sent

The above graph shows that after the proposed modification have been applied there is a gain in the average packet delivery ratio .Packet delivery is defined as the ratio of packets received by receiver to that of the packets sent by the sender. The gain obtained is consistent for any number of packets. This shows that our proposed scheme has reduced the rate of collisions and thereby has brought down the rate of packet loss .This validates our claim that the gradual contention window variation scheme does indeed bring down the packet collision rate.

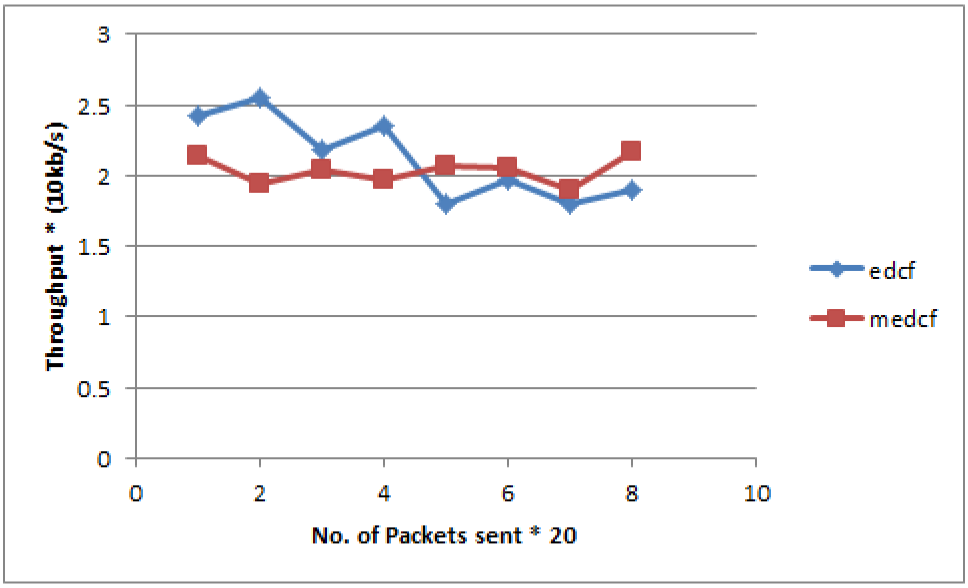

Figure 5: Throughput VS No. of Packets sent

When the proposed scheme is applied it is observed that the average throughput suffers in our scheme when the number of packets is less than a certain maximum value. From the above graph the value is found to be around 90 packets per station for the high priority data. When the number of packets increases beyond a certain value we observe an improvement for our scheme. This indicates that the proposed Contention window management scheme gives a better throughput performance at high traffic condition than at low traffic conditions. At high traffic conditions collision rate becomes higher. Thus we can conclude that our scheme is able to reduce the packet loss due to collisions to give a better throughput at higher traffic.

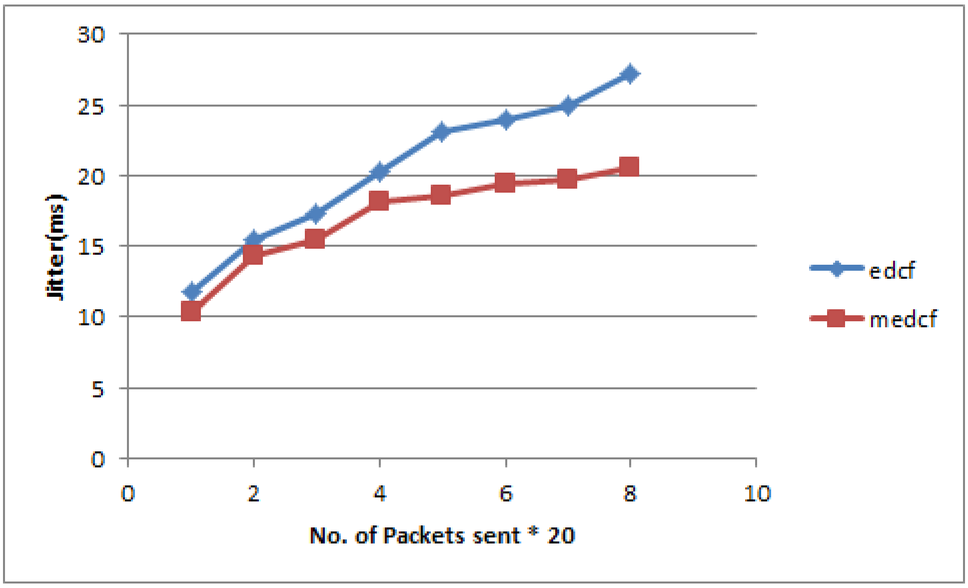

Figure 6: Jitter VS No. of Packets sent

In the above graph the average jitter of the network shows a steady improvement for any number of packets when the proposed scheme is applied .Jitter indicates the variation in delay experienced in a network. This indicated that the gradual increase and decrease of the Contention Window causes the delay between packets to be more uniform thereby reducing the average jitter. Since the time for which the stations defer transmission on suffering collision varies less than in the Binary Exponential back-off followed by the EDCF scheme the proposed scheme in giving a reduced average jitter value for the network.

5.2.2 For Mobile Nodes

The following results are obtained when mobile nodes are used instead of static nodes:

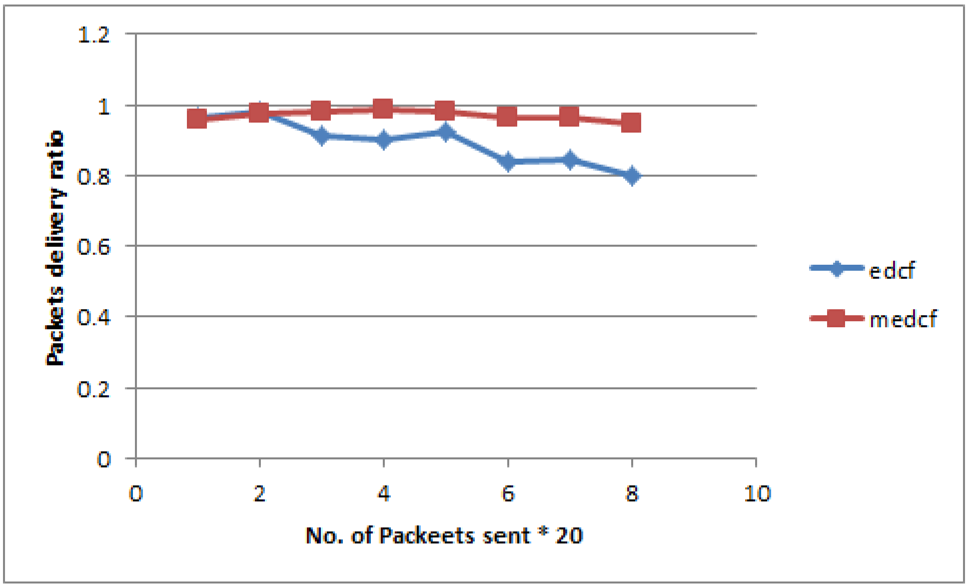

Figure 7: Packets Delivery Ratio VS No. of Packets sent

The graph obtained shows that after the proposed modification have been applied there is a gain in the packet delivery ratio similar to what was obtained for static nodes .The gain obtained is also consistent for any number of packets. This shows that our proposed scheme has reduced the rate of collisions and has brought down the rate of packet loss .Given the fact that mobile nodes suffer higher packet loss and transmission failures our proposed scheme performs well in maintaining a consistent packet delivery ratio for mobile nodes .

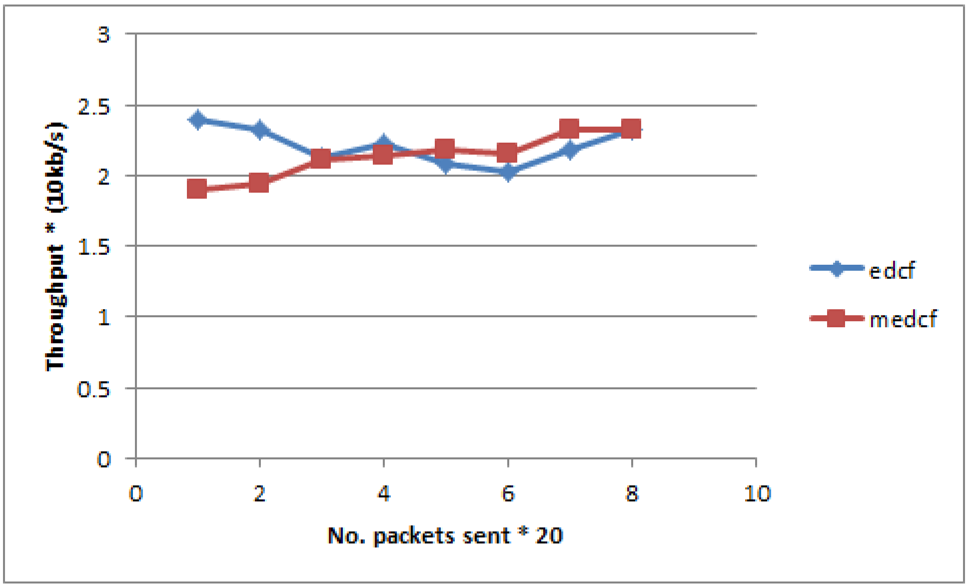

Figure 8: Throughput VS No. of Packets sent

As in case of static nodes the average throughput suffers in the proposed scheme when the number of packets are less but it improves as the number of packets increases beyond a certain value . In this case it is about 80 packets per station for high priority traffic .However the gain in average throughput of the network is not as impressive as the static nodes. At high traffic conditions collision rate becomes higher. It becomes still higher for mobile nodes .However we can conclude that the proposed scheme is able to reduce the packet loss to some extent for mobile nodes and hence gives a better throughput at higher traffic.

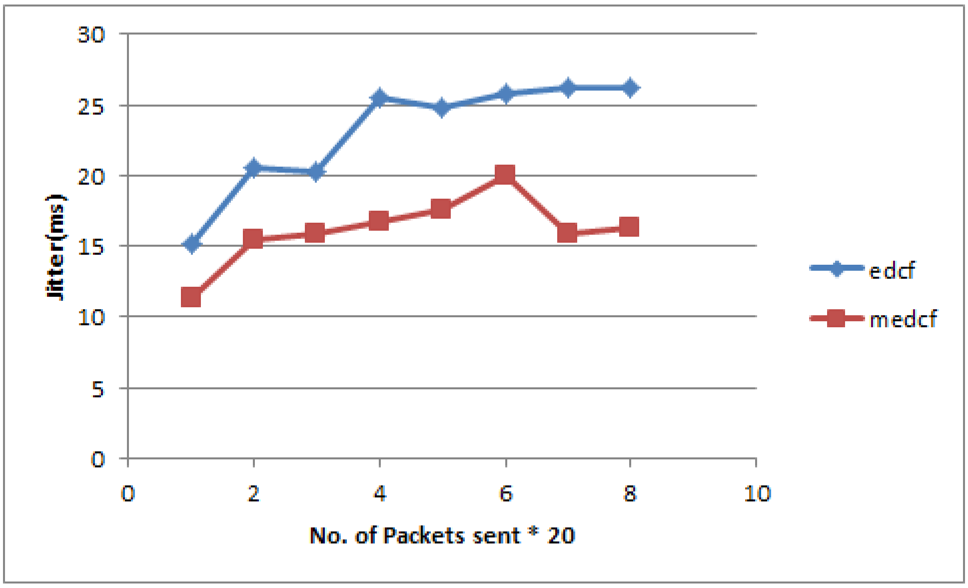

Figure 9: Jitter VS No. of Packets sent

In the above graph the effect of the proposed scheme on the average jitter value is higher for mobile nodes than for static nodes .There is a consistent improvement in the average jitter value for any no of packets sent .This indicates that the slow and non-uniform variation of the Contention Window in the proposed scheme helps to bring down the variation in delay during transmission for static as well as mobile stations.

6 Chapter

Conclusion and Future work

6.1 Conclusion

In this thesis we studied the various QoS enhancement schemes in the MAC layer for wireless networks .We have further proposed a modification to the existing 802.11e EDCF by varying the Contention Window of high priority traffic in a gradual and non-uniform manner and then demonstrated the effect of the proposed scheme by carrying out the simulations and compared the results with the existing EDCF scheme .From the simulations and results we conclude that the proposed scheme for increasing and resetting the contention window results in the gain in some of the performance parameters : The average packet delivery ratio shows a consistent improvement for both static and mobile nodes .The average throughput shows improvement when higher number of packets are sent for both .The average jitter is less for both static and mobile node. Thus we see that the slow , non-uniform increase and decrease of the contention window for high priority does indeed results in an improvement for these network performance parameters.

6.2 Future Work

The Back-off algorithm and the Contention window variation schemes have a strong impact on the performance of a network and in providing QoS for particular classes of traffic. In this thesis we have proposed a scheme for varying the CW which resulted in the improvement of some of the performance parameters .Further study may be done to tune the scheme further to get even better results for parameters such as mean delay .The impact of network environment may be studied and mathematical analysis may be done to determine the optimal factors by which the CW can be increased or decreased to improve the performance of the scheme even further.

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