Enhance Routing Metric Based Optimized Link State Routing (OLSR) Protocol for VANET

by

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In the Name of Allah, The Most Beneficent, The Most Merciful: “My Lord, enable me to be grateful for Your favor which You have bestowed upon me and upon my parents and to do righteousness of which You approve. And admit me by Your mercy into [the ranks of] Your righteous servants. (An-Naml:19) ”.

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LIST OF ABBREVIATIONS

ACAR	Adaptive CAR
ACO	Ant Colony Optimization
ACO-ER	Efficient Routing Algorithm based-on ACO
AGF	Advanced Greedy Forwarding
AMR	Adaptive Message Routing
AODV	Ad Hoc On-demand Distance Vector
A-STAR	Anchor-Based Structure and Traffic-aware Routing
AWCP	Adaptive Weighted Clustering Protocol
BAHG	Back-bone assisted Hop Greedy
BEA-OLSR	Best Energy-aware OLSR
BER	Bit Error Rate
BLA	Bee Life Algorithm
BOA-VRP	Bio-inspired Optimization Algorithm for Vehicle Routing Problem
C2C-CC	Car to Car Communication Consortium
CAP	Connectivity-aware Routing Protocols
CAR	Connectivity-aware Routing
CBF	Contention-based Forwarding
CF	Control Factor
C-GPSR	Chameleon Method GPSR
CM	Chameleon Method
CM-AODV	Chameleon Method AODV
CR	Crossover Factor
DCF	Distributed Coordination Function
DE	Differential Evolution
DREAM	Distance Routing Effective Algorithm for Mobility
DSDV	Distance-Sequence Distance Vector Routing Protocol
DSR	Dynamic Source Routing
DSRC	Dedicate Short Range Communication
DTN	Delay Tolerant Network
DV	Distance Vector
DYMO	Dynamic MANET On-demand
ETX	Expected Transmission Time
FCC	Federal Communication Commission

FL	Fuzzy Logic
GA	Genetic Algorithm
GeoSVR	Geographical Stateless VANET Routing
GG	Gabril Graph
GLS	Grid Location Service
GPCR	Greedy Perimeter Forwarding Routing
GPS	Global Position System
GPSR	Greedy Perimeter Stateless Routing
GRANT	Greedy Routing with Abstract Neighbor Table
GRP	Geographical Routing Protocol
GSR	Greedy and Stateless Routing
GySTAR	Improved Greedy TAR
I2I	Inter Infrastructure
IAP	Infrastructure Assisted Protocol
IETF	International Engineering Task Force
IGRP	Intersection-based Geographical Routing
IOLSR	Intelligent Optimized Link State Routing
IP	Internet Protocol
IRTIV	Intelligent Routing Using Real-time Traffic Information in VANET
IZRP	Intra Zone Routing Protocol
LF	Loss Function
LHS	Left Hand Side
LL	Lower Limit
LOUVRE	Landmark Overlays for URBAN Vehicular Routing Environments
LS	Link State
MAC	Medium Access Control
MANET	Mobile Ad-Hoc network
MAODV	Multi-cast AODV
MAV-AODV	Multi-cast with ACO Based-on MAODV
MO PSO	Multi-Objective PSO
MODE	Multi-Objective Optimization Differential Evolution
MPR	Multi point relay
MURU	Multi-hop Routing for Urban VANET
NVTime	Neighbor Validity Time

OA	Orthogonal Array
OBSG	Optimization Broadcasting scheme for VANET with GA
OBU	Onboard Unit
OCM	Optimization Control Message
OF	Objective Function
OLSR	Optimized Link State Routing
OPT	Option
OT	Optimization Target
PDR	Packet Delivery Ratio
pPSO	Parallel PSO
PRP	Proactive Routing Protocols
PSO	Particle Swarm Optimization
QoS	Quality of Service
RBVT	Road-based routing Using Vehicular Traffic
REP	Reply
RERP	Route Reply
RERQ	Route Request
RERR	Route Error
RFC	Request for comment
RHS	Right Hand Side
RNG	Relative neighborhood Graph
RRP	Reactive Routing Protocols
RSU	Road Side Unit
RTCP	Real-time connectivity Awareness
RTT	Round Trip Time
SADV	Static node Assisted Dissemination Protocol for VANET
SAP	Street-aware Routing Protocols
SAR	Spatially-aware Routing
SF	Smart Forwarding
SI	Swarm Intelligent
SIFT	Simple Forwarding Trajectory
SLAB	Statistical Location-Assisted Broadcast
SNR	Signal-to-Noise Ratio
STAR	Spatial and Traffic-aware Routing

TARCO	Traffic-aware Routing Protocol
TC	Topology Control
TO-GO	Topology Assisted Geographical Routing
TOM	Taguchi Optimization Method
UL	Upper Limit
USDOT	United State Department of Transportation
UVAR	UAV-Assisted VANET Routing Protocol
V2I	Vehicle to Infrastructure
V2V	Vehicle to Vehicle
VADD	Vehicle Assisted Data Delivery
VANET	Vehicular Ad Hoc Network
VETT	VANETs Expected Transmission Time
VT	Trial Vector
WAVE	Wireless Access in Vehicle Environments
ZRP	Zone Routing Protocol

Memantapkan Matrik Penghalaan Berdasarkan Pautan Optimum Penghalaan Bagi VANET

ABSTRAK

Rangkaian Ad Hoc Kenderaan (VANETs) menggapai minat penyelidik-penyelidik dan agensi kerajaan sebagai penyelesaian teknologi bagi sistem pengangkutan manusia. VANETs bertujuan menyediakan sambungan antara kenderaan di rangkaian jalan dan infrastruktur dalam skim komunikasi ad hoc. Dalam VANETs, setiap kenderaan menggunakan mekanisme penghalaan untuk mencari laluan bagi menghantar mesejnya ke destinasi terakhir, di mana mesej-mesej tersebut dihantar dalam fesyen pelbagai hop. Tingkah laku tersebut menekankan kesan mekanisme protokol penghalaan dalam prestasi VANETs. Dalam tahun-tahun kebelakangan ini, analisis protokol penghalaan VANETs dan impaknya terhadap prestasi rangkaian dengan senario rangkaian yang berbeza telah membangunkan pemahaman yang tepat terhadap keperluan dan matlamat untuk merancang protokol penghalaan VANETs. Tambahan pula, dalam kajian literatur, banyak mekanisme protokol penghalaan dicadangkan untuk menangani keperluan VANETs. Walau bagaimanapun, mekanisme penghalaan yang dicadangkan dalam kajian literatur tersebut hanya mempertimbangkan senario rangkaian tunggal dalam VANETs. Walau bagaimanapun, kenderaan atau nod bergerak di dalam VANETs cenderung untuk bergerak jarak jauh, yang memberikan implikasi mengenai penglibatan mereka dalam pelbagai rangkaian senario dan topologi. Tingkah laku yang dipatuhi oleh nodus VANETs menghasilkan keperluan untuk mekanisme penghalaan yang memenuhi kriteria lebih daripada satu senario rangkaian dan topologi. Masalah ini kurang dipertimbangkan dalam kajian literatur. Oleh itu, tesis ini mencadangkan metrik penghalaan *Jangkaan Penghantaran Masa VANETs* (*VETT*) untuk menangani perubahan topologi dinamik dalam VANETs. Metrik yang dicadangkan mentakrifkan prestasi *Pautan Optimum Penghalaan Stat* (OLSR) dalam senario rangkaian yang berbeza sebagai masalah pengoptimuman objektif. Mekanisme yang dicadangkan ini disepadukan dengan protokol OLSR sebagai protokol penghalaan geografi. Hasil simulasi yang meluas ditunjukkan dengan membandingkan antara mekanisme penghalaan yang dioptimumkan dan yang tidak dioptimumkan. Mekanisme tersebut dinilai untuk pelbagai rangkaian metrik termasuk kepadatan lalu lintas, saiz paket dan jumlah kereta untuk dua topologi rangkaian iaitu bandar dan lebuh raya. Keputusan menunjukkan bahawa metrik penghalaan (VETT) yang dicadangkan meningkatkan prestasi OLSR untuk pelbagai senario VANETs dalam keadaan penangguhan, nisbah penghantaran paket (PDR), kehilangan paket serta penghantaran. Mekanisme pengoptimuman objektif (VETT) mengurangkan kelewatan lebih daripada 30% dan meningkatkan PDR dan keluaran melebihi 15%. Selain itu, analisis prestasi protokol penghalaan untuk senario VANETs yang berbeza menunjukkan perbezaan di dalam prestasi protokol penghalaan tunggal dalam senario yang berbeza. Ini menyokong hipotesis bahawa topologi rangkaian mempunyai impak yang besar terhadap prestasi protokol penghalaan. Tesis ini menyimpulkan bahawa pengoptimuman protokol penghalaan adalah penting bagi meningkatkan prestasi VANETs. Pengoptimuman satu objektif menghasilkan

penambahbaikan prestasi penghalaan yang hebat. Walau bagaimanapun, ia tidak dapat menambahbaik lebih daripada satu prestasi secara serentak

Enhance Routing Metric Based Optimized Link State Routing protocol (OLSR) Protocol for VANET

ABSTRACT

Vehicular Ad Hoc Networks (VANETs) grasp the interest of researchers and many governmental agencies as technological solution for human's transportation systems. VANETs aims at providing connectivity among vehicles on the road and infrastructure network in ad hoc communications scheme. In VANETs each vehicle uses a routing mechanism to find a path for sending its messages to the last destination, where messages are sent in a multi hop fashion. The behavior emphasis the impact of the routing protocol mechanism in the performances of VANETs. In recent years, the analysis of VANETs routing protocols and their impact on the performances of network with different network scenarios has significantly developed a precise understanding of the requirements and goals for designing a VANETs routing protocol. Further, in the literature many routing protocol mechanisms are proposed to deal with VANET's requirements. Nonetheless, proposed routing mechanisms in the literature considered a single network scenario in VANETs. However, Vehicles or moving nodes in VANETs are tending to travel in long distances, which implies their engagement in multiple network scenarios and topologies. The adhered behavior of VANET's nodes results in a need for a routing mechanism that addresses the requirement of more than one network scenarios and topologies. This problem is less considered in the literature. Hence, this thesis proposes VANETs Expected Transmission Time (VETT) routing metric to tackle the dynamic topology changes in VANETs. The proposed metric defines the performances of Optimized link stat routing protocol (OLSR) in different network scenarios as an objective optimization problem. The proposed mechanism is integrated with OLSR protocol as geographical routing protocol. Extensive simulation results are presented by comparing between the performances of optimized and non-optimized routing mechanisms. The mechanisms are evaluated for varying network metrics including traffic density, packet size, and number of cars for two network topologies; city and highway. The results show that the proposed routing metric (VETT) improves the performance of OLSR for multiple VANET scenarios in-terms of delay, packet delivery ratio (PDR), packet loss, and throughput. The objective optimization mechanism (VETT) reduces the delay by more than 30% and increases the PDR and throughput by more than 15%. Furthermore, the performance analysis of routing protocols for different VANET scenarios shows divergences in the performances of a single routing protocol in different scenarios. This supports the hypothesis that network topology has a major impact on the routing protocol performances. This thesis concludes that the optimization of routing protocol is necessary to improve the performances of VANET. A single objective optimization results in a great routing performances improvement. However, it is not capable of improving more than one performances simultaneously.

CHAPTER 1: INTRODUCTION

1.1 Research Background

Nowadays, the rapid evolution and cost reduction of wireless communication technologies have made them suitable for a wide spectrum of mobile and wireless applications. There are huge number of vehicles travelling along highways and streets around the world which produce millions of data being transmitted daily throughout the entire world. According to (Money, 2012), today there are approximately 6.8 billion people in the world and by 2044 that number will grow to about 9 billion (this would result in many problems, one of which is in the transportation system). As the total number of vehicles is growing from 800 million cars today to 2-4 billion by 2050, global gridlocks and traffic jams will occur in many different places. Therefore, Vehicular Ad-Hoc Networks (VANET) appears as a technology solution for the adhered issue, and grasps the attention of both government's agencies, industries and researchers (Englund, Chen, Vinel, & Lin, 2015; Shankar & Singh, 2015).

VANET is a special case of Mobile Ad hoc Network (MANET) application, having an impact on the wireless communications and Intelligent Transport System (ITS) (Chang, Xiang, Shi, & Lin, 2009). The main goals of VANET is to exchange information between vehicle's driver to avoid unpleasant traffic situations, enhance traffic management and offer infotainment services. These services can help reduce road collision by 82% as stated in the United State Department of Transportation (USDOT) report (Kenney, 2011). VANET can provide road safety in means of intersection collision warning, emergency warning between vehicles, road condition information exchange between vehicles, and post-crash estimation systems (Al-Sultan, Al-Doori, Al-Bayatti, & Zedan, 2014).

VANET is composed of Roadside Units (RSU) and Vehicle "On-Board Units" (OBU). Both RSU and OBU are equipped with embedded systems to provide communication, position information and capable of intelligent computations. Intercommunication between RSUs and OBUs divides VANET architecture into three communication ways: Vehicle to Vehicle (V2V), Vehicle to Infrastructure (V2I), and Inter-infrastructure communication (I2I). Figure 1.1 depicts the three communication infrastructures of VANET. Further, communication between VANET units is defined by two standards: Dedicated Short Range Communication (DSRC) and Wireless Access in Vehicle Environments (WAVE) (Li, 2010). The United States Federal Communications Commission (FCC) assigned the 75 MHz spectrum in the 5.9 GH band for DSRC communication. The physical and Medium Access Control layer are operated with IEEE802.11p protocol standards (Kenney, 2011). IEEE proposed a full protocol stack for VANET in 1906.1 draft which known as WAVE (Li, 2010). WAVE contains six sub layers, and each layer is dedicated for specific network functionalities (Blum, 2015).

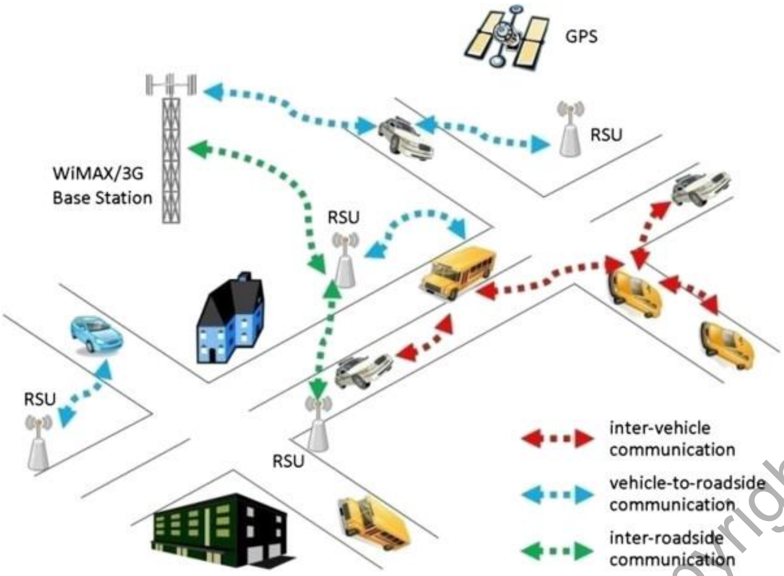

Figure 1.1: VANET Architecture.

WAVE is faced with many research challenges. Challenges faced by WAVE standard that addresses the limitations of VANET are reviewed and investigated by many researchers (Al-Sultan et al., 2014; Felipe Cunha et al., 2016; Eze, Zhang, & Liu, 2014; Liang, Li, Zhang, Wang, & Bie, 2015; ur Rehman, Khan, Zia, & Zheng, 2013). Research issues in VANET are a direct result of the unique characteristics in VANET such as the high dynamic nature of VANET topology and the predictable mobility of road vehicles (Liang et al., 2015). Moreover, the similarity between VANET and MANET makes VANET inherits most of MANET research problems such as the instability in wireless connectivity and the multi-hop communication fashion. This work focuses on the problem of the dynamic nature of VANET's topology, and the problem of designing a robust routing protocol for VANET.

The fact that, vehicles are tending to travel in long distances is a major factor for the high dynamic nature in VANET. It's also causes the same node to be attached to different network scenarios. This problem necessitated the need for a robust routing protocol design, which cops with different network requirements. For example, a routing protocol might have a good performance in one network scenario such as a city, however, this performance may have degraded or contrasted for another scenario such as highway network. The contrasts in the protocol performances is due to change in the network topology parameters including number of nodes and mobility trajectory. In the literatures many protocols are designed for a certain topology and scenario requirements (Bitam, Mellouk, & Zeadally, 2015; H. Cheng & Cao, 2008; Eiza, Ni, & Member, 2013; Fazio, Rango, & Sottile, 2015; Hajlaoui, Guyennet, & Moulahi, 2016; In, 2008; Jerbi & Senouci, 2009; Kopp, Member, Tyson, & Pose, 2016). However less literature addresses the multi-scenario issue in VANET. This thesis developed a new routing metric named Expected Transmission Time in VNET (VETT) to improve the performances of Optimized link stat routing protocol (OLSR).

In this thesis VETT will be developed to improve the performance of OLSR. The protocol is firstly optimized on three different VANET scenarios (City, Highway and Hybrid) in-terms of three routing parameters (Traffic generation (TG), Packet Size (PS) and Number of cars (NC)) to define and justify a certain performance metric. Further the selected protocol is modified to automatically change their routing parameters values according to the current network scenario.

The work in this thesis is based-on simulation experiments. The discrete event simulator OMNET++5.1 and the INET3.5 network framework is used for the simulation purpose. OLSR is a standard protocol implementation and based-on the INET 3.5 modules that are an implementation of this protocol draft. Further the VANET topologies