Indian Journal of Science and Technology, *Vol 10(19), DOI: 10.17485/ijst/2017/v10i19/112375, May 2017*
ISSN (Print) : 0974-6846
ISSN (Online) : 0974-5645

Priority Station Based Queuing Approach to Improve Quality of Service in IEEE 802.11e EDCF

H. S. N. Murthy[1], Naveed Farhana[2]* and C. H. Sreenivasa Rao[3]

[1]Department of ECE, JNTUCE, Hyderabad – 500085, Telengana, India; murtyhsn@yahoo.com
[2]R&D Cell, JNTUH, Kukatpally, Hyderabad – 500085, Telengana, India; farhana_naveed@rediffmail.com
[3]Department of ECE, ACE Engineering College, Ghatkesar – 501301, Hyderabad, Telengana, India; sreenivasaraophd@gmail.com

Abstract

Objectives: To enhance the performance of EDCF for the higher priority traffic under heavy load condition by providing higher throughput to provide desired QoS. To achieve this, we propose a method called Priority Station Based Queuing (PSBQ). An enhancement called as The IEEE 802.11e Enhanced Distributed Coordination Function (EDCF) has been developed to fulfill the growing need for the Quality of Service (QoS) in IEEE 802.11. **Methods/Statistical Analysis:** In EDCF standard the prioritization applies to the stations based on First in First Out approach (FIFO). Here, the size of the contention window size is reset according to the static equation after successful transmission for each traffic class, resulting in the degradation of the performance. So, we proposed our PSBQ which is the modified version of the already existing mechanism known as PRED, which applies the priority to the stations based on Random Early Detection (RED) instead of FIFO in EDCF Mechanism. **Finding:** In our approach to enhance the throughput of high priority traffic class, a priority is obtained by to the station based on Adaptive Random Early Detection (ARED), which is an Active Queuing mechanism and tuning was perform. On the parameter of the PSBQ, according to the network conditions and lastly the revision of the contention window adjustment is applied dynamically. **Application/Improvements:** Simulations was performed using the OpnetSimulator to evaluate its performance and found the results to be better in achieving prioritized, good service differentiation regarding throughput for higher priority traffic class under heavy load conditions to provide a desirable QoS.

Keywords: Collision, Enhanced Distributed Coordination Function, Priority Station based Queuing Algorithm, Quality of Service, Throughput, Wireless Network

1. Introduction

With the increasing demand of applications available over wireless networks and also due to the advent in the advancement of technology and miniaturization of Integrated Circuit (IC) results in a large amount of sophisticated devices. It is offered that wireless access be the ultimate hop of the communication path in Wireless Local Area Network (WLAN)[1] and the Medium Access Control (MAC) is the fundamental protocol, which have to provide the an effective scheme to share the wireless medium between different devices like portable stations, smart phones and handheld devices that were developed resulting in Real-time applications such as video conference, IPTV and VoIP etc. which are delay sensitive and require maximum throughput to meet their QOS requirements[2].

**Author for correspondence*

The IEEE 802.11 protocol, which is the Elementary mechanism to access the wireless spectrum, is known as DCF (Distributed Coordination Function)[3] and it is a contention-based mechanism. Also, it is simple, robust and also has fast installation and fewer maintenance costs but it is highly suitable for best effort services, does not provide any priority and service differentiation to the multiple traffic class.

To meet the multiple services in Wireless Local Area Network and also to provide the QoS requirement, this is necessary for live video, VoIP, etc. A new mechanism called as Enhanced Distributed Coordination Function (EDCF)[4] was developed by IEEE 802.11 working group, which provides a good of services differential by prioritizing traffic categories by assigning different parameters to different priority such as Arbitrary Inter-Frame Space (AIFS) and Contention window. The highest priority traffic class is allowed to access to the spectrum before the low priority traffic class.

There have been many performance studies proposed both in simulation studies and analytical models to increase the performance of the IEEE 802.11e EDCF and hence the Quality of Service.

Among the authors[5] proposed a scheme, which differentiates between a higher priority class and the low priority class with different contention window, wherein[6] suggests a dynamic window mechanism and suggested slow decreases in the contention window size[7]. Transmission Opportunity (TXOP) allocation scheme and service differentiation[8,9] have been embraced to maximize the throughput and reduce the backoff delay. However,admission mechanisms[10,11] also suggested acquiring the demanded Quality of Service. In[12–14] suggested that the concept of Super-slot to minimize the rate of collision is to increase the throughput and also provides the fairness among the different traffic classes.

In our suggested mechanism, to improve the throughput of IEEE 802.11e based on the PSBQ mechanism, which is based on a applying queuing mechanism to the stations, this concept was introduced by the researchers in for the first time known as Priority Random Early Detection (PRED)[15]. They use Random Early Detection (RED) to prioritize the classes in the station and showed the improvement in throughput for higher priority traffic class and showed the improvement with EDCF through simulation studies. We use the Adaptive RED queuing algorithm because the drawback of RED is to adjust the average queue size, which is fluctuating due to changing channel conditions, resulting in the unpredictable delays which are not desirable for QoS. We suggest ARED, as it adjusts the average queue by adjusting the dropping probability by a scaling parameter α and β (discussed in section detail 2.2). Also, the size of the buffer is reduced to 50 when compared to 70 in[15]; it means the longer the buffer size, the longer the delays. Also, we suggest different collision resolution mechanisms based on calculating the collision rate in adopting the contention window size discussed in[16]; simulation showed that our proposal gives an improvement in throughput for the higher priority class compared to EDCF as well as PRED. The paper is divided into following sections as follows: In Section 2, related work has been discussed, in Section 3 we offer overall details about our proposal, Section 4 gives brief-out about the collision resolution mechanism and Section 5 shows the simulation results and discussion and Section 6 concludes the paper.

2. Related Works

2.1 Enhanced Distributed Coordination Function (EDCF)

EDCF[3,4] is a viable scheme defined in IEEE 802.11 standard is to develop and to fulfill the requirement of demanding QoS in Wireless LAN by supporting 8 users priorities, which are mapped to 4 Access Categories (AC_i) as AC (VO) for Voice traffic, AC (VI) for video traffic, AC (BE) for best effort traffic and AC (BK) for background traffic. Each (AC_i) within every station behaves like a virtual station autonomously contents for accessing the channel. The back-off process is also carried out individually after detecting that the medium is ideal for a time equal to Arbitrary Interface Space AIFS (AC_i). Each AC_i uses (AIFS[ACi]), CWmin [ACi] and CWmax [ACi] and Persistence Factor (PF), as a replacement for of the DIFS time, CWmin and CWmax of the DCF. The clashes between the virtual queue within each station are fixed by permitting access to the higher priority class with EDCF. After each successful transmission of ACi, the equivalent CW_i will be set to CW_{imin}. Once the transmission is unsuccessful, CWi is calculated as $CW_i = \min(CW_{imax}, CW_i * PF)$. It waits for Arbitrary inter-frame space (AIFS) time and the back-off timer is reset to a random number from (1, CWi +1) with the unit of the time slot.

2.2 Active Queue Management (AQM)

It is a mechanism to control the congestion control at the station buffer. The idea behind AQM is to avoid congestion before the buffer gets filled up and full. Most of the popular AQM mechanisms[17–19] are queue based, most popular among them is called as Random Early Detection (RED) ,which measures the queue length, if it is more than the average queue length, it drops the packets depending upon the statistical probability and if the buffer is found empty, the incoming packets are buffered, as the size of the queue grew, the dropping probability also increases, that means the dropping probability of the packet are increase[18].Many RED variants, such as WRED were also developed and this drop the packets according to the packets' type. Also,PRED. The PI (Proportional Integral) controller[19] uses the attributes of the queue to fix the steady value of queue length to the specified reference value[20]. All the stated techniques discussed RED algorithm and its variant has a problem with the adjustment of average queue length and also parameter setting.

Adaptive RED (ARED): In[21], adaptive RED gives as a controller to control and also to monior the average queue size. It states that the dropping probability P_{max} is scaled by constant factors of 'α' and 'β' depending upon the threshold it crosses. Here, the dropping Probability P_{max} varies according to the condition of the network load. If the load is light a dropping probability is also slight and if the network load increases the dropping probability is also increases as it can be depictedfrom the Figures 1 and 2.

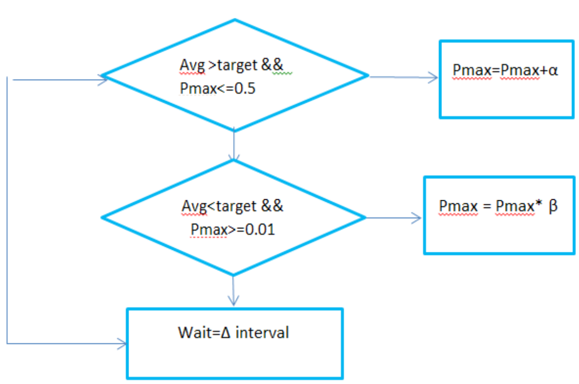

Figure 1. Adaptive RED flow chart.

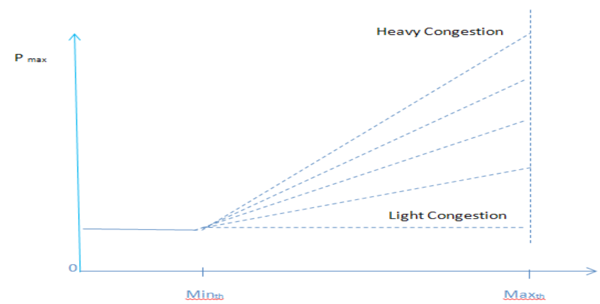

Figure 2. Average queue length.

2.3 Priority Random Early Detection (PRED)

In[15] are the only researchers who introduced a queuing mechanism in a station with multiple services for the first time known as Priority Random Early Detection (PRED), which combined Random early detection with IEEE 802.11e Enhanced DCF.

In the PRED algorithm, the packets enter the station queue uses EDCF to contend the channel and offers Min_{th} (AC_i) and Max_{th} (AC_i) to each access category and Maximum values are assigned to higher priority class than the lower priority class. Also, its parameter, q(ACi) are used for tunning the packets according to the condition of the network load. Under heavy traffic load condition, here q(AC_i) is a cut-off value which judges whether the incoming packets can execute PRED algorithm, the value of q(AC_i) will be decreased or increased depending on the collision. It means if collision arises, the q(AC_i) will be decreased by certain value and q(AC_i) will be added after successful consecutive successful transmission (un collide _ time) under less traffic load condition the changes of q(AC_i) is low and in heavy load traffic, the gap of q(AC_i) decreases, so with low priority traffic will be discarded and still the high priority maintains the Quality of Service even in the increasing network load. Also, introduced a new parameter *cont_c* after consecutive collisions even CW (AC_i) reaches CW_{max} (AC_i) gets doubled, consecutive collisions (*cont_c*). So, the problem of collision under heavy network load can be resolved. Here the drawback with the PRED algorithm is that it uses the RED algorithm for its early detection and drops the packets, variation of average queue size with the amount of congestion and parameter settings thus queuing delay cannot be early estimated.

Another drawback is that the size of the queue was set to 70 packets, such a large buffer sizes may results in high delays, especially for lower priority traffic. If the delay is significant, hence, the packets may be considered as lost, corrupted or retransmitted[22].

3. Proposed Algorithm

In the proposed algorithm, we use the adaptive ARED algorithm to queue the packets that enter the station and the packets, which enter local queue content in the channel by using the Enhanced Distributed Coordination Function (EDCF). Here, in the proposed algorithm known as Priority Station based Queuing Algorithm (PSBQ), the values of L Targets queue size (L), α and β parameters control the average queue length which is assigned to each of the AC_i depending on their priority. The value of L is assigned larger to high priority class compared to the low priority.

L(AC3)>LA(AC2)>L(AC1)>L(AC0).

ARED algorithm supports prioritization to the station and the packets out of the station queue can use EDCF to contend the channel. So, proposed algorithm can help prioritized medium access for needed Quality of Service wireless LAN. In order to guarantee the Quality of Service requirement under different network load conditions, we have introduced a parameter called as q(ACi), it is a threshold which suggests that the arriving packets can perform ARED or not, whether the station is greater than q[ACi], the arriving packets are dropped otherwise they can perform ARED, the initial value of q(ACi) is equal to the size of the station queue which is set as 50 after collision the q[ACi] is decreased to:

$q[ACi] = q[AC_i]-\Delta[AC]$,Where i=0,1,2,3

$\Delta[AC_i]$ is a constant.

$\Delta[AC0] > \Delta[AC1] > \Delta[AC2] > \Delta[AC3]$

After consecutive successful transmissions, the $q[AC_i]$ increases by:

$q[ACi] = q[AC_i]+\Delta[AC_i]$

Under light traffic load $q[AC_i]$ is slight, but under heavy network traffic load, $q[AC_i]$ will increase, as the packets with lower packets drop first and higher priority can maintain the Quality of Service. The pseudocode of the algorithm is shown in Figure 3.

```
For each AC
        Initialization
            Set default values
              Target Length=[50,45,40,35]
               Max_th=    [30 35 40 50]
               Min_th= [15 17 20 25]
α= min (0.01, P_max/4)
                  β=0.9
                  q[ ACi]=50
                  ACi=[0-3]
for each packet arrival
if current queue size >  q(ACi)
drop the arriving packet
else
             perform ARED
end if.
          If collision
Reset uncollide time=uncollide time -1
         q[ACi]=  q[ACi]+Δ(ACi)
end if.
```

Figure 3. Pseudocode for the adaptive tuning of PSBQ algorithm.

4. Collision Resolution Mechanismin EDCF

As the channel time-varying innature and $q[AC_i]$, a collision resolution by contention window is suggested basedon[16,23] approach. As in setting of the Contention Window (CW) using static method decreases the throughput and increases the collision rate especially under heavy load conditions. So, here the average collision rate f^j_{avg} is calculated at the step of 'j'. For each update, the f^j_{avg} is calculated iteratively as:

$$f^j_{avg} = (1-\alpha)\, f^j_{current} + \alpha + f^{j-1}_{avg}$$

Where 'j' refers as the j^{th} update Period and $f^j_{current}$ denotes for instantaneous collision rate,

α = smoothing factors. To obtain the priority for different classes,traffic updates its CW_i, each traffic class should use a different factor called as M.F.

$$MF\,[i]=\min\,[1+i+2]^*\, f^j_{avg}\, ^*0.6 \quad i = 0,1,2,3$$

Here, M.F denotes a factor, which is used to reset the new contention window and must not exceed the previous contention window, allows the higher priority category to reset the CW parameters with a small M.F value than the low priority class. After success transmission of traffic class i, CW [i] updates as:

$$CW_{new}\ (i)=max\ [CW_{min}\ (i)\ ,\ CW_{old}\ [i]\ *MF(i)]$$

By this approach, the probability of getting the collision is reduced and hence delay. After collision, of different traffic class of i, the CW[i] is then increased by a persistence factor equal to PF(i).

$$CW_{new}\ (i)=min\ [CW_{max}\ (i),\ CW_{old}\ [i]\ *PF(i)]$$

PF(i) value is set different for different priority class providing the high priority class with small PF. This technique offers high priority traffic a high probability to generate small CW values than low priority traffic.

5. Simulation Results and Discussion

To evaluate the performance, simulations are carried out using a Wireless LAN, which works in infrastructure mode with a single Access Point (AP) and 'n' are the number of stations. Each station to have four Access Categories (AC) such as Voice, video, Best Effort and Background traffic transmitting packets simultaneously within the same transmission ranges. The size of the packets over a simulated network adopted as 1024 bytes with the queue length to be 50 packets. The simulation parameters for Medium Access layer (MAC) and Physical Layer (PHY), which are used in simulations are tabulated in Table 1. Our approach has introduced Priority Station Based Queuing approach to enhance the performance of higher priority traffic class under different network conditions and found the results to be better than the PRED and EDCF protocol.

Table 1. Simulation parameters

Parameter	Definition	Value
PHY Header	Physical layer header	192 bits
MAC Header	MAC layer Header	272 bits
ACK Frame	Acknowledgement Frame	304 bits
RTS Frame	Request to sent	352 bits
CTS Frame	Clear to sent	304 bits
Payload	Data Payload	8000 bits
Data Rate	Sending Data rate	54 Mbps
Time Slot	Time Slot	20µsec
SIFS	Short inter frame space	10 µ sec
AIFS	Arbitrary inter frame	[2,2,3,7]
CW_{min}	Minimum Contention window size	[7,15,31,31]
CW_{max}	Maximum Contention window size	[15,31,1023,1023]

Figure 4 we can observe that the performance of IEEE 802.11e EDCF is better under slight traffic load, but it is decreased when the number of stations is more, since the collision probability increases under heavy traffic load, whereas it is observed that for the PSBQ Algorithm, the throughput is lesser compared to the EDCF, since ARED gives priority to the high priority traffic class compared to the low priority traffic. The performance can further be increased by tuning the parameter of PSBQ as Δ [AC] equal to 0.01,0.05,0.035,0.001. From, Figure 5 we can observe that by applying the PSBQ algorithm the drop packet rate of AC(3) and AC(2) is decreased and hence decreases the delay. The probility of accessing the channel by higher priority (ACs) will be more compared to the other priorities.

Figure 6 shows the overall throughput for the all the three mechanism EDCF, PRED and PSBQ are plotted and observed that throughput of lower priority class is low for PSBQ, but it is larger for the high traffic class.

Figure 7 shows the collision rate and observed that all the three mechanisms - EDCF, PRED and PSBQ, the collision rate is almost same but increases for the high traffic class when compared to PRED and PSBQ, resulting in the reduction of delay and hence increases in throughput.

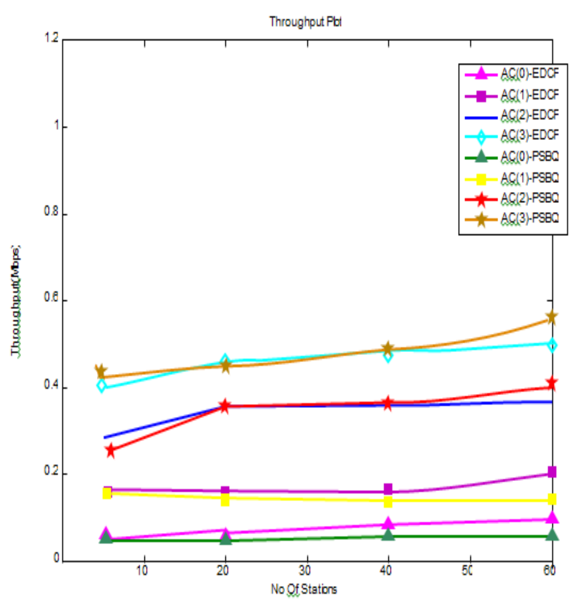

Figure 4. Throughput plot for EDCF and PSBQ.

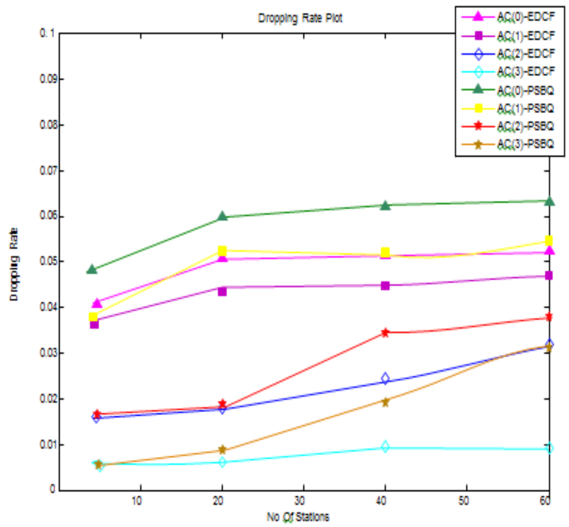

Figure 5. Dropping rate For EDCF and PSBQ.

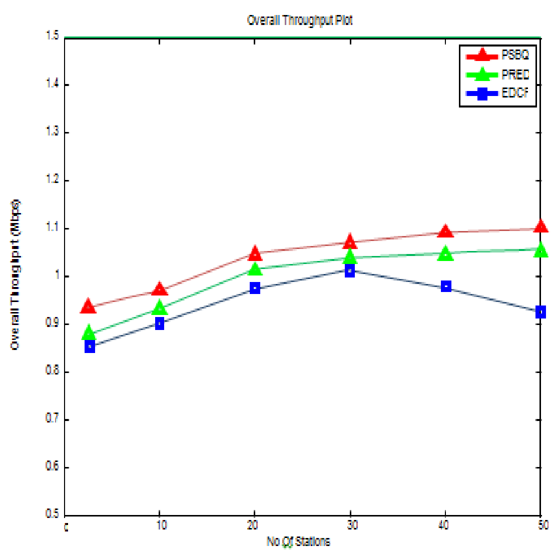

Figure 6. Overall throughput.

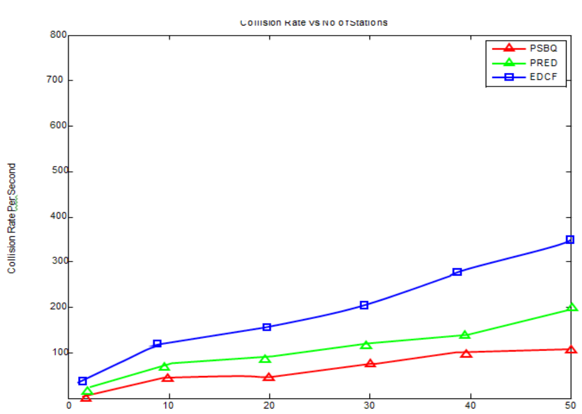

Figure 7. Collision rate.

6. Conclusions

We conclude that our proposed approach a station based queuing algorithm called PSBQ, which has the following features: First, the priority was applied to a station based on ARED, instead of FIFO as traditionally done in EDCF by which there is an increase in the throughput of the high priority traffic class. Second, the parameter of the PSBQ is tuned according to the collisions observed and the network load, further to increase the throughput. Lastly, avariation of the contention window is performed dynamically using collision rate to minimize the rate of collisions and hence increasing the overall throughput. We evaluated the performance of PSBQ through simulations and evaluation to be beneficial to the high priority traffic class than for the PRED and EDCFs and showed the improvement of the throughput for the high priority traffic.

7. References

1. Hiertz G, Denteneer D, Stibor L, Zang Y, Costa XP, Walke B. The IEEE 802.11Universe. IEEE Communication Magazine. 2010 May; 48(1):62–70. Crossref
2. Wi-Fi CERTIFIED for WMM – Support for Multimedia Applications with Quality of Service in Wi-Fi Networks. Wi-Fi Alliance. 2004 Sep 1.
3. IEEE Standard 802.11-1997. IEEE Standard for Local and Metropolitan Area Networks/ Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specification.
4. IEEE, IEEE Std 802.11-2012: Specific requirements. Part 11: Wireless LAN, Medium Access Control (MAC) and Physical Specification. 2012 Mar.
5. Deng DJ, Ke CH, Chen HH., Huang YM. Contention window optimization for IEEE 802.11 DCF access control. IEEE Transactions on Wireless Communications. 2008; 7(2):5129–35.
6. Sithira Abeysekera BAH, Matsuda T, Takine T. Dynamic contention window control scheme in IEEE 802.11e EDCA-based wireless LANs. IEICE Transaction Communication. 2010; 93(1):56–64. Crossref
7. Aad I, Ni Q, Castelluccia C, Turletti T. Enhancing IEEE802.11 performance with slow CW decrease. IEEE 802.11e Working Group Document. 2002. 802.11-02/674.
8. Misic J, Rashwand S. Analysis of impact of TXOP allocation on IEEE 802.11e EDCA under variable network load. IEEE Trans Parallel Distribution System. 2012; 23(5):785–99. Crossref
9. Cecchetti G, Ruscelli AL, Mastropaolo S, Lipari G. Providing variable TXOP for IEEE 802.11e HCCA real-time

networks. Proceeding of IEEE Wireless Communications and Networking Conference (WCNC); 2012. p. 1508–13.

10. Hu J, Min G, Jia W, Woodward ME. Admission control in the IEEE 802.11e WLANs based on analytical modeling and game theory. Proceeding of IEEE GLOBECOM; 2009. p. 1–6.
11. Liu Y, Meng M. Survey of admission control algorithms in IEEE 802.11e Wireless LANs. Proceeding of International Conference on Future Computer and Communication; 2009. p. 230–3. Crossref
12. Kang K, Jiang H, Lin X. Research on multi-slot virtual collision mechanism for IEEE 802.11 DCF. Proceedings of 2008 Vehicular Technology Conference. 2008. p. 1–6. Crossref
13. Yao XW, Wang WL, Wu TC, Yao XM, Yang SH. A novel hybrid slot allocation mechanism for 802.11e EDCA protocol. Information Processing Letters (Elsevier). 2014; 114(2):25–30.
14. Farhana N, Murthy HSN. A novel, slotted allocation mechanism, to provide QoS for EDCF protocol. International Journal of Computer Engineering and Technology. 2016 May-Jun; 7(3):164–73.
15. Weng CE, Li RY, Hsu CH. Joint priority random early detection and IEEE 802.11e EDCF to support QoS in WLAN. International Journal of Innovative Computing Information and Control. 2012 Aug; 8(8):5425–38.
16. Romdhani L, Ni Q, Turletti T. Adaptive EDCF enhanced service differentiation for IEEE 802.11 wireless ad-hoc networks. Proceedings of IEEE WCNC. 2003; 2(1):1373–8.
17. Bai Y, Ito MR. Application-aware buffer management: New metrics and techniques. IEEE Transactions on Broadcasting. 2005 Mar; 51(5):114–21. Crossref
18. Floyd S, Jacobson V. Random early detection gateways for congestion avoidance. IEEE/ACM Trans Network. 1993 Aug; 1(4):397– 413. Crossref
19. Mahajan R, Floyd S. Controlling high-bandwidth flows at congestion router. Proceeding of 9th Int Conf Network Protocols; 2001. p.192–201.
20. Feng WC, Kandlur DD, Saha D, Shin KG. Adaptive packet marking for maintaining end-to-end throughput in a differentiated-services internet. IEEE/ACM Transaction on Networking. 1999 Oct; 7(5):685–97.
21. Floyd S, Gummadi R, Shenker S. Adaptive RED an algorithm for increasing the robustness of RED's active queue management. AT&T Center for Internet Research at ICSI; 2001 Aug.
22. Brachman A, Christ L. On the shortcoming of EDCA queues in the presence of multiservice traffic. Proceedings of WMNC/PWC; 2009. p. 69–79.
23. Zhu H, Cao G, Yener A, Mathias AD. EDCF-DM: A novel enhanced distributed coordination function for Wireless Ad Hoc Networks. Proc of IEEE Communications Society; 2004.