Adaptive FEC Error Control Scheme for Wireless video Transmission

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***Abstract*— Transmission errors have detrimental impact on video quality in wireless network. Hence, this requires highly efficient error correction scheme to significantly improve the quality of the media content. Deploying error correction technique alone would not strategically eradicate the problem unless some adaptation mechanism has been included in order to make efficient decision while adding more redundant information base on the channel condition. Adapting with channel condition can significantly enhance the network performance and video quality as well. In this paper, we paper presents an approach using forward error correction and cross layer mechanism which dynamically adapts with the channel condition to recover the loss packets in order to enhance the perceived video quality. The scheme has been developed and tested on NS-2 simulator and it shows more dramatic improvement in video quality.**

***Keywords*— channel condition, Error correction, transmission error, error-prone transmission environment, forward error correction (FEC), cross layer design**

I. Introduction

There has been an alarming increase in demand for multimedia applications and services due to technological advancement in computing, communication and networking. These applications will have increase prominence and utilization as their demand increases in security, surveillance and monitoring, education, entertainment and transportation. However, supporting wireless video application requires more strategic plan and approach. The unpredictable nature of the wireless network and increase in heterogeneous devices and connections to access the video content has made it difficult and challenging to provide the required QoS and support [1]. Hence, there is need for more sophisticated video error correction techniques and strategies are required to meet up with the dynamics of the wireless environment. Error correction techniques play an extremely important role in maintaining the video quality over unpredictable channels. The ability to adapt dynamically with the condition of the channel while sending redundant packets will have dramatic impact on the overall performance.

The rapid advancement in internet technology has resulted in more integration and seamless wireless connection. Basically the nature of the traffic will eventually require a diverse QoS in order to ultimately support different traffic demand [2] especially with the emergence of more multimedia applications. Real-time video transmission over wireless has been a major issue of concern due to time varying nature of the wireless network and bandwidth requirement [3]. Wireless multimedia has dramatically reshaped the communication industry such that it is difficult to find electronic gadget which does not have wireless technology integrated to it. For instance, Bluetooth technology has enabled efficient integration of mobile devices, cameras and printers to the wireless LAN in order to access computers, cars and other hand held devices.

Basically, transmitting video applications over wireless medium require high bandwidth and it is susceptible to errors. The transported video is normally compressed to reduce the bandwidth requirement, but still require significant amount of bandwidth for effective video transmission. In fact, the quality of the video should be maintain in wireless network due to unpredictable nature of the transmission medium which has detrimental effect on the video quality. As such high compression efficiency is required to meet up with the aforementioned challenges and constraint. Different error correction techniques have been developed with different features and capabilities to tackle the problem of transmission errors.

The organization of this paper is as follows. Section II is primarily aimed at reviewing the video transmission errors and correction techniques. Section III will focus mainly on proposed system model. Results for simulation experimentation will be discussed in section IV. Finally, a summary and conclusion are provided in Section V.

II. OVERVIEW OF ERROR CONTROL AND CORRECTION TECHNIQUES

The issue concerning transmission errors need to be address in order to ultimately support video transmission over wireless. Several error correction techniques have been proposed to mitigate the impact of transmission impairment [4][5][6][7][8]. It is very realistic that there has been more dramatic development in wireless multimedia technology and has subsequently lead to different challenges which require more sophisticated solution. QoS support is required in mobile devices due to limited energy, bandwidth, unpredicted channel and mobility. Both computational complexity and energy should be considered since providing adequate QoS require high performance which eventually leads to high energy consumption. Trade off between energy and QoS need to be considered while designing multimedia applications and services.

However, in order to significantly improves the video quality, there is need to minimize the end to end delay. As it can be seen in fig 1, the delay can be due encoding, transmission channel and decoding. Transmission delay causes packet loss and congestion which subsequently lead to poor network performance. As it has already been mentioned that multimedia applications are sensitive to delay and precautionary measures need to taken to meet up with the delay requirement. For instance, multimedia streaming application can tolerate more delay than interactive applications such video telephony and video conference. Hence, meeting up with time deadline for the aforementioned application is very important for effective transmission.

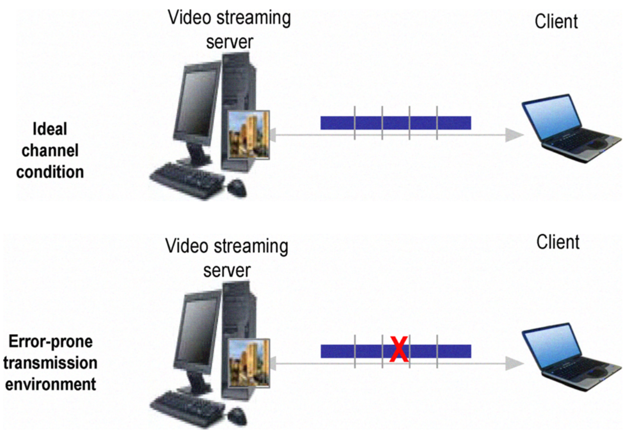


Figure 1 Ideal and Erroneous channel condition

The video to be transmitted is encoded and bit stream are generated. The generated bit streams can be transmitted over the network when the transmission medium is error free. Alternatively, the packets can be channel coded using FEC and transmitted over the wireless network. Finally, the packets are unpacked at the receiver and reconstructed. Transmission impairment can affect the bit stream generated along the channel.

Basically, it is necessary to provide the required quality of service (QoS) at both transmitter and receiver in order to prevent incessant packet loss and corruption as a result of congestion or impairment due to the wireless medium. In fact, this phenomenon is very common in wireless and Internet networks. Automatic repeat request (ARQ) has been used quite extensively to recover the loss or corrupted frames but for delay sensitive applications such video will automatically degrade the perceived video quality. Hence, it is very important to deploy error resilient techniques to ultimately support real-time video transmission over wireless network.

It is very important to note that a single bit error can subsequently lead to propagation error from one frame to another. At times is very difficult to determine the error location. This eventually causes serious degradation of video quality if the error location has not been detected by the decoder. Consequently, data between two synchronization points can be loss as a result of losing synchronization of the bit streams while decoding corrupted variable length. Video decoder should have the capability to detect errors at the transport or video layer and act accordingly.

In wireless network, transmission errors are very common due to time-varying channel condition which results in lost of information. It is very important to estimate the lost information at the decoder. FEC mechanism can be applicable in streaming and broadcast. However, the major bottleneck with FEC is the fact that it adds more delay and consequently affects real-time applications which are very sensitive to delay. Also, compression involves removing more redundant information and there is tendency for removing more important information as well. This eventually results in very difficult situation while concealing the lost information.

FEC can be used for error correction code and error erasure as well. Basically, additional redundant data is generated and transmitted with the original data. This can eventually lead to more network traffic and delay if redundant information is constantly transmitted without any control. Cross layer solution is required to counter the aforementioned problem [9]. Redundant data can only be transmitted base on the network traffic and channel condition. Several research works have been conducted which utilize the combination of FEC and ARQ scheme. In [10], it has proposed a cross layer error detection scheme for wireless video transmission based on priority. Also, [11] has indicated that more robust and efficient video transmission over wireless LAN can be achieved.

III. PROPOSED SYSTEM MODEL

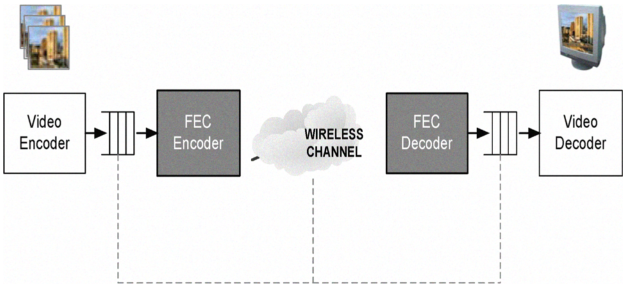


Figure 2 system model

As it can be seen from figure 2, the system model comprised of transmission unit, channel and receiver unit. The video data was encoded using H.264 [12] and stored in streaming server. The encoded video data is streamed by the clients through the AP and hence the error correction scheme was placed on the AP. This is primarily for two main reasons namely: proximity and capability. The parameters shown in table I was used to simulate the above scenario.

Table 1. Simulation parameters and settings

Parameter	Setting
Transmission mode	DSSS
Wireless standard	IEEE 802.11b
PhyType	Phy/WirelessPhy/802_11
Mac Type	Mac/802_11
Data packet	1500
Data rate	1 to 11 mbps
Video Encoder	H.264
Video Format	QCIF(176X144)
Number of frames	300
Channel model	Gilbert Elliott's

A. Channel model

The channel was model using Gilbert-Elliot's to mimic the wireless channel condition due its busty nature. In order to critically analyse the profound impact of transmission impairment on video quality, two state markov chain is considered. It is very obvious that markov chain has been used more extensively for modeling and analysis memory channels. The details about formulas used for evaluating the channel capacity of general markov channel can be found in [13]. Gilbert-Elliott is the special case of markov channel and it basically has two states. The channel condition was set to 0.4. The worst error condition has been used primarily to test the capability of the scheme. Then different video samples were transmitted over the wireless channel and their respective video quality computed according to equation 1.

B. Video Quality Evaluation

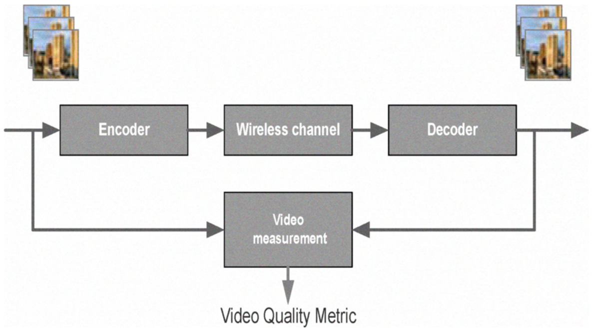


Figure 3 Video quality measurement

In order to evaluate the performance of the scheme base on the video quality metric, we used objective test. The video quality was evaluated using PSNR metric, and it has been extensively used to measure the maximum possible signal energy to the error energy. As such this can be extremely useful tool to compare the video transmitted and video received at the receiver. By comparison, the actual difference or loss in video quality can be determined. The PSNR can be express mathematically by

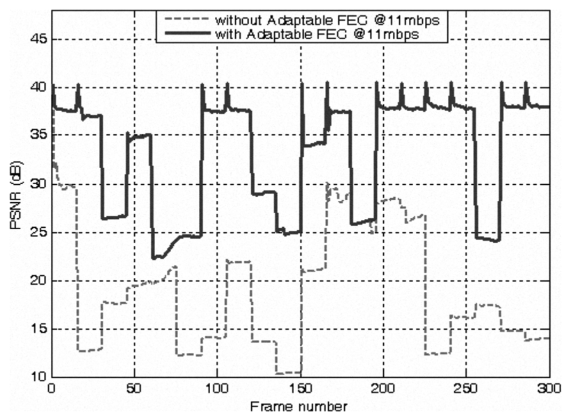
$$PSNR = 10.\log_{10} \frac{255^2}{MSE} \quad \text{[dB]} \qquad (1)$$

where MSE is the mean square error

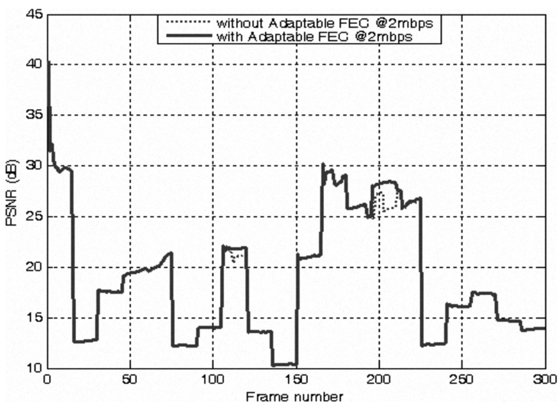
The experimentation was conducted based on the scenario shown in fig 2 in order to test and verified different video samples over wireless channel condition. Video sequences such foreman and coastguard monitor were used. Based on the experimentation conducted, it has clearly indicated that the FEC scheme deployed effectively recover some of the lost packets and subsequently the video quality significantly improve as the data rate increases as shown in fig. 4. However, increase in transmission error seriously affects the video quality, but the extent of spread in transmission error depends on data rate and error resiliency of the codec. By increasing the data rate when the error is high can lead to transmission error and this significantly affect the video quality at the destination.

IV. RESULTS & DISCUSSION

The scenario demonstrated above was simulated in NS-2 [14], and both minimum and maximum achievable bandwidth for 802.11b have been used. High video quality can be achieve with high data rate under normal condition but very susceptible to interference. The error correction scheme significantly improves the video quality in both cases. It can be notice that scheme at low data rate does not actually achieve much in terms of improving the video quality. With the application of cross layer to interact between the physical and MAC such that the channel condition can be determined and hence redundant packets are transmitted base on the channel status. This has significantly reduced the network traffic and latency as well. In table II, it can be seen that the video quality increase as the data rate increases when using the adaptable FEC scheme and when not applicable. In a nut shell, the video quality has been enhanced at the expense of additional delay. It is obvious that increase in delay can contribute to traffic and congestion but achieving the packet deadline is extremely important when dealing the delay sensitive application such video.



4(a)



4(b)

Figure 4 Impact of adaptable FEC scheme on video quality

Table 2. Video quality at different data rate

		Video Quality (dB)	
Video Samples	Data Rate (Mbps)	Without Adaptable FEC	With Adaptab FEC
Foreman	1	18.60	18.60
	2	30.51	33.03
	5.5	33.84	36.42
	11	34.22	39.24
Coastguard	1	14.17	14.71
	2	18.78	18.91
	5.5	28.63	29.82
	11	31.46	33.22

Table II shows the average video quality for foreman and coastguard sequence under different data rates. In each of the cases, there has been dramatic increase in video quality with the application of FEC scheme. More than 1 dB improvement in video streaming quality has been achieved when compared to without using FEC. Also, the error correction mechanism increases the delay as well. Trade off between delay and video quality should be taken into consideration because some applications are very sensitive to delay.

V. CONCLUSION

In this paper, we proposed a FEC mechanism which dynamically add redundant packet base on the channel condition. This is extremely important especially when dealing with sensitive application to minimize the processing time and reduce the traffic over the network for reliable and effective communication to harness. The scheme uses cross layer design approach to effectively share and exchange information for efficient decision making. The video quality has dramatically increased at the expense of increasing delay due to additional computational time and traffic as well.

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