

MASTER'S THESIS

Packet loss recovery in internet telephony

Chow, Wing Yan

Date of Award:
2007

[Link to publication](#)

General rights

Copyright and intellectual property rights for the publications made accessible in HKBU Scholars are retained by the authors and/or other copyright owners. In addition to the restrictions prescribed by the Copyright Ordinance of Hong Kong, all users and readers must also observe the following terms of use:

- Users may download and print one copy of any publication from HKBU Scholars for the purpose of private study or research
- Users cannot further distribute the material or use it for any profit-making activity or commercial gain
- To share publications in HKBU Scholars with others, users are welcome to freely distribute the permanent URL assigned to the publication

Packet Loss Recovery in Internet Telephony

CHOW Wing Yan

**A thesis submitted in partial fulfillment of the requirements
for the degree of
Master of Philosophy**

Principal Supervisor: Prof. LEUNG Yiu Wing

Hong Kong Baptist University

July 2007

ABSTRACT

Internet telephony is promising for long-distance calls because of its low service charge and value-added functions. Packet loss is a challenge to Internet telephony as it affects voice quality. Some packet loss recovery schemes have been proposed in the literature to combat packet loss and enhance voice quality. Their main idea is that the sender transmits redundancy so that the receiver can make use of this redundancy to possibly recover the lost packets.

In this thesis, we consider an Internet telephony system in which the service provider operates a telephone gateway in each servicing city to serve the general public. We propose a more powerful packet loss recovery scheme, called lightweight piggybacking, for this Internet telephony system. The source telephone gateway produces very small redundancy via two stages of erasure coding and fragmentation on the low bit-rate version of original voice streams, such that the small redundancy can be shared by multiple voice streams to a large extent for more powerful packet loss recovery at the destination telephone gateway. We further enhance the lightweight piggybacking scheme in a multipath environment provided by a large Internet telephony system, such that the resulting scheme can recover bursty loss even more powerfully.

We conducted simulation experiments to evaluate the performance of lightweight piggybacking. Compared with the conventional piggybacking scheme, the lightweight piggybacking scheme can effectively: (i) increase the probability of recovering the lost packets using the same or smaller amount of redundancy, and (ii) recover the loss of multiple and consecutive packets. When the telephone gateways of a large Internet telephony system form a multipath transmission environment, lightweight piggybacking is even more powerful for packet loss recovery.

TABLE OF CONTENTS

DECLARATION	I
ABSTRACT	II
ACKNOWLEDGEMENTS.....	III
TABLE OF CONTENTS.....	IV
LIST OF TABLES	VIII
LIST OF FIGURES	IX
CHAPTER 1. INTRODUCTION TO INTERNET TELEPHONY.....	1
1.1 BACKGROUND	1
1.2 OVERVIEW OF INTERNET TELEPHONY	2
1.2.1 Architecture	3
1.2.1.1 Computers to Computers.....	3
1.2.1.2 Computers to Telephones/ Telephones to Computers.....	4
1.2.1.3 Telephones to Telephones	4
1.2.2 Codecs	5
1.2.3 Signaling Protocols	7
1.2.3.1 H.323	7
1.2.3.2 Session Initiation Protocol (SIP).....	8
1.2.4 VoIP Tools	8
1.2.5 Challenges	9
1.2.5.1 Delay	10
1.2.5.2 Packet Loss.....	11
1.3 OVERVIEW OF PACKET LOSS RECOVERY SCHEMES	12

1.3.1	Sender-based Approaches	12
1.3.1.1	<i>Parity Coding</i>	13
1.3.1.2	<i>Piggybacking</i>	13
1.3.1.3	<i>Erasure Codes</i>	14
1.3.1.4	<i>Shared Packet Loss Recovery</i>	16
1.3.1.5	<i>Stream Replication</i>	17
1.3.1.6	<i>Layered Coding</i>	18
1.3.1.7	<i>Multiple Description Coding</i>	19
1.3.2	Receiver-based Approaches	20
1.3.2.1	<i>Insertion</i>	20
1.3.2.2	<i>Interpolation</i>	21
1.3.2.3	<i>Regeneration</i>	21
1.3.3	Transmission-based Approach	22
1.3.3.1	<i>Path Diversity</i>	22
1.4	DISCUSSION	24
1.5	SUMMARY	25
CHAPTER 2.	LIGHTWEIGHT PIGGYBACKING	26
2.1	INTRODUCTION	26
2.2	LIGHTWEIGHT PIGGYBACKING	27
2.2.1	Steps of Lightweight Piggybacking	28
2.2.1.1	<i>Step 1 – Discarding Least Important Layers</i>	28
2.2.1.2	<i>Step 2 – First Stage of Erasure Coding</i>	29
2.2.1.3	<i>Step 3 – Fragmentation and Second Stage of Erasure Coding</i>	29
2.2.1.4	<i>Step 4 – Piggybacking</i>	29

2.3	PACKET LOSS RECOVERY	30
2.3.1	Steps of Packet Loss Recovery	30
2.3.1.1	<i>Step 1 – Reproducing Redundant Packets by Erasure Decoding and Reassembly.....</i>	<i>30</i>
2.3.1.2	<i>Step 2 – Producing Further-compressed Voice Packets.....</i>	<i>31</i>
2.3.1.3	<i>Step 3 – Recovering Lost Packets by Second Stage of Erasure Decoding</i>	<i>31</i>
2.3.2	Conditions of Loss Recovery	31
2.3.3	Illustrative Example	32
2.4	DISCUSSION.....	33
2.4.1	Redundancy Requirement	33
2.4.2	Loss Recovery Capability	33
2.4.3	Packet Size	34
2.4.4	Time Complexity.....	34
2.5	LIGHTWEIGHT PIGGYBACKING OVER MULTIPATH.....	37
2.5.1	Source Telephone Gateway Operation.....	38
2.5.2	Destination Telephone Gateway Operation	42
2.6	SIMULATION RESULTS.....	42
2.6.1	Simulation Models	42
2.6.1.1	<i>Independent Loss.....</i>	<i>42</i>
2.6.1.2	<i>Dependent Loss</i>	<i>43</i>
2.6.2	Simulation Methods	44
2.6.3	Single Path Transmission of Lightweight Piggybacking	46
2.6.3.1	<i>Low to High Loss Rate</i>	<i>46</i>
2.6.3.2	<i>High to Very High Loss Rate.....</i>	<i>52</i>

2.6.3.3	<i>Burst Loss</i>	58
2.6.4	Multipath Transmission of Lightweight Piggybacking.....	61
2.6.4.1	<i>Low to High Loss Rate</i>	61
2.6.4.2	<i>Burst Loss</i>	65
2.6.5	Design Recommendations.....	70
2.7	CONCLUSION.....	76
CHAPTER 3. CONCLUSIONS AND FUTURE WORK.....		78
3.1	CONCLUSIONS	78
3.2	FUTURE WORK	79
BIBLIOGRAPHY		81
CURRICULUM VITAE		91