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Adaptive Cross-Layer System for Improved Mobile Television Services

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***Abstract* — Encoded video packets are susceptible to channel errors. The performance of video contents under varying network conditions is investigated in this work. The weight, length and impact of different video packets are studied. Based on the insights gained, an adaptive cross-layer system, utilizing network abstraction layer unit length and flexibility of IP-based wireless network in exchanging network information for content adaptation is proposed for improved mobile television services. The optimized system utilizes real time control protocol in monitoring quality of video packets for adaptation process based on network characteristics.**

***Keywords* — Cross-Layer, Error Protection, Mobile Video Services, Wireless Networks, Network Abstraction Layer, Real Time Control Protocol.**

I. Introduction

Compressed video bit streams are generated and transmitted in packets over wireless channel. It becomes susceptible to channel errors [1] [2] which corrupt video packets. Application of mobile television services are increasing in demand due to its flexibility. This surge in demand put pressure on the limited network resources. The phenomenon causes the video contents to start struggling for more network requirements in terms of bandwidth in order to meet the users' quality requirements. However, as the number of service increases the limited network resources become insufficient to cater for successful delivery of the video contents over constrained transmission network, and become worst during channel fading and congestion. However, compressed media streams experience high error rates due to fading, interference, pathloss, power constraints [3] [4] [5] [6]. These factors affect the received video quality performance. Advanced video coded supports error-resilient features such as data partitioning, intra update, slice interleaving for robustness of media stream over error prone channels. However, the error-resilience schemes in the source compression is not enough to combat the impact of channel distortions on received video quality, hence requires advanced protection scheme to control the channel errors and improve quality of media services [7] [8] [9] [10]. It is difficult to provide a guaranteed quality of experience because temporally high bit error rates cannot be avoided during fading. Transmission errors of a wireless communication channel may range from single bit errors to burst errors. The varying degrees of errors condition limit the effectiveness of traditional mechanisms such as Automatic Retransmission on Request (ARQ) and Forward Error Correction (FEC). ARQ mechanism involves retransmission of the corrupted video packets in response to receiver requests. However, ARQ incurred delays in process of re-transmission of loss video packets. Hence, ARQ may not be effective for delay sensitive video applications and critical for real-time conversional services. Forward Error Correction (FEC) maybe employed to improve the reliability of coded video streams but limited in effectiveness if we have to cope with limited bandwidth requirements. On bad channel condition such as fading or network congestion, more advanced mechanism is necessary because compressed video signal is extremely vulnerable against transmission errors. However, error concealment strategy cannot totally avoid image degradation and the accumulation of several small errors will finally result in a poor received video quality. It is observed that error propagation constitutes the main challenges in mobile television services. Thus, this research work proposes an adaptive cross layer system for improved mobile television services.

II. System Model

In this work, an adaptive cross-layer system is applied to improve quality mobile television services. The scheme involves dynamic adaptation of Network Abstraction Layer Units Length (NALU), using IP-based wireless network in exchanging network information for efficient content adaptation process. The Real Time Control Protocol (RTCP) is applied in monitoring the quality of video packets delivery for adaptation of NALU based on network characteristics. Figure 1, shows the overview of the proposed system model.

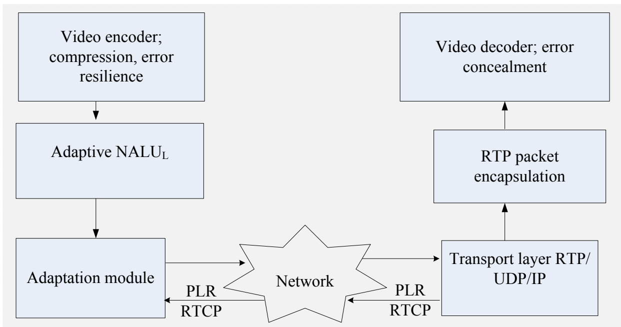

Figure 1: Adaptive cross layer system architecture

Adaptive cross layer system architecture is modeled in Figure 1. The system consists of video encoder which implements source encoding and error resilience functionalities. The encoder carried out packet structure

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adaptation of the NALU. The adaptation module performs packet structure adaptation based on the channel condition and video content. It employs a cross layer design strategy and variable packet structure in the adaptation process. The system regulates the packetisation structure of the media streams based on the network conditions and media content. Depending on the feedback information on prevailing channel conditions and video distortion, the system intelligently adjust the network abstraction layer units length of the media stream to enhance robustness of the media stream. When the prevailing network condition gets bad, the system adapts Network Abstraction Layer Units Length relative small and adjust it relative high when the prevailing channel condition improves. The aim of the system is to improve robustness of video streams and improve received video quality performance under fixed constrained-network resources.

III. Experimental Configuration

A testbed was set up to validate the effectiveness of the proposed scheme. The channel condition was analyzed using the packet loss rate of the media stream. Standard test video sequences are used in the experimental process. The application layer of the system model is simulated using advanced video coding reference software [11]. The additive white Gaussian noise (AWGN) channel model is used in the research work [12]. In the experiment, video server stores different standard test videos sequence. H.264/AVC encoder performs encoding and error resiliency functionalities including packetization for improved transportation of media streams over wireless network. The adaptation module performs Network Abstraction Layer Units Length adaptation operations for the transmission processes. The transmission parameters for video streams are adapted based on the prevailing channel condition which is measured in terms of the packet loss rate. The compression configuration of the video streams include: group of picture size of 16, a macro block size of 16×16 pixels, frame rate of 25fps and 352x288 spatial resolutions. Each standard test video sequence has a total number of 300 frames. After compression, the video stream is passed through simulated wireless channel, then decoded at the receiving section. The channel performance is carried out with pre-simulated error patterns composed of traces of different signal-to-noise ratio for different modulation schemes. The pre-simulated error traces is used to corrupt the video streams transmitted through the simulator. The performance of the proposed scheme is measured in terms of received video quality performance using peak-signal-to-noise-Ratio model. Peak Signal-to-Noise Ratio (PSNR) measures video quality by correlating the maximum possible value of the luminance and the mean squared error [13]. Higher PSNR values indicate better quality.

IV. Result and Discussion

The performance of the proposed system is tested with standard video samples in CIF format. In the simulation process, the corresponding Signal to Noise value is mapped to the modulation and channel coding scheme. The pre-encoded video streams are then transmitted through the simulated channel. The simulations were repeated 15 times to obtain stable results. Figure 2 presents the performance of the scheme in terms of PSNR values. It is observed that video quality performance obtained under the proposed Adaptive Cross-layer System performs better compared to the video quality performance obtained under the traditional approach (without adaptive cross layer system). The reason for the quality improvement as observed in the Adaptive Cross layer system is the enhancement of error protection supported by systematic adaptation of the Network Abstraction Layer Units Length (NALU) of the media streams. The results under two test scenarios are presented in Table I.

Without Adaptive Cross Layer System	Adaptive Cross Layer System
	

Table I shows the test results for Soccer test video sequence. Under similar channel condition, the proposed adaptive cross layer system performance is enhanced compared to the video quality performance obtained without adaptive cross layer system. The quality performance enhancement observed is due to the fact that the proposed scheme offers stronger protection of the video streams against channel errors. Thus, less video number of video packets get corrupted compared to the system without adaptive cross layer system.

V. Conclusion

The paper examined various video transmission techniques and proposed an adaptive cross-layer system for improved mobile television services. The proposed scheme enhances the performance of the compressed video streams over wireless channels by adapting network abstraction layer unit length based on the channel conditions and video content property. Experimental results show significant enhancement in the received video quality performance when compared to the conventional approach.

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