Eliminating the Freezing Frames for the Mobile User over Unreliable Wireless Networks

Hussein Muzahim Aziz
School of Computing
Blekinge Institute of Technology,
S-372 25 Ronneby, Sweden.
+46457385876
hussein.aziz@bth.se

Håkan Grahn
School of Computing
Blekinge Institute of Technology,
S-372 25 Ronneby, Sweden.
+46457385804
hakan.grahn@bth.se

Lars Lundberg
School of Computing
Blekinge Institute of Technology,
S-372 25 Ronneby, Sweden.
+46457385833
lars.lundberg@bth.se

ABSTRACT

The main challenge of real time video streaming over a wireless network is to provide good quality service (QoS) to the mobile viewer. However, wireless networks have a limited bandwidth that may not be able to handle the continues video frame sequence and also with the possibility that video frames could be dropped or corrupted during the transmission. This could severely affect the video quality. In this study we come up with a mechanism to eliminate the frozen video and provide a quality satisfactory for the mobile viewer. This can be done by splitting the video frames to sub-frame and transmitted over multiple channels. We will present a subjective test, the Mean Opinion Score (MOS). MOS is used to evaluate our scenarios where the users can observe three levels of frame losses for real time video streaming. The results for our technique significantly improves the indicate perceived that video quality.

Categories and Subject Descriptors

C.2.1 [**Computer –Communication Networks**]: Network Architecture and Design – Wireless Communication

General Terms

Measurement, Performance, Human Factors

Keywords

Streaming video, mobile device, frame splitting, multichannel, dropping rate, and MOS.

1. INTRODUCTION

Real time video communication over wireless networks faces several challenges such as high error rate, bandwidth variations and limitation, and capability constraints on the handhold devices. Among these, the unreliable and error nature of the wireless channel is the major challenge to stream video over wireless channels [6].

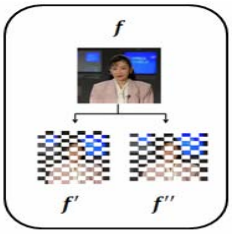
In the case of bad signals ratio, and with high error rates, in the mobile network, the quality of the transmitted video will be affected negatively and the viewer perceives a frozen frame for a certain duration followed by a more or less abrupt change in the picture content due to frame dropping [13, and 12]. It's very hard to guarantee the transmission for all the video frames over single channels, thus, multi channels are proposed by several researchers to increase connection reliability [4] and to enhance the network capacity [5].

Our proposed technique is to overcome the freezing frames in the mobile device and provides a smooth video playing over wireless network. This is done by splitting each frame into two sub-frames containing half of the picture into each. Then the two sub-frames are streamed through two wireless channels. If there is a missing sub-frame from any stream a reconstruction mechanism will take place in the mobile device at its full frame shape. Our subjective test shows that the proposed techniques could be useful to provide a satisfactory quality to the mobile viewer.

2. BACKGROUND AND RELATED WORK

Streaming technology delivers media over a network from the server to the client in real time. Streaming video is the classical technique for achieving smooth playback of video directly over the network without downloading the entire file before playing the video [7, 17, and 19]. Streaming video requires high reliability with a low bounded jitter (i.e. variation of delays) and reasonably high transmission rate [8]. Video streaming requires a steady flow of information and delivery of frames by a deadline; wireless radio networks have difficulties to provide such reliably service [20].

The availability of multiple channels for wireless communication provides an opportunity for performance improvement of video application. The term multichannel refers to wireless technology that can use more than one radio channel. The use of multiple wireless channels has been advocated as one approach for enhancing network capacity. Some wireless devices achieve this property using multi-radio systems, with each interface communicating on a different physical channel. Other devices have just a single radio transceiver, which is tune able to any of the available channels [3]. The use of multiple paths through the transport network for streaming has been proposed to help overcome the loss and delay problems that afflict streaming media and low latency communication. In addition, it has long been known that multiple paths can improve fault tolerance and link recovery for data delivery, as well as provide larger aggregate bandwidth, load balancing, and faster bulk data downloads [1]. Shenoy and Vin [15], suggested that the video server can partition



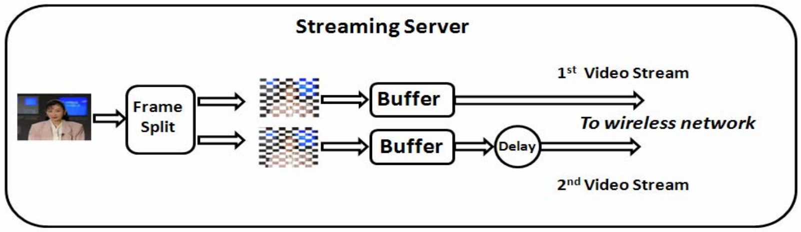
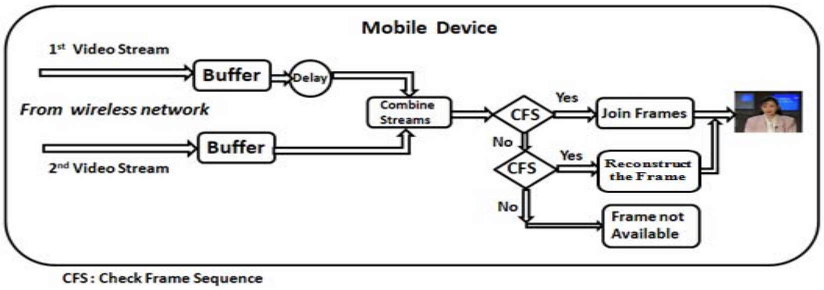


Figure 1. Frame split. **Figure 2. Streaming split sub - frames over two wireless channels.**



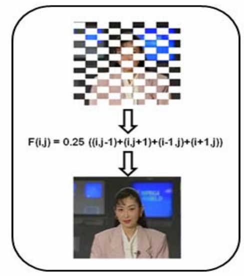


Figure 3. Receiving sub-frames streams of video in the mobile device. **Figure 4. Reconstruct frame**.

each video stream into two sub-streams (a low-resolution and a residual component stream) in order to support interactivity.

During the interactive mode, only the low-resolution stream is transmitted to the client, this can reduces the amount of data that needs to be retrieved and sent to the client's mobile. Apostolopoulos [1] uses two different paths to send even and odd frames encoded using Multiple Description Coding (MDC). He also suggests that it can be beneficial to send different amounts of traffic on different paths.

Aziz and Lundberg [2], come up with a mechanism to play the complete video frame sequence in the mobile station over error prone channels to eliminate the video freezing. This can be done by transferring the video frames in gray scale, while the second stage is to create duplicated frames that can be transmitted over two channels in the cellular network. After the two video streams have been received by the mobile client, there is a possibility that frames could be missing or corrupted in any stream, to overcome the missing frame or unreadable frame a switching between video streaming channels will take place to make sure that the video player in the mobile device will play the complete video frame sequence, but the main limitation for their work is that the video is played in gray scale and the overhead are increased to double because of the duplicate frames are transmitted over two channels.

3. THE PROPOSED TECHNIQUE

Mobile video streaming is characterized by low resolutions and low bit rates. The bit rates are limited by the capacity of UMTS radio bearer and restricted processing power of mobile terminals; the commonly used resolutions are Quarter Common Intermediate Format (QCIF, 176×144 pixels) for cell phones [14].

Mobile real time application like video streaming suffers from high loss rates over the wireless network [11], and the effect of that on the mobile users may notice some sudden stop during the playing video, the picture momentarily frozen, followed by a jump from one scene to a totally different one.

The use of multiple channels over a single channel is to overcome the problems of limited bandwidth, and to increase the channel capacity for streaming videos [5]. Multichannel has been proposed recently in mobile cellular network by many researcher like [5, and 18], where multichannel provides information to clients via multiple channels.

Our proposed technique is to avoid the freezing picture in the mobile device. The mobile user requests a connection and starts to stream the video. Each frame in the video sequence will be split into two sub-frames. The authors identify three ways for splitting the frames, the first one is based on rows wised splitting, while the second is based on columns wised splitting and the third is pixels splitting, where each sub-frame contains the odd and the even information based on the above. In this study, we will use pixel splitting frames, to creates two sub-frames out of each frame where one sub-frame contains the even pixels and the another contains the odd pixels as shown in Figure 1, and each sub-frame will be queued in different buffers and it will be ready to stream the sub-frames over two wireless channels but the second stream will be delay for 2 seconds after the first stream as in Figure 2. The reason behind that is to minimize the effects of any dropping frames or interruption to the wireless channel under different network condition to the same sub-frames. Streaming the video based on independent transmission on the two channels will be used in order to achieve such purpose, where the frame sequence $f' = \{ f'_1, f'_2, \dots, f'_{n-1} \}$ will transmitted over the first stream, while, $f'' = \{ f''_1, f''_2, \dots, f''_{n-1} \}$, will transmitted over the second stream.

The mobile station will start receiving the video stream and it will be held in the jitter buffer until the available amounts of frames have been received to start playing. This is for the normal case when there is single channel handling a single stream. According to our proposed system after the first stream has been received by the mobile device it will be hold in the buffer and it will delayed for 2 seconds until the mobile device starts receiving the second stream of video and it will be hold in the other buffer as shown in Figure 3. After both buffers received the right amount of sub-frames the combination of the both stream will take place, as

$$f = \{(f_1^u, f_1^l), (f_2^u, f_2^l), (f_3^u, f_3^l), \ldots, (f_{N-1}^u, f_{N-1}^l)\}$$

.

After the both sub-frame are combined, a checking procedure will used to check the availability of the sub–frames, as an example, the first Check Frame Sequence (CFS), will check whether the both sub- frames that are related to the same frame are available or not. If both of them are available then join mechanism will applied to return the frame to its original. In case when there is a network interruption, where the sub-frames are corrupted and will be unreadable by the decoder or the sub-frames are dropped. The second CFS will check if there is at least one sub-frame are available or not, if it's not available then we considered that the frame is dropped from the frame sequence. If there is at least on sub-frame are available, the reconstruction of the sub-frame will take place in the mobile device by taken the average of the neighboring pixel to replace the missing pixel (this is the reason why we chose pixels splitting), to get fully frame shape, as shown in Figure 4.

4. SUBJECTIVE VIEWING TEST

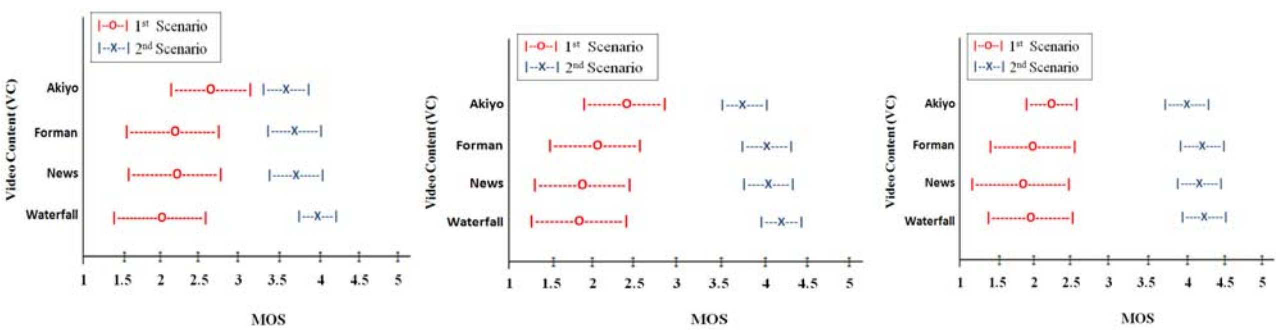
4.1 Testing Materials and Environments

The video test sequences used in this work were the samples of video sequences Akiyo, Foreman, News, and Waterfalls. The video sequences were chosen because of their deferent characteristics. Each video are coded as 25 frames/second with a resolution of 176 x 144, the transmission rate are 30 frames/second, and the number of frames are transmitted are 1800 frames. The video sequences are shown on 17 FlexScan S2201W LCD computer display monitor of type EIZO with a native resolution of 1680 x 1050 pixels. The video sequences for the original and our proposed scenario are displayed with resolution of 176 x 144 pixels in the centre of the screen with black background with duration of 60 seconds for each video sequence.

The Simulink [16], is used to simulate the proposed technique and for three different dropping rates for the same network traffic condition. Under the light traffic and the dropped rate is between 3-4%, for the medium traffic load the dropped frame rate is between 6-7%, and for the high traffic load the dropped frame rate is between 8-9%.

4.2 Testing Methods

Following the guidelines outlined in BT.500-11 recommendation of the radio communication sector of the International Telecommunication Union (ITU-R) [9], a subjective experiment has been conducted at Blekinge Institute of Technology in Sweden. Where the user observed two scenarios, the first scenario, when the observer evaluate the normal video transmission over wireless networks with the effect of three different load, and the second scenario, our proposed scenario.



a. Light dropped rate **b. Medium dropped rate** **c. High dropped rate**

MOS grade scale (1-bad, 2-poor, 3-fair, 4-good, 5-excellent)

Figure 5. The MOS for different video contents with different dropping rate.

The participated of thirty non-expert viewer in the test subjects were 26 males and 4 females. They were all university staff and students, and their ages range of 20 to 33 of age.

It is well known that peak signal-to-noise ratio (PSNR) does not always rank quality of an image or video sequence in the same way that a human being. There are many other factors considered by the human visual system and the brain [10]. The mean opinion score (MOS) measurements are used to evaluate the video quality.

Staff and students evaluated the video quality after each sequence using a five grade MOS scale (1-bad, 2-poor, 3-fair, 4-good, 5-excellent) in a prepared form.

The amount of data gathered from the subjective experiments with respect to the opinion scores that were given by the individual viewers. A concise representation of this data can be achieved by calculating conventional statistics such as the mean score and confidence interval, of the related distribution of scores [9].

5. EXPERIMENTAL TEST

The quality of video is subjected to the personal opinion; this means that the quality of service improvements for video transmission has the only goal to satisfy the average human watching the contents of the video. The MOS is obtained through human evaluation tests, where 30 of staff and students are observed the two scenarios. In figure 5, shows the comparison test for the video content (VC) and for different dropping rate percentage, where the centre and span of each horizontal bar indicate the mean score and the 95% confidence interval, respectively.

For the normal scenario it can been shown clearly that the observer manage to identify the dropping frames and the frozen picture, where the MOS is lower than 4 corresponding to the five –level quality scale ranks for the light dropping rate and lower than 3 for the medium and the high dropping rate, due to the higher percentage of the dropping frames, which the viewer easily notice the frozen picture. While for our proposed scenario, the MOS is larger than 3, corresponding to the quality scale ranks and for the three dropping rates. It can be observed that the video present to the viewers resulted in a wide range of perceptual quality ratings indeed for both experiments.

After we analysis their score we feel that our proposed scenario could be a satisfactory technique to eliminate the freezing frames when streaming videos over unreliable network.

6. CONCLUSION

Transmitting a real time video stream over a single channel cannot guarantee that all the frames could be received by the mobile devices. The characteristics of a wireless network in terms of the available bandwidth, frame delay and frame losses cannot be known in advanced. Using multiple channels instead of a single channel is to overcome the problems of limited bandwidth and fading and to increase the channel capacity for streaming videos.

In this work we proposed a frame splitting and streaming technique over two channels under different loads to estimate the effects on a video frame sequence. Our analysis is based on the human opinion and it showed that there is a significant performance improvement for video smoothness under different dropping load over wireless network as compared to traditional techniques. We conclude that our proposed technique appears to provide a promising direction for eliminating the freezing picture for real time transmission under high loss rate and low network capacity channels.

7. ACKNOWLEDGMENTS

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