TCP SINTOK: TRANSMISSION CONTROL PROTOCOL WITH DELAY-BASED LOSS DETECTION AND CONTENTION AVOIDANCE MECHANISMS FOR MOBILE AD HOC NETWORKS

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Abstrak

Rangkaian *Ad hoc* Mudah Alih (MANET) terdiri daripada peranti mudah alih yang bersambung antara satu sama lain dengan menggunakan saluran tanpa wayar. Ia membentuk satu rangkaian sementara tanpa bantuan infrastruktur tetap; yang mana hos adalah bebas untuk bergerak secara rawak dan juga bebas untuk menyertai atau meninggalkan sesuatu rangkaian. Sifat berpusat MANET tampil dengan cabaran baru yang melanggar konsep reka bentuk Protokol Kawalan Penghantaran (TCP); sejenis protokol dominan untuk Internet pada masa kini. TCP sentiasa merumuskan kehilangan paket sebagai petunjuk kesesakan rangkaian dan menyebabkan ia melaksanakan pengurangan mendadak kepada kadar penghantaran data. MANET mengalami beberapa jenis kehilangan paket disebabkan oleh ciri mobiliti dan pertelagahan capaian saluran tanpa wayar dan ini akan melemahkan prestasi TCP. Oleh itu, kajian eksperimental ini menyiasat satu protokol yang dikenali sebagai TCP Sintok. Protokol ini mempuntai dua mekanisme: Mekanisme Pengesanan Kehilangan berasaskan kelewatan (LDM) dan Mekanisme Pengelakan Perebutan (CAM). LDM diperkenalkan untuk menentukan punca kehilangan paket dengan memantau trend sampel kelewatan hujung-ke-akhir. CAM telah dibangunkan untuk penyesuaian pada kadar penghantaran (tetingkap kesesakan) mengikut keadaan rangkaian semasa. Kajian eksperimen telah dijalankan bagi mengesahkan keberkesanan TCP Sintok dalam mengenal pasti punca kehilangan paket dan menyesuaikan kadar penghantaran yang bersesuaian. Dua varian protokol TCP yang dikenali sebagai TCP NewReno dan ADTCP telah dipilih untuk menilai prestasi TCP Sintok melalui simulasi. Keputusan menunjukkan bahawa TCP Sintok memperbaiki ketaran, kelewatan dan daya pemprosesan berbanding dengan dua varian tersebut. Hasil penemuan penyelidikan ini mempunyai implikasi penting dalam menyediakan pemindahan data yang boleh dipercayai dalam MANET dan menyokong penempatan pada komunikasi peranti mudah alih.

Kata kunci: Protokol kawalan penghantaran, Rangkaian *ad hoc* mudah alih, Pengelakan pertelagahan, Teori penyesuaian komunikasi

Abstract

Mobile Ad hoc Network (MANET) consists of mobile devices that are connected to each other using a wireless channel, forming a temporary network without the aid of fixed infrastructure; in which hosts are free to move randomly as well as free to join or leave. This decentralized nature of MANET comes with new challenges that violate the design concepts of Transmission Control Protocol (TCP); the current dominant protocol of the Internet. TCP always infers packet loss as an indicator of network congestion and causes it to perform a sharp reduction to its sending rate. MANET suffers from several types of packet losses due to its mobility feature and contention on wireless channel access and these would lead to poor TCP performance. This experimental study investigates mobility and contention issues by proposing a protocol named TCP Sintok. This protocol comprises two mechanisms: Delay-based Loss Detection Mechanism (LDM), and Contention Avoidance Mechanism (CAM). LDM was introduced to determine the cause of the packet loss by monitoring the trend of end-to-end delay samples. CAM was developed to adapt the sending rate (congestion window) according to the current network condition. A series of experimental studies were conducted to validate the effectiveness of TCP Sintok in identifying the cause of packet loss and adapting the sending rate appropriately. Two variants of TCP protocol known as TCP NewReno and ADTCP were chosen to evaluate the performance of TCP Sintok through simulation. The results demonstrate that TCP Sintok improves jitter, delay and throughput as compared to the two variants. The findings have significant implication in providing reliable data transfer within MANET and supporting its deployment on mobile device communications.

Keywords: Transmission control protocol, Mobile ad hoc network, Contention avoidance, Communication accommodation theory

Declaration Associated with This Thesis

Some of the works presented in this thesis have been published or submitted as listed below.

[1] **Adib M. Monzer Habbal** and Suhaidi Hassan, “A Model for Congestion Control of Transmission Control Protocol in Mobile Wireless Ad hoc Networks ”, Journal of Computer Science (JCS), Vol. 9(3), pp. 468-473 (2013), ISSN: 1549-3636. [Citation indexed by SCOPUS]

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"*Work; so Allah will see your work and (so will) His Messenger and the believers*;"

(The Holy Quran - AtTawbah 9:105)

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Dedication

For my family . . .

in memory of my father M. Monzer;

my mother Faten; and

my brothers Amjad, and Ayman

my wife Rawaa; and

our daughter Faten

Table of Contents

List of Tables

List of Figures

List of Appendices

List of Abbreviations

ABSE	-	Adaptive Bandwidth Share Estimation
ACK	-	Acknowledgement
ADSN	-	ACK Duplication Sequence Number
ADTCP	-	TCP-friendly Transport Protocol for Ad hoc Networks
AIMD	-	Additive Increase, Multiplicative Decrease
AODV	-	Ad Hoc On-Demand Distance Vector
ASP	-	Adaptive Packet Size
ASP-FeW	-	Adaptive Packet Size on Top of FeW
BEB	-	Binary Exponential Backoff
BER	-	Bit Error Rate
BDP	-	Bandwidth Delay Product
CAM	-	Contention Avoidance Mechanism
CAT	-	Communication Accommodation Theory
CR	-	Contention Ratio
CSMA/CA	-	Carrier Sensing Multiple Access with Collision Avoidance
CWA-CD	-	Congestion Window Adaptation through Contention Detection
CWL	-	Congestion Window Limit
CWND	-	Congestion Window
DACK	-	Delay ACKnoweledgment
DCF	-	Distributed Coordination Function
DIFS	-	Distributed Inter Frame Space
DRM	-	Design Research Methodology
DS-I	-	Descriptive Study-I
DS-II	-	Descriptive Study-II
DSR	-	Dynamic Source Routing
DUPACK	-	DUPlicate ACKnowledgements
ECN	-	Explicit Congestion Notification
ELFN	-	Explicit Link Fail Notification
ELU	-	Efficient Link Utilization
FEDM	-	Fuzzy-based Error Detection Mechanism

Few	-	Fractional Window increment
FIFO	-	First In First Out
FTP	-	File Transfer Protocol
GM	-	Gauss Markov
GUI	-	Graphical User Interface
HTTP	-	HyperText Transfer Protocol
IADTCP	-	Improved-ADTCP
IETF	-	Internet Engineering Task Force
IDD	-	Inter-packet Delay Difference
IW	-	Initial value of cwnd
LDA	-	Loss Differentiation Algorithm
LRA	-	Loss Recovery Algorithm
LW	-	Loss Window
LDM	-	Loss Detection Mechanism
LRL	-	Long Retry Limit
M-ADTCP	-	Modified AD-hoc Transmission Control Protocol
MAC	-	Media Access Control
MANET	-	Mobile Ad hoc NETwork
MME-TCP	-	Multi-metric Measurement based Enhancement of TCP
MATLAB	-	MATrix LABoratory
NS-2	-	Network Simulator ver2
OLSR	-	Optimized Link State Routing
OOO	-	Out-Of-Order
PCT	-	Pair wise Comparison Test
PDA	-	Personal Digital Assistant
PHY	-	PHYsical layer
PLR	-	Packet Loss Ratio
POR	-	Packet Out-of-order Arrival
RPGM	-	Reference Point Group Mobility
PS	-	Perspective Study
RC	-	Research Clarification
RFC	-	Request For Comments

RSD	-	Relative Sample Density
RTO	-	Retransmission Time Out
RTHC	-	Round-Trip Hop-Count
RTS/CTS	-	Request To Send / Clear To Send
RTT	-	Round Trip Time
RW	-	Random Waypoint
RWND	-	Receiver's Advertised Window
SACK	-	Selective ACKnoweledment
SANET	-	Static Ad hoc NETwork
SIFS	-	Short InterFrame Space
SMTP	-	Simple Mail Transfer Protocol
SMSS	-	Sender Maximum Segment Size
SRL	-	Short Retry Limit
SRTT	-	Smooth RTT
SSTHRESH	-	Slow Start THRESHold
STG	-	Short Term Goodput
STT	-	Short Term Throughput
TCP	-	Transmission Control Protocol
TCP/IP	-	Transmission Control Protocol/Internet Protocol
TCP ADA	-	TCP with Adaptive Delayed Acknowledgement
TCP AR	-	TCP Adaptive RTO
TCP-AP	-	TCP with Adaptive Pacing
TCPCC	-	TCP-Channel utilization and Contention Ratio
TCP DAA	-	Dynamic Adaptive Acknowledgement
TCP DCA	-	TCP Delayed Cumulative Ack
TCP DCR	-	TCP Delayed Congestion Response
TCP DOOR	-	TCP Detection of Out-of-Order and Response
TCP-MEDX	-	TCP-Mobile Error Detection eXtension
TCP-R	-	Protocol for Mobility-induced Packet Reordering
TCPW	-	TCP Westwood
TPSN	-	TCP Packet Sequence Number
PAT	-	Partition-Aware TCP

P2P	-	Peer-to-Peer
PDA	-	Personal Digital Assistant
PLR	-	Packet Loss Ratio
POR	-	Packet Out of order Delivery Ratio
Us	-	Sender's Utilization
Un	-	Neighbors' Utilization
VANET	-	Vehicular Ad hoc NETwork
VCRH	-	Variance of Contention RTT per Hop
WWW	-	World Wide Web
WLAN	-	Wireless Local Area Network

CHAPTER ONE
INTRODUCTION

The Internet success has contributed to the adaptation of the Transmission Control Protocol/Internet Protocol (TCP/IP) suite to build different types of communication networks including ad hoc network [2]. Transmission Control Protocol (TCP), the predominant transport protocol, is used in the TCP/IP stack to support the multitude of Internet services. This thesis presents a new Transmission Control Protocol, named TCP Sintok, and its verified performance in IEEE 802.11 ad hoc networks. This chapter aims to place the thesis of this work within its context, where the general background of the research is described briefly. This chapter begins with an introductory overview of TCP and ad hoc networks, followed by a brief description of the popular applications of ad hoc networks. Characteristics of mobile ad hoc networks are deliberated in Section 1.2, while Section 1.3 discusses the motivating factors that drive the need for studying the design concept of TCP congestion control. The problem statement is stated in Section 1.4 where the current issues and challenges of TCP are addressed. In Section 1.5, the research questions are presented, so as to frame the research objectives and scope of which are presented in Section 1.6 and 1.7, respectively. Meanwhile, the research significance is highlighted in Section 1.8, and finally, the thesis organization is outlined in Section 1.9.

1.1 TCP and Ad hoc Networks

The need for wireless computing devices such as tablets, Personal Digital Assistants (PDAs), and notebooks has accompanied the increasing interest in the usage of ad hoc networks. An ad hoc network is a set of wireless mobile or static devices that connect to each other using wireless links, forming a temporary network without depending on fixed infrastructure [12]. In contrast to infrastructure based wireless networks, nodes

The contents of the thesis is for internal user only

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