Techniques for Quality of Service Improvement in Internetworks

by

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To my parents

Contents

Abstract

Quality of service in the Internet has long been a concern of computer network researchers. TCP congestion control is one of critical issues in achieving a good quality of service in Internetworks, for TCP which is able to provide a reliable data transmission over Internet is a core of modern Internet protocols suite. TCP uses a "window size" variable to limit the maximum number of packets that can be outstanding. TCP congestion control research focuses on design of congestion control algorithms which dynamically adjust congestion window (Cwnd) size and improve quality of service in terms of higher network throughput, smaller packets time delay and better fairness in network resource allocation to network users. This thesis presents design of new TCP congestion control algorithms as applications of modern control theory and game theory. The thesis consists of three primary parts: TCP congestion control background research, TCP congestion controller based on control theory and game theoretic TCP congestion control algorithm.

The thesis first conducts background research in TCP congestion control including review and comparison of various TCP congestion control algorithms proposed by researchers. The background research shows that TCP Vegas is the most appropriate algorithm which is chosen as a foundation of research work in this thesis, for it is relatively easy to build control theoretic model and game theoretic model based on TCP Vegas for new algorithms design due to unique functions and parameters in TCP Vegas. A linear feedback system model Vegas for TCP previously developed by White and Chiera provides a foundation upon which the new algorithms and methodologies of this thesis are developed. The first problem addressed is a H_∞ congestion controller based on modification of TCP Vegas as a robust generalisation of the H_2 approach of White and Chiera.

The thesis then proposes a centralised TCP congestion controller as an application of Linear Quadratic Gaussian (LQG) robust control method. A centralised control model is established based on TCP Vegas by using the linear approach of White and Cheira,

in which Cwnd of users are control inputs and packets time delays are control measurements. A LQG controller which consists of a Kalman filter and LQG regulator is designed to provide an optimal control for the control model. The primary aim of this work is to investigate potential performance benefits which might be gained by users in a sub-network sharing information about their TCP congestion control states.

Naturally following the investigation of co-operation from a control viewpoint, is an approach based on game theory. The thesis makes a significant contribution to the development of adaptive mechanisms in repeated games. The thesis develops a new weighted regret matching (WRM) controller for TCP congestion control using the game theoretic approach. A WRM approach leading to a set of correlated equilibria for non-cooperative games is proposed, which uses regret functions to update the probability mass function on users' actions set and leads the probability distribution of users' global behavior converge to a set of correlated equilibria. A TCP congestion control game model based on TCP Vegas is established and WRM approach is applied to the game model in which network users choose their Cwnd according to probability distribution function suggested by WRM algorithm. The parameters setting of WRM controller is discussed and the performance of proposed controller in TCP congestion control is investigated based on a single bottle-neck queue network simulated in Matlab. The compatibility and fairness of WRM controller is investigated in NS-2, a widely used network simulation software for network research, to provide a realistic network environment for this research.

Statement of Originality

This work contains no material that has been accepted for the award of any other degree or diploma in any university or other tertiary institution and, to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made in the text.

I give consent to this copy of the thesis, when deposited in the University Library, being available for loan, photocopying and dissemination through the library digital thesis collection.

Signed

Date

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Conventions

Typesetting

This thesis is typeset using the LaTeX2e software.

The fonts used in this thesis are Times New Roman and Sans Serif.

Referencing

Referencing and citation style in this thesis are based on the Institute of Electrical and Electronics Engineers (IEEE) Transaction style.

Units

The units used in this thesis are based on the International System of Units (SI units).

Spelling

The Australian English spelling is adopted in this thesis.

Publications

Papers [1]

[1] J. Zhou and L. B. White, "A H_∞ controller design for TCP congestion control," in *Australian Communications Theory Workshop*, Melbourne, February 2011, pp. 60–65.

[2] J. Zhou and L. B. White, "A centralized controller design for TCP congestion control," in *ready for publication*, 2013.

[3] J. Zhou and L. B. White, "A weighted regret natching algorithm leading to correlated equilibrium," in *ready for publication*, 2013.

[4] J. Zhou and L. B. White, "A new tcp congestion control algorithm based on game theoretic regret matching algorithm," in *ready for publication*, 2013.

[1] [2] has been submitted to 2 journals, but was not accepted because of a perceived mismatch between the paper and the main thrusts of the journals. It appears difficult to find a suitable outlet for dissemination of this work. However, paper drafts are available on researchgate.org.

Abbreviations

ACK	Acknowledgement
CCC	Centralised Congestion Controller
CE	Correlated Equilibrium
Cwnd	Congestion Window
IP	Internet Protocol
ISP	Internet Service Provider
LAN	Local Area Network
LQG	Linear Quadratic Gaussian
NEP	Nash Equilibrium Point
NS-2	Network Simulator 2
PDF	Probability Distribution Function
PMF	Probability Mass Function
QoS	Quality of Service
RED	Random Early Detection
RLS	Recursive Least Square
RTT	Round Trip Time
SAP	Simple Adaptive Procedure
TCP	Transport Control Protocol

WRM Weighted Regret Matching

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