PSNR Analysis for MDC Based Video Streaming Over Peer-To-Peer Networks

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Abstract- Video streaming applications have newly attracted a large number of participants in a distribution network. Traditional client-server based video streaming solutions sustain precious bandwidth provision rate on the server. Recently, several P2P streaming systems have been organized to provide on-demand and live video streaming services on the wired and wireless network at reduced server cost. Peer-to-Peer (P2P) computing is a new pattern to construct disseminated network applications. Typical error control techniques are not very well matched and on the other hand, error prone channels have decreased the handling of video data greatly for video transmission over wireless networks and wired networks based on IP protocol. These two facts united together provide the essential motivation for the development of a new technique that is capable of dealing with transmission errors in video systems. This paper estimate and analyze the presence of noise in a video sent to a peer over a P2P network using flexible multiple description coding method which improves the frame loss possibilities over independent paths and ensures guaranteed reception of video file even if any of the subsequent frames are lost during the transmission. It introduces concealment technique for the lost frames of transmitted video at the receiver end more effectively. Experimental results show that, the approach attains reasonable quality of video performance over P2P network.

Index Terms- Video Streaming, Bandwidth, P2P Network, Multiple Description Coding.

I. Introduction

A peer-to-peer (P2P) network is a man made infrastructure which links computers in a small office with copper wires. This network is also grander scale network, in which special protocols and applications set up direct relationships among users over the Internet[1]. The initial use of P2P networks in business followed the deployment in the early 1980s of free-standing computers. In its simplest form, a P2P network is created when two or more computers are connected and share resources without going through a separate server computer. A P2P network can be an ad hoc connection—a couple of computers connected via a universal serial bus to transfer files. Although video compression and streaming have experienced phenomenal growth since the introduction of first video compression methods and commercial streaming products, there still remain many challenges to be addressed to achieve resilient and efficient video delivery over unreliably varying environments like the Internet and wireless channels. The difficulty in the multimedia system is from the fact that both channel characteristics and video content vary in time which requires adaptation of encoding and streaming techniques to network and video content. Recently, many adaptive solutions have attracted attention of several researchers. Content-adaptive mode selection in video encoders and motion adaptive update step of the motion compensated temporal filtering[2,3] are examples of recently proposed content adaptive solution approaches.

Channel adaptive streaming has already flourished as an area in itself with many recently popular research topics like optimal forward error correction (FEC) assignment in lossy environments[4], rate-distortion optimal channel adapted video streaming[5], optimal redundancy setting in multiple descriptions coding[6], optimal mode switching in lossy networks[7] etc. Some robust and scalable video coding techniques such as Multiple Description Coding (MDC) or Scalable Video Coding (SVC)[8] can be applied in media streaming, these techniques are well suited for situations where the quality and availability of connections vary over time. Using MDC or SVC in a P2P streaming scenario, the demanding host can choose the best hosts/servers candidate to make the transfer, and ask for different descriptors or layers in each case. As all information is travelling by using different routes, if one of the descriptions or layers suffers packet loss or delay, the receiver is still able to decode the video. The technique is MDC because it allows real-time software coding of the media that will be spread all along the P2P network. Currently, real-time coding using SVC technique is still a challenge due to the high computational requirements (to date, there is no SVC real-time software encoder, just there are few real-time hardware encoders below HD resolution).

II. Relate Work

Conventional video compression standards employ a similar design which referred as single-condition systems, since they have a single state (e.g. the previous coded frame) which if lost or damaged and, can lead to the deficit or severe ruin of all consequent frames until the state is reinitialized (the prediction is refreshed). Multiple Description Coding (MDC) [8,9] is an approach proposed to address overcome the traffic loss over transmission channels. It is a source coding technique that generates multiple, equally important bitstreams, called descriptions, for a single video file. Different levels of reconstructed video qualities can be achieved by successfully decoding different subsets of descriptions. The advantage of doing this is that descriptions can be streamed to a receiver using disjoint streaming paths, which can potentially increase the resilience to packet loss. Unlike scalable coding, there is no interdependency among MDC descriptions, and every description can be separately decoded, successfully decoding more descriptions results in better video quality. This flexible multiple description coding method improves the frame loss possibilities over independent paths and ensures guaranteed reception of video file even if any of the subsequent frames are lost during the transmission. This feature makes MDC appealing for use in the design of a concurrent video streaming.

MDC is particularly beneficial for delay-sensitive, real-time applications such as streaming video, in which packet losses may significantly corrupt the quality. Conventional approaches to combat channel errors such as Automatic Retransmission reQuest (ARQ) and Forward Error Correction (FEC) require retransmission of the lost packets or to addition of redundant bits for the purpose of error detection and correction. However, ARQ-based approaches are not applicable in applications when a back-channel is not available or when the retransmission delay is not acceptable. For FEC-based approaches, because of the highly varying network conditions, it is difficult to adaptively adjust the amount of redundancy, which makes the FEC either inefficient or ineffective.

A simple and practical MDC scheme known as Multiple Description Scalar Quantizer(MDSQ) was proposed by Vaishampayan et al. [10]. In this scheme, two sub-streams are generated by producing two indices for each quantization level. The index assignment is designed to be equivalent to a fine quantizer when both indices are received, but a coarse quantizer when only one index is received. One simple implementation can be created by using two quantizer whose decision regions are offset by half a quantization step size. Another MDC scheme available is Multiple Description Transform Coding (MDTC) [11]. In this ideal source coding, the coefficients used to represent the signal are uncorrelated as possible to maximize the coding efficiency. However, under this paradigm it is very difficult to estimate the value of a lost coefficient from those that remain. To achieve robustness against coefficient losses, the transform coefficients can be divided into multiple groups where the correlations within each group are minimized while inter-group correlations are tolerated.

The Recursive Optimal per-Pixel Estimate (ROPE) [12] algorithm allows the encoder to estimate the pixel-by-pixel predictable distortion of the decoded video appropriate to channel failure. This algorithm needs an input regarding approximation of the packet deficit rate and the information on error concealment method employed in the decoder. An extended ROPE algorithm accurately estimates the rate distortion due to various loss patterns and applies it for optimal mode selection using rate-distortion optimization. The rate distortion selection scheme causes a slight performance degradation while providing advantages of finer priorities over network transmission and lower complexity. Finally, it exhibits high computational costs and long encoding time.

A Slepian-Wolf based inter frame transcoding (SWIFT) scheme [13] transcodes an inter-coded P-blocks to a new type of block called X-block for the purpose of error robustness. The X-block can be losslessly transcoded back to the exact original P-block when there is no transmission error, and can also be decoded robustly like an I-block when there are errors in the predicted block. The compression of the proposed X-block is based on Slepian Wolf coding (SWC) which can achieve partially intra-like robustness with inter-like bit rate. SWIFT method improves the error resilience capability of off-line compressed video. At the decoder, the transcoded video can be converted back to the original compressed video in error free case and can also be robustly decoded when error occurs.

2.1 Multiple Description coding over Peer-to-Peer Networks

Multiple description coding has been introduced as a generalization of source coding subject to a fidelity criterion for communication systems that use diversity to overcome channel impairments. MDC is an interesting tool for robust communication over lossy networks such as the Internet, peer-to-peer, diversity wireless networks and sensor networks..MDC with side information at the receiver is particularly relevant for robust transmission in sensor networks where correlated data is being transmitted to a common receiver, as well as for robust video compression where the encoder's low complexity is a requirement. Marisa Quaresma et. Al[9]. has given the idea that in video streaming, the idea of MDC is to split a single stream several descriptions (bit-streams) and transmit them over several channels to the target. Each description contains a part of the original stream. To restore the original picture all descriptions are needed. The advantage here is, in order to see the video stream one description is sufficient. If one description is lost the video stream still can be played but with lesser quality. MDC is especially helpful in case of unreliable transport channels and the growing interest in voice, image and video communications over the Internet. For example, the loss of one packet can lead to the loss of a large number of source samples and hence in an interruption of the stream. But with MDC there won't be any interruption, only variations in the stream quality. One way to enhance the reliability of a communication system is by using Multiple Description Coding (MDC). With MDC, several coded bit-streams (referred to as descriptions) of the same signal are generated. The coder is designed so that a better signal reproduction can be achieved with more descriptions, but the quality of the decoded signal is acceptable even with only one description. Obviously, for the reconstruction quality from any one of the descriptions to be acceptable, each description must carry sufficient information about the original signal. This requires that a certain degree of correlation be embedded between the multiple descriptions, which will reduce the coding efficiency compared to conventional single description coding (SDC). [14]

III. Proposed Solution

The formal definition of real-time for video service is that the processing time is less than the time to get a sample. In most cases, the word real-time video means decoding the video in real-time. In order to play the media file, after downloading it completely, and saved to the local, it can be played out. On the contrary, streaming video will be played out only after a buffering time which will cause only small delay and at the same time, the successive part of the stream file is kept on downloading. If the video file is split into multiple packets and have no redundancy at all and if one packet is lost, important information will be lost, this will decrease the quality of the received video file. So, in order to solve these problems, many effective solutions have attracted, out of which the Multiple Description Coding[8] algorithms belongs to such group.

IV. SOLUTION STRATEGY

In this paper it has been shown that how to use multiple description coding together with P2P networks, which will improve the quality of the received video file, since the multiple packets are distributed for more than one source. Therefore, if one of the sources goes down the entire video file will not be lost. This paper defines a solution to the problems of streaming the video content over the peer-to-peer network using the robust multiple description coding algorithm. The Figure 4 shows the simple block diagram of multiple description coding algorithms, with streaming on Real-Time Transport Protocol (RTP) connections, for peer to peer video streaming system.

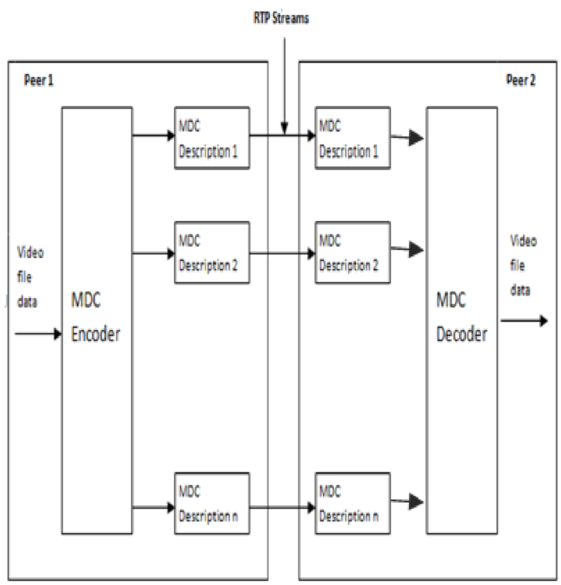

Figure 4. General structure of MDC over RTP Stream

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To achieve this, the encoding technique used is multiple descriptions coding, which allows the video to be split into multiple descriptions with redundant information. If one of the descriptions is lost along the network the other will still be received, which will allow the receiver not to lose the entire information of the lost /description, since the received description has information that concerns to the lost description. In this way, the video quality shall not be dramatically decreased.

V. EXPERIMENTAL RESULTS

The Figure 5a) shows the original video file used by local peer on which MDC is applied. After applying MDC, local peer will share the video file, the Figure 5b) shows the video file received by the remote peer. By implementing MDC method, instead of losing the whole video file, remote peer will get video file with less quality. Here the video quality will be reduced because, while transmitting the video file from local peer to remote peer some packets (frames) will be lost. Hence by using MDC method we can avoid reconstruction of video file.

Figure : 5a) Original video.

5b) Received video

Peak Signal to Noise Ratio (PSNR)

The term peak signal-to-noise ratio (PSNR) is an expression for the ratio between the maximum possible value (power) of a signal and the power of distorting noise that affects the quality of its representation. Because many signals have a very wide dynamic range, (ratio between the largest and smallest possible values of a changeable quantity) the PSNR is usually expressed in terms of the logarithmic decibel scale. Image enhancement or improving the visual quality of a digital image can be subjective. The statement that one method provides a better quality image could vary from person to person. For this reason, it is necessary to establish quantitative/empirical measures to compare the effects of image enhancement algorithms on image quality. Using the same set of tests images, different image enhancement algorithms can be compared systematically to identify whether a particular algorithm produces better results. The metric under investigation is the PSNR. If one can show that an algorithm or set of algorithms can enhance a degraded known image to more accurately resemble the original, then the algorithm is better.

For the following implementation, an assumption is made regarding a standard 2D array of data or matrix. The dimensions of the original image matrix and the dimensions of the degraded image matrix must be identical. The mathematical representation of the *PSNR* is as follows:

$$PSNR = 20\log_{10}\left(\frac{MAX_f}{\sqrt{MSE}}\right) \quad \ldots\ldots \textbf{(1)}$$

where the *MSE* (*Mean Squared Error*) is:

$$MSE = \frac{1}{mn}\sum_{0}^{m-1}\sum_{0}^{n-1}\|f(i,j) - g(i,j)\|^2 \quad \ldots\ldots\textbf{(2)}$$

This can also be represented in a text based format as:
*MSE = (1/(m*n))*sum(sum((f-g).^2))*

*PSNR = 20*log(max(max(f)))/((MSE)^0.5)*

where, :
f **:** Represents the matrix data of our original image
g **:** Represents the matrix data of our degraded image in question.
m **:** Represents the numbers of rows of pixels of the images and i represents the index of that row.
n **:** Represents the number of columns of pixels of the image and j represents the index of that column.
MAX_f **:** Is the maximum signal value that exists in the original "known to be good" image.

In case of videos, PSNR can be computed for *I* frames of original and watermarked video

Table 6.1 PSNR values (in dB) of test images.

# of frames	PSNR	**# of frames**	PSNR
1	18.46	**16**	17.89
2	18.32	**17**	17.89
3	18.20	**18**	17.90
4	18.19	**19**	17.90
5	18.15	**20**	17.97
6	18.14	**21**	17.97
7	18.08	**22**	18.00
8	18.07	**23**	18.00
9	18.01	**24**	18.05
10	18.01	**25**	18.07
11	17.92	**26**	18.05
12	17.92	**27**	18.04
13	17.90	**28**	18.05
14	17.88	**29**	18.05
15	17.88	**30**	18.04

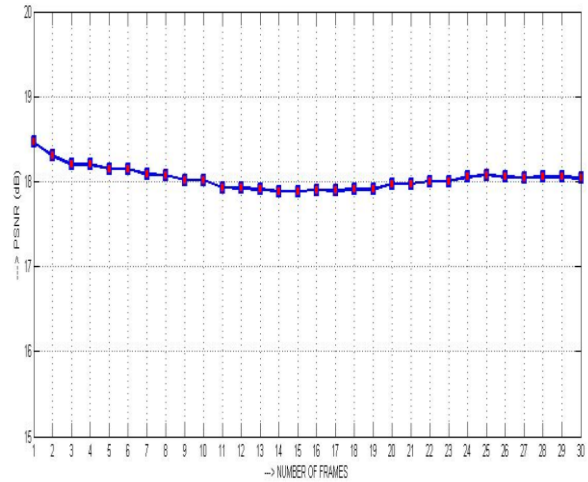

Figure 6.1: PSNR performances in terms of number of frames.

The Figure 6.1 shows the graph for Peak Signal Noise Ratio (PSNR) performance in terms of number of frames received by remote peer. Due to this PSNR remote peer will get low quality video. The table 6.1 shows the collected data of PSNR for number of frames. These data are used to draw the graph as shown in above Figure.

VI. Conclusion

This paper proposed the analysis of MDC in which estimation of the noise in a video sent to a peer over a P2P network using flexible multiple description coding method which improves the frame loss possibilities over independent paths and ensures guaranteed reception of video file even if any of the subsequent frames are lost during the transmission. A promising approach for error concealment in video streaming over error prone networks. MDC approach proposed to address overcome the traffic loss over transmission channels. This source coding technique different levels of reconstructed video qualities can be achieved by successfully decoding different subsets of descriptions. The advantage of doing this is that descriptions can be streamed to a receiver using disjoint streaming paths, which can potentially increase the resilience to packet loss. Unlike scalable coding, there is no interdependency among MDC descriptions, and every description can be separately decoded, successfully decoding more descriptions results in better video quality. This feature makes MDC appealing for use in the design of a concurrent video streaming At the receiver end, this approach can recover the damaged images itself without adding the extra information. Experimental results show that the proposed method efficiently recovers the detailed content and the PSNR quality is improved about 2. 5 dB with respect to the conventional spatial concealment algorithms. When the image error ratio goes more than 50%, then the image is mostly corrupt and our approach conceals to some extent with acceptable viewing quality. Presently FST approach checks and conceals a single frame at a time, when multi-frames are lost, modification has to be done in FST approach which is an ongoing work.

REFERENCES

[1] Ion Stoica, Robert Morris, David Liben-Nowell, David R. Karger, M. Frans Kaashoek, Frank Dabek, And Hari Balakrishnan," Chord: A Scalable Peer-To-Peer Lookup Protocol For Internet Applications"- Ieee/Acm Transactions On Networking, Vol. 11, No. 1, February 2003

[2] Content Adaptive Wyner-Ziv Video Coding Driven By Motion Activity1 joao.ascenso@lx.it.pt, 2catarina.brites@lx.it.pt,

[3] Motion-Compensated Temporal Filtering Within The H.264/Avc Standard Emrah Akyvol', A.Murat Tekulp'.', MRehu Civanlur' ' College of Engineering, Koc University, Istanbul, Turkey 2 Department of Electrical and Computer Engineering, University of Rochester, Rochester, NY 14627

[4] Fp@Lx.It.Pt 1 Instituto Superior De Engenharia De Lisboa – Instituto De Telecomunicações 2,3 Instituto Superior Técnico – Instituto De Telecomunicações 3. Forward Error Correction For Multipath Media Streaming Dan Jurca, Member, Ieee, Pascal Frossard, Senior Member, Ieee, And Aleksandar Jovanovic-- Ieee Transactions On Circuits And Systems For Video Technology, Vol. 19, No. 9, September 2009

[5] Rate-Distortion Optimized Hybrid Error Control For Real-Time Packetized Video Transmission Fan Zhai, Member, Ieee, Yiftach Eisenberg, Member, Ieee, Thrasyvoulos N. Pappas, Senior Member, Ieee, Randall Berry, Member, Ieee, And Aggelos K. Katsaggelos, Fellow, Ieee--- 40 Ieee Transactions On Image Processing, Vol. 15, No. 1, January 2006

[6] An optimal code expansion for multiple description quantization Sanjeev mahrotra Philip A.chou

[7] Robust Peer-to-Peer Video Streaming Based on Multiple Description Coding Marisa Quaresma, Ângelo M. Arrifano, Manuela Pereira, Mário M. Freire, and Marc Antonini

[8] Media Streaming using Multiple Description Coding in Overlay Networks

Yadav Sachin, Yadav Ranjeeta,Mishra Shailendra,

International Journal of Computer Science and Information Security 01/2010;

[9] Marisa Quaresma, Angelo M. Arrifano, Manuela Pereira, Mario M. Freire, and Marc Antonini, "Robust Peer-to-Peer video streaming based on Multiple Description Coding", TRAMANET Project contract PTDC/EIA/73072/2006, 2009

[10] V. A. Vaishampayan, (1993) "Design of multiple description scalar quantizers," IEEE Trans. Inform. Theory, vol. 39, no. 3, pp. 821–834

[11] Y. Wang, M. T. Orchard, V. A. Vaishampayan, and A. R. Reibman, (2001) "Multiple description coding using pair-wise correlating transforms," IEEE Trans. Image Processing, vol.10, no. 3, pp. 351–366.

[12] Yiting Liao, Gibson, J.D , (2009) "Enhanced error resilience of video communications for burst losses using an extended ROPE algorithm", IEEE International Conference on Acoustics, Speech and Signal Processing, pp.1853-1856.

[13] Xiaopeng Fan, Au, O.C., Mengyao Ma, Ling Hou, Jiantao Zhou,Ngai Man Cheung, (2009) "On improving the robustness of compressed video by Slepian-Wolf based lossless transcoding", Proceeding of IEEE International Symposium on Circuits and Systems,doi: 0.1109/ISCAS.2009.5117898, pp: 884 - 887.

[14] Comparison Between Multiple Description And Single Description Video Coding With Forward Error Correction

Bernardini, R. ; Durigon, M. ; Rinaldo, R. ; Vitali, A. Multimedia Signal Processing, 2005 IEEE 7th Workshop on Digital Object Identifier: 10.1109/MMSP.2005.248546
Publication Year: 2005.

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