ISSN:2321-1156

International Journal of Innovative Research in Technology & Science(IJIRTS)

Hybrid Approach for Efficient Distribution of Television Applications over Wireless Channel

U. Ukommi and E. Ubom

Abstract

The modern trend in communication process is shifting from traditional audio to audiovisual pattern including video telephony and multimedia communications. The consumption trend in television applications has also deviated from traditional linear television to flexible applications including Video-on-Demand (VoD), Internet Protocol Television (IPTV) and interactive television applications. However, these applications require reasonable bandwidth for immersive received quality. It becomes challenging under constrained wireless network resources to satisfy users demand efficiently. Thus, the aim of this research work which presents a 'Hybrid Approach for Efficient Distribution of Television applications over wireless channel'. The discussed approach harnesses the dynamic nature of video content in the design process. The experimental results show enhancement in the distribution process in terms of improved received quality.

Introduction

The current demand of immersive television applications over wireless networks by mobile users is posing a challenge to the service providers in terms of demand on the limited wireless network resources to deliver immersive television applications quality to the users. Consumption of television applications over wireless channel by users is increasing in demand due to its portability and availability of mobile devices such as smart phones and laptops. In mobile television applications, video plays significant role as the dominant application. Thus, video applications over wireless networks form the basis of the research work. However, distribution of these applications is challenging due to high demand of limited bandwidth resources. Moreover, compressed media stream is susceptible to channel distortion due to certain factors including fading, interference, pathloss. These factors affect the received quality performance of television applications. Video codec [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 higher protection approach to control the channel errors and improve received quality performance of received television applications. Conventionally, impacts of channel errors can be controlled by existing technologies such as Automatic Re-transmission on Request approach where the corrupted video packets are retransmitted in response to decoders requests. However, Automatic Re-transmission on Request incurred delays in process of retransmission of loss video packets. Hence, Automatic Re-transmission on Request is not suitable for delay sensitive video applications. Channel coding such as Forward Error Correction maybe employed in video communication system to enhance the reliability of transmitted video streams over error prone channel. In Forward Error Correction, the additional video packets (redundancy) for protection incur 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 analysis of existing video distribution technologies, improving the quality performance of wireless television applications based on the dynamic characterization of video content is discussed in the Hybrid Approach for Efficient Distribution of Television Applications over Wireless Channel.

The Proposed Approach

The Hybrid Approach for Efficient Distribution of Television Applications over wireless channel (HADTV) is discussed in this paper. The aim of HADTV is to improve robustness of television application over error prone channel and support immersive video quality performance under constrained wireless network resources. In the proposed approach, television distribution parameters are based on the dynamic characteristic of the video content. The dynamic characterization of the video stream in this context is signified by the amount of motion activity in the content. Motion activity in this context is defined as the magnitude of motion displacement in video sequence. Video streams with high motion activity characterization are prioritized transmitted with more channel protection while video streams of low motion characterization are transmitted with less protection approach. In the transmission process, video streams are grouped into classes based on the dynamic characterization of the video streams.

System Design

The system design of the proposed Hybrid Approach for

Efficient Distribution of Television Applications over wireless channel (HADTV) is described in this section. The system design composes of transmission and receiving chains. The transmission process includes capturing of events, encoding and transmission while the receiving section consists of receiver, decoder and display. Mobile television applications such as video communication involves capturing of natural scene by video camera, encoding by video compression algorithms and distribution of the compressed media streams over a wireless 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 characterization in this context defines dynamic characterization of the media content. This is measured in terms magnitude of motion in the video sequences. Changes in the motion characteristics between successive video scenes are mainly caused by object motion and global motion. Examples of object motion include a goal keeper in a football scene, an athlete in action. Typical examples of global motion include 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 dynamic characteristic of media content. The model for estimating measuring dynamic characterization of the media streams is discussed in the literature [8][9]. However, the spatial and temporal resolutions of the video sequence and the number of frames in the test media stream are also taken into consideration in the experimental process.

Experimental Configuration

The experimental process to evaluate the effectiveness of the proposed approach systems is configured as shown in Figure 1. Several simulations are performed to assess the reliability of the proposed approach. Figure 2 presents the experimental configuration for evaluation of the proposed Hybrid approach.

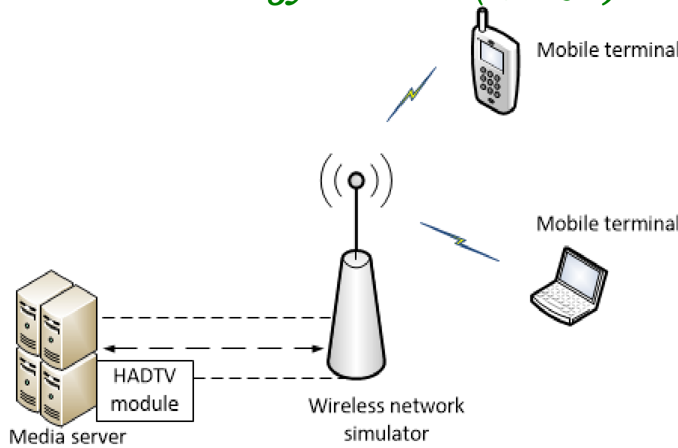

Figure 1: Experimental configuration

In the system configuration, the content dynamic characterization is analyzed using the optical flow algorithm of Lucas and Kanade [10]. Different standard test media sequences characterized with various dynamic characterizations are analyzed using the algorithm. The application layer of the system design is modeled using H.264/AVC reference software [11]. The Additive White Gaussian Noise (AWGN) channel model is used in the research work [12]. Figure 2 shows the experimental configuration for evaluation of the discussed approach. In the experiment, the media server stores different video contents of diverse dynamic characterization. H.264/AVC encoder performs encoding and error resiliency functionalities including packetization for improved transportation of media streams over wireless network. The HADTV module performs adaptation operations for the distribution processes. The transmission parameters for media streams are adapted based on the content dynamic characterization. The performance of the proposed approach is tested with the standard test video sequences: Football, Soccer, and Weather test media sequences, representing different types of media broadcast content services stored in a centralized media server. The compression configuration of the video streams include 30fps in Common Intermediate Format. Each test media sequence has a total number of 600 frames. The received video streams are decoded using H.264/AVC reference software. The transmission of the compressed media streams is simulated at different wireless channel conditions and transmission approach. 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. 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

ISSN:2321-1156

International Journal of Innovative Research in Technology & Science(IJIRTS)

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 [13]. The overall media quality performance 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. More details on path loss, fading and wireless network channel are available in the literature [14] [15].

Results and Discussions

The performance of the proposed system was tested with three standard media video sequences in Common Intermediate Format. The tested video sequences include standard Soccer, Football, and Weather test sequences. In the experiment process, the corresponding Signal-to-Noise-Ratio value is mapped to the Modulation and Channel Coding Scheme. The pre-encoded media streams are then transmitted to the mobile terminal through the wireless simulator. The simulations were repeated ten times to obtain reliable results. The results are obtained by averaging the PSNR video quality performance values. Figure 2 presents the quality performance of the proposed approach in terms of PSNR(dB).

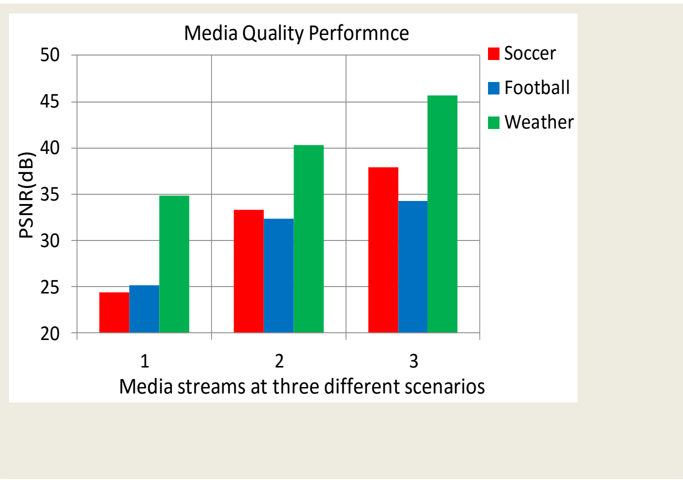

Figure 2: Quality Performance at three different test scenarios

Comparing the results obtained under three different test conditions. It has been observed that media quality performance obtained under scenario-3 outperforms that of test scenario-2 and scenario-1 respectively. The main reason for the quality improvement as observed in the case of Soccer test video sequence is a result of systematic mapping of media streams of high dynamic characterization on prioritized channel for better protection against channel errors.

Figure 2 shows the test results for Soccer, football and Weather test media sequences with different dynamic content characterization. The experimental were performed at three different test scenarios as depicts in Figure 2. Based on the observations from Figure 2, at the same source bitrates, video quality performance at scenario 3 shows significant improvement compared to the quality performance at scenario-1 and scenario 2 respectively. The quality performance improvement observed in scenario-3 is due to the adoption of the proposed hybrid approach. In the process, the media with higher dynamic characterization is mapped on better distribution channel with higher error protection approach. The hybrid approach harnesses the knowledge of content characterization and channel condition in the media distribution process. This improves the protection level of the media streams with high dynamic characterization against the impact of channel errors. Thus, the content with high dynamic characterization distributed through mapping on the improved channel conditions were delivered without much distortion on the received media quality performance. It has also been observed that the quality performance of Weather test sequence with low dynamic characterization is significantly better at the three test conditions. This is due to the fact the low dynamic test media sequence suffers negligible distortion at the network level. Transmission of media streams using this context improves the overall received quality performance of the tested media streams.

Conclusion and Future Work

Hybrid Approach for Efficient Distribution of Television Applications over wireless channel has been investigated in this research paper. The paper first studied the existing technologies for media distribution over wireless channel. In contrast to the exiting approaches in the literature, the proposed hybrid approach harness the knowledge media characterization and the channel condition in the distribution of compressed media streams. The hybrid approach selectively maps the content with high dynamic characterization on robust channel for enhanced protection against channel distortions. The contents with low dynamic characterization are distributed through low priority channel. The proposed hybrid approach saves the limited wireless network resources through intelligent adaptation of the transmission resources based on media stream dynamic characterization. Test results show significant enhancement in the overall received media quality performance. Future work investigates advanced approach to further improve the received quality performance of mobile television services.

Acknowledgments

The authors are grateful to the participants who contributed to the successful conclusion of the research work. The contribution of Akwa Ibom State University to the research work is also acknowledged. However, the role of Internal Journal of Innovative Research in Technology and Science is appreciated. Thank you for the support.

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