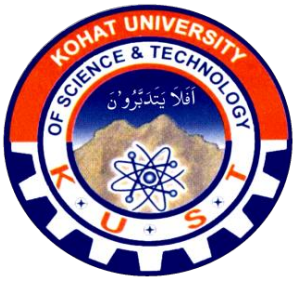
ENHANCING TRANSMISSION CONTROL PROTOCOL PERFORMANCE IN WIRELESS AD-HOC NETWORKS

by

Noor Mast



Institute of Computing
Kohat University of Science & Technology, Kohat-26000
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June 2023

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Submitted in partial fulfilment of the requirements for the degree of PhD in Computer Science

by

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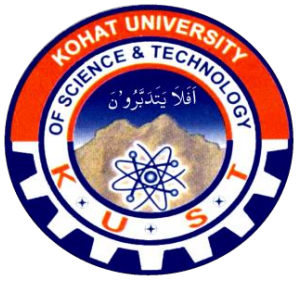
Registration No. (CS420201001)



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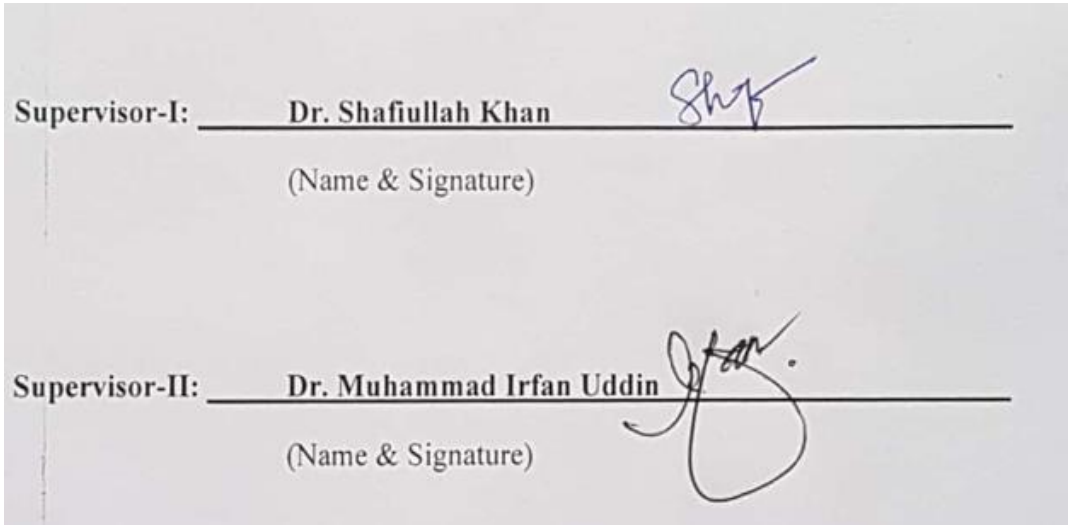

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This is to certify that this thesis entitled "**Enhancing Transmission Control Protocol Performance in Wireless Ad-hoc Networks**" presents a bonafide record of original research work carried out by NOOR MAST in partial fulfilment of the degree of PhD in Computer Science, Kohat University of Science & Technology, Kohat. We find the work satisfactory for the award of the degree if other requirements are met. The Viva Voce held on July 5, 2023.

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In the name of Allah, the Most Gracious, the Most Merciful, all praise is to Allah for giving me inspiration and strong-heartedness along this journey.

At this moment of submission of my thesis, I would like to thank all those good human beings I have come across in this journey.

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Abstract

This thesis focuses on enhancing Transmission Control Protocol (TCP) performance in Wireless Ad-hoc Networks (WANETs), where the IEEE 802.11 MAC protocol is utilised as a de facto standard to access the medium. Following a study of the various issues TCP faces in WANET, it becomes clear that channel contention is one of the primary issues affecting TCP performance in WANET. To improve the performance of TCP in WANETs, two potential solutions are provided in this thesis:

(1) A solution called Cross-layer Solution for Contention Control (CSCC) that enables a node sending data over a TCP connection to be aware of the channel contention and to adjust the data injection rate into the network accordingly. Using NS2 (Network Simulator 2), the CSCC mechanism's performance was compared to TCP NewReno. The suggested CSCC technique achieved high fairness index and surpassed TCP NewReno in terms of throughput. In contrast to TCP NewReno, there were fewer packets retransmitted using the CSCC technique, which is an indication of contention control.

(2) The second solution, called Channel Usage Based Backoff (CHUBB), has been suggested to tune the BEB algorithm of the IEEE 802.11 MAC protocol. In the CHUBB algorithm, each node adopts a multiplicative factor for use according to its transmission ratio over a particular interval; a larger transmission ratio for a node means a larger multiplicative factor and vice versa. Moreover, one exemplary aspect of the proposed mechanism is that it estimates the network status independently without burdening the network. While the most challenging aspect is selecting the proper interval to measure channel usage and assigning an appropriate value to the multiplicative factor on the bases of the transmission ratio of the node. Selecting inappropriate values can limit the algorithm's performance.

When both TCP and UDP were used at the transport layer, the suggested CHUBB algorithm outperformed the BEB in throughput and achieved a high fairness index. Moreover, the number of retransmissions is low with the proposed algorithm.

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LIST OF ABBREVIATIONS

ACK	Acknowledgement
AODV	Ad-hoc On-demand Distance Vector
APS FeW	Adaptive Packet Size on top of FeW
C^3TCP	Cross-layer Congestion Control for TCP
CC	Channel Contention
CHUBB	Channel Usage Based Backoff
COPAS	Contention-based Path Selection
CSCC	Cross-layer Solution for Contention Control
CTS	Clear-To-Send
CW	Contention Window
cwnd	Congestion Window
DCF	Distributed Coordination Function
DD ACK	Dynamic Delay Acknowledgement
DIFS	Distributed Inter-Frame Space
DSR	Dynamic source Routing
ELFN	Explicit Link Failure Notification
FAIR+	Feedback Assisted Improved Recovery +
FeW	Fractional Window Increment
GPSR	Greedy Perimeter Stateless Routing
IP	Internet Protocol
MAC	Medium Access Control
MANET	Mobile Ad-hoc Network
NAV	Network Allocation Vector
NRED	Neighbourhood Randomly Early Detection
PACK	Proxy Acknowledgement
RREP	Route Reply
RREQ	route request packet
RTO	Retransmission TimeOut
RTS	request-to-send
RTT	Round Trip Time
rwnd	Receiver Window

SACK	Selective Acknowledgment
SIFS	Short Inter-Frame Space
SMTP	Simple Mail Transfer Protocol
SN	Sequence Number
ssthresh	Slow Start Threshold
TCP	Transmission Control Protocol
TCP/RCWE	TCP/Restricted Congestion Window Enlargement
TCP-DAA	TCP Dynamic Adaptive ACK
TCP-DCA	TCP-Delayed Cumulative ACK
TCTC	TCP ConTention Control
WANETs	Wireless Ad-hoc Networks
WCCP	Wireless Congestion Control Protocol

Chapter - 1 - INTRODUCTION

1.1. Background

Transmission Control Protocol (TCP) [1] is a transport layer protocol initially developed for wired networks. It delivers a trustworthy service to transmit data from sender to receiver. TCP suffered from congestion losses in the early days; as a result, congestion control algorithms were added [2], [3]. Due to its reliable service, TCP is heavily used in various Internet applications like file transfer, email, remote assess, and the web. Furthermore, up to 90% of internet traffic is said to be transferred using TCP [4], [5], which makes TCP an essential protocol for transmission and requires significant attention for further improvements. However, in the last two decades, there has been remarkable growth in two things in the communications field.

(a) The number of Internet users.
(b) The use of wireless technology.

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- Nodes set up wireless connectivity with each other without the aid of any access point, using the shared medium.
- A node plays the role of host and router.
- No centralized control.
- Nodes may be static or mobile.
- Nodes are free to join or leave the network.
- Can be set up anywhere.