The Appropriate FEC Parity Amount to Guarantee High Quality for Video Streaming

Mahmoud Ali Al-Shugran

UNIVERSITI UTARA MALAYSIA
2009

The Appropriate FEC Parity Amount To Guarantee High Quality for Video Streaming

This thesis is presented to the Graduate School
In fulfillment of the requirements for
Master of Science (Information and Communication Technology)
Universiti Utara Malaysia

By

Mahmoud Ali Al-Shugran
(801359)

KOLEJ SASTERA DAN SAINS
(College of Arts and Sciences)
Universiti Utara Malaysia

PERAKUAN KERJA KERTAS PROJEK
(Certificate of Project Paper)

Saya, yang bertandatangan, memperakukan bahawa
(I, the undersigned, certify that)

MAHMOUD ALI IBRAHIM AL-SHUGRAN
(801359)

calon untuk Ijazah
(candidate for the degree of) **MSc. (Information Communication Technology)**

telah mengemukakan kertas projek yang bertajuk
(has presented his/ her project paper of the following title)

THE APPRORIATE FEC PARITY AMOUNT TO GUARANTEE HIGH QUALITY FOR VIDEO STREAMING

seperti yang tercatat di muka surat tajuk dan kulit kertas projek
(as it appears on the title page and front cover of project paper)

bahawa kertas projek tersebut boleh diterima dari segi bentuk serta kandungan dan meliputi bidang ilmu dengan memuaskan.
(that the project paper acceptable in form and content, and that a satisfactory knowledge of the field is covered by the project paper).

Nama Penyelia Utama
(Name of Main Supervisor): **ASSOC. PROF. DR. SUHAIDI HASSAN**

Tandatangan
(Signature) :

Tarikh
(Date) : 10/5/2009

PERMISSION TO USE

In presenting this thesis in partial fulfillment of the requirements for a postgraduate degree from University Utara Malaysia, I agree that the University Library may make it freely available for inspection. I further agree that permission for copying of this thesis in any manner, in whole or in part, for scholarly purpose may be granted by my supervisor(s) or, in their absence by the Dean of the Graduate School. It is understood that any copying or publication or use of this thesis or parts thereof for financial gain shall not be allowed without my written permission. It is also understood that due recognition shall be given to me and to University Utara Malaysia for any scholarly use which may be made of any material from my thesis.

Requests for permission to copy or to make other use of materials in this thesis, in whole or in part should be addressed to:

Dean of Graduate School

University Utara Malaysia

06010 UUM Sintok
Kedah Darulaman

ABSTRACT

Efficiency and capability of forward error correction (FEC) mechanism to recover from losses, is the main idea behind its utilization in Real-time applications like video streaming over Internet. The number of Internet users continue to increase every day, thus network traffic will increase. Such increasing in network traffic will cause network congestion to increase, increasing in network congestion make data loss obvious problem that affect streaming video presentation quality.

The efficiency of FEC mechanism come from the reduction of the time needed to recover lost packets, and there is no need for an additional channel for retransmission. The goal of FEC is to add redundancy that can be used to recover from packet loss in multimedia application, this big task for FEC comes with main condition; to achieve acceptable and the desired quality of presentation, FEC has to be introduced with minimum overhead for real-time application.

However, depending on the fact that packet loss is often unknown and time varying. So, the amount of extra data that will be sent with the original data in the FEC block is predetermined comparing to the loss, hence loss recovery rate depends on the amount of redundancy data. For this reason FEC may take three characteristics depending on the amount of redundant data, *effective* (if the redundant is sufficient to the lost data), *ineffective* (if the redundant is too little to the lost data), or *inefficient* (if the redundant is too much to the lost data).

Our research will concentrate on this problem to propose a suitable solution, by matching the appropriate redundancy that can achieve effectiveness, through sending the proposed FEC parity amount aside with the original data of video application. Proposed results will guarantee minimum packet loss and packet loss ratio in streaming application for video.

Furthermore, through this study we will verify the affect of variance amount of redundancy data on the loss recovery rate, to find the appropriate parity amount, which can be effective in the presence of data loss. During that, Simulation results will demonstrate our progress for this project step by step to insure the works. Through extensive simulation, we will evaluate the scalability of the chosen redundancy data amount to improve aggregate FEC performance through video transmission.

ACKNOWLEDGMENTS

I would like to state my sincere appreciation to the following people, who have given me support and encouragement during this research:

My beloved father and beloved mother for all the guidance and support from them.

Furthermore, my special thanks to my supervisor Assoc. Prof. Dr. Suhaidi Hassan for all the advice, encouragement and supervision.

My appreciation to all the ns-2 users who have shared all the knowledge and opinions, last but not the least, to all my friends who supported me.

CONTENTS

CHAPTER 1

INTRODUCTION

CHAPTER 2

LITERATURE REVIEW

CHAPTER 3

RESEARCH METHODOLOGY

CHAPTER 4

SIMULATION PHASE AND PROCESS

CHAPTER 5

RESULT ANALYSIS AND PRESENTATION

CHAPTER 6

CONCLUSIONS AND RECOMMENDED FURTHER STUDY

List of Figures

List of Tables

List of Abbreviation

ARQ	Automatic Repeat Request
AWK	A Graphical Simulation Display Tool
C++	Object Oriented Programming Language
CBR	Constant Bit Rate
DT	Drop Tail Management
ECC	Error-Correcting Code
FEC	Forward Error Correction
ECN	Explicit Congestion Notification
FTP	File Transfer Protocol
IP	Internet Protocol
Ns-2	Network Simulator 2
OTcL	Object-oriented Tool Command Language
PLR	Packet Loss Ratio
QoS	Quality of Service
RNG	Random Number Generator
RTP	Real-time Transport Protocol
RTT	Round Trip Time
RS	Reed-Solomon
TCP	Transmission Control Protocol
TCP/IP	Transmission Control Protocol over Internet Protocol
UDP	User Datagram Protocol
UDP/IP	User Datagram Protocol over Internet Protocol

Chapter 1

Introduction

1.1 Introduction

This chapter provides an overview of the entire study. It contains a general overview for each section through this report structure. In section 1.2 we present the background of this study, in section 1.3 the problem statement, then in section 1.4 the research goals, followed by the objectives in section 1.5, which directly goes through the research questions in section 1.6, the significance and scope of the study in section 1.7 and 1.8 sequentially and the structure of the report in section 1.9, and finally in section 1.10 we end this chapter with a small summary.

1.2 Background

Recently new types of distributed applications have appeared, called distributed applications [1], because they run on different end systems. These distributed applications have a major deference for the old applications, which is the need for new types of *service requirements* that the older applications do not need. For these distributed applications the services that were provided by the network infrastructures like Internet, differ according to the kind of application, where the *service requirements* provided to elastic applications like e-mail are different from those *service requirements* provided to multimedia applications like streaming video as a real-time application.

The reason behind this difference [2], that elastic applications like e-mail can manage the delay of data arrival, and the variance in delay time, but at the same time

The contents of the thesis is for internal user only

References

[1] J. F. Kurose and K. W. Ross, "Computer Networking," A Top-Down pproach, fourth edition, 2007, pp. 615-702.

[2] R. Steinmetz and K. Nahrstedt, "Multimedia Application and Security," Springer Verlag, 2004, pp. 3-15.

[3] S. Tao, J. Apostolopoulos, and R. Guerin, "Real-time monitoring of video quality in IP networks," IEEE/ACM Transactions on Networking, vol. 16, pp. 1052-1065, 2008.

[4] C. Perkins, O. Hodson, and V. Hardman, "A survey of packet loss recovery techniques for streaming audio," IEEE network, vol. 12, pp. 40-48, 1998.

[5] F. Fitzek, A. Kopsel, A. Wolisz, M. Krishnam, and M. Reisslein, "Providing application-level QoS in 3G/4G wireless systems: a comprehensive framework based on multirate CDMA," IEEE Wireless Communications, vol. 9, pp. 42-47, 2002.

[6] R. Puri, K. Lee, K. Ramchandran, and V. Bharghavan, "Application of FEC-based Multiple Description Coding for Internet Video Streaming and Multicast," presented at Proc. Packet Video Workshop, 2000.

[7] K. Kawahara, K. Kumazoe, T. Takine, and Y. Oie, "Forward error correction in ATM networks: an analysis of cell lossdistribution in a block," presented at INFOCOM'94. Networking for Global Communications., 13th Proceedings IEEE, 1994.

[8] S. Kang and D. Loguinov, "Impact of FEC overhead on scalable video streaming," presented at Proceedings of the international workshop on Network and operating systems support for digital audio and video, 2005.

[9] S. Yuk, M. Kang, D. Kim, B. Shin, and D. Cho, "Adaptive redundancy control for systematic erasure code based realtime data transmission in Internet," presented at 2000 IEEE International Conference on Communications, 2000. ICC 2000, 2000.

[10] S. Chin and R. Braun, "Improving video quality using packet interleaving, randomisationand redundancy," presented at Local Computer Networks, 2001. Proceedings. LCN 2001. 26th Annual IEEE Conference on, 2001.

[11] T. Stock and X. Garcia, "On the potentials of forward error correction mechanisms applied to real-time services carried over B-ISDN," Lecture Notes in Computer Science, vol. 1044, pp. 107-118, 1996

[12] R. Kalathur and M. Bassiouni, "Forward error correction with buffer management in multimedia ATMnetworks," presented at Southcon/94. Conference Record, 1994.

[13] X. Yu, J. Modestino, and Y. Chan, "A model-based evaluation methodology for assessing the efficacy of packet-level fec for delay-constrained video network transport," presented at 2006 IEEE International Conference on Image Processing, 2006.

[14] M. Gamage, M. Hayasaka, and T. Miki, "A connection-oriented network architecture with guaranteed QoS for future real-time applications over the Internet," *Computer Networks*, vol. 50, pp. 1130-1144, 2006.

[15] G. Dan, V. Fodor, and G. Karlsson, "A Rate-Distortion Based Comparison of Media-Dependent FEC and MDC for Real-Time Audio," presented at IEEE International Conference on Communications, 2006. ICC'06, 2006.

[16] F. Zhai, R. Beryy, T. Pappas, and A. Katsaggelos, "A rate-distortion optimized error control scheme for scalable video streaming over the Internet," presented at Multimedia and Expo, 2003. ICME'03. Proceedings. 2003 International Conference on, 2003.

[17] M. Johanson, "Adaptive forward error correction for real-time internet video," presented at Proc. of the 13th Packet Video Workshop, 2003.

[18] K. Park and W. Wang, "AFEC: an adaptive forward error correction protocol for end-to-endtransport of real-time traffic," presented at Computer Communications and Networks, 1998. Proceedings. 7th International Conference on, 1998.

[19] M. Hayasaka, M. Gamage, and T. Miki, "An efficient loss recovery scheme for on-demand video streaming over the internet," presented at Advanced Communication Technology, 2005, ICACT 2005. The 7th International Conference on.

[20] I. Cidon, A. Khamisy, and M. Sidi, "Analysis of packet loss processes in high-speed networks," *IEEE Transactions on Information Theory*, vol. 39, pp. 98-108, 1993.

[21] J. Bolot, T. Turletti, and S. INRIA, "Adaptive error control for packet video in the Internet," presented at Image Processing, 1996. Proceedings., International Conference on, 1996.

[22] X. Yu, J. Modestino, and I. Bajic, "Performance analysis of the efficacy of packet-level FEC in improving video transport over networks," presented at IEEE Interntional Conference on Image Processing, 2005. ICIP 2005, 2005.

[23] I. Rhee and S. Joshi, "Error recovery for interactive video transmission over the Internet," *IEEE Journal on Selected Areas in Communications*, vol. 18, pp. 1033-1049, 2000

[24] R. Fang, D. Schonfeld, R. Ansari, and J. Leigh, "Forward error correction for multimedia and teleimmersion data streams," *FEC*, vol. 1, pp. P3.

[25] H. Wu, M. Claypool, and R. Kinicki, "Adjusting forward error correction with quality scaling for streaming MPEG," presented at Proceedings of the international workshop on Network and operating systems support for digital audio and video, 2005.

[26] A. Yamaguchi, M. Arai, and K. Iwasaki, "Evaluation of multicast error recovery using convolutional codes," presented at Dependable Computing, 2000. Proceedings. 2000 Pacific Rim International Symposium on, 2000.

[27] O. Almomani, S. Hassan and S. Awang Nor" Effects of Packet Size on FEC Performance "international conference on network Application, protocols and services 2008 (NetApps 2008), 21-22 november 2008

[28] O. Almomani, S. Hassan and O. Ghazali,"Optimalfec Blocksize Formedia Streaming Over Internet", in the Proceeding of the International Graduate Conference on Engineering and Science (IGCES 2008), Johor, Malaysia, 23rd-24th December 2008.

[29] N. Oguz, "A simulation study of forward error correction for lost packet recovery in B-ISDN/ATM," presented at 1993 IEEE International Symposium on Information Theory, 1993. Proceedings, 1993.

[30] K. Nahrstedt, "Quality of service in networked multimedia systems," *Handbook of Internet and Multimedia Systems and Applications*, pp. 217, 1999.

[31] R. Puri, K. Ramchandran, K. Lee, and V. Bharghavan, "Forward error correction (FEC) codes based multiple description coding for Internet video streaming and multicast," *Signal Processing: Image Communication*, vol. 16, pp. 745-762, 2001.

[32] J. Bolot, T. Turletti, and S. INRIA, "A rate control mechanism for packet video in the Internet," presented at INFOCOM'94. Networking for Global Communications., 13th Proceedings IEEE, 1994.

[33] D. Jurca and P. Frossard, "Optimal FEC Rate for Media Streaming in Active Networks," presented at Proceedings of IEEE ICME, 2004.

[34] A. Nafaa, T. Taleb, and L. Murphy, "Forward error correction strategies for media streaming over wireless networks," *IEEE Communications Magazine*, vol. 46, pp. 72, 2008.

[35] J. Ahn, Y. Lee, J. Yoon, and K. Lee, "Analyzing the Effect of a Block FEC Algorithm's Symbol Size on Energy Consumption in Wireless Sensor Networks," *Lecture Notes in Computer Science*, vol. 4239, pp. 440, 2006.

[36] W. Dapeng, Y. Hou, Z. Wen-wu, Z. Ya-Qin, and J. Peha, "Streaming video over the Internet: approaches and directions," *IEEE transactions on circuits and systems for video technology*, vol. 11, pp. 282-300, 2001.

[37] J. Boyce and R. Gaglianello, "Packet loss effects on MPEG video sent over the public Internet," presented at Proceedings of the sixth ACM international conference on Multimedia, 1998.

[38] X. Li, M. Ammar, and S. Paul, "Video multicast over the Internet," *IEEE network*, vol. 13, pp. 46-60, 1999.

[39] E. Lin, C. Podilchuk, T. Kalker, and E. Delp, "Streaming video and rate scalable compression: What are the challenges for watermarking?," *Journal of Electronic Imaging*, vol. 13, pp. 198, 2004..

[40] D. Wu, Y. Hou, and Y. Zhang, "Transporting real-time video over the Internet: challenges and approaches," *Proceedings of the IEEE*, vol. 88, pp. 1855-1877, 2000.

[41] Q. Zhao, C. Li, X. Zhang, and D. A.-L. Liu, Dongtao, "ANew FEC Scheme for Real-time Transmission of High Definition Video over IP Network," presented at Intelligent Pervasive Computing, 2007. IPC. The 2007International Conference on, 2007.

[42] S.-R. Kang and D. Loguinov, "Modeling Best-Effort and FEC Streaming of Scalable Video in Lossy Network Channels," Networking, IEEE/ACM Transactions on, vol. 15, pp. 187-200, 2007.

[43] K. Munadi, M. Kurosaki, K. Nishikawa, and H. Kiya, "Efficient packet loss protection for JPEG2000 images enabling backward compatibility with a standard decoder," presented at Image Processing, 2004. ICIP'04. 2004 International Conference on, 2004.

[44] G. Dán, V. Fodor, and G. Karlsson, "On the effects of the packet size distribution on FEC performance," *Computer Networks*, vol. 50, pp. 1104-1129, 2006.

[45] H. Matsuoka, T. Yoshimura, and T. Ohya, "End-to-end robust IP soft handover," presented at IEEE International Conference on Communications, 2003. ICC'03, 2003.

[46] S. Aoki, T. Shimizu, S. Nishimura, and K. Aoki, "Efficient Reliable Multicast Using FEC and Limited Retransmission for HDTV IP Broadcasting," presented at 5th IEEE Consumer Communications and Networking Conference, 2008. CCNC 2008, 2008.

[47] T. Kondo, K. Nishimura, and R. Aibara, "Implementation and evaluation of the robust high-quality video transfer system on the broadband Internet," presented at Applications and the Internet, 2004. Proceedings. 2004 International Symposium on, 2004

[48] F. Zhai, R. Beryy, T. Pappas, and A. Katsaggelos, "A rate-distortion optimized error control scheme for scalable video streaming over the Internet," presented at Multimedia and Expo, 2003. ICME'03. Proceedings. 2003 International Conference on, 2003.

[49] S. Jharee and K. Soyjaudah, "Recovery of small bursts of voice packets using RS erasure code with low decoding delay," *AFRICON 2007*, pp. 1-7, 2007.

[50] M. Luby, M. Mitzenmacher, M. Shokrollahi, and D. Spielman, "Efficient erasure correcting codes," *IEEE Transactions on Information Theory*, vol. 47, pp. 569-584, 2001.

[51] J. Park, E. Chong, and H. Siegel, "Efficient multicast stream authentication using erasure codes," *ACM Transactions on Information and System Security (TISSEC)*, vol. 6, pp. 258-285, 2003.

[52] R. Morelos-Zaragoza, J. Wiley, and I. Sons, *The art of error correcting coding*: Wiley, 2006. , Ltd. ISBN: 0-470-01558-6

[53] T.Issariyakul and E. Hossain, "Introduction to NetworkSimulator NS2", ISBN: 978-0-387-71759-3 e-ISBN: 978-0-387-71760-9, DOI: 10.1007/978-0-387-71760-9, Library of Congress Control Number: 2008928147, 2009 Springer Science+Business Media, LLC

[54] E. Biersack, "A simulation study of forward error correction in ATM networks."

[55] N. Oguz and E. Ayanoglu, "A simulation study of two-level forward error correction for lost packet recovery in B-ISDN/ATM," presented at IEEE International Conference on Communications, 1993. ICC 93. Geneva. Technical Program, Conference Record, 1993.

[56] O. Ghazali, "scalable and smooth TCP-friendly received-based layered multicast protocol,", Ph.D. dissertation, Malaysia University Utara Malaysia,2008

[57] P. Frossard, "FEC performance in multimedia streaming," *IEEE Communications Letters*, vol. 5, pp. 122-124, 2001.

[58] K. Harfoush, A. Bestavros, and J. Byers, "Measuring bottleneck bandwidth of targeted path segments," presented at IEEE INFOCOM 2003. Twenty-Second Annual Joint Conference of the IEEE Computer and Communications Societies.

[59] W. Alyson and L. Nikolaos ,"Modern Statistical and Mathematical Methods In Reliability", LC Call Number: TA169 -- .M64 2005eb,ISBN: 9789812563569 9789812703378 ,Dewey Decimal Number: 620/.00452,2005