ENHANCEMENT OF ADAPTIVE FEC MECHANISM FOR VIDEO TRANSMISSION OVER 802.11 WLANS

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ABSTRACT. Forward Error Correction (FEC) techniques have been adopted with Automatic Repeat reQuest (ARQ) to overcome packet losses and avoid network congestion in various wireless network conditions. The number of FEC packets need to be generated adaptively because usually wireless network has varying network condition. In the current Adaptive FEC mechanism, the FEC packets are determined based on average queue length and average packet retransmission time. However, in order to determine average queue length, estimating its weight value (i.e. smoothing factor) is a challenging task. Smoothing factor is an important parameter as it affects the generation of FEC packets. Thus, this work conducted the estimation of suitable smoothing factor value to determine the average queue length according to packet loss rate over the wireless network. The simulation results show that the enhanced FEC mechanism outperformed other Adaptive FEC mechanisms in terms of recovery efficiency.

Keywords: Forward Error Correction (FEC), Automatic Repeat request (ARQ),

INTRODUCTION

Transmission of real-time video over the wireless network usually disturbed by video packet loss that caused by interference, terrestrial obstructions and reflection of transmission signal (Ding et al., 2006). To make sure that the video delivered at the receiver in good quality, Forward Error Correction (FEC) can be used to recover the video packets from losses. The principle of FEC is to add redundant packets so that original packets can be reconstructed in the occurrence of packet loss. In order to generate the appropriate number of FEC, Automatic Repeat reQuest (ARQ) mechanism can be adopted with FEC mechanism. The reason of using FEC with ARQ mechanism is because wireless network faces various network conditions as each mobile nodes experience different channel condition. Thus, it is difficult to decide how many FEC packets to be generated. Small numbers of redundant packets leads to small overhead but it might not be able to recover all loss packets therefore produce bad video quality. On the other hand, large numbers of redundant packets produce large overhead and consume too much bandwidth unnecessarily but produce good video quality.

Recently, there are many researchers work on investigating the combination of FEC and ARQ mechanism. The EAFEC mechanism proposed by Lin et al. (2006) has implemented dynamic FEC combined with ARQ mechanism at base station. This mechanism recovers packet loss according to the network status. Meanwhile, Du et al. (2009) proposed Mend FEC which is an enhancement from EAFEC mechanism where it can improve quality of video in sudden video changing scene. However, both of the mechanisms used uniform error model to verify the mechanisms. Generally, uniform error model is easier to implement compared to GE model. However, uniform error model has disadvantages as it is unable to represent the burst error network that usually occurred in the wireless network. Latré et al. (2007) have proposed AHAFEC mechanism that can alter the amount of FEC packets and the number of maximum retransmission at base station under burst error network. Unfortunately, they do not provide any information regarding the amount FEC packets required to recover the loss packets. Thus, the recovery efficiency can not be determined.

The aim of enhanced FEC mechanism is to improve the performance of existing Adaptive FEC mechanism in term of recovery efficiency. The performance metric such as PSNR, recovery efficiency and FEC efficiency are used in the performance evaluation.

ENHANCEMENT ON SMOOTHING FACTOR VALUE IN QUEUE LENGTH

The existing Adaptive FEC uses Exponential Weighted Moving Average (EWMA) to estimate the value of average queue length. EWMA is used to minimize the bias against transient burst in the queue length. Whenever the packets queue in the buffer, the average queue length is updated according to equation 1:

$$avg_q = (1 - w_q) \times inst_q + w_q \times avg_q \quad (1)$$

avg_q the average queue length

w_q the smoothing factor

$inst_q$ the current queue

Smoothing is a factor to produce weight average values in order to eliminate the effect of short term fluctuation due to the traffic patterns (Abbas et al., 2004). Based on this equation, w_q that is also called a smoothing factor play an important roles to determine the queue size used in the averaging process (Romdhani et al, 2003). w_q is set with static value in the range of [0, 1] to determine the average queue length. Harun et al. (2010) shows that greater value of w_q will produce the best quality of video i.e., 0.9 when the wireless error rate is low. Otherwise, when the wireless conditions become worst, the w_q need to be set to minimal value, i.e. 0.1, so that more redundant packet can be generated. As a conclusion, the w_q is important in determining the appropriate average queue length and producing quality video at the receiving.

The appropriate values of smoothing factor can be generated based on the number of packet retransmission failed at the MAC layer. When the packet retransmission failed is low, the value of smoothing factor is set to high value. Therefore, the number of FEC generated is also low because the error rates it low. On the other hand, as the packet retransmission failed is increased, the value of smoothing factor is decreased. The decreasing of these values resulting in the ability to generate more FEC packets to recover the packet failed due to the increasing of error rates.

Here, the new values of w_q can be generated as:

if (avg_{rT} < th3)
  w_q = 0.5;
else if (avg_{rT} < th4)
  w_q = int (0.5*(th4 – avg_{rT})/th4-th3);
else
  w_q = 0.1;

Denotes that avg_{rT} is the average of packet send failed during retransmission at the MAC layer, th5 is the low threshold and th6 is the high threshold value for the number of packet failed. When avg_{rT} is less than the certain threshold (th5), the value of w_q is set to 0.5. If the avg_{rT} is larger than th6 value, the value of w_q is set to 0.1. Otherwise, the value of w_q decreases based on the increasing of packet retransmission failed.

SIMULATION TOPOLOGY AND SETTING

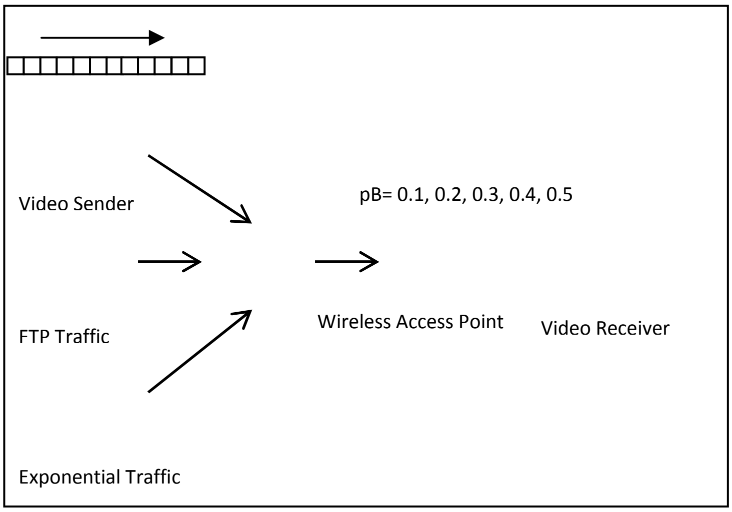

Figure 21. Simulation Topology for Experiments

The simulation topology in this paper is shown in Figure 1. In this simulation, video server transmits video streams over the Internet using wired link while wireless nodes are connected using wireless link. The video traffic trace used for this experiment is “Highway” video using H.264 video coding with JM 1.7 codec. JM 1.7 has been used in this experiment because the newer version of JM doesn’t support packet losses (Ke et al., 2006). This means that when some parts of compressed file have removed due to those packets are lost during transmission, the distorted file is unable to be decoded. Thus JM 1.7 is used to encode and decode video sequence. The “Highway” format is QCIF and the Group of Picture (GOP) structure is IPPPPPPPPPPPPPP which is Simple Profile. “Highway” video trace consists of 2000 frames which are divided into transmitting slice. Each slice is about 500 bytes and transmitted via multicast transmission with the GE error model. The P_{GG}, P_{BB} and P_G are set at 0.96, 0.94 and 0.001 respectively. The packet error probability (P_B) represent the channel is in bad state is varied from 0.1 to 0.5 with 0.1 intervals. The frame rate for this video is 30 (frame/sec) and the total video packets sent are 4829. There are two background traffics in this simulation. The first is FTP traffic that transmitted using TCP packets. The second is exponential traffic transmitted using UDP packets. Transmission rate is 1 Mbps which include burst and idle time are both set as 0.5ms. The link between wireless AP and the wireless node is IEEE 802.11b 11Mbps while the link between the Internet and wireless AP is 100Mbps. The link between Internet and each traffic source is set as 10Mbps.

SIMULATION RESULTS AND DISCUSSIONS

This section discussed the simulation results obtained from the performance evaluation done on the Adaptive FEC mechanism and modification of Adaptive FEC mechanism. All the results are generated from different error rate which is from good network status (0.1) to bad network status (0.5).

Table 1. No. of FEC

	EAFEC	Enhanced FEC	Mend FEC
pB=0.1	3±1	1±0	55±3
pB=0.2	14±0	15±1	82±1
pB=0.3	49±2	57±2	152±3
pB=0.4	119±5	110±3	244±6
pB=0.5	195±6	148±4	331±5

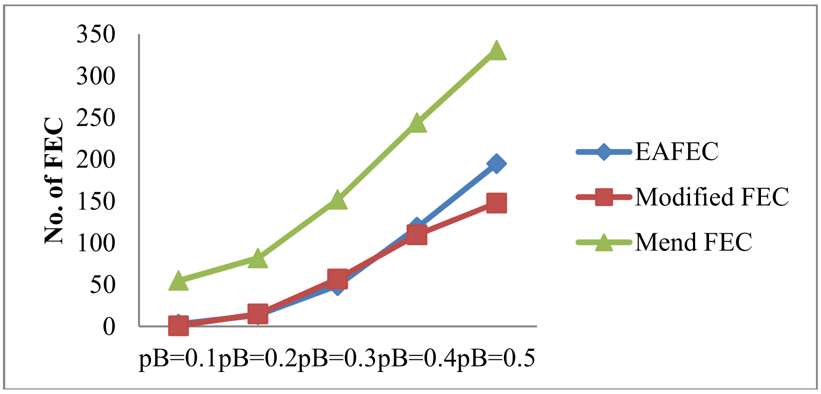

Figure 2. No. of FEC vs error probability

As shown in Table 1 and Figure 2, the number of FEC packets are increased as the packet error rate increased. This is the fact that high packet error rates leads to high packet retransmission until the packet has been correctly received at the receiver. As the packet error increased, Mend FEC generates the highest value of FEC followed by EAFEC and Enhanced FEC. Compared with EAFEC and Enhanced FEC, obviously from the results that Mend FEC generated high FEC packets even when the packet error rate is low. Thus, when network condition is good, Mend FEC is not suitable to be used to prevent network congestion caused by the excessive FEC packets. In contrary, Enhanced FEC generates lower FEC packets compared to other.

Table 2. Recovery efficiency

	EAFEC	Enhanced FEC	Mend FEC
pB=0.1	0±0	0±0	0±0
pB=0.2	0.0095±0.0049	0.0149±0.009	0.0059±0.0015
pB=0.3	0.03±0.06	0.05±0.002	0.029±0.005
pB=0.4	0.0456±0.0071	0.1119±0.0120	0.0609±0.0052
pB=0.5	0.0935±0.0070	0.1956±0.0165	0.1179±0.0055

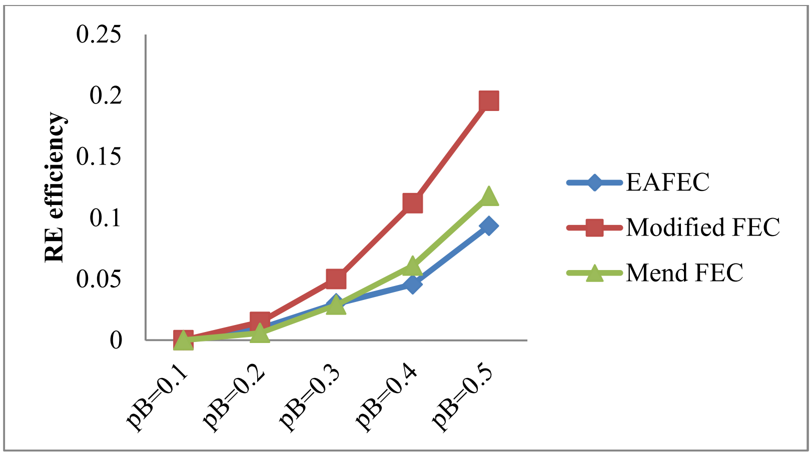

Figure 3. Recovery efficiency vs error probability

Recovery efficiency (RE) is used to measure the ratio of the amount recovered video packet to the total amount of FEC packets. As shown in the Table 2 and Figure 3, Enhanced FEC achieved greater RE compare to EAFEC and Mend FEC. Hence, Enhanced FEC provides a better packet loss recovery performance compared to the others. The number of FEC packets generated by Enhanced FEC are utilized more efficiently to recover the packet loss. The lowest RE value is contributed by EAFEC mechanism because it generates more than one FEC block for a same video block. For real video trace file, the missing packet sequence can only be recovered by the same packet sequence generated by FEC. For example, packet no.1 can be recovered by FEC packet no.1 but not the packet no.2 or 3.

Table 3. FEC efficiency

	EAFEC	Enhanced FEC	Mend FEC
pB=0.1	0.9995±0.00015	0.9998±0.000002	0.9885±0.0005
pB=0.2	0.9972±0.0001	0.9969±0.0001	0.9833±0.0003
pB=0.3	0.9903±0.0004	0.9889±0.0004	0.9704±0.0005
pB=0.4	0.9769±0.001	0.9801±0.0006	0.9545±0.0011
pB=0.5	0.9643±0.0011	0.9757±0.007	0.9426±0.0009

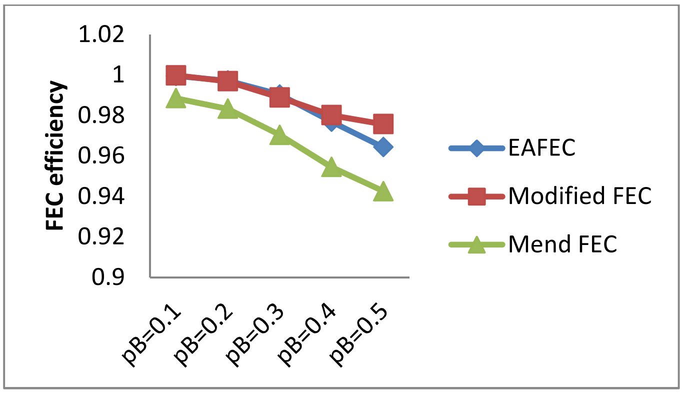

Figure 4. FEC efficiency vs Error probability

The FEC efficiency determines how efficient the FEC packets used to recovered packet loss. The best value of FEC efficiency is equal to 1, which means full utilization of FEC packet or in the condition where no FEC packets transferred due to the video transmission is free from packet loss. As shown in Table 3 and Figure 4, the FEC efficiency decreases as the packet error rate increase. This is the fact that more video packets are dropped in bad network condition. Moreover, Enhanced FEC achieved greater FEC efficiency when error probability increases. This is contributed by the reasonable value of smoothing factor that allows the lower generation of FEC packets for Mend FEC mechanism and thereby the amounts of wasted FEC packets are reduced accordingly. In contrary, Mend FEC contributes the lowest FEC efficiency because unused FEC packets are generated along the time.

Table 3. PSNR

	EAFEC	Enhanced FEC	Mend FEC	Remarks (MOS)
pB=0.1	40.4	40.4	40.4	5 (Excellent)
pB=0.2	40.2	40.32	40.31	5 (Excellent)
pB=0.3	39.97	40.06	40.04	5 (Excellent)
pB=0.4	39.24	39.33	39.46	5 (Excellent)
pB=0.5	38.32	38.55	38.85	5 (Excellent)

As shown in Table 3 and Figure 5, Mend FEC mechanism achieves higher PSNR than other mechanisms due to high FEC packets injected to the video transmission. This is due the fact that high FEC packets leads to high probability to recover packets from loss. When the pB is less than 0.3, Enhanced FEC achieved same PSNR value to mend FEC. However, when pB reach 0.4, the PSNR is reduced because the number of FEC also need to be reduce to avoid network congestion during video transmission. Comparing with EAFEC, Enhanced FEC gives better result because it's high error recovery.

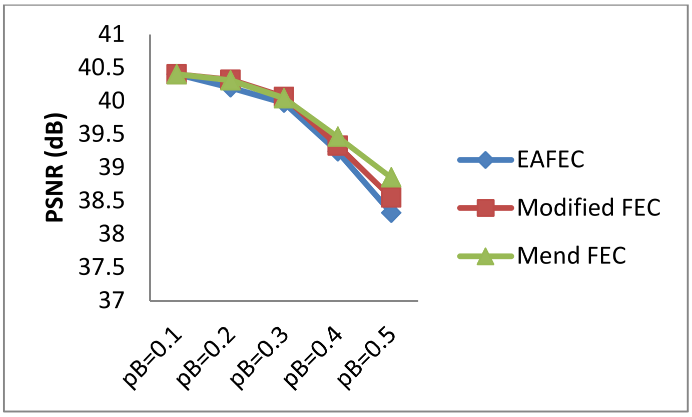

Figure 5. PSNR vs Error probability

CONCLUSION

After analysing the result of the experiments, clearly that performance of Enhanced FEC is better than the others in term of high error recovery using low FEC packets. The performance improvement of Enhanced FEC is related to the reasonable value of smoothing factor setting for the queue length. For the future, the work can be extended by implementing the Enhanced FEC in real network.

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