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Adroit Buffer Augmentation for Reliable Video Transmission over WLAN

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Abstract

Objective: The video transmission over Wireless LAN (WLAN) requires the better Quality of Service (QoS). Over the time varying characteristics of WLAN, better QoS requirement for the video applications makes it a more challenging task. Presently IEEE802.11n standard is in use for supporting WLAN with the main goal to provide higher throughput. In IEEE 802.11n, the main emphasis is on achieving higher throughput. However, real time video applications such as video conferencing are more sensitive to delay, so an adequate provision has to be imposing at MAC layer of IEEE802.11n to overcome the delay dependencies of video traffic. **Methodology:** We proposed an adroit buffer augmentation methodology for the reliable H.264/SVC video codec transmission over WLAN. The proposed methodology dynamically adjusts the video queue length (AC [VI]) at MAC layer and there after use cross-layer mapping. The dynamically adjustment of video queue length is achieved by measuring the traffic congestion. **Findings:** After exhaustive experimental simulations, the obtained result shows that our proposed methodology performs better than the conventional video transmission schemes. **Application:** The proposed methodology can be imposed at IEEE 802.11 MAC for achieving better video quality.

Keywords: Cross-Layer Mapping, EDCA, IEEE802.11n, QoS, Video Over WLAN

1. Introduction

With colossally expanding the utilization of media applications over wireless devices, the group of IEEE802.11 Wireless Local Area Network (WLAN) norms has turned into the real stipulation for providing better quality. Today approximately all enterprise places have been implemented through the IEEE802.11 WLANs.[1] Various new applications are extending the need of interactive media applications over WLAN. From traditional VoIP to online portable gaming and video conferencing are the applications handled by the wireless devices.

In the newer introduced WLAN standards, the new enhancements are empowered at MAC and PHY layers. The enhancements made the new wireless standards more capable and versatile in providing better performance than the legacy wireless devices. Recently the IEEE 802.11n standard is used for the deployment of WLAN. To deliver better QoS for video or voice applications, Enhanced Distributed Channel Access (EDCA) is used at MAC layer by the 802.11n standard.

The importance of new WLAN device's functionality such as smart phones, leads to an excess usage of image and video related applications. The example is video calling and sharing of video content. Even using the new enhanced WLAN standard and in spite of having various enhancements for improving video transmission over WLAN, video streaming over WLANs is still a challenging task, particularly when video services need to exhibit the desired guaranteed QoS for their applications, like video conferencing where a delay can degrade the QoS.[2,3]

The primary issue faced by WLANs protocols is that wireless channel is dynamic in terms of traffic and error prone due to collisions, so video transmission over the wireless channel is both time-dependent and error sensitive.[4,5] During the video transmissions over WLAN, the error or delay in a frame not only affects the current video frame but also the predecessor video frames.[6,7] For real time transmission, an approach is required to ascertain time varying dependencies of video packets. Thus, two issues i.e. providing better video quality in adaptive wireless network conditions and delay dependencies of

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video packets during video transmission over WLAN has been the source of inspiration for proposing Adroit Buffer Augmentation for Reliable Video Transmission (ABARVT) methodology.

In this paper, we use the H.264/SVC video codec for the evaluation of the proposed methodology. The reason for selecting the H.264/SVC codec is due to its variable bit-stream temporal scalability that can be utilizing in different traffic scenarios.

The remainder of this paper is: In section II, we briefly describe the QoS Mechanism in IEEE 802.11n. In Section III, we briefly describe the overview of H.264/SVC video codec. In section IV, our proposed ABARVT is explained. In section V, experimental results are analyzed and we conclude in section VI.

2. IEEE 802.11n QoS Mechanism

The IEEE 802.11n standard was introduced as the next generation WLAN. This standard can reach up to the speed of 600 Mbps by introducing the concept of Multiple-Input Multiple-Output (MIMO) technology at its PHY layer.[8]

The IEEE 802.11n WLAN protocol has number of enhancements over the legacy 802.11 MAC schemes. The enhancements are mainly done to achieve higher throughput. The 802.11n WLAN defines the new coordination functions for assuring and prioritizing the data traffic for gaining the transmission medium gain access known as Enhanced Distribution Co-ordination Access (EDCA).[9] In advances of EDCA, Cross-Layer Mapping is also used for providing better QoS by differentiating video slices and maps them to different access categories. EDCA and Cross-Layer mapping is explained.

2.1 Enhanced Distribution Co-ordination Access (EDCA)

The EDCA enhance the original 802.11 DCF by distinction of network traffic based on their quality class. EDCA differentiates incoming data traffic into four-traffic classes' viz.[10,11] Voice traffic, Video traffic, Best-Effort traffic and Background traffic. To transmit distinct data to lower PHY layer, EDCA provides different access categories to each type of traffic that act as an individual queue. Network traffic is differentiated according to their quality class.

IEEE 802.11n WLAN has four Access Categories (AC) at its MAC layer as shown in Figure 1. Each AC has individual buffers forming the queue. Each AC is reserved for different traffic and works as an independent queue. The queues of different traffic class have different priorities. The queue with higher priority gets the transmission medium access first. Different access categories with their abbreviated name and priority are shown below in Table 1.[12] In EDCA, video traffic is having their own queue buffers. Voice traffic (AC [VO]) is having maximum priority and then video traffic (AC [VI]) and background Traffic (AC [BK]) has the least priority.

Table 1. Different Access Categories with their priority

S. No.	Data Traffic Class	Abbreviated Name	Priority
1	Voice Traffic	AC[VO]	1
2	Video Traffic	AC[VI]	2
3	Best-effort Traffic	AC[BE]	3
4	Background Traffic	AC[BK]	4

The MAC layer as per IEEE 802.11n EDCA with four access categories representing the different data streams is shown in Figure 1.

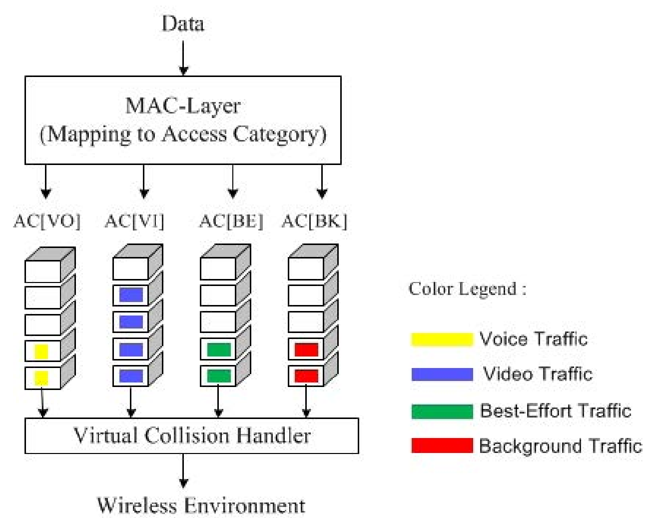

Figure 1. IEEE 802.11n MAC Layer with four Access Categories.

In 802.11n, the incoming data at MAC layer is classified among the four traffic classes shown in Table 1. After classification of incoming data, the data is passed on to the respective access categories. Individual access categories work as an independent entity among a same WLAN station and according to their priority, they transmit their data to PHY layer through virtual collision handler. Priority distinction followed by EDCA can give better service to the multimedia applications such as voice and video applications. However, EDCA parameters cannot alter dynamically according to the network traffic conditions.

2.2 Cross-Layer Mapping

In Cross-Layer mapping for video transmission, the video data frame is classified into video slices (I-slice, P-slice, B-slice) supported by the video standard. The video slices are then passed to different Access Categories (AC). The main aim of the cross layer design is to utilize the other ACs for transmission of video frames. Thus, cross layer design provides better performance of video transmission over WLAN when the other AC's are empty or no other traffic is flowing in the network. In EDCA and cross layer mapping, the buffer size remains constant for every AC.[13]

In both the schemes i.e. EDCA and cross-layer mapping, if any AC gets overflow, the incoming data frames are dropped out from that AC due to the unavailability of buffers. Even if we have free buffers at different ACs, free buffers cannot be utilized for that congested AC. Thus, the video transmission performance can be improved by dynamically buffer augmentation along with the cross layer design by reducing delay and jitter.

In Table 2, we summarize the literature survey on the limitations of EDCA and Cross-layer Mapping utilization for video transmission over WLAN.[14-21]

In light of above limitations, we proposed an Adroit Buffer Augmentation methodology for the reliable video transmission over WLAN. Due to the better temporal scalability, H.264/SVC video codec is used for the video applications. The proposed methodologies dynamically adjust the MAC AC [VI] length according to the network traffic and later if required, methodology applies Cross-Layer mapping during the higher traffic congestion.

3. H.264/SVC Video Codec

H.264/AVC was introduced with the goal to take less memory storage while converting video into a digital encoded format. The main goals of the H.264/AVC standardization are to have enhanced compression performance and to make it network independent for video calling and video storage applications.[22] Due to this network rate distortion, H.264/AVC efficiency has improved in comparison to legacy video codec's.

For an efficient transmission and storage of video, H.264/MPEG10 or Advance Video Coding (AVC) converts digital video into encoded formats through which storage capacity of video is decreased. The ability of H.264/AVC is limited due to different requirements of different users with different displays, connected through variable wireless network links.[23] Some of the H.264/AVC examples such as video conferencing, video playback, video surveillance, and video recording are affected due to overloaded network traffic.

In continuation with H.264/AVC, a Joint video team of ITU-T VCEG and the ISO/IEC MPEG -2007 proposed H.264 Scalable Video Coding (SVC) standard. In SVC, the word scalable means to get rid of some parts from video bit stream in order to meet the varying network traffic congestions.[24] According to dynamic bandwidth adaption, the scalable video coding allows the decoder to decode selective part of the coded bit stream.

H.264/SVC video codec is comprises of three video frame slices: Intra-Coded Frame (I-Frame), Predictive Frame (P-Frame) and Bi-Directionally frame (B-Frame).[24] I-Frame contains the basic video quality and can be decode by itself. P-frame is decoded through preceding I or P frames. B-frame is decoded through preceding and succeeding I and P frames. In H.264/SVC combinations

Table 2. Limitation of EDCA and Cross-Layer Mapping

Methodology	Author(s)	Limitations
EDCA	14	As traffic increase in network, EDCA scheme degrades the QoS of video traffic.
	15	As the traffic at particular access category increases, it generates congestion there which leads to the packet drops at that AC.
	16,17,18	EDCA parameters are not adaptable with the dynamic nature of WLAN traffic.
Cross-Layer Mapping	19,20	While passing video slices from other access categories, the priority of video traffic lowers down to the priority of that access category. It increases the waiting time of video data in other lower priority queues.
	21	Buffers of other ACs cannot be utilized for time-bounded applications even the buffers of other ACs are free that results in degradation of video quality.

of P-frames and B-frames forms the enhancement layers while the basic video quality is contained by 'I-Frames'.

The layered architecture of H.264/SVC is comprises of one base layer and one or more multiple number of enhancement layers as shown in Figure 2.[25] The basic video quality is provided in the base layer. By adding enhancement layer with base layer, it increases the video quality. If the network bandwidth availability is limited due to traffic congestion or noisy environment, one or more enhancement layers can be discarded. Discarding of enhancement layers is done to avoid run-time blocking off. Instead of blocking whole video, the video is delivered with some degraded quality. Thus new scalable video compression technique to accomplish versatile data transfer, gain us attention to use H.264/SVC video codec in dynamic traffic conditions.

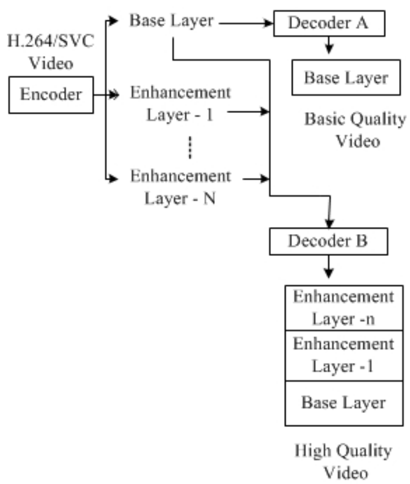

Figure 2. H.264/SVC video codec basic principle.

4. Proposed ABARVT Methodology

The proposed ABARVT methodology tries to make the best possible use of video buffer space at AC [VI] and also maintain the hypothesis of passing comparatively less important video frames through other ACs. The above decisions are adapted with the dynamic nature of wireless network traffic.

In the proposed ABARVT methodology, the buffers are borrowed from other ACs and append them to the video queue buffers. In doing so, we overcomes the buffer shortage at AC[VI] during traffic saturation. Moreover, the priority of the buffers of lower AC is changed to the priority of video buffers that makes the transmission of all the video frames with the same priority queue. Changing the priority of lower access categories' buffers to higher priority will not only reduce the average waiting time of video frames but will also facilitated in reducing latency and less susceptible to the jitter.

The proposed ABARVT scheme works in two phases. In first phase, buffer augmentation is done by analyzing the congestion at network. In second phase, Cross-Layer mapping decision is taken to pass the video frames through different queues. The decision is depends on the traffic congestions.

In phase-1 of ABARVT, the main emphasis is to borrow buffers from lower priority queues. The borrowings of buffers are the adaptable to the network traffic congestion. The methodology tries to use the available buffers of different access categories optimally to append them at video AC.

Procedure: Buffer-Augmentation ()

- Get the value of $AC[VI]_{MBL}$
- Determine the $AC[VI]_{BOP}$ at that instance.
- Determination of MAC queue rates
  - Ascertain the value of $AC[VI]_{MQIR}$ at video queue.
  - Ascertain the value of $AC[VI]_{MQER}$ at video queue.
- Determine the rate of traffic flow difference at video queue.

$$AC[VI]_{TLD} = AC[VI]_{MQIR} - AC[VI]_{MQER}$$

- Determine the buffer augmentation factor at video queue

//It is a representation of the traffic on the network.

$$AC[VI]_{CF} = AC[VI]_{TLD} / AC[VI]_{MQIR}$$

- Calculate the number of buffers to be borrowed.

$$Buffers_{TB} = AC[VI]_{BOP} * AC[VI]_{CF}$$

- Borrowing of Buffers:

//Maximum Number of buffers that can be borrowed is set to 30% of AC[BK] and AC[BE]

  - if($Buffers_{TB}$< 30% of AC[BK])
    - Borrow Buffers from AC[BK]

Algorithm 1.1 Phase -1 of ABARVT

Requires:

$AC[VI]_{MBL}$	:	Maximum buffer limit of video queue.
$AC[BE]_{MBL}$	:	Maximum buffer limit of best-effort queue.
$AC[BK]_{MBL}$	:	Maximum buffer limit of background queue.
$AC[VI]_{MQIR}$	:	MAC queue injection rate of video access category.
$AC[VI]_{MQER}$	:	MAC queue ejection rate of video access category.
$AC[VI]_{TLD}$	:	Traffic flow difference in video queue.
$AC[VI]_{CF}$	:	Buffer augmentation factor at video queue.
$Buffers_{TB}$	:	Total Number of buffer elements to be borrowed.
$Buffers_{TBBE}$	:	Number of buffer elements to be borrowed from best-effort queue.
$AC[VI]_{UTB}$	:	Updated total number of buffer elements in video queue.
$AC[BE]_{UTB}$	:	Updated total number of buffer elements in best effort queue.
$AC[BK]_{UTB}$	:	Updated total number of buffer elements in background queue.

Set $AC[BK]_{UTB} = AC[BK]_{MBL}$ - BuffersTB

○ else

▪ Borrow 30% buffers of AC[BK]

Set $AC[BK]_{UTB} = AC[BK]_{MBL}$ - 30% Buffers of AC[BK]

$Buffers_{TBBE}$ = $Buffers_{TB}$ - 30% Buffers of AC[BK]

▪ Borrow Remaining Buffers from AC[BE]

Set $AC[BE]_{UTB} = AC[BE]_{MBL}$ - $Buffers_{TBBE}$

 Update the total number of buffers in video queue.

$AC[VI]_{UTB} = AC[VI]_{MBL} + Buffers_{TB}$

Endprocedure

In phase -2 of ABARVT, a Cross-Layer decision is taken to pass different video frames to PHY layer from different access categories. Before passing the video frame to any access category, two considerations are taken: Firstly, network congestion and secondly priority of the video frame. Phase-2 of ABARVT is present below:

Procedure: Cross-Layer Mapping ()

o if (AC[VI]BOP<= AC[VI]MBL)

Transmit video frame to AC[VI]

• else

◊ if(AC[VI]BOP< AC[VI]UTB)

⊙ if(Video Frame type == 'I-Frame')

Transmit 'I- frame' via AC[VI]

◊ else

◆ if(AC[BE]BOP<= AC[BE]UTB)

Transmit 'P/B- frame' via AC[BE]

◊ else

Transmit 'P/B- frame' via AC[BK]

◆ end if

⊙ end if

☐ else

Invoke EDCA with updated video buffer length

▪ end if

o end if

Endprocedure

Algorithm 1.2 Phase -2 of ABARVT

Requires:

Outputs of Phase-1		
Classification of video frames into 'I/P/B' Frames		
$AC[VI]_{BOP}$	:	Video buffers occupied at an instance.
$AC[VI]_{MBL}$	:	Maximum buffer limit of video queue.
$AC[BE]_{BOP}$	:	Best-Effort buffers occupied at an instance
$AC[VI]_{UTB}$	:	Updated total number of buffer elements in video queue.
$AC[BE]_{UTB}$	:	Updated total number of buffer elements in best effort queue.
$AC[BK]_{UTB}$	:	Updated total number of buffer elements in background queue.

Buffer occupancy of access categories represents the congestion at the transmission medium.[26,27] More the buffer occupancy represents higher degree of congestion in transmission medium. The MAC Queue Ejection Rate (MQER) directly depends on the congestion. The lower traffic represents higher MQER and vice versa. Whereas the MQIR is constant as it depends on the video codec standard.

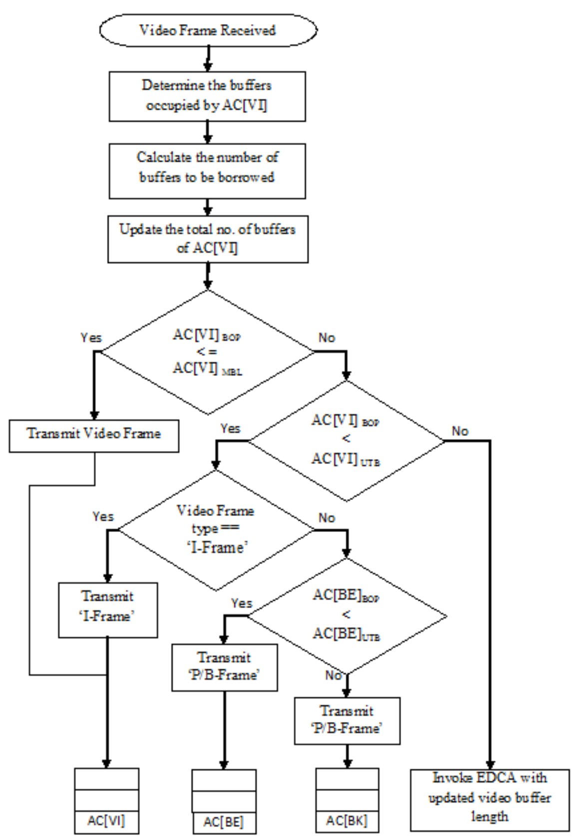

Figure 3. Flowchart of proposed ABARVT scheme.

When the video traffic is arrived at MAC, occupied buffers at video queue (AC[VI]) is estimated. The video buffer occupancy now plays an important role to adroit the total number of buffers and mapping of video frames to different access category.

In our proposed methodology, as the network congestion increase the number of buffers to be borrowed from other access categories proportionally increases. During higher congestion, the video queues are fulfilling fast so the proposed methodology passes the less important video frames via AC [BE] or AC [BK]. Passing of less important video frames to other access category helps to reduce the congestion at AC [VI].

A flow chart of the proposed Adroit Buffer Augmentation for Reliable Video Transmission (ABARVT) methodology is presented in Figure 3.

5. Experimental Result

The evaluation of proposed ABARVT methodology is simulated in Network Simulator (NS2). The NS2 is characterized by myEvalSVC and Joint Scalable Video Model (JSVM) video traces.[28-31] JSVM is an open source tool used for encoding and decoding of H.264/SVC video codec's. The myEvalSVC evaluation tool is collaborated with NS2 to support H.264/SVC video codec transmission over wireless network.[32]

We classify the network traffic in generic terms as below: No Network Congestion, Moderate Network Congestion and Heavy Network Congestion. The above suggested network congestions scenarios are mainly classified by measuring the video traffic. The network handling only one video stream is considered as having no traffic congestion or having minimum network traffic load. Transmitting of two or three video streams concurrently over the network is classified as moderate network congestion or intermediate traffic load that is in permissible limit. Transmitting more than three video streams concurrently are classified as heavy network congestion or the network load that is not suitable for the better video QoS.

For the simulation, we consider small amount of best-effort and background traffic. Thus for the evaluation of ABARVT methodology, one best-effort traffic along with background traffic is transmitted from access point to receiver station. The numbers of video streams are accommodated according to the desired network congestions. The topology for the simulation scenario of ABARVT consists of an Access Point and IEEE 802.11n receiver station that is shown in Figure 4.

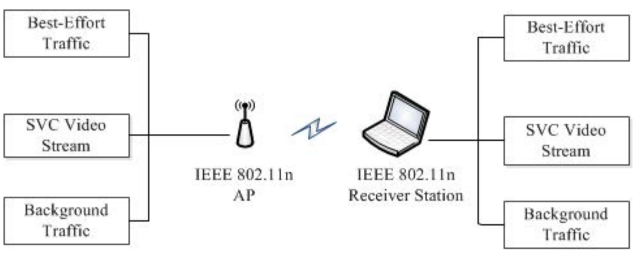

Figure 4. Scenario Specification for ABARVT Methodology.

The proposed ABARVT methodology is evaluated in comparison with the standard EDCA protocol along with the methodology proposed by that is named as Dynamic Load Distribution Cross layer Algorithm (DLDCA).[33] In the reported methodologies, the cross-layer mapping of video frames is done by sensing the AC [VI] length.[33] In the DLDCA if the video queue length is below lower threshold value, all 'I/P/B' frames are transmit through AC [VI]. If the occupied video queue length is between lower threshold and higher threshold, then I-Frame is transmit through AC [VI] and 'P/B –Frame' are transmitted through AC [BE] or AC [BK].

After extensive simulation of the proposed ABARVT methodology over the experimental setup, the results of performances metrics for measuring the QoS of video such as end-to-end delay, jitter and PSNR are summarized and analyzed below.

In the graphs (Figure 5 to Figure 11) presented below the average values obtained at MQER with 500Kbps, 750Kbps and 1.0Mbps is consider for heavy network congestion. The average values obtained at MQER with 1.25Mbps, 1.50Mbps and 1.75Mbps is considered for intermediate network congestion. In addition, the average values of MQER with 2.00Mbps, 2.25Mbps and 2.50Mbps is considered for no network congestion. Figure 5 shows the comparison of End-to End Delay in Standard EDCA Protocol, DLDCA and ABARVT methodology at No network congestion, Intermediate network congestion and Heavy network congestion.

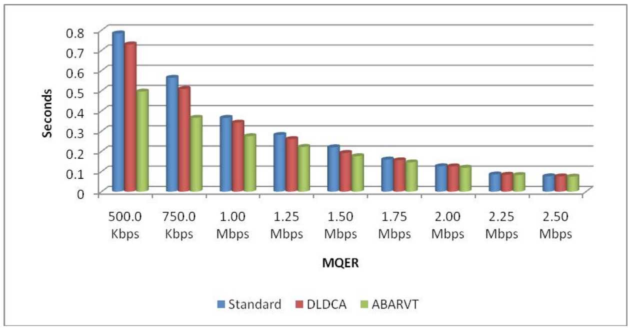

Figure 5. Comparison of End-to End Delay of Standard EDCA Protocol, DLDCA and ABARVT methodology at No, Intermediate and Heavy network congestion.

In higher traffic congestion, the proposed ABARVT methodology performs better than standard EDCA due to the availability of extra video buffers where end-to-end delay is reduced on average by 32.23% in ABARVT methodology as compared with EDCA standard scheme and 26.60% in comparison with the DLDCA. In intermediate traffic congestion, the proposed ABARVT methodology reduce on average by 16.72% and 10.06% respectively with standard EDCA and DLDCA methodology. In no network traffic congestion, ABARVT methodology reduced end-to-end delay on average of 3.72% and 2.86% respectively with standard EDCA and DLDCA methodology. In no network traffic congestion, end-to-end delay is closer to other methodologies because the requirement and availability of video buffer are around same for the better transmission of video and also due to lower chances of collisions. Figure 6 shows the comparison of jitter in Standard EDCA Protocol, DLDCA and ABARVT methodology at No, Intermediate and Heavy network congestion.

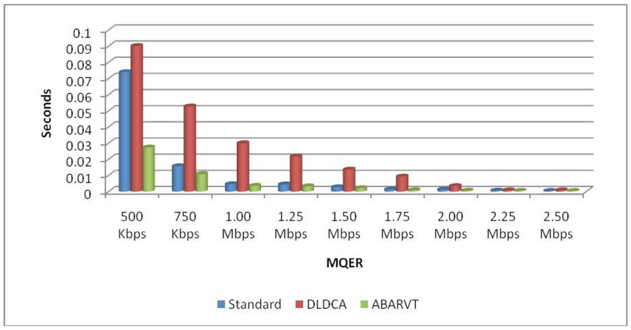

Figure 6. Comparison of Jitter of Standard EDCA Protocol, DLDCA and ABARVT methodology at No, Intermediate and Heavy network congestion.

In our proposed ABARVT methodology, the dropping of video frames from the video access category due to unavailability of video buffers space has been rectifed. The more video buffers in turn leads to less retransmission of arrived video frames at MAC. In higher traffic congestion, the increased buffer space along with higher priority frame transmission policy leads to fluent transmission from video queue. The above features of the proposed methodology shows better jitter result in comparison with the standard EDCA and DLDCA methodology. In the DLDCA scheme the mapping of 'P/B video slice' to lower priorities queues leads to the uneven delay which in turn shows more jitter than both our proposed methodology and standard EDCA scheme. In high traffic congestion, ABARVT methodology reduces jitter on average of 38.61% and 86.54% respectively with standard EDCA and DLDCA methodology.

In intermediate traffic congestion, the proposed ABARVT methodology performs better, where it reduce jitter on average of 27.14% and 79.01% respectively with standard EDCA and DLDCA methodology. In no network traffic congestion, ABARVT methodology reduces jitter on average of 25.9% and 57.94% respectively with standard EDCA and DLDCA methodology. Figure 7 shows the comparison of PSNR in Standard EDCA Protocol, DLDCA and ABARVT methodology at No, Intermediate and Heavy network congestion.

In the proposed ABARVT scheme as the MQER of video access category decreases it borrows more buffer from other access categories that in turn decrease the overall dropping of video frames from the AC[VI]. While in DLDCA scheme, when video access category gets reaches to maximum usable limit it emphasis on saving firstly 'I-video slice' then 'P-video slice' and then 'B-video slice'. In doing so mainly, P-video slice frames and B-video slice frames are mapped to best effort and background queue. The mapping of 'P/B' video slice to other ACs leads to the loss or excessive delay of 'P/B' frames which degrades the PSNR value. Thus, in the higher traffic congestion the proposed ABARVT performs better than standard EDCA scheme and proposed DLDCA scheme. In high traffic congestion, ABARVT methodology increases PSNR on average by 8.28% and 7.11% respectively with standard EDCA and DLDCA methodology.

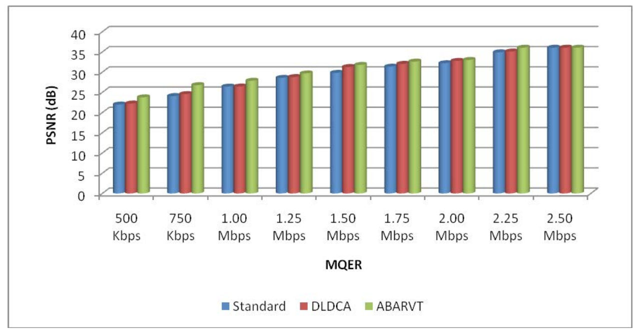

Figure 7. Comparison of PSNR in Standard EDCA Protocol, DLDCA and ABARVT methodology at No, Intermediate and Heavy network congestion.

During less traffic at video queue there is no need of borrowing buffers from other ACs and even no need for cross-layer mapping, therefore the proposed ABARVT methodology performs approximately evenly with respect to standard EDCA scheme and DLDCA scheme. In no network traffic congestion, ABARVT methodology gains PSNR on average by 1.91% and 1.12% respectively with standard EDCA and DLDCA methodology.

Figure 8 shows the comparison of packet delivery ratio of Standard EDCA Protocol, DLDCA and ABARVT methodology at No, Intermediate and Heavy network congestion.

By predicting the current traffic flow and future video injection rate (MQIR), the decision is taken to borrow buffers from other queues. This provides more buffer space in video access categories, which can accept more video frames, that has to be transmitted.

In the heavy traffic scenario, due to adroit nature of video access category, the buffers are borrowed according to the traffic. Due to more availability of video buffers, the incoming video frames don't overflow from the AC [VI]. In high network traffic congestion, ABARVT methodology increases packet delivery ratio on average by 15.51% and 5.34% respectively with standard EDCA and DLDCA methodology. Thus by saving the video frames from being dropped out from video queue, the packet delivery ratio of the proposed ABARVT shows better results than standard EDCA and DLDCA methodology.

In intermediate network traffic congestion, ABARVT methodology increases packet delivery ratio on average by 13.33% and 3.34% respectively with standard EDCA and DLDCA methodology.

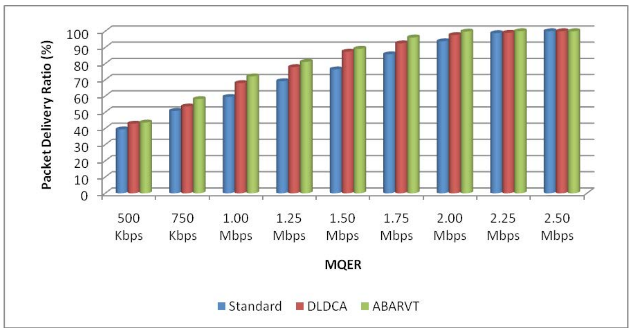

Figure 8. Comparison of Packet Delivery Ratio of Standard EDCA Protocol, DLDCA and ABARVT methodology at No, Intermediate and Heavy network congestion.

As the traffic congestion decreases, video buffer length becomes same to the standard video buffer length. Due to the same video queue length in no network congestion, the proposed ABARVT methodology demonstrates approximately equally to the standard EDCA scheme and DLDCA. Therefore in no network traffic congestion, ABARVT methodology increases packet delivery ratio on average by 2.52% and 1.07% respectively with standard EDCA and DLDCA methodology.

Figure 9 and Figure 10 shows the comparison of P-Frame loss and B-Frame loss respectively in Standard EDCA Protocol, DLDCA and ABARVT methodology at No, Intermediate and Heavy network congestion. In DLDCA scheme, the emphasis is done to transmit video slice frames according to their priorities in the video sequence. In heavy traffic congestion, DLDCA first priority is to map I-frame to the video queue or voice queue as per the availability of buffer space and map 'P/B -Frames' to the lower priority queues where they may lose due to traffic jam or delay constraints. Whereas in the proposed ABARVT methodology, after raising the video queue length and afterwards taking a precautionary cross-layer mapping of 'P/B -Frames' to other access categories helps in saving the 'P/B –Frames' losses.

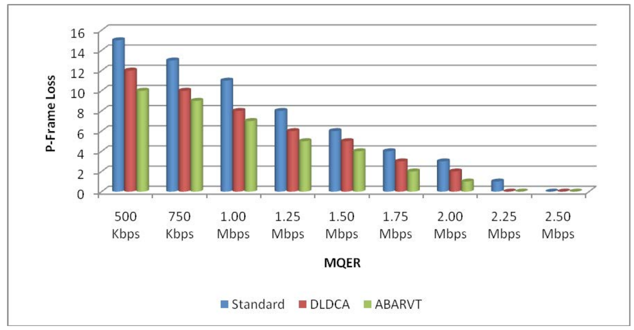

Figure 9. Comparison of P-Frame loss in Standard EDCA Protocol, DLDCA and ABARVT methodology at No, Intermediate and Heavy network congestion.

In high network traffic congestion, ABARVT methodology saves 'P-frames' on an average by 33.48% and 23.33% respectively with standard EDCA and DLDCA methodology. In intermediate network traffic congestion, ABARVT methodology saves 'P-frames' on an average by 22.22% and 13.05% respectively with standard EDCA and DLDCA methodology.

In high network traffic congestion, ABARVT methodology saves 'B-frames' on an average by 37.28% and 32.06% respectively with standard EDCA and DLDCA methodology. In intermediate network traffic congestion, ABARVT methodology saves 'B-frames' on an average by 30.87% and 30.55% respectively with standard EDCA and DLDCA methodology.

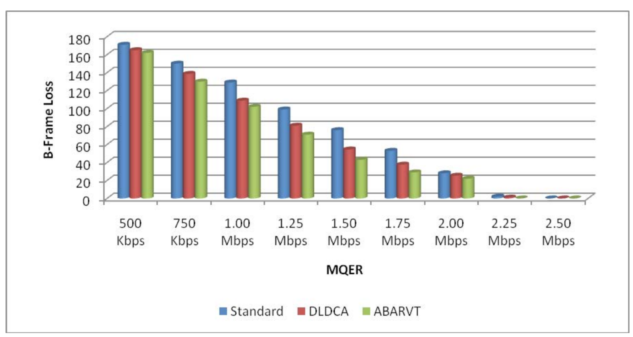

Figure 10. Comparison of B-Frame loss in Standard EDCA Protocol, DLDCA and ABARVT methodology at No, Intermediate and Heavy network congestion.

As the P-Frames and B-Frames also play an important role in re-construction of the video at receivers, the video quality gets better at destination in the proposed ABARVT methodology by saving the P/B-Frames. In no network congestion, the availability of network resources make all the methodology viz. standard EDCA, DLDCA and ABARVT works similar and more or less there is no P and B Frame loss.

Figure 11 shows the comparison of video queue utilization in Standard EDCA Protocol, DLDCA and the proposed ABARVT methodology at no network congestion, Intermediate network congestion and heavy network congestion.

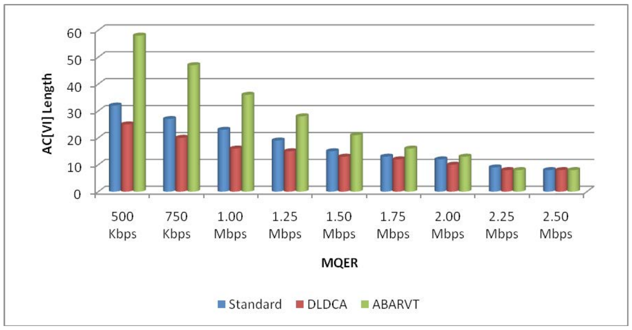

Figure 11. Comparison of video queue utilization in Standard EDCA Protocol, DLDCA and ABARVT methodology at No, Intermediate and Heavy network congestion.

As seen in figure 11 from higher traffic congestion to intermediate traffic congestion, the average occupied video queue length in ABARVT is greater than standard EDCA and DLDCA. In the proposed methodology, as the traffic congestion increases it borrows buffers from other access categories. Having adroit buffer length will reduce the dropping of incoming video frames from AC[VI] which in turn give better QoS in terms of delay and jitter. In ABARVT methodology, video queue utilization is raised by 70.61% and 80.92% respectively with standard EDCA and DLDCA methodology during the high network traffic congestion. It is seen from the graph in figure 11, as the network congestion decreases the number of buffers borrowed from other ACs also reduces. In intermediate traffic congestion, video queue utilization is raised by 36.81% and 60.51% respectively with standard EDCA and DLDCA methodology. It has been observed from the figure 11 that the number of buffers to be borrowed is directly proportional to the network congestion. In no network congestion, due to availability of buffers in AC[VI] there is no need of borrowing buffers thus video queue utilization is closer to each other in standard EDCA scheme, DLDCA and the proposed ABARVT methodology.

End-to-End delay, Jitter and PSNR are the performance metrics that are mainly used to measure the video quality. From the results obtained, it has been observed that proposed ABARVT methodology reduces the End-to-End delay and Jitter in comparison with standard EDCA protocol and DLDCA. ABARVT also gains the PSNR value in comparison with standard EDCA protocol and DLDCA. The results obtained for other performance metrics such as packet delivery ratio, saving of 'P and B – frames' and video queue utilization also prove that ABARVT methodology performs better in providing the more beneficial video quality. In no traffic load scenario, due to the less requirement of video buffers ABARVT performs evenly in comparison to standard EDCA and DLDCA. The results obtained through experimental evaluation for measuring QoS performance metrics is summarized below in form of table presented in Table 3. From the obtained experimental results, it can be concluded that ABARVT performs considerably better in higher network traffic congestions.

Figure 12 shows the snapshots of decoded video frame of "Bus.cif" at the reciver station. The snapshots exemplifies that proposed ABARVT methodology (Figure12.d) provides better video display than the standard EDCA (Figure 12.b) and DLDCA methodology (Figure 12.c).

Table 3. Summarize result of proposed ABARVT methodology in comparison with EDCA and DLDCA

Methodology	Performance Metric	High Traffic Congestion	Intermediate Traffic Congestion	No Traffic Congestion
EDCA	End-to-End Delay *(reduced)*	32.23%	16.72%	3.72%
	Jitter *(reduced)*	38.61%	27.14%	25.9%
	PSNR*(increased)*	8.28%	4.82%	1.91%
DLDCA	End-to-End Delay *(reduced)*	26.60%	10.06%	2.86%
	Jitter *(reduced)*	86.56%	70.01%	57.94%
	PSNR*(increased)*	7.11%	2.18%	1.12%

(a) Original Video (b) Decoded Video in EDCA Video

(c) Decoded Video in DLDCA (d) Decoded Video in ABARVT

Figure 12. Comparison of decoded video frame in standard EDCA scheme, DLDCA and ABARVT methodology.

6. Conclusions

In proposed ABARVT methodology, after adjusting the video queue length, cross-layer mapping is done to reduce the congestion at video queue. During the cross-layer mapping, the frames of important base layer are passed through video queue and less important video frames are passed through lower priority queues. Cross-layer mapping works as an extra precautionary method in high traffic congestion and it helps to reduce congestion particularly at video queue. After exhaustive experimentations with the proposed methodologies over NS2 simulator, the experimental results clearly shows that proposed ABARVT methodology performs better than standard EDCA and DLDCA methodology. The proposed methodology is able to reduce the average end-to-end delay and jitter as compared to standard protocols. The PSNR value of received video in our proposed methodology is also increased. ABARVT considerably works better in the high traffic congestions. Therefore, the proposed ABARVT methodology can be use for the achieving better QoS during the video transmission over WLAN.

7. References

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