Citation for the published Conference paper:

Title:
Graceful degradation of mobile video quality over wireless network

Author:
Hussein Aziz, Lars Lundberg

Conference Name:
IADIS International Conference Informatics

Conference Year:
2009

Conference Location:
Algarve, Portugal

GRACEFUL DEGRADATION OF MOBILE VIDEO QUALITY OVER WIRELESS NETWORK

Hussein Muzahim Aziz and Lars Lundberg
Department of Software Engineering and Computer Science
Blekinge Institute of Technology,
S-372 25 Ronneby, Sweden

ABSTRACT

Real-time video transmission over wireless channels has become an important topic in wireless communication because of the limited bandwidth of wireless network that should handle high amount of video frames. Video frames must arrive at the client before the playout time with enough time to display the contents of the frames. Real-time video transmission is particularly sensitive to delay as it has a strict bounded end-to-end delay constraint; video applications impose stringent requirements on communication parameters, such as frame lost and frame dropped due to excessive delay are the primary factors affecting the user-perceived quality. In this study we investigate ways of obtaining a graceful and controlled degradation of the quality, by introducing redundancy in the frame sequence and compensating this by limiting colour coding and resolution. The effect of that is to use double streaming mechanism, in this way we will obtain less freezing at the expense of limited colours and resolution. Our experiments, applied to scenarios where users can observe three types of dropping load for real time video streaming, the analytical measurements tools are used in this study to evaluate the video quality is the mean opinion score and we will demonstrate this and argue that the proposed technique improves the use perceived of the video quality.

KEYWORDS

Streaming video, duplicate frames, multichannel, dropping rate, switching stream and MOS.

1. INTRODUCTION

Mobile wireless network becomes very popular now due to the wide spread of computer laptops, mobile devices and PDAs. Mobile wireless networks are expected to support different type of services, such as video services which make a great demand on the wireless networks bandwidth. Bandwidth is one of the most critical resources in wireless networks, and thus, the available bandwidth of wireless networks should be managed in an efficient manner (Chang & Chen, 2003). The video coding standards are being developed to satisfy the requirements of applications for various purposes, excellent video/picture quality, higher coding efficiency, and error robustness (Zhang, 2005).

Song et al (Song et al, 2002) identifies the major difference between mobile wireless environments and wired one as follows: (i) the available bandwidth and (ii) the size of screen. They believe that the impact of two compression parameters may change dependent upon the maximum screen size, and the available bandwidth. Low bandwidth provided by wireless networks is often insufficient to support streaming video over a single channel; multiple channels can be used to provide a logical channel with a sufficient (or nearly sufficient) bandwidth (Xu & Hemami, 2002). Video communication over a dynamic environment, like a mobile wireless network is much more difficult than over a static channel, since the bandwidth, delay, and packet loss are not known in advance and are unbounded (Vassiliou et al, 2006). Video applications involve real-time streams of information that need to be transported in a dynamic and high-performance way. The goal of this paper is to come up with a mechanism to play the complete video frame sequence in the mobile station over error prone channels, this can be done by transferring the video frames in the server from colour to gray scale, the main idea of colure transfer is to reduce the video frames size while the second stage is to create a duplicated frames that can be transmitted over multiple channels in the cellular network. After the two video streams have been received by the mobile client, the switching mechanism between the two streams will take place whenever there is a missing frame from the video sequence. This will improve the robustness of the video transport, since a lost frame in one channel can be recovered from other channel. To the best of our knowledge, our work is the first study on playing the complete video frame sequence till if there is a frame lost at any stream.

2. BACKGROUND AND RELATED WORK

Streaming video is the classical technique for achieving real time video directly over the network without downloading the entire file before playing the video (Bai & Williamson, 2004), (Xiaozhen et al, 2005) and (Zhu et al, 2003). Streaming video requires high reliability with a low bounded jitter (i.e. variation of delays) and reasonably high transmission rate (Hsu et al, 1999). Video streaming requires a steady flow of information and delivery of frames by a deadline; wireless radio networks have difficulties to provide such reliably services (Zhu & Girod, 2007). The availability of multiple channels for wireless communication provides an excellent opportunity for performance improvement. 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 tuneable to any of the available channel (Cao & Williamson, 2006). 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 (Apostolopoulos, 2001). Zhou et al (Zhou et al, 2003), present a transmission scheme to improve MPEG-4 streaming using multipath. The MPEG stream is divided into a base and enhancement layer. The base layer is duplicated over the paths available to provide robustness for transmission of important frames. The enhancement layer content is then separated into multiple descriptions and sent over the multiple paths leading to incremental increase in the video quality with reception of more and more enhancement packets. While Apostolopoulos (Apostolopoulos, 2001) use two different paths to send even and odd frames encoded using Multiple Description Coding (MDC), he suggests that it can be beneficial to send different amounts of traffic on different paths. Most of the schemes discussed above are verified for two paths. With two paths all the above algorithms provide performance improvements over the single path but none of them manage to deliver the complete video frame sequence to the mobile station as been transmitted by the server.

3. STREAMING VIDEO OVER TWO CHANNELS

Mobile video streaming is characterized by low resolutions and low bit rates. The bit rates are limited by the capacity of UMTS (Universal Mobile Telecommunications System) 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 (Ries et al, 2007). Wireless network have a limited bandwidth which have not been able to handle the continues of the video frame sequence and also with the high possibility that the video frame could be timed out while they are waiting in the buffer, which all of what we described above could affect the video quality for the mobile viewer. Shenoy and Vin (Shenoy & Vin, 1995), suggested that the video server can partition 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. While, multichannel is been proposed recently in mobile cellular network by many researcher like (Zheng et al, 2005) and (Chereddi &Vaidya, 2006), when multichannel provides information to clients via multiple channels.

During the busy traffic, the mobile station request from the server to establish the connection to stream the video, the corresponding video streams are obtained by encoding the original uncompressed video frame from colure to gray scale; this will reduce the frame size by 34%. In the mean time a duplicated video frame will be generated by the server and will be queued in two different buffers and it will be ready to stream the video in two wireless channels but the second stream will be delayed by 2 seconds after the first stream as in Figure 1, the reason behind that is to avoid dropping the same frames from each stream, while some frames are timed out under different network load condition.

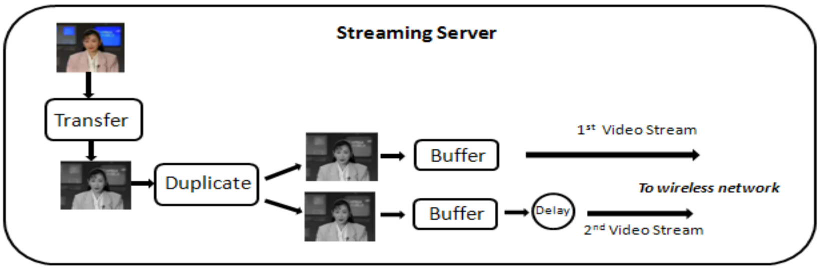


Figure 1. Streaming duplicate frames over two wireless channels.

When the mobile client establish the connection with video server, the client will start receiving the stream of video and it will be held in the jitter buffer until the available amount of frames have been received to start playing, this is for the normal case when there is one channel handling a single stream, while according to our proposed system after the first stream has been received by the mobile device it will be delayed for 2 seconds until the mobile station start receiving the second stream of video frames. After both streams received the right amount of frames to be played, the mobile's user will start viewing the video frame sequence from any healthy stream. In case, frames are dropped in one stream, the switching mechanism will be applied between the two streams at the time when the dropping occurs. Switching between streams are used to make sure that the mobile screen will display the complete video frame sequences in case there is a missing frame from any stream channel as been shown in Figure 2. If the same frame is lost in both streams, then we cannot handle this and there will be some freezing in the video.

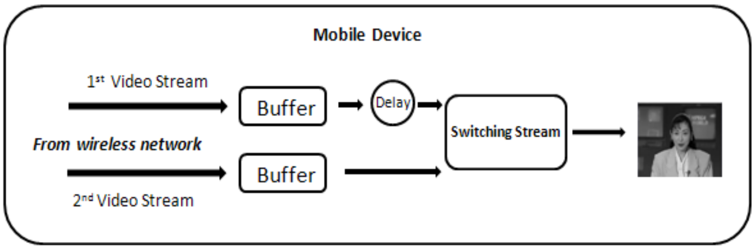


Figure 2. Receiving duplicate streams of video in the same mobile device.

The simulation environments used for this study is Simulink (www.mathworks.com). Three different dropping rates for the same network traffic have been run for the proposed work, to observe the switching mechanism. Under the light traffic where the frame dropped rate is between 3-4%. While 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%. The sequence of video frames which are received by the mobile buffer could not contains the same sequences of frames as some of them could be dropped during the transmission and also the first stream of video need to wait for 2 seconds until the next stream arrived. Two buffers have been introduced in this work to handle the arriving frame sequence in each stream, and also to hold the stream which is not been played until the switching between streams has taken place.

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 and News, the video sequences were chosen because of their deferent characteristics. the number of frames are coded for each video are 25 frames/second with a resolution of 176 x 144, while the transmission rate are 30 frames/second and the number of frames are transmitted are 1800 frames. A 17 FlexScan S2201W LCD computer display monitor of type EIZO with a native resolution of 1680 x 1050 pixels, while the video sequences for the original and our proposed scenario are displayed with resolution of 176 x 144 pixels in the center of the screen with black background with a duration of 60 seconds for each video sequence.

4.2 Testing Methods

According to the guidelines outlined in recommendation BT.500-11 of the radio communication sector of the International Telecommunication Union (ITU-R) (International Telecommunication Union, 2002), a subjective experiment was conducted for two groups of viewer's. Both experiments have been conducted at Blekinge Institute of Technology in Sweden. Two different groups observe two different scenarios, the first group, observed the first scenario where the evaluation done for normal video transmission over wireless networks with the original video colure display and for three different load effect, while the second group, observed our proposed scenario (the second scenario). Thirty non-expert test subjects, 28 males and 2 females, participated in each group. They were all university staff and students and their ages range of 20 to 41 of age. The score grades in this methods range from 0 to 100 which is mapped to the quality ratings were made on the 5-grade discrete category scale labeled with Excellent, Good, Fair, Poor and Bad. We conducted a physical experiment in a Lab, with controlled lighting and set-up conforming to the ITU-R recommendation. The amount of data gathered from the two subjective experiments groups 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. The statistical analysis of the data from the subjective experiments reflects the fact that perceived quality is a subjective measure and hence may be described statistically. The mean opinion score (MOS), obtained as the arithmetic mean of the scores, is used as the degradation assessment result as (1)

$$\mu = \frac{1}{N}\sum_{i=0}^{N} u_i \qquad (1)$$

Where u_i denotes the opinion score given by i^{th} viewer and N is the number of viewers. The confidence interval associated with the MOS of each examined video is given by

$$[\mu - \delta, \mu + \delta] \qquad (2)$$

Its note that the deviation term δ in (2) can be derived from the standard deviation σ and the number N of viewers and given for 95% confidence interval according to ITU-R recommendation

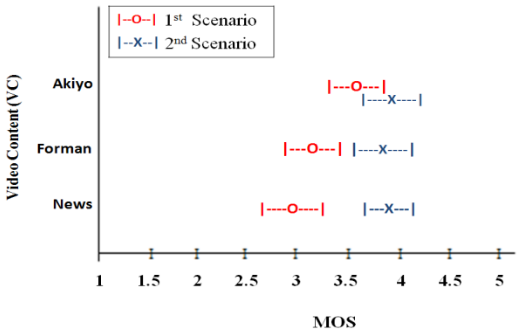
$$\delta = 1.96\frac{\sigma}{\sqrt{N}} \qquad (3)$$

Where the standard deviation σ , is define as square root of the variance

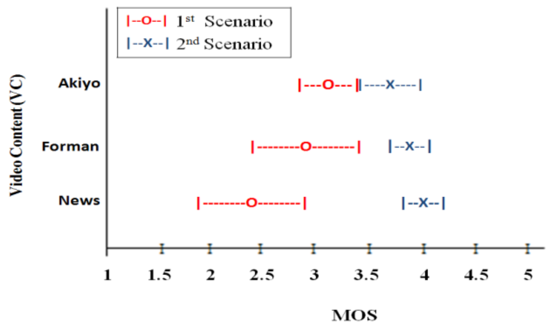
$$\sigma^2 = \sum_{i=1}^{N}\frac{(\mu - u_i)^2}{N-1} \qquad (4)$$

4.3 Testing Results and Discussions

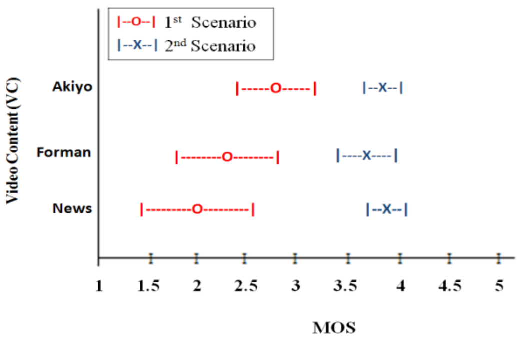
It is well known that peak signal-to-noise ratio (PSNR) does not always rank quality of an image or video sequence in the same way that a human being. There are many other factors considered by the human visual system and the brain (Martinez-Rach et al, 2007). The mean opinion score (MOS) measurements are used to evaluate the video quality. Quality of video is subject of 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 usually obtained through human evaluation tests; two groups of 30 students/lecturers are conduct for these measurements. Figure 3, shows the comparison test for video content (VC) and for different dropping rate percentage, where the center and span of each horizontal bar indicate the mean score and the 95% confidence interval, respectively.



a. Light dropped rate



b. Medium dropped rate



c. High dropped rate

Figure 3. The MOS for different video contents via different dropping rate.

For the first scenario with different dropping rate, its shows that, the MOS lower than 4 corresponding to the ‘bad’, ’poor’, ’fair’, and ‘good’ ranks of the five-level quality scale whereas for the second scenario with different load, the MOS larger than 3, corresponding to the ‘good’ and ‘excellent’ ranks. It can be observed that the material 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 propose scenario (2nd scenario) could be a perfect technique to make sure that the all video frame sequence played smoothly and without any freezing during the transmission.

5. CONCLUSION

Real-time video streaming is particularly sensitive to delay, frame loss and frames dropped due to excessive delay are the primary factors that have a negative effect on the received video quality over wireless network. Every video frame must arrive at the client before its playout time, with enough time to decode and display the contents of the frame. If the video frame does not arrive on time, the playout process will pause and the frame is effectively lost. Our proposed technique is to run the complete frame sequence in the mobile device, this can been done by streaming the same gray video two times and transmitted over two wireless channels and can be received by two buffers in the same mobile device. A switching mechanism is highly needed for video transmission over multichannel in the mobile device and for two reasons: (1) to prevent video frames from missing deadline, (2) dropping or corrupted frames in the transmission channels, this can be done by switching between video streaming channels and it will provide the right sequence of the frame to be played in the mobile devices. Through the simulation study with human opinion it showed that there is a significant performance improvement for video quality under different drooping load over wireless network, we conclude that our proposed technique is useful to provide a smooth video to the mobile viewer. This particularly true for mobile network with poor capacity and high dropping rates.

ACKNOWLEDGMENTS

We would like to thanks the staff and students of the School of Engineering at the Blekinge Institute of Technology, Ronneby, Sweden for participating in the subjective experiments.

REFERENCES

Apostolopoulos J. G., 2001. Reliable Video Communication over Lose Packet Networks using Multiple State Encoding and Path Diversity," *Visual Communication and Image Processning Conference*, pp. 392-409.

Bai G. and Williamson C., 2004. The Effects of Mobility on Wireless Media Streaming Performance. *Proceedings of Wireless Networks and Emerging Technologies (WNET),* Banff, AB, Canada, pp. 596-601.

Cao J. and Williamson C., 2006. Towards Stadium-Scale Wireless Media Streaming. *Proceedings of IEEE/ACM MASCOTS*, Monterey, California, pp. 33-42.

Chang J-Y and Chen H-L, 2003. Dynamic-Grouping Bandwidth Reservation Scheme for Multimedia Wireless Networks. *IEEE Journal on Selected area in Communications,* Vol. 21 No. 1, pp. 1566 – 1574.

Chereddi C. P. K. & Vaidya N. H., 2006. Design and Implementation of a Multi-Channel Multi-Interface Network. *The 2nd International Workshop on Multi-hop Ad Hoc Networks: From Theory to Reality*, Florence, Italy, pp. 23 – 30.

Hsu C.Y. et al, 1999. Rate Control for Robust Video Transmission over Burst-Error Wireless Channels. *IEEE Journal on Selected Areas in Communications*, Vol. 17, No. 5, pp 756 - 773.

International Telecommunication Union, 2002. Methodology for the subjective assessment of the quality of television pictures," ITU-R, Rec. BT.500-11.

Martinez-Rach M. et al, 2007. Quality Assessment Metrics vs. PSNR under Packet Loss Scenarios in MANET Wireless Networks. *International Workshop on Mobile Video (MV 2007),* Augsburg, Germany.

Ries M. et al, 2007. Performance Evaluation of Mobile Video Quality Estimators. *15th European Signal Processing Conference*, Poznan, Poland, pp. 159-163.

Song et al, 2002. Empirical Study of User Perception Behavior for Mobile Streaming. *International Multimedia Conference, Multimedia'02*, Juan-les-Pins, France, pp. 327 – 330.

Shenoy P. J. and Vin H. M., 1995. Efficient Support for Scan Operations in Video Servers. *ACM Multimedia Conference*, San Francisco, CA, pp. 131-140.

Vassiliou V. et al, 2006.Requirements for The Transmission of Streaming Video in Mobile Wireless Networks. *International Conference on Artificial Neural Networks (ICANN2006),* Athens, Greece, pp. 528-537.

Xiaozhen (Jean) C. et al, 2005. Media Streaming Performance in a Portable Wireless Classroom Network. *Proceedings of IASTED European Workshop on Internet Multimedia Systems and Applications (EuroIMSA),* Grindelwald, Switzerland, pp. 246-252.

Xu W. and Hemami S. S., 2002. Spectrally Efficient Partitioning of MPEG Video Streams for Robust Transmission over Multiple Channels. *IEEE Proc. of International Conference on Image Processing*, Rochester, NY,USA.

Zhang Y., 2005. Advanced Video Coding: MPEG-4/H.264 and Beyond.*CMPT 880 - SPECIAL TOPICS: MULTIMEDIA NETWORKING,* 2005. http://www.cs.sfu.ca/~johnnyz/personal/cmpt880-2/ johnnyz _880_ final.pdf

Zheng B. et al, 2005. TOSA: A Near-Optimal Scheduling Algorithm for Multi-Channel Data Broadcast. *The 6th International Conference on Mobile Data Management*, New York, USA, pp. 29 – 37.

Zhou J. et al, 2003. Multi-path Transport of FGS Video.*13th International Workshop on Packet Video*, Nantes, France.

Zhu H. et al, 2003. Bandwidth Scalable Source-Channel Coding For Streaming Video over Wireless Access Networks. *WNCG Wireless Networking Symposium*, Austin, USA.

Zhu X. and Girod B., 2007. Video Streaming Over Wireless Networks. *Proc. European Signal Processing Conference, (EUSIPCO-07)*, Poznan, Poland, pp. 1462-1466.