# Content-based Unequal Error Protection Scheme for Enhanced Wireless Video Broadcast

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**ABSTRACT- Supporting good video quality services over wireless network is challenging due to system constraints, dynamic channel condition and high packet loss rate. Hence more efficient error resilience mechanism is necessary. In this paper, error protection schemes are investigated and Content-based Unequal Error Protection Scheme is proposed for improved quality of wireless video services. The study aims at developing a transmission scheme capable of enhancing the quality of wireless video services. The performance of the proposed unequal error protection scheme is tested on simulated wireless platform. The experimental results obtained under various test conditions demonstrate that the proposed scheme can enhance the received video quality performance.**

***Index Terms—*** Error protection, video services, broadcast, video quality, wireless network.

## I. Introduction

Distribution of video contents over wireless channel to users is increasing in demand due to its flexibility and accessibility. However, compressed media streams experience high error rates due to certain factors including fading, interference, pathloss. These factors affect the received video quality performance. H.264/AVC [1] 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 received video quality performance. Conventionally, impacts of channel errors can be controlled by Automatic Re-transmission on Request (ARQ) approach where the corrupted video packets are retransmitted in response to receiver requests. However, ARQ incurred delays in process of retransmission of loss video packets. Hence, ARQ may not be suitable for delay sensitive video applications. Channel coding such as Forward Error Correction (FEC) maybe employed in video communication system to enhance the reliability of transmitted video streams over error prone channel. In video applications, the additional video packets (redundancy) transmitted incur extra cost (more bandwidth requirement) and delays. Advancement in mobile communication system has made it possible to exploit adaptive modulation scheme in improving the quality of video transmission over error prone channel. Several applications of adaptive modulation scheme are found in the literature [2] [3] [4], where the modulation parameters are adapted based on the channel conditions and signal strength. In addition to the existing applications, enhancing video protection scheme according to the importance of video streams is proposed in the Content-based Unequal Error Protection Scheme for enhanced wireless video broadcast.

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## II. THE PROPOSED SCHEME

Content-based Unequal Error Protection Scheme for Enhanced wireless video broadcast (CUEP) is proposed, the aim of CUEP is to improve robustness of video streams over error prone channel and improve received video quality performance under fixed constrained-network resources. In the proposed scheme, video transmission parameters are based on the importance of the video streams. The importance of the video stream is characterized by its motion activity. Motion activity in this context is defined as the magnitude of motion displacement in video sequence. Video streams with high motion activity characterization are highly prioritized and mapped on more robust constellation while video streams of low motion characterization are transmitted on less robust transmission scheme. Video streams are grouped into classes according to the importance of the media streams and prioritized based on the motion characteristics pattern.

## III. SYSTEM ARCHITECTURE

The proposed CUEP system architecture composes of transmission and receiving components. The transmission process includes capturing, encoding and transmission while the receiving section consists of receiver, decoder and display. Figure 1 presents the CUEP system architecture and various components.

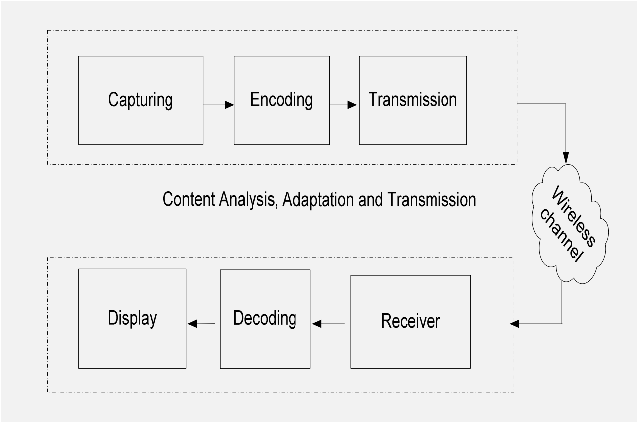


Figure 1: CUEP System Architecture

Video communication involves capturing of natural scene by video camera, encoding by video compression algorithms and transmission of compressed media streams over a delivery channel. The encoding block performs video compression function by exploiting redundancies in video sequence and application of various algorithms to enhance robustness of the media streams. In the proposed scheme, the transmission process significantly depends on the video characteristics, resource constraints and channel characteristics. Technically, wireless video communication is more challenging due to the limited bandwidth availability and high bit error rates which inflict quality degradation on the received video performance. The transmitted video stream is decoded at the receiving section. Finally, the reconstructed video stream is processed and displayed on the receiving device. More details on the video communication systems including digital video compression, transmission and decoding are discussed in the literature [5][6].

Content characteristic in this context defines motion intensity, which characterize magnitude of motion activity in the video sequences. Changes in the motion characteristics between successive video scenes are mainly caused by object motion (e.g., a goal keeper in a football scene, an athlete in action, etc) and global motion (e.g., camera motion such as zoom, pan). In object motion, different objects experience different motion characteristics in the video scene. In camera motion, objects within the video scene experience similar motion. Since camera motion produces homogeneous motion characteristic within the video scene, motion compensation results in reduction of residual energy and an increase in compression performance [7]. Thus, in this work object motion is considered as the influential parameter in estimating motion intensity. The mathematical model for measuring motion intensity of the video streams is given by [8]:

$$M_s = \sum_{i=0}^{L-1} \Delta_F \times \frac{R}{T} \qquad (1)$$

where $M_S$ represents motion intensity of the video sequence over $L$ number video frames. $\Delta_F$ is the motion intensity of a video frame. $R$ and $T$ are the spatial and temporal resolutions of the video sequence, respectively.

## IV. SIMULATION

Simulations are performed to assess the effectiveness of the proposed scheme. The motion intensity is analyzed using the optical flow algorithm of Lucas and Kanade [9]. Different standard test video sequences characterized with various motion activities are analyzed using the algorithm. The application layer of the system model is simulated using H.264/AVC reference software [10]. The additive white Gaussian noise (AWGN) channel model is used in the research work [11]. Figure 2 presents the simulation set-up for the proposed CUEP scheme.

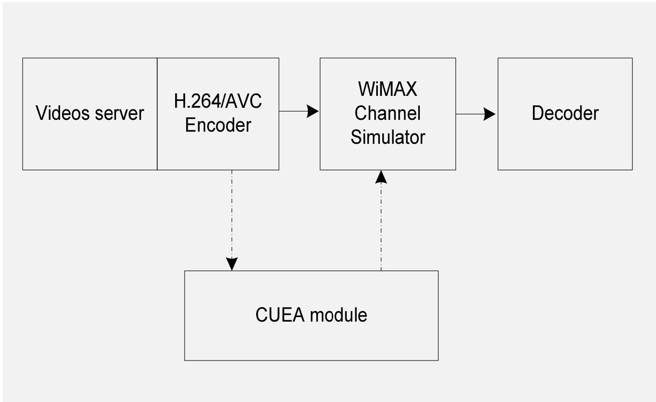


Figure 2: Simulation Set-up

Figure 2 presents the block diagram of CUEP simulation process. The video server stores different videos of diverse content characteristics. H.264/AVC encoder performs encoding and error resiliency functionalities including packetization for improved transportation of media streams over wireless network. The CUEP module performs adaptation operations for the transmission processes. The transmission parameters for video streams are adapted based on the content characteristics and the prevailing channel conditions. The performance of the proposed scheme is tested with the standard test video sequences: Football, Soccer, Akiyo and Hall test video sequences, representing different types of video broadcast content services stored in a centralized video server. The compression configuration of the video streams include: Group of Picture GOP size of 8, frame rate of 30fps, CIF 352x288 spatial resolutions and a macroblock size of 16×16 pixels. Each test video sequence has a total number of 300 frames. The received video streams are decoded using H.264/AVC reference software. The transmission of the compressed video streams is simulated at different channel conditions and transmission schemes. The channel performance is carried out with pre-simulated error patterns composed of traces of different Signal-to-Noise Ratio (SNR) for different modulation schemes generated using physical layer WiMAX simulator. The model simulates a time varying channel including the effect of multipath for the ITU vehicular A scenario. The pre-simulated error traces is used to

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corrupt the video streams transmitted through the simulator. In the simulation, only the downlink subframe is considered. The downlink subframe composed of 30 subchannels and 13 time symbols, forming 390 slots. Each slot allows a certain number of data bits depending on the modulation and coding scheme of the system. The data slot error patterns are obtained by comparing the data bits within original data slot to the transmitted data slot. If there is any bit error within the data slot, it is then declared as an error.

The performance of the proposed scheme is measured in terms of received video quality performance. As a measure of perceived video quality performance, Peak-Signal-to-Noise-Ratio (PSNR) model is used in the received video quality performance assessment. Peak Signal-to-Noise Ratio (PSNR) measures video quality by correlating the maximum possible value of the luminance and the mean squared error (MSE). PSNR is calculated using equation [12]:

$$PSNR_{dB} = 20\,Log_{10}\left(\frac{2^{X}-1}{\sqrt{MSE}}\right) \quad (2)$$

$$MSE = \frac{\sum_{i=1}^{M}\sum_{i=1}^{N}\left[A(i,j)-B(i,i)\right]^2}{M.N} \quad (3)$$

where A(i,j) and B(i,j) are the values of the original and reconstructed pixels. *M* and *N* represent the frame resolution (height and width), while *X* represents the number of bits in the picture (for e.g. an 8-bit resolution = $2^8 - 1 = 255$). The overall video quality is obtained by averaging the PSNR values throughout the video sequence. Higher PSNR values indicate better quality. Although, PSNR is not the most reliable metric of video quality assessment, it is employed in the research due to its less complexity, ease in calculation and widely usage for video quality assessment. Table I presents the system parameter settings for the simulation process.

Table I: System Parameters for simulations

| System | Parameter |
|---|---|
| Test video sequence | Soccer, Football, Foreman, Hall, Sean, Weather. |
| Encoder | H.264/AVC |
| Spatial resolution | CIF (352*288) |
| Mean bitrates | 768Kbps |
| Video format | 4:2:0, YUV |
| GOP | 8.0 |
| Frame | 300 |
| Frame rate | 30 fps |
| Packet size | 512 bytes |
| Modulation & FEC | 16QAM-½, 64QAM-½, 64QAM-2/3 |
| Permutation scheme | PUSC |
| Path loss model | ITU-R |

Table I shows the system parameters and settings used for the simulations process. ITU-R model is adopted in modeling the path loss. More details on path loss, fading, are available in the literature [13] [14].

## V. RESULTS AND DISCUSSIONS

The performance of the proposed system is tested with six standard test video sequences in CIF format. The tested video sequences include Soccer, Football, Foreman, Hall, Sean and Weather. In the simulation process, the corresponding SNR value is mapped to the Modulation and Channel Coding Scheme (MCS) that support Bit Error Rate (BER) of $10^{-4}$. The pre-encoded video streams are then transmitted through the simulator. The simulations were repeated 20 times to obtain stable results. The results are obtained by averaging the PSNR video quality performance values. Table 2 presents the PSNR values. Comparing the results obtained under different scenarios: it is observed that video quality performance obtained under scenario-C (16QAM-1/2) outperforms that of scenario-B (64QAM-1/2) and scenario-A (64QAM-2/3) respectively. The main reason for the quality enhancement as observed in the case of Soccer test video sequence is the enhanced error protection features supported by 16QAM-1/2 compared to 64QAM-1/2 and 64QAM-2/3 respectively. The results under different test scenarios are presented in Table II.

Table II: PSNR Video Quality Performance at different MCS

| Test Video Sequence | PSNR (dB) Video Quality Performance | | |
|---|---|---|---|
| | Scenario-A | Scenario-B | Scenario-C |
| Soccer | 24.40 | 33.29 | 37.95 |
| Football | 25.15 | 32.37 | 34.25 |
| Foreman | 28.26 | 36.73 | 39.06 |
| Hall | 30.42 | 37.82 | 40.69 |
| Sean | 35.06 | 43.94 | 44.51 |
| Weather | 34.82 | 40.31 | 45.64 |

Table II shows the test results for Soccer, football, Foreman, Hall, Sean and Weather test video sequences, at different test conditions. Based on the observation from Table II, at the same source bitrates, video quality performance at scenario-C is enhanced compared to the video quality performance at scenario-B. The reason for the quality performance enhancement in scenario-C is due to the fact that more robust transmission parameters are deployed in the process which improves protection of the video streams against the impact of channel errors.

## VI. CONCLUSION AND FUTURE WORK

Content-based Unequal Error Protection Scheme for Enhanced Wireless Video broadcast has been proposed in this paper. The paper first investigated the various video transmission schemes. In contrast to the exiting approach in the literature, the proposed scheme adopts simple methodology and enhances error protection of the compressed video streams over error prone channel by adapting the transmission parameters based on the significant of the video streams. Test results show significant enhancement in the received video quality performance. Future work looks into more complex scenarios involving mobility and more advanced techniques to further enhance the video quality performance of video services over wireless channel.

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