ADAPTIVE MANET OLSR ROUTING PROTOCOL FOR OPTIMAL ROUTE SELECTION IN HIGH DYNAMIC NETWORK

NORI MOHAMMED ABDULKAREM AL-KHARASANI

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By

NORI MOHAMMED ABDULKAREM AL-KHARASANI

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Doctor of Philosophy

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DEDICATIONS

I would like to dedicate this thesis
To my late mother who taught me to use what I have learned to help people.
To my late father who taught me that a wish with hard work would come true.
They taught me to be brave and patient.
To my brothers, my sisters, my wife, and my wonderful kids.
To my supervisor and entire committee.
"YEMEN ".

&

To all whom I love.

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Doctor of Philosophy

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Chairman: Zuriati Ahmad Zukarnain, PhD
Faculty: Computer Science and Information Technology

Vehicular ad hoc networks (VANETs) are able to supply scalable and cost-efficient solutions for wide range of VANETs applications. The concept of multi-hop vehicle-to-vehicle wireless communications is essential for developing routing protocols. However, due to the rapid topology changes and frequent network disconnections, designing an efficient Multi-hop routing protocol for VANET environments is a very challenging problem. This is because of the vehicles mobility and road obstacles, which cause link failure frequent inefficiency in traditional mobile ad hoc routing protocols. Thus, the information that a vehicle collects using HELLO-Interval messages from its neighbours are not up to date to maintain the routes. When vehicles node cannot maintain routes successfully, the rapidly link failure limits the efficiency of routing. It introduce more control topology packets in the network to establishes new routes which lead to additional routing overhead and end to end delay. Therefore, Ad-hoc routing protocols need to address the problem of configuration adaptation and route selection mechanism to be suitable for VANETs.

In this context, a major concern in designing an efficient routing protocol in VANETs lies on their configurations and route selection mechanisms. The promising applications of VANETs target little delay, overhead, stability and scalability network. For these reasons, optimizing routing configuration parameters, the cluster-based Quality of Service (QoS) and cross-layer parameters are an effective technique and widely accepted to improve routing performance. The main objective is to optimize utilization of the available network information in order to enable a balanced trade-off between the routing efficiency and VANETs constraints. In This thesis, three specific problems that impact VANETs routing efficiency are studied.

The first objective to optimizing routing configuration parameter in different urban scenarios. The new framework model is introduced in order to provide a robust and reliable communication in VANETs, where the balance between the time needed to maintain the discovered routes and QoS requirements is necessary. The routing efficiency and roads constraints trade-off with adjustable soft communication is explored by tuning routing configuration parameters. The statistical framework based on QoS requirements is introduced for optimal solutions.

The second objective considers improving route selection in dynamic network. The standard link reachability metric and the willingness of node cam not guarantee the stability of route. The absent of mobility metrics in route selection scheme leads to reduce the quality of route selection in VANET. The trusted communication range constraint takes into consideration to reduce the impact of dynamic mobility on routing efficiency, and path stability. A suitable algorithm called Link Stability Aware selection Multi Points Relay (LSA-MPR) is introduced, which find a route that satisfies constraints on multiple objectives for selecting the next hop as a relay node designed especially for VANETs, it finds a route that satisfies the constraints on multiple objectives based on Received Signal Strength Indicator (RSSI) and Signal to Interference-Noise Rate (SINR).

The third objective considers reducing control topology overhead as well as improving the scalability of network. To provide the necessary robustness, a new Cluster-based Adoptive Cooperative Algorithm (CACA) for VANET is introduced to improve the scalability of the network and reduce control overhead. A number of factors are chosen to improve relay vehicle selection mechanism; The vehicle's relative mobility, vehicle weighted, link reachability, and bandwidth metrics. These are considered to reduce link failure, routing overhead and enhance packet delivery ratios. The proposed Quality of Path QoP metric is incorporated into the modified relay selection algorithm, which improves the efficiency of relay selection mechanism to find optimal path with high link quality.

The extensive simulation is performed to evaluate the proposed contributions, which have been presented with respect to urban network scenarios in order to evaluate the performance of the proposed contributions compared to various existing approaches. The comparison-based simulation of both default and modified routing protocols is carried out under certain performance parameters; Packet Delivery Ratio (PDR), Average End-to-End Delay (AE2ED), Normalized Routing Load (NRL), Average number of MPR, and Stability. The simulation results show that the BOLSR-PSO, LSA-MPR, and CACA significantly improve routing efficiency routing efficiency in VANET networks. The aim of this improvements are not only to maintained Packet Delivery Ratio, stability and scalability, but also to reduce the network overhead, and average delay.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

PROTOCOL PENGHALAAN BERSEUAIAN MANET OLSR UNTUK PEMILIHAN LALUAN OPTIMUM DI RANGKAIAN DINAMIK TINGGI

Oleh

NORI MOHAMMED ABDULKAREM AL-KHARASANI

Februari 2020

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Rangkaian ad hoc kenderaan (VANETs) dapat membekalkan penyelesaian berskala dan kecekapan kos untuk pelbagai aplikasi VANET. Konsep pelbagai-hop komunikasi tanpa wayar kenderaan-ke-kenderaan adalah penting untuk membangunkan protokol penghalaan. Walau bagaimanapun, disebabkan oleh perubahan topologi pesat dan pemotongan rangkaian yang kerap, mereka bentuk protokol penghalaan Multi-hop yang cekap untuk persekitaran VANET adalah masalah yang sangat mencabar. Ini disebabkan oleh kenderaan dan halangan jalan raya, yang menyebabkan kegagalan pautan yang kerap tidak cekap dalam protokol penghalaan tradisional sementara. Oleh itu, maklumat yang dikumpulkan kenderaan menggunakan mesej HELLO-Interval dari jiran-jirannya tidak mengikut garis masa terkini dalam mengekalkan laluan. Apabila nod kenderaan tidak dapat menyelenggara laluan dengan jayanya, pautan pantas gagal mengatasi kecekapan penghalaan. Ia memperkenalkan lebih banyak paket topologi kawalan dalam menetapkan laluan baru yang membawa kepada lebihan penghalaan tambahan dan kelewatan akhir sehingga tamat. Oleh itu, protokol routing sementara perlu bagi menangani masalah mekanisme pemilihan penyesuaian dan laluan konfigurasi agar sesuai untuk VANET.

Dalam konteks ini, kebimbangan utama dalam merancang protokol penghalaan yang cekap di VANET terletak pada mekanisme pemilihan dan konfigurasi laluan mereka. Aplikasi yang menjanjikan VANETs mensasarkan sedikit kelewatan, lebihan, kestabilan dan rangkaian berskala. Di atas sebab ini, mengoptimumkan parameter konfigurasi penghala, kualiti perkhidmatan (QoS) berasaskan kluster dan parameter rentas lapisan adalah teknik yang berkesan dan diterima secara meluas untuk meningkatkan prestasi penghalaan. Objektif utama adalah untuk mengoptimumkan penggunaan maklumat rangkaian yang

ada untuk membolehkan perdagangan seimbang antara kecekapan penghalaan dan kekangan VANET. Dalam tesis ini, tiga masalah khusus yang mempengaruhi kecekapan routing VANET dapat dipelajari. Kajian pertama berusaha mengoptimumkan parameter konfigurasi penghalaan dalam senario bandar yang berlainan. Model rangka kerja baru diperkenalkan untuk menyediakan komunikasi yang kuat dan dapat diandalkan di VANETs, di mana keseimbangan antara waktu yang diperlukan untuk mempertahankan laluan yang ditemui dan keperluan QoS diperlukan. Kecekapan penghalaan dan kekangan jalan raya berdagang dengan komunikasi lembut laras dieksplorasi dengan menala parameter konfigurasi penghalaan. Rangka kerja statistik berdasarkan keperluan QoS diperkenalkan untuk penyelesaian yang optimum.

Kajian kedua berusaha menganggap peningkatan mekanisme pemilihan geganti dalam tingkah laku dinamik dari mobiliti nod dan perubahan kerap dalam topologi rangkaian. Kekangan rangkaian komunikasi yang dipercayai mengambil kira kesan mobiliti dinamik pada kecekapan laluan, dan kestabilan jalan. Algoritma yang sesuai dipanggil Kestabilan Pautan Pilihan pemilihan Multi Points Relay (LSA-MPR) diperkenalkan bagi mencari laluan yang memenuhi kekangan pada beberapa objektif untuk memilih hop seterusnya sebagai nod geganti yang direka khas untuk VANET, ia mendapati laluan yang memuaskan kekangan ke atas pelbagai objektif berdasarkan Penunjuk Kekuatan Isyarat Diterima (RSSI) dan Isyarat ke Kadar Kebarangkalian Gangguan (SINR).

Kajian ketiga berusaha mempertimbangkan mengurangkan topologi kawalan serta meningkatkan skalabilitas rangkaian. Untuk memberikan keteguhan yang diperlukan, Algoritma Koperasi Adoptive Cooperative (CACA) yang berasaskan Cluster untuk VANET diperkenalkan untuk meningkatkan kebolehan berskala rangkaian dan mengurangkan lebihan kawalan. Sejumlah faktor dipilih untuk meningkatkan mekanisme pemilihan geganti kenderaan; Mobiliti relatif kenderaan, berat kenderaan, kebolehcapaian pautan dan metrik jalur lebar. Ini dianggap mengurangkan kegagalan pautan, mengatasi lebihan dan meningkatkan nisbah penghantaran paket. Cadangan Quality of Path QoP metrik dimasukkan ke dalam algoritma pemilihan geganti yang diubahsuai, yang meningkatkan kecekapan mekanisme pemilihan geganti untuk mencari jalan yang optimum dengan kualiti pautan yang tinggi.

Simulasi yang luas dilakukan untuk menilai sumbangan yang dicadangkan, yang telah dibentangkan berkaitan dengan senario rangkaian bandar untuk menilai prestasi sumbangan yang dicadangkan berbanding dengan pelbagai pendekatan yang sedia ada. Simulasi berasaskan perbandingan kedua-dua protokol dan pengubah suaian dijalankan di bawah parameter prestasi tertentu; Nisbah Penghantaran Packet (PDR), Kelewatan Semula Akhir Ke Akhir (AE2ED), Beban Peralihan Normal (NRL), Bilangan MPR, dan Kestabilan. Hasil simulasi menunjukkan bahawa BOLSR-PSO, LSA-MPR, dan CACA meningkatkan mekanisme pemilihan geganti dan mengatasi kecekapan dalam rangkaian VANET. Tujuan penambahbaikan ini bukan hanya untuk mengekalkan nisbah penghantaran packet, kestabilan dan skalabilitas, tetapi juga untuk mengurangkan lebihan rangkaian, dan kelewatan purata.

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This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Doctor of Philosophy. The members of the Supervisory Committee were as follows:

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LIST OF ABBREVIATIONS

AODV	Ad Hoc On-Demand Distance Vector
AWK	Alfred Aho, Peter Weinberger and Brian Kernighan
BOLSR	Balanced Optimized Link State Routing
CACA	Cluster-based Adept Cooperative Algorithm
CBL	Chain Branch Leaf
CBR	Constant Bit Rate
COOP	Topology Control
D2D	Device-to-Device
E2ED	End-to-End Delay
GSA-PSO	Particle Swarm Optimization Gravitational Search Algorithm
IP	Internet Protocol
LS	Link State
LSA	link Stability Aware
MANET	Mobile ad-Hoc Network
MANETs	Mobile ad-Hoc Networks
MPR	Multipoint Relays
MRLAM	Mobility, Residual energy and Link quality Aware Multipath
NCA	Topology Control
NFA	Topology Control
NRL	Normalized Routing Load
NS-2	Network simulator version 2
OLSR	Optimized Link State Routing
OLSR-LD	Link Defined OLSR
OSM	Open Street Map
PDR	Packet Delivery Ratio
PL	Packet Loss
PSO	Particle Swarm Optimization
QoP	Quality of Path
QoS	Quality of Service
QoS-OLSR	Quality of Service Optimized Link State Routing
RSSI	Received Signal Strength Indicator
SINR	Signal-to-Interference Plus Noise Ratio
SLS	Stable Link Selection
SUMO	Simulation of Urban Mobility
TC	Traffic Category
TCP	Transmission Control Protocol
UDP	User Datagram Protocol
V2I	Vehicle-to-Infrastructure
V2V	Vehicle-to-Vehicle
VANET	Vehicular ad-hoc network
VANETs	Vehicular ad-hoc networks
Wi-Fi	Wireless Fidelity

CHAPTER 1

INTRODUCTION

This chapter provides a background and an overview of ad-hoc routing protocol in Vehicular ad-hoc network (VANET), identifies the research problems and motivation. It also presents the research objectives, describes the scope of this research. Furthermore, this chapter highlights the research significance, justifies the benefits, and clarifies the implications of this research. Finally, this chapter summarizes with the organization of the thesis.

1.1 Background

A VANET is a collection of mobile nodes connected by wireless links to form wireless ad-hoc network. Mobile nodes are free to move randomly and can communicate with each other and act as a router to exchange information on behalf of other vehicles. In fact, VANET is a special case of a Mobile Ad hoc Networks Mobile ad-Hoc Network (MANET) [5] [6] with high mobility, self-organization, infrastructure-less in which vehicle nodes move randomly and organize themselves arbitrarily without relying on fixed infrastructure [7]. Hence, each node seeks the assistance of its neighbouring nodes when forwarding packets. Wireless ad-hoc mobile networks support many applications in various fields, particularly emergency and safety application [8]. Vehicular network is developed to provide a low-cost communication with significant features to support different type of communication and applications [9]. Vehicular network consists of Vehicle-to-Infrastructure (V2I), Vehicle-to-Vehicle (V2V), Device-to-Device (D2D)) and hybrid combination supported by wireless access technologies such as IEEE 802.11b and IEEE 802.11p [10, 11].

Many real-time and safety applications in vehicular communication require the assistance of multi-hop communications. Therefore, the concept of multi-hop ad-hoc networks is expected to be the primary mode of communication in VANETs, especially with technological advances realized in the field of the fifth generation (5G) communication technology [12] [13]. It can be utilized for a diversified set of applications that need high speed, high reliability, and rapid response. However, VANETs have some unique characteristics compared with mobile ad-hoc networks. The network topology which is highly dynamic due to fast movement of vehicles and the topology is often constrained by the road structure. Furthermore, the obstacles such as traffic lights, buildings, or trees reduce significantly the communication quality and connectivity. The communication links exist between vehicles is shortly lived and frequent link breakage happened frequently which lead to unstable network topology. One of the main challenges in Vehicular ad-hoc networks (VANETs) is the routing protocol in which several techniques and methods were introduced to resolve the routing issue in VANETs [14].

Finding a reliable, stable, robust, and optimal path via vehicular multi-hop network is a fundamental task. To successfully deliver packets to their desired destination, it should consider the mobility constraints as well as road obstacles when designing routing protocols. Several techniques are introduced to find the most appropriate path to a given destination [13] [15] [16] [17]. Some routing protocols use flooding control messages technique to allow nodes to communicate with each other and maintain their routing tables and remain updated, while the others techniques allow node to initiate a route discovery process using geographical location concept to route packets to their destination. Thus, designing a routing protocol that provides stability and reliability in VANET is a key factor for support most safety applications. In other word, routing protocol should guarantee delivering a high percentage of data packets to their target destinations within minimum end-to-end delay and the lowest cost possible.

In order to support many applications with different Quality of Service (QoS) requirements, the key factors that should be taken into account when designing routing protocol are tuning routing configuration parameters, frequent link failure, and routing scalability [18] [19] [20] [21] [22] [23] [24]. Another aspect to be considered when designing the routing protocol to suit VANET environment is the mobility constrains and road obstacles [25] [26]. Furthermore, the vehicle distance, density and speed have a significant impact on the network connectivity of VANET, this rapidly change the topology in the network resulting in a weaker performance of the route selection mechanism [27].

In VANETs, the data traffic is dynamically exchanged by wireless technology according to the characteristics of speed and location of vehicles to sense the quality of links connectivity and calculate routing cost. However, the high dynamic mobility and frequent link failure are actually the main factors to design and deploy an efficient routing protocol that guarantee QoS constraints. Designing routing protocol that cope with high mobility and bandwidth constraints faces many particular challenges as follows:

- In VANETs there are many routing protocol heavily based on the flooding approach which are without any central organization, it support a wide range of VANET applications such as safety, security, and dissemination applications. These attributes will inevitably bring a broadcast storm especially in high vehicles density network, the gathering and exchange data about road traffic has a great impact on the stability, scalability of the network.
- VANET has to cope with unfavourable wireless communication characteristics; the limitations of the communication range, roadside infrastructure or long distance connection should be taken into consideration when designing routing protocol.
- The highly dynamic changes in network topology of VANET due to mobil-

ity of vehicles, the transmission management events makes it hard, resulting in frequent link failures and packets collision.

1.2 Motivation

VANETs become a major research motivation for Intelligent Transportation System (ITS) academic developers. This is because of its low-cost constructions, high effectiveness and wide variety of applications. These features beside the concept of multi-hop ad-hoc networks are expected to be the primary mode in the field of the fifth generation (5G) communication technology [28]. However, establishing an adaptive and efficient routing paths for routing packets correctly to a given destinations in VANET environment is a complex task [29]. The unique characteristics of VANET limits the efficiency of routing protocols to find the available routes in such network. Vehicles have a dynamic behaviour, high mobility, speed and direction that make routing a very challenging issue. The vehicle in VANETs are limited to road layout while moving, and the existing communication links lifetime between vehicles is shortly lived [30] [31].In VANETs, the robust, stable and reliable routing is a major issues. In order to make routing protocol more suitable for VANETs, the issues of dynamic behaviour, mobility, speed, and distance are to be taken into consideration when designing routing protocol.

Optimized Link State Routing (OLSR) [32] protocol is considered to be an efficient routing protocol designed especially for mobile multi hop wireless ad-hoc networks. The differences in mobility models and communication environments between Mobile ad-Hoc Networks (MANETs) and VANETs, makes the current MANET routing protocols inefficient and unreliable to satisfy the requirements of VANETs applications. In OLSR, to maintain routes to all nodes within two-hop set, we need to exchanged routing topology information periodically which is the technique's weakness. The rapid changes in VANET network topology makes proactive routes invalid quickly. Furthermore, establishing routes based on geographic position aware technique could leads to frequent path breakage due to the vehicle mobility. This is particularly notable when nodes are located closely to the sender communication border [33]. Guaranteeing a fully symmetric and connected path between the sender and the receiver is a basic requirement for routing packet successfully in moderate mobility such as MANET. In the case of high dynamic network topologies such as VANET, route selection mechanism of routing protocol should be adapted to satisfy connectivity probability, QoS requirements, and scalability constraints; such as minimum routing cost, delay of high packet delivery ratio.

Obviously, the limited bandwidth can easily induce network congestion because of the higher traffic loads and reduce the efficiency of forwarding data packets. Thus in this thesis, it is important to take into consideration cross-layer parameter to improve the performance of route selection mechanism in high dynamic mobility. Reducing control messages overhead and alleviating network congestion in VANETs are also critical challenging issues that need to be addressed. In addition, adaptive route selection mechanism in VANET is an important factor to ensure a stable and scalable routing protocol.

1.3 Problem Statement

In order to guarantee the routing packet correctly, the routing protocols should have correct and sufficient and information about the network topology. Each node used this information to compute routes to all destinations in the network. If the mobility of the nodes is high, the network topology frequent changes and the node has to be updated routing information in order to reflect the topology changes and ensure the stable route. In the case of the OLSR protocol, the nodes need to detect link changes quickly and broadcast topology updates with little delay. The neighbor detection and topology dissemination are done mainly through exchanging messages between nodes. However, In a highly dynamic network, routing protocols should consider the mobility issues which affect the transmission range between two devices and change routes dynamically. When a device moves, it may cause link failure that increases packet loss as well as the number of retransmission packets. Mobility has a great impact on many factors such as routing, channel access and applications.

During the last decade, more and more research is dedicated to studying the suitability of MANET routing protocol studied [34], [35], [36], [37], and to enhance the efficiency of MANET protocols to deal with high mobility of nodes, random topology, and heterogeneous networks [38]. The realistic mobility environments used to evaluation of MANET routing protocols in the high dynamic network such as VANET network [39], Therefore, the Mobility is an important factor in wireless networks, it represents the movement of mobile nodes and how their speed and direction are changed over time.The network simulation can be processing the mobility model in two different ways: using real experiments traces fails that obtained from real events, using the statistical characteristics obtained from generating synthetic. In a highly dynamic network, there is no one single routing protocol that meets all requirements high-speed mobility. Thus, we choose OLSR in our simulation protocol due it features. MANET protocol suffers from frequent route failure problems, an increase in the size of the routing table, packet overhead problems, signal blockage, and additional time required during the route discovery process.

In the present thesis, we face the OLSR efficiency problem in a highly dynamic network, which deals with the optimization of the main OLSR functionality [1], by means of three different optimization techniques (optimal configuration parameters, Optimal physical communication distance, and clustering-based routing selection). These issues should be taken into consideration when adapt routing protocols for a highly dynamic network. To address the challenges of routing protocol, the traffic flow, traffic density, and initial distribution should be defined in order to study the mobility impact on the routing performance, especially in terms of packet delivery ratio, packet loss, and terms of throughput. Despite its fundamental importance, there is still no comprehensive study on the adaptation of MANET routing functionality in which take into consideration the high dynamic network constraints. In particular, the following problems have not been well addressed together in previous studies:

In such networks, the unique characteristics of of high dynamic network presents a new set of essential challenges, which reduce the efficiency of routing protocol to find a feasible route that meets the predefined QoS requirements. The network topology changes rapidly due to high dynamic network and road constraints, where the periodic interval time, route process, and route computing could be really short to guarantee the communication reliability and stability of network topology. OLSR Protocol is a best-effort routing protocols adopted based on QoS requirements to work well in MANETs. This protocol is usually adapted by using tuning routing configuration parameters. However, most of the proposed work adapted this OLSR protocol based on specific QoS performance metrics such as End-to-End Delay (E2ED) or Throughput metric which thereby will affect other QoS performance in the network. The problem arises when more frequent link disconnection occur rabidly which lead to increase routing cost rabidly. Thus, using all QoS performance metric to tune global performance of the network is a vital issue to guarantee an efficient routing protocol in term of throughput, packet delivery ratio, delay, overhead, and packet loss in in high dynamic network. Since optimizing routing configuration parameters without using automatic intelligent technique very difficult, it is due to the enormous number of solution possibilities (NP-problems).

Most of the MANET and VANET applications critically rely on the efficiency of routing protocols. In the moderate wireless network with specific link state information, OLSR usually ensures that all nodes at all times have sufficient and correct topological information in order to compute routes to all destinations in the network, each node maintains routing information to every other node in the network using the link-state algorithm. Thus, an optimal routing strategy that makes better use of resources is crucial to deploy efficient routing that actually works in volatile networks. In OLSR, link reachability is one of the most important factors used to guarantee the stability of the routing. However, in a highly dynamic network, the stability of the communication links between nodes is affected by high mobility. The network topology may also change frequently, Moreover, the reliability and stability of the link could be often interrupted due to the dynamic nodes movement, various road patterns, and much more obstacles such as buildings and trees. So, the nodes can not adjust their transmission range and reception parameters to guarantee successful packet reception. The routing functionality such as Multipoint Relays (MPR) can not overcome this issue without considering the stability of links based on nodes mobility constraints, and geographical information. Networks with high link failure suffer from routing overhead and highest E2ED. This is because routing cannot ensure timely and reliable delivery of messages. If more network topology information and additional mobility metrics are available, The mobility information, node status, and link status can used by the nodes to adjust their transmission range and reception parameters to make better routing decisions and guarantee successful packet reception. Thus, a reliable and stable route is a fundamental issue in these networks.

The scalability of MANET is related to the efficiency of the routing protocol in adapting to frequently changing network topology and link status. OLSR propagate periodic topology messages to advertise topology changes and maintaining the routing table for all the possible routes, it depend on the native the cluster-based multipoint relay selection scheme to reduce the size of Traffic Category (TC) messages through routing discovery phase. Moreover, the native cluster-based OLSR protocol has two limitations. First, the simple mechanism of MPR selection which chosen the set of relay nodes arbitrarily without taking into account the bandwidth and the quality of link reachability metrics. The second limitation arises during the selection process which leads to elect nodes with a minimum number of two-hop link reachability. The native cluster-based cannot ensure the scalability of OLSR in the large network with high mobility. The absence of high mobility factors in the relay selection mechanism reduces the quality of route selection, the nodes in the network cannot announce itself as a mobile node to be elected as cluster head node or selected as MPR node. The source node uses additional control messages overhead to provoke network congestion.

1.4 Research Objectives

The overall aim of this thesis is to optimize the efficiency of OLSR routing protocol in MANET. To support a wide range of applications, routing protocols of MANETs must be able to efficiently transmit packets to related destinations. In order to cope with the challenges described in section one, we study the most important and existing issues as well as strategies associated with MANET routing protocols to understand their principles and operations. This will help in understanding some of the available optimization techniques that are used to identify the related issues of ad-hoc routing protocols for dynamic environments. The goals of this research is addressed through the following objectives:

- To design statistical framework model to optimize the OLSR configuration parameters performance inin high dynamic network, which define a number of QoS performance metric parameters based on accurate statistical communication cost. This communication cost function is defined to describe the statistical result obtained from the a number of vehicles communication at each scenario. The intelligent swarm technique is incorporated to process the communication cost and to provide the optimal solutions for enhancing the efficiency of routing protocol in high dynamic network.

- To develop a new metric to reduce the influence of both mobility and link failure factors named A link Stability Aware (LSA) metric. This metric taking into account a number of factors as a metric to guarantee the stability of the link connection. A cross-layer interactive knowledge in terms of Signal-to-Interference Plus Noise Ratio (SINR), Received Signal Strength Indicator (RSSI) are using to enhance the quality of nodes mobility knowledge, the packet loss, optimal communication distance, quality of the link, and optimal zone position are using as parameters. This metric is incorporated into the MPR scheme beside the ordinary minimum hop count metric and Willingness function to allow OLSR functionality to guarantee the reliability and stability of the communication link in a highly dynamic network.

- To adapt and develop the native clustering of MPRs relay selection algorithm of OLSR protocol based on the trade-off between high dynamic mobility constraints and QoS requirements. The aims of the proposed algorithm is to minimize the control packet overhead by establishing a minimum hop path. A new Cluster-based Adept Cooperative Algorithm (CACA) for VANET is introduced based on a novel route metric designed with the purpose of allowing routing functionality to find path with the maximum bandwidth. The Quality of Path (QoP) metric designed to improve the scalability of the network by reducing the amount of control packet overhead significantly and to avoid the collision caused by the cluster-head transmission of MPR nodes.

1.5 Research Scope

The scope of this thesis is to focus on several aspects of routing protocol in mobile networking and, in particular, on methods for improving routing selection and reducing control messages overhead in high dynamic environments. The target of this thesis focuses on adapting MANET OLSR routing protocol for a deal with a high dynamic network by; Firstly, designing an optimization framework to provide an efficient routing protocol by tuning MANET OLSR configuration parameters. This optimization carried out by means of three main parts: a simulation procedure, statistical communication cost functions, and an optimization algorithm. Secondly, the cross-layer parameters are taken into consideration when defining a new metric for selecting a reliable and stable path in high dynamic network environments. The MPR scheme is adapted by incorporate the new metric in order to enhance the reachability and connectivity in the network. Thirdly, a new Cluster-based Adoptive Cooperative Algorithm is designed to minimize the control packet overhead by establishing a path with the minimum hop. The performance evaluation for route constructions is taken into account in order to study the scalability behavior of our proposed protocol under mobility and road constraints.

1.6 Research Significance

Routing plays a very important role in the overall performance of any network. The concept of beaconing in wireless ad-hoc network is the main key factor usually used to maintain routes which is expected to have a major role in fifth generation (5G) system to support safety applications [12]. The new advantages features of wireless Wireless Fidelity (Wi-Fi) communication in MANET has opened the field of green network for the researchers and designer to develops MANETs routing protocol for high dynamic network. According to the issues, adapting routing techniques in several MANET routing protocols still provide an acceptable performance, which fails to represent the efficient solutions for the varying urban challenges. Several approaches are introduced to optimize the performance of routing protocol in VANETs routing in recent years, in which the performance of most of these protocol primary relays on the type of traffic information. However, limited link lifetimes, high vehicle velocity, and frequent network partitions have an adverse impact when providing accurate traffic information making it a challenge. This ignores a significant number of viable route selection parameters and forwarding options. Optimizing routing protocol using intelligent techniques and cross-layer interactive knowledge are strongly considered, especially in a topology-based routing protocols. This is due to their high performance and low complexity overhead, which observe the quality of link in different mobility communication condition. This significantly enhance routing decision-making and offer a superior network performance.

1.7 Thesis Organization

A brief background and motivation of the research are presented in this chapter, as well as the research problem, significance, objectives, and research scope. Furthermore, the rest of this thesis is organized as follows.

In chapter 2, we introduce OLSR routing protocol in multi-hop wireless ad-hoc network and presents the scheme of multipoint relay selection mechanism issues as well as the Willingness functionality modes. It also shows the related works that address the MPR relay schemes based on our overview. In addition, it shows several related research studies that address different relay selection and prioritizing algorithms. Finally, comparison of different MPR selection schemes and some route selection metric issues are also presented.

Chapter 3 presents and identifies the definitions and the performance analysis strategies, research framework, and the proposed discrete event simulator that is used in this research. The experimental set-up and topologies as well as the performance metrics and validation of the model have been presented in this chapter.

In Chapter 4, we describe and explain in details the configuration parameters, and the range of each parameter to improve mobile network in MANET and VANET. It starts with addressing the impact of vehicles mobile and road obstacles on the the efficiency or routing parameters. Then, it describes the OLSR configuration parameters including the problem formulation, and provides a new definition of communication weight in terms of node connectivity and communication cost. It also presents statistical framework optimization design to calculate the communication cost. Finally, it provides an extensive performance evaluation of Balanced Optimized Link State Routing (BOLSR) and comparing it with the existing approaches and show its viability.

Chapter 5 presents the link Stability Aware LSA metric which developed to reduce the influence of both mobility and link failure factors on the efficiency of route selection mechanism. This mechanism is using cross-layer interactive knowledge. The existing MPR selection scheme is adapted to deal with LSA metric in which reduces the probability of link failure and packet loss. Finally, provides an extensive performance evaluation of LSA-MPR and compares it with the existing approaches demonstrating that the scheme improves the stability of the network.

Chapter 6 presenters a novel cluster-based Adept Cooperative Algorithm (CACA) for VANET. First, it describes the details of CACA algorithm, followed by introducing the quality of path metric which is developed based on cluster-based QoS approach that take into account the optimal distance and mobility factors. This is followed by relay selection metric to avoid choosing a path the suffers from overhead caused by link failure and link congestion. The CACA algorithm is evaluated through extensive simulations and demonstrate that the algorithm improves the scalability of network by an efficient selection of optimal relay vehicles. The Quality of Path (QoP) metric designed to improve the scalability of the network the amount of control packet overhead significantly and to avoid the collision caused by the cluster-head transmission of MPR nodes.

Finally, a conclusion of the whole thesis with some suggestions, limitations and potential future work are given in chapter 7.

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