Enhancing the Wi-Fi Direct protocol for Vehicular Ad-hoc Networks

Wageesha Nilmini Manamperi

(168070G)

Thesis submitted in partial fulfillment of the requirements for the degree
Master of Science By Research

Department of Electronic and Telecommunication Engineering

University of Moratuwa
Sri Lanka

June 2018

Declaration

I declare that this is my own work, and this thesis does not incorporate without acknowledgement any material previously submitted for a degree or diploma in any other university or institute of higher learning, and to the best of my knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgement is made in the text.

Also, I hereby grant to the University of Moratuwa the non-exclusive right to reproduce and distribute my thesis, in whole or in part, in print, electronic, or any other medium. I retain the right to use this content in whole or part in future work (such as articles or books).

Signature: Date: 13/06/2018

The candidate, whose signature appears above, carried out research for the MSc dissertation under my supervision.

Signature: Date: 13/06/2018

Signature: Date: 13/06/2018

Abstract

We present a technique for enhancing Wi-Fi Direct (WD) for vehicular environments. Dedicated short range communication (DSRC) has been standardized for communication in Intelligent Transportation Systems (ITS). However, due to high costs at initiation, alternative communication strategies are of interest in order to facilitate the quick deployment of ITSs. WD, which is a relatively mature technology available in mobile devices, has come across as a possible alternate candidate. However, the presence of large communication delays in the WD protocol stack is a shortcoming in deploying this in highly dynamic vehicular scenarios. The objective of our work is to propose and evaluate a method to overcome some of the large transmission delays in WD. Our proposal is to use a broadcast mechanism in the downlink between the group owner (GO) and the clients of a WD group, as an alternative to the currently used peer-to-peer (P2P) method.

We study our technique by simulating a bi-directional highway scenario with multiple lanes. We set up the vehicular channel model using two well-known models: Friis propagation model and the Nakagami fading model. Performance measures such as average total delay, average energy consumption of the GO, average packet loss ratio, and average packet reception ratio are presented.

While the proposed GO Broadcast method reduces the downlink delay, it increases the probability of packet losses due to the lack of retransmissions. Our results demonstrate a gain in terms of average total delay and the average energy consumption of the GO. We use a theoretical analysis as well as a simulation study using OMNeT++. It is also shown that the degradation in performance on the downlink due to packet losses is within tolerable limits, given that the size of the group is selected properly.

Index terms— Broadcast mechanism, Group formation, Peer-to-Peer (P2P), Vehicular Ad-hoc Network (VANET), Wi-Fi Direct (WD)

Acknowledgements

First and foremost, I would like to express my sincere gratitude to my supervisors Dr. Tharaka Samarasinghe and Prof. Dileeka Dias for their precious advice, valuable insights, and guidance throughout the research. I thank them for sharing their expertise, and specially for making time in their busy schedules to help me with my Masters.

In addition to my supervisors, I would like to thank Dr. Asanga Udugama, for being my progress committee chair and for his assistance and comments for improving and completing the research. I would also like to thank Dr. Ruwan Udayanga, for being my progress committee member and for providing valuable comments throughout my Masters.

I would like to thank my university, The University of Moratuwa, for providing me financial support throughout this year.

I wish to thank my colleagues who helped me directly and indirectly.

Last but not least, I would like to express my deepest gratitude to my beloved parents, sisters, for their endless support, love, and care.

This work was supported by the Senate Research Committee under grant SRC/LT/2015/07.

Thank you
Wageesha Nilmini Manamperi

Contents

List of Figures

List of Tables

List of Abbreviations

Abbreviation	Description
ACK	Acknowledgement
AP	Access Point
BPSK	Binary Phase Shift Key
CSMA/CA	Carrier Sense Multiple Access with Collisions Avoidance
CTS	Clear to Send
D2D	Device-to-Device
DHCP	Dynamic Host Configuration Protocol
DSRC	Dedicated Short Range Communication
GO	Group Owner
IEEE	Institute of Electrical and Electronics Engineers
IP	Internet Protocol
ITS	Intelligent Transportation System
IV	Intent Value
LAN	Local Area Network
MAC	Medium Access Control
MANET	Mobile Ad-hoc Network
MTU	Maximum Transmission Unit
NED	NEtwork Description
NIC	Network Interface Controller
OBU	On Board Unit
P2P	Peer To Peer
PLR	Packet Loss Ratio
PRR	Packet Reception Ratio
QoS	Quality of Services
RSSI	Received Signal Strength Indicator
RSU	Road Side Unit
RTS	Request to Send

SSRC	Stations Short Retry Count
V2I	Vehicle-to-Infrastructure
V2V	Vehicle-to-Vehicle
VANET	Vehicular Ad-hoc Network
WD	Wi-Fi Direct
WPS	Wi-Fi Protected Setup