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Optimizing the Use of the Access Categories in Wireless Networks for Multimedia Streams

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Abstract: Solving the problem of the quality of multimedia traffic in wireless networks is a very important topic in the field of scientific research. In this article, we present a solution to optimize the transmission of video in the IEEE 802.11 wireless networks by modifying the behavior of the MAC (Medium Access Control) layer for video traffic; a breakdown of the latter on the different types of access is given. The platform operates by using both improved wireless standard IEEE802.11e and the model proposed to improve the streaming in wireless networks interlayer. A test is performed to simulate this solution, using the open source network simulator NS2; the results obtained show that our solution improves visibly multimedia transmission indicators namely the delay and the packet loss rate.

Key words: Wireless network · 802.11 · EDCA · Evalvid · MAC layer

INTRODUCTION

802.11 wireless networking standards provide a certain degree of quality of service for multimedia streaming with enhanced 802.11e, but many problems remains to be improved.

Several studies have been suggested to improve the quality of service in wireless networks particularly by focusing on the parameters of the access to the MAC layer for each type of flow path:

CW (contention windows) [1]
AIFS (Arbitration Inter Frame Space) [2]
TXOP (Transmission Opportunity) [3]

In this paper, we investigate the performance of the transmission of h264 video on a wireless network using the advanced 802.11e MAC layer protocol. We propose and evaluate a new approach to manage the queues of MAC layer to improve the quality of video transmitted. We compare the results of our solution with the existing protocol.

the paper structure consists of a presentation of the EDCA access mechanism 802.11e wireless channel, then we discuss briefly our solution to optimize the video transmission in wireless network Thirdly we present the system simulation video Evalvid and NS2 network simulator, finally we illustrate our solution for the management of queues for the MAC layer and the results obtained.

EDCA Mechanism Channel Access in 802.11e: The EDCA (Enhanced distributed channel access) mechanism provides access to the wireless medium with a differentiated propagation for QSTAs (QoS Stations); using eight priorities UP (User Priorities). The EDCA mechanism defines four access categories AC (Access category), AC-VO (for voice traffic), AC-VI (for video traffic), AC-BE (for Best Effort traffic) and AC-BK (for background traffic) Figure 1 illustrates the different categories of access [4].

AC-VO has the highest priority and AC-BK has the lowest priority. Each AC has its own queue and parameters settings. These EDCA parameters are the minimum contention window (CWmin), maximum contention window (CWmax), the duration of the inter-frame space arbitrary AIFS (Arbitration Inter-Frame Space), & the limit duration of the transmission opportunity (TXOPlimit). CW window is defined at the beginning as CWmin and after each successful transmission. Instead of a DIFS (DCF Interframe Space), a wireless node must defer transmission with AIFS.

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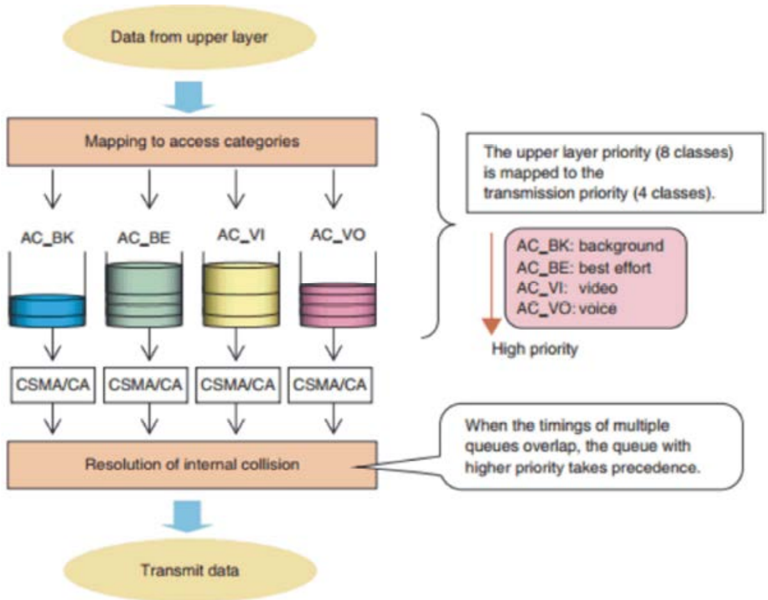

Fig. 1: The different access categories IEEE802.11e

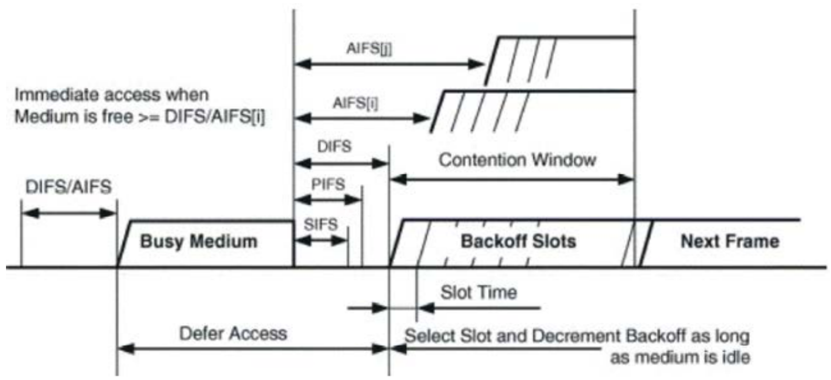

Fig. 2: Inter-frame relationship between DCF and EDCA mechanism

The differentiation of priorities between ACs is performed by setting different parameters values, which are the AIFS number (AIFNS), the size of the contention window CW and transmission opportunity (TXOP) limits. Figure 2 illustrates the inter-frame space used in the DCF mechanism and EDCF.

New Proposal for Access to the Wireless Channel: 802.11e always provides for video traffic the same access category. Therefore, other access categories are not used, it contributes to the degradation of the quality of the received video especially when network is saturated.

We showed in our first publication that the use of queues of the access categories other than the video one improve the indicators of the quality of service at the PSNR gain of about 1 dB and reduce the delay of transmission about 30% [5].

In our last approach we analyzed choosing the best combination of ACs queues to send the video stream with the tool assessment of video Evalvid [6]

Overview of Evalvid: The EvalVid framework [7] is a set of tools that evaluate the quality of video transmitted over a communication real network or simulated. It measures the parameters of quality of service: delay, jitter rate packet loss and PSNR. Currently H.264, MPEG-4 and H.263 are supported [8]. The Figure 3 illustrates the interface between the tool Evalvid and the networks simulator NS2.

The main components of the evaluation framework are described as follows:

Source: The video source can be either in the YUV QCIF (176 x 144) or in the YUV CIF (352 x 288) formats.

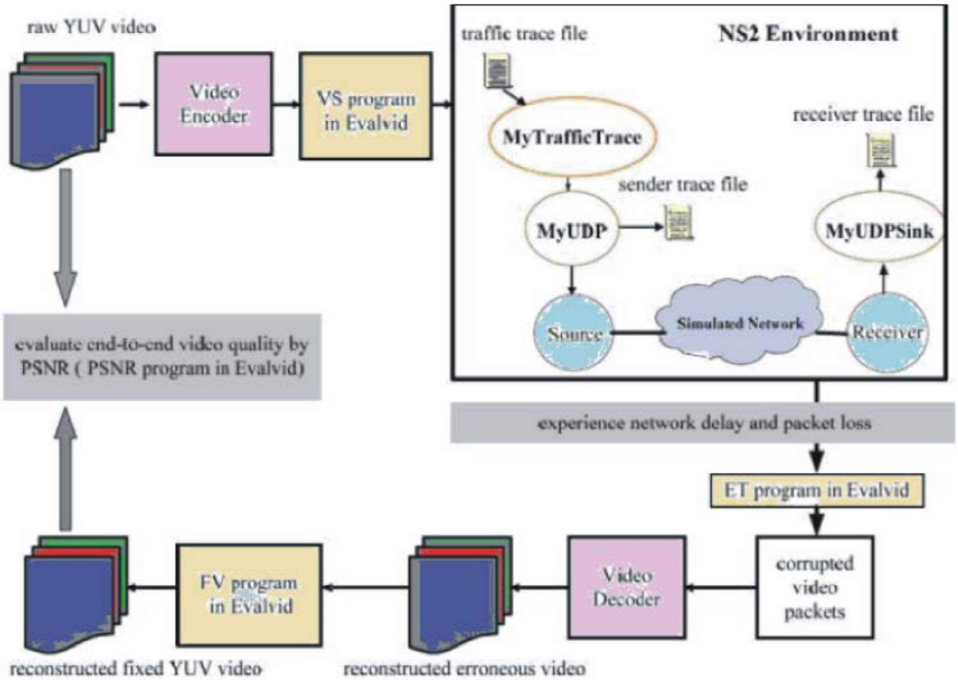

Fig. 3: Interfaces between EvalVid and NS2

Video Encoder and Video Decoder: Currently, EvalVid supports two MPEG4 codecs, namely the NCTU codec and ffmpeg.

VS (Video Sender): The VS component reads the compressed video file from the output of the video encoder, fragments each large video frame into smaller segments and then transmits these segments via UDP packets over a real or simulated network. For each transmitted UDP packet, the framework records the timestamp, the packet id and the packet payload size in the sender trace file with the aid of third-party tools, such as tcp-dump or win-dump, if the network is a real link. Nevertheless, if the network is simulated, the sender trace file is provided by the sender entity of the simulation. The VS component also generates a video trace file that contains information about every frame in the real video file. The video trace file and the sender trace file are later used for subsequent video quality evaluation.

ET (Evaluate Trace): The ET component creates a frame/packet loss and frame/packet jitter report and generates a *reconstructed* video file, which corresponds to the possibly corrupted video found at the receiver side as it would be reproduced to an end user. In principle, the generation of the possibly corrupted video can be regarded as a process of copying the original video trace file frame by frame, omitting frames indicated as lost or corrupted at the receiver side.

FV (Fix Video): Digital video quality assessment is performed frame by frame. Therefore, the total number of video frames at the receiver side, including the erroneous ones, must be the same as that of the original video at the sender side. If the codec cannot handle missing frames, the FV component is used to tackle this problem by inserting the last successfully decoded frame in the place of each lost frame as an error concealment technique.

PSNR (Peak Signal Noise Ratio): PSNR is one of the most widespread objective metrics to assess the application-level QoS of video transmissions. The following equation shows the definition of the PSNR between the luminance component Y of source image S and destination image D:

$$PSNR(n)_{dB} = 20 \log_{10} = \left(\frac{V_{peak}}{\sqrt{\frac{1}{N_{col} N_{row}} \sum_{i=0}^{N_{col}} \sum_{j=0}^{N_{row}} [Y_S(n,i,j) - Y_D(n,i,j)]^2}} \right)$$

where $V_{peak} = 2^k$-1 and k = number of bits per pixel (luminance component). PSNR measures the error between a reconstructed image and the original one.

My Traffic Trace: The MyTrafficTrace agent is employed to extract the frame type and the frame size of the video trace file generated from the output of the VS component of EvalVid. Furthermore, this agent fragments the video frames into smaller segments and sends these segments to the lower UDP layer at the appropriate time according to the user settings specified in the simulation script file.

MyUDP: Essentially, MyUDP is an extension of the UDP agent. This new agent allows users to specify the output file name of the sender trace file and it records the timestamp of each transmitted packet, the packet id and the packet payload size. The task of the MyUDP agent corresponds to the task that tools such as tcp-dump or win-dump do in a real network environment.

MyUDPSink: MyUDPSink is the receiving agent for the fragmented video frame packets sent by MyUDP. This agent also records the timestamp, packet ID and payload size of each received packet in the user specified file.

Simulation and Results of Our Solution: The simulation is performed with the NS2 simulator [9]. The test system consists of a wireless transmitter node of streaming media (one IP voice stream, three video streams, a CBR flow and Best Effort flows TCP) and a wireless receiver node. The minimum optimal threshold over waiting packets in queue is 10 and the maximum threshold is set to 40 packets. The sample used is the h264 video Foreman_qcif.mp4.

The following algorithm was introduced in the 802.11e MAC layer to differentiate the use of the queues compared to the state of the thresholds:

```
case 1:
    int(pri_[2].getavgLen()< threshold1);
    pri_[2].target_handle(target_);
    pri_[2].recv(p,h);
    done=1;
    break;

case 2:
    int(pri_[2].getavgLen()< threshold2) &&
    int(pri_[2].getavgLen()> threshold1);
    pri_[1].target_handle(target_);
    pri_[1].recv(p,h);
    done=1;
    break;
case 3:
    int(pri_[2].getavgLen()> threshold2);
    pri_[0].target_handle(target_);
    pri_[0].recv(p,h);
    done=1;
    break
```

On analyzing the streaming video with our mechanism by combining different types of queues, knowing as AC_VO = AC0, AC_VI = AC1, AC_BE = AC2 and AC_BK = AC3.

We use successively three queues instead of a single, so we compared different combinations called modes: (AC1 AC2 AC3) mode, (AC1 AC0 AC3) mode, (AC2 AC1 AC0) mode, (AC2 AC1 AC0) mode and the mode of 802.11e standard.

It was deduced that the use of the combination (AC1 AC0 AC2) gives the best performance video received of 658 packets sent for each stream; Table 1 and Figure above:

Note that the packet loss rate has been significantly reduced with the combination (AC1 AC0 AC2).

The calculation of PSNR (Peak Signal to Noise Ratio) deduced the following results:

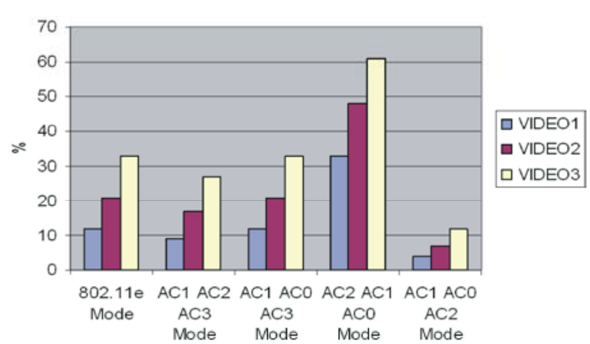

Fig. 4: Packet loss rate of different transmission modes

Table 1: Numbers of packets received with different modes of video transmission

	Mode 802.11e	%	Mode AC1 AC2 AC3	%	Mode AC1 AC0 AC3	%	Mode AC2 AC1 AC0	%	Mode AC1 AC0 AC2	%
VIDEO1	578	0,88	597	0,91	578	0,88	442	0,67	630	0,96
VIDEO2	521	0,79	545	0,83	521	0,79	340	0,52	610	0,93
VIDEO3	441	0,67	479	0,73	441	0,67	258	0,39	581	0,88

Table 2: Mean PSNR of the different modes of video transmission

Mode	PSNR (dB)
802.11e	33.280596
(AC1 AC2 AC0)	33.599161
(AC1 AC0 AC2)	34.279349

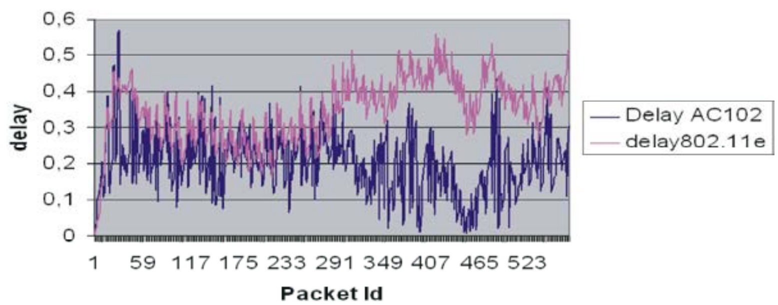

Fig. 5: Comparison of transmission delays between our solution and that of 802.11e

Fig. 6: Comparison of the 257th picture received by our solution and the one received by the 802.11e amendment

Fig.7: Comparison of the 148th picture received by our solution and the one received by the 802.11e amendment

Fig. 8: Comparison of the 257th picture received by our solution and the one received by the 802.11e amendment

This confirms that the best combination of queues for the transmission is that of the succession [AC1 AC0 AC2].

The calculation of transmission delays deducted the following comparison below:

It was deduced that the use of our solution has significantly improved the packets transmission delays with about 40% better than our first solution proposed in [4] (improvement of 30%)

Also the extraction of a received video pictures showed that our solution produced a better visual quality:

CONCLUSION

Our approach to the management of queues in the MAC layer has revealed that our solution provides better performance than the 802.11e amendment.

Redistribution of access categories of the MAC layer has decreased the rate of packet loss over 16%, the PSNR indicator of the quality of the transmitted video is improved by more than 1 dB and the average delay of the packet transmission has been reduced by 40%.

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