UNIVERSITI PUTRA MALAYSIA

NEIGHBOR-BASED ON-DEMAND ROUTING ALGORITHMS FOR MOBILE AD HOC NETWORKS

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By

ALI MOHAMED E. EJMAA

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

November 2017

DEDICATIONS

To my parents, my lovely wife, my wonderful kids, my brothers and my sisters.
To my supervisor and entire committee.
Last but not least, I would like to dedicate this thesis to my beloved motherland, LIBYA.
And to All whom I love.

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

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Chairman: Prof. Shamala Subramaniam, PhD
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Mobile Ad hoc NETwork (MANET) is a set of wireless mobile nodes temporary connected without existing network infrastructure or centralized administrations. These nodes with random movement and limited resources have created quite a number of new challenging research issues. One such issue is the routing, which has recently received significant attention from many researchers. In particular, the problems of the dropping decision, routing overhead and network density in the route request stage.

The routing overhead is due to the broadcasting method used in route discovery, which floods the network with a Route REQust message (RREQ). Accordingly, the aim of this research is to address the deficiency of the broadcasting method at route request stage.

To overcome the issues related to the broadcasting method, several routing algorithms have been proposed over the Ad hoc on demand Distance Vactor (AODV) such as Neighbor Coverage-Based Probabilistic Rebroadcast (NCPR). Although the NCPR did overcome the AODV routing algorithm in terms of reducing the routing overhead, such algorithm has its drawbacks. Thus, there is a room for further enhancement to develop a routing algorithm as to mitigate the drawbacks with the NCPR.

The dropping decision of the redundant RREQ in the NCPR algorithm completely relies on preset variables, such variables require to be set by the system administrator based on the scenario. Unfortunately, the setting which is proper for a specific scenario is not suitable for another. Furthermore, the connectivity

factor which is used to estimate the connectivity ratio at each node is still unable to estimate such ratio accurately. Therefore, a Dynamic Connectivity Factor Probabilistic (DCFP) is proposed, based on a novel formula that dynamically adjusts the dropping decision based on the neighbor information gathered from the node itself.

As the number of nodes or the network traffic load increases, the NCPR fails to relieve the routing overhead due to the increase in the RREQ redundant messages. Thus, a Scalable Neighbor-Based Routing algorithm (SNBR) is proposed, which reduces the routing overhead in the NCPR, by eliminating the redundant RREQ. The broadcasting in this algorithm is governed by the inverse relation between the number of neighbors and the probability of the rebroadcasted RREQ messages. This algorithm enhances the network performance, even though the network is experiencing an increase in the number of nodes or traffic load.

Naturally, nodes in MANET are free to move forming an arbitrary topology and at any time the network density may change . Such change may lead to an extreme performance degradation, especially when the routing algorithm relies on fixed threshold values in the dropping decision. Accordingly, a Novel Density-Aware Routing algorithm (NDAR) is proposed. The proposed algorithm totally eliminates the need for fixed threshold values through the use of a novel formula that can easily estimate the node density and replace the fixed threshold value based on the neighbor information.

All the three proposed algorithms are evaluated using discrete event simulation, in particular Network Simulator tool (NS2), and compared with the latest routing algorithm (NCPR) and fundamental algorithm (AODV) using five performance metrics. The first algorithm DCFP outperforms the NCPR algorithm in terms of normalize routing overhead by 11.27%, while maintaining the same packet delivery ratio. In addition, with regard to the second algorithm SNBR, the results show that SNBR overcomes the NCPR algorithm terms of normalize routing overhead by 58.80% as its due to its dropping factor. Furthermore, the third algorithm NDAR presents further enhancement and better performance in all five performance metrics as compared to NCPR and AODV algorithms in a low or high density of nodes. In terms of the applications, The DCFP is more suitable to be used for education applications, while the SNBR is a good algorithm designed to be used for rescue system as data and energy is the main concern. Finally, the NDAR is more suitable for personal area and home networking.

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

ALGORITMA PENGHALAAN BERASASKAN PERMINTAAN NOD BERSEBELAHAN UNTUK RANGKAIAN AD HOC MOBILE

Oleh

ALI MOHAMED E. EJMAA

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Rangkaian Mobile Ad Hoc (MANET) adalah satu set rangkaian bergerak tanpa infrastruktur rangkaian atau pengurusan terpusat tersedia. Pergerakan nod rangkaian MANET yang rawak dan mempunyai had sumber telah menimbulkan pelbagai isu dan cabaran baru dalam penyelidikan. Salah satu isu yang menjadi tumpuan penyelidik adalah berkenaan bidang penghalaan (routing) dalam rangkaian komputer. Di antara topik yang menjadi tumpuan adalah permintaan penghalaan rangkaian komputer yang meliputi peringkat pembuatan keputusan pengguguran paket rangkaian, overhed dan permintaan routing paket rangkaian. Kaedah penyiaran rangkaian yang digunakan untuk mendapatkan laluan dengan memenuhkan rangkaian menerusi Route REQest message (RREQ) telah menyebabkan berlakunya overhed. Oleh yang demikian, tujuan penyelidikan ini adalah bagi menangani masalah kekurangan kaedah penyiaran rangkaian tersebut pada peringkat permintaan routing.

Beberapa algoritma routing telah diperkenalkan ke atas protokol Ad Hod On Demand Distance Vector (AODV) bagi menyelesaikan isu berkaitan kaedah penyiaran rangkaian ini. Di antaranya adalah algoritma Neighbor Coverage-Based Probabilistic Rebroadcast (NCPR). Kaedah NCPR telah berjaya mengatasi algoritma AODV dengan mengurangkan overhed kepada routing. Walaubagaimanapun, terdapat kekurangan pada algoritma tersebut. Sehubungan dengan itu, masih ada ruang yang boleh ditambahbaik kepada algoritma NCPR. Di dalam algoritma NCPR, keputusan untuk menggugurkan mesej RREQ yang berlebihan adalah bergantung sepenuhnya kepada pembolehubah yang telah diprasetkan. Pentadbir sistem akan memprasetkan pembolehubah tersebut bergantung kepada senario. Malangnya, ada tetapan yang telah dibuat hanya sesuai untuk satu senario dan tidak boleh dilaksanakan untuk senario yang lain. Tambahan pula, faktor penyambungan yang digunakan dalam pengiraan anggaran nisbah sambungan di setiap nod rangkaian masih

tidak dapat dianggar dengan tepat. Dengan itu, satu algoritma yang novel diperkenalkan, menggunakan formula yang disesuaikan dengan keputusan menggugurkan nod bersebelahan secara dinamik, dan berasaskan maklumat nod bersebelahan yang dikumpulkan daripada nod induk tersebut. Algoritma ini dipanggil neighbor-based Dynamic Connectivity Factor Probabilistic routing Algorithm (DCFP).

Algoritma NCPR gagal untuk mengurangkan overhed routing apabila bilangan nod atau beban trafik rangkaIan meningkat. Ini disebabkan oleh peningkatan mesej yang belebihan dalam RREQ. Oleh itu, algoritma Scalable Neighbor-Based Mobile Routing Algorithm (SNBR) diperkenalkan. Algoritma ini telah dapat mengurangkan kos overhed routing dalam NCPR menerusi penyingkiran mesej RREQ yang berlebihan. Kaedah penyiaran dalam algoritma ini ditadbir melalui hubungan yang ditukar antara bilangan nod bersebelahan dengan kebarangkalian penyiaran semula mesej RREQ. Algoritma ini telah berjaya meningkatkan prestasi rangkaian, walaupun dalam situasi rangkaian tersebut menerima peningkatan bebanan trafik dan nod rangkaian.

Nod rangkaian dalam MANET yang boleh bergerak bebas secara semulajadi mewujudkan topologi yang tidak menentu. Ekoran itu, pada setiap masa, ketumpatan rangkaian boleh berubah. Perubahan ini boleh menyebabkan penurunan prestasi secara mendadak terutama, dalam situasi algoritma routing bergantung kepada fixed threshold value untuk keputusan menggugurkan nod. Oleh yang demikian, algoritma Density-Aware Routing Algorithm (NDAR) diperkenalkan. Algoritma ini telah menyingkirkan sepenuhya keperluan fixed threshold value menerusi penghasilan satu formula yang novel. Formula ini dengan mudah dapat menganggarkan ketumpatan nod seterusnya menggantikan fixed threshold value berasaskan maklumat daripada nod bersebelahan.

Ketiga-tiga algoritma yang diperkenalkan dinilai menggunakan kaedah simulasi discrete event simulation. Secara terperincinya, proses penilaian tersebut menggunakan alat simulasi dikenali NS2 Tool. Kesemua algoritma tersebut kemudiannya, dibandingkan dengan algoritma NCPR yang terkini dan algoritma AODV yang asas menggunakan lima metrik prestasi. Algoritma pertama, DCFP telah mengatasi algoritma NCPR untuk metrik normalize routing overhead sebanyak 11.27% di samping mengekalkan nisbah penghantaran paket. Untuk tambahan, algoritma kedua, SNBR juga telah mengatasi algoritma NCPR bagi metrik yang sama sebanyak 58.80% disebabkan faktor pengguguranya. Tambahan pula, algoritma ketiga, NDAR menunjukkan penambahbaikan berterusan dan peningkatan prestasi dalam lima metrik yang diuji berbanding dengan algoritma NCPR dan AODV sama ada dalam kapasiti nod yang tinggi atau rendah ketumpatannya. Dalam aspek penggunaan, algoritma DCFP adalah sesuai diaplikasikan dalam rangkaian pendidikan manakala SNBR pula sesuai direkabentuk dalam rangkaian sistem penyelamatan di mana data dan tenaga adalah sebagai pertimbangan utama dalam rangkaian sistem tersebut. Akhir sekali, algoritma NDAR pula sesuai diaplikasikan dalam rangkaian persendirian.

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LIST OF ABBREVIATIONS

AODV	Ad hoc On-demand Distance Vector
BSP	Broadcast Storm Problem
CBR	Constant Bit Rate
DA	Density Aware formula
DAF	Dynamic connectivity-Aware Factor
DCF	Dynamic Connectivity Formula
DCFP	Dynamic Connectivity Factor Probabilistic
DDF	Dynamic Density Factor
DSDV	Destination-Sequenced Distance Vector
DSR	Dynamic Source Routing
DYMO	Dynamic MANET On-demand
FANET	Flying Ad hoc NETwork
Fc	Connectivity Factor
FONIAH	Flooding based on One-hop Neighbor Information & Adaptive Holdinglong
FP	Forwarding Probability
FSR	Fisheye State Routing
GPS	Global Positioning System
IHU	I Heard You
IOS	International Organization for Standardization
IoT	Internet of Things
LAR	Location-Aided Routing
MANET	Mobile Ad hoc NETwork
MANETs	Mobile Ad hoc NETworks
MPRs	Multi-Point Relays
NCPR	Neighbor Coverage-based Probabilistic Rebroadcast
NDAR	Novel Density-Aware Routing algorithm
NS-2	Network Simulator 2
OLSR	Optimized Link State Routing
OSI	Open Systems Interconnection
RAD	Random Assessment Delay
RERR	Route ERRor
RREP	Route REPly
RREQ	Route REQuest message
SAPF	Speed Adaptive Probabilistic Flooding
SLURP	Scalable Location Update Routing Protocol
SNBR	Scalable Neighbor-Based Routing algorithm
TC	Topology Control
UDP	User Datagram Protocol
VAN	Vehicle Area Network
VANET	Vehicular Ad Hoc NETwork
WRP	Wireless Routing Protocol
WSNs	Wireless Sensor Networks
ZRP	Zone Routing Protocol

CHAPTER 1

INTRODUCTION

The field of wireless communication is witnessing an unprecedented growth in the scale and diversity, and becoming more popular than ever before. This is due to the proliferation of wireless data communication technologies and low cost mobile devices (Ayyash et al., 2015). Currently, there are two major approaches for wireless communication either based on an established cellular network infrastructure or organize an arbitrary and temporary ad hoc network among all mobile nodes interested in communicating with each other. The major challenge of the former approach is that such networks are limited to places where there is an existing cellular network infrastructure. In contrast, the second approach can be establish without constrains at any place and time (on-demand).

The continuous progress in wireless communications has led to new research trends, which enable wireless networks to be highly deployed in daily life. Mobile Ad hoc NETwork (MANET) is the most promising field of ad hoc networks. MANET is one a self-organized network with arbitrary distributed nodes (Ayyash et al., 2015). MANET has witnessed rapid development due to its ability to work along with different wire and wireless network such as Wireless Sensor Networks (WSNs) or Internet of Things (IoT). By using a unique sentence, while WSNs are networks of things, MANETs are networks of people: they are dynamically formed and allow people in a restricted area to send, receive, and share data, without the need of either infrastructure or centralized support (Bellavista et al., 2013).

Moreover, MANET is widely recognized with its low cost, diversity, and simplicity of its mobile devices. Such devices can form a reliable network in a short time for use as a rescue information system after a natural disaster such as fire, flood, or earthquake, at which the communication infrastructure may no longer be available or accessible. After a natural disaster, MANET is the preferable available option of wireless networks since such network could be easily configured in a short period without need for fixed infrastructure network. Vehicular Ad Hoc NETwork (VANET) are a particular case of mobile ad hoc network where it can effectively be considered a subset of MANETs, in which mobile nodes are vehicles.

Furthermore, with a view to serving different types of applications, MANET has potential to work along with varied types of networks, such as VANET, Flying Ad hoc NETwork (FANET), cellular networks or the Internet as shown in Figure 1.1 (Carvalho et al., 2016). Indeed, the applications of MANETs are diverse. These applications are not limited to areas such as emergency and crisis management, but also local level, commercial and military battlefield applications (Ayyash et al., 2015).

Figure 1.1: Mobile Ad Hoc Network

1.1 Applications of MANET

The set of applications of MANET is varied, ranging from small, static networks that are constrained by power sources, to large-scale, mobile, highly dynamic networks. In fact, MANET as a network is popular, since it is easy to be configured in a short time (NIST, U.S, 2016). In addition, due to the fast growth and diversity of mobile devices, and the massive demand on media sharing through mobile devices, MANET becomes the most efficient network to be used by a considerable number of applications such as:

- **Mobile conferences**: MANET enable mobile conferencing for business users, who need to collaborate outside their office, where no network infrastructure is available. There is a growing need for mobile computing environments, where different members of a project need to collaborate on design and development.
- **Personal area and home networking**:MANET are quite suitable for home as well as personal area networking applications.
- **Education Network**: mobile ad hoc network has potential to form a network to be used in classes, to share files or Internet connection.
- **Crisis Management Network**: this network can be used to provide an application for crisis management system after natural crises took place, at which the infrastructure communication is entirely destroyed or no longer available as depicted in Figure 1.2.
- **Military battlefield applications**: MANETs were mostly created for military purposes and applications (Rajabhushanam and Kathirvel, 2011). In these situations, the importance of ad hoc networking stems from main-

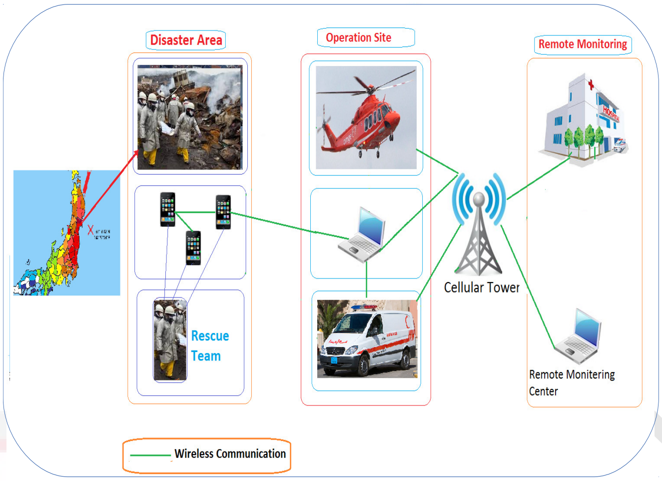

Figure 1.2: MANET Applications

taining an information exchange network among the soldiers, vehicles, and military information headquarters(Ayyash et al., 2015).

1.2 MANET Constraints

Despite the advantages that the MANET network offers, it has some constrains that are presented as follows:

- **Dynamic Topology:** naturally, node are mobile and free to move at any time to random places. This would add some issues in providing good performance and reducing from the link breakage.
- **Limited Resources:** such network is known with its finite resources in terms of bandwidth and energy as result of mobility requirements.
- **Self-organized:** nodes in this kind of network are independent and they must track and collect neighborhood information during the connection time. Nodes may work as host or route at any time.
- **Multi-hop routing:** in MANET, nodes communicate with each other through single or multi-hop routing protocols in order to deliver data packets from a source to destination(Ayyash et al., 2015). Route may change and no longer available during the transmission time.
- **Distributed function:** due to the infrastructure-less nature of MANET, the control management of the network is distributed among the mobile nodes. Therefore, nodes involved in a MANET should collaborate amongst each other to implement routing and distributed functions. These distributed

functions include distributed coordination function (DCF), point coordination function (PCF), and a modified PCF to operate over infrastructure-less networks by combining the operation of both DCF and PCF.

- **Varied link-capacity:** as the nodes are mobile nodes, the link are share among the nodes in the same area, accordingly they may compete to send their date and makes from such link vary in from at different time.

- **Security:** wireless links used in MANET are more susceptible to attacks than the wire link. Wormhole attack is most threatening security attack in ad hoc network where an attacker node receives packet at one location and replay them at other location which is remotely located far (Kaur et al., 2017)

As mentioned previously that nodes in MANET are free to move at any time in the absence of central control, the routing becomes one of the most challenging issues (Saleh et al., 2017). Moreover, such network has limited resources such as battery lifetime and bandwidth. As consequence, each type of network must probably choose the most suitable routing algorithm, in order to efficiently serve its applications to gain the optimum possible performance with available resources. The next section provides an overview of different types of the routing protocols and the MANET's routing protocols.

1.3 Routing Protocols

Routing protocols can be classified into three main groups: reactive, proactive, and hybrid based on the routing information gathering. Although there are some other classifications of the routing based on different approaches , these are out of the research scope. Such as multicast initiator, multicast topology, core or coreless, network maintenance method, dependency on unicast routing protocol and reliable multicast routing (Ghasemi and Bag-Mohammady, 2012).

In the reactive routing protocols, the route to a certain destination is discovered only when it is required, outdated, or invalid. Such routing protocols have low routing overhead and fewer storage requirements. In contrast, in the proactive routing protocols, the data delivery latency is low, since the path information is readily available. However, in the proactive routing protocols, there is an extra routing overhead due to a frequent update of the routing table. Moreover, the routing table size increases as the size of the network increases. On the other hand, in the hybrid routing protocols, the data is sent to a central entity (node) that can further process the received data and discriminated accordingly(Al-Karaki and Kamal, 2004). Saeed et al. (2012) has added another category to previously routing protocols groups. From their point of view the the routing algorithms are classified depending on the packet casting type, either unicast or multicast.

In Mobile Ad hoc NETworks (MANETs), reactive routing protocols are the most used and preferable due to their low overhead and the natural characteristics of these networks, such as low battery lifetime and limited bandwidth. Although, in last few years, there are many researches and work have been done on (MANETs) routing, there are still some challenges and issues because of the limited resources and mobile characters of such networks. Due these mentioned reasons, to design an effective and intelligent routing algorithm is still a challenge in (MANETS) (Chauhan and Sharma, 2016). In fact, the easiest and the most effective method for many routing algorithms at difference stages, is the broadcast method which is discussed in detail in the following section.

1.3.1 Broadcast in MANET

Generally, broadcasting is the distribution of audio and/or video content or other messages to a dispersed audience via any electronic mass communications medium, but typically one using the electromagnetic spectrum (radio waves), in a one-to-many model (Peters, 2012).

Broadcast at the physical layer can be based on two transmission approaches; the one-to-all and one-to-one approach. In the first one, the broadcasted message is sent to all nodes or neighbors within the transmission range of any node, while in the second approach, the broadcasted message is sent to only one node within the transmission range of any node. However, in this thesis, the one-to-all approach is used.

In contrast, at the network layer, broadcasting is considered as an indispensable method for numerous routing protocols such as Ad hoc On-demand Distance Vector (AODV), (Perkins et al., 2003) and Dynamic Source Routing (DSR)(Johnson et al., 2007).

Basically, the tradition and the straightforward mechanism to send data between nodes in a considerable number of routing algorithms is the broadcast (flooding), in particular, the route discovery stage, where the Route REQuest message (RREQ) message are broadcasted to almost all neighbors of the forwarding node as shown in Figure 1.3. Such mechanism definitely guarantees a great reachability at the cost of degrading the system performance, in which the delay and routing overhead showed a dramatic increase. In addition, when the transmission media is overwhelmed by these RREQ messages, a collision of the data packets takes place due to the signal overlapping as shown in Figure 1.4. Designing efficient forwarding scheme can reduce redundancy and collisions (Alghamdi et al., 2017).

Moreover, such broadcast may lead to contention between the nodes, as they share the same transmission media. As a result, sending and receiving data become the most complicated process.

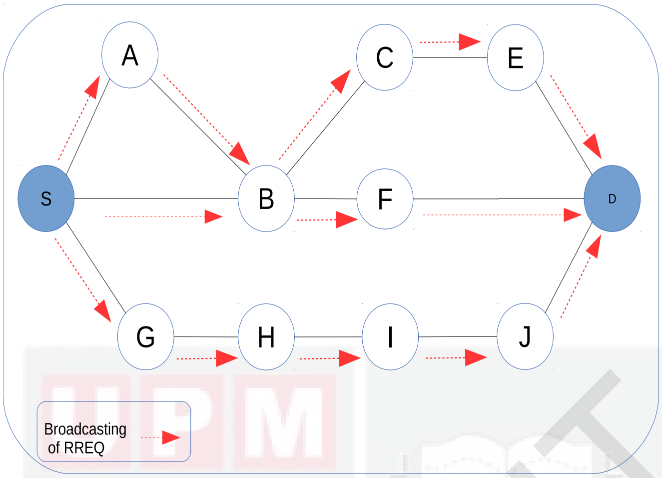

Figure 1.3: Broadcasting in the Route Discovery Stage

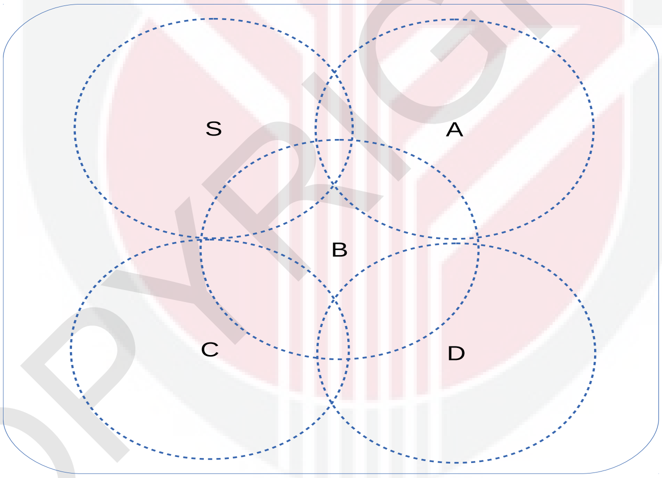

Figure 1.4: The Signal Overlapping for 5 Nodes

1.4 Motivation

Despite the fast development of MANET devices and its applications, the routing algorithms still unable to serve such devices efficiently. In addition, the state of art presented in Chapter 2 clearly shows that the available routing algorithms insufficient to serve the MANET devices efficiently, due to many redundant messages broadcasted in the whole network. For instance, In (Dodke et al., 2016), from the result it is seen that packet delivery ratio of AODV is higher as compare to DSR. Also from the result it is seen that DSR consume

40 less energy as compared to AODV. In addition, in NCPR and AODV, when the number of nodes increases more than 100 nodes, the performance of both protocols has been effected by these redundant RREQ packets (based on the simulation done). Such issues in the currently available routing algorithms open a space for further enhancement. This research was motivated by its benchmark shortage, in terms of the inherited routing overhead and low packet delivery ratio and not to mention the fixed preset variables which are highly required to be addressed. Such enhancements in current algorithms, enable many systems to provide the important information on time, especially in disaster situations.

In the disaster situations, the fast delivery of data is the main concern for the rescue system, therefore a routing algorithm with low end to end delay is the most desirable to be used. Furthermore, it is important to have a routing algorithm which consume a low energy for the network with as the nodes for outdoors network. In terms of the applications, it is necessary to find an algorithm that is more suitable to be used for education applications, while the another algorithm must be designed to be used for rescue system as data and energy is the main concern. Finally, one more algorithm is suitable for personal area and home networking.

1.5 Problem Statements

A considerable number of the predominate routing algorithms offers quick adaption to the dynamic link conditions and low routing overhead such as Neighbor Coverage-based Probabilistic Rebroadcast (NCPR) as compared to AODV protocol. In NCPR algorithm, the dropping decision for the redundant RREQ is completely relying on preset variables, such variables require to be set by the system administrator based on the scenario.

Unfortunately, the setting which is proper for a specific scenario is not suitable for another due to the dynamic character of MANET. Furthermore, the connectivity factor which is used to estimate the connectivity ratio at each node, is still unable to estimate such ratio accurately. Thus, using such algorithms in a network with a high density of nodes or high traffic load negatively affects the network performance. Therefore, a novel dynamic routing algorithm is highly needed, which could replace the preset variables and dynamically estimate the connectivity ratio using local available parameters at the forwarding node itself.

The NCPR algorithm significantly enhances the overall network performance in terms of routing overhead, end to end delay, packet delivery ratio and MAC collision, such enhancements are based on reducing the redundant RREQ messages. However, NCPR fails to relieve the routing overhead, as result of the RREQ redundant message, when the number of nodes or the network traffic load increases. Such issue results from the dropping mechanism used in this algorithm. Thus, another algorithm must be used to accommodate with network scalability in terms of the number of nodes and network traffic load.

Furthermore, It is worthy to note that mobility brings many challenges when designing protocols for these networks (Abbas and Rahman, 2016). Naturally nodes in MANET are free to move forming an arbitrary topology at any time the network density may change frequently from low to high or from high to low. Such change may lead to an extreme performance degradation, especially when the routing algorithm relies on fixed threshold values in the dropping decision. Thus, enhancements addressing these issues and makes from such algorithm more powerful to gain a better ability to work under varied density of nodes is required by developing a new adaptive routing algorithm.

1.6 Research Objectives

The main goal of this thesis is to enhance the performance of the routing algorithms for MANET. In particular, such goal is divided into three significant objectives, as follows:

- To develop a novel neighbor-based routing algorithm aims to develop a novel formula that replaces the critical preset variables and the fixed connectivity factor, in order to immediately respond to the changing in the topology and the density of nodes without preset variables from the network. While, providing an accurate connectivity ratio.
- To develop a scalable neighbor-based routing algorithm which reduces the routing overhead in NCPR, by eliminating the redundant RREQ. Such algorithm aims to enhance the network performance, even though the network is experiencing an increase in the number of nodes or traffic load.
- To develop an optimized density-aware routing algorithm through the use of a dynamic formula that improves the network performance and makes from such routing algorithm able to accommodate varied density of nodes. Such formula aims to estimate the network density and accordingly drops the redundant RREQ packets.

1.7 Research Scope

Basically, routing in a network with arbitrary topology, mobile nodes and without any centralized control is considered a complex task. Therefore, this thesis concentrated on studying the NCPR routing algorithm in MANET. Furthermore, it focuses on enhancing the network performance at the routing layer of the end to end system. In particular, the research focuses on the routing overhead in the route discovery stage as many RREQ is broadcasted to find a path to a certain destination. Such improvements are to meet the huge demand of a considerable number of applications, in total isolation from underlying networks as recommended by Open Systems Interconnection (OSI) model.

The proposed algorithms are developed and tested in wireless mobile nodes with random movement, using the well-known Network simulator 2 (NS-2) (McCanne and Floyd, 1998). Such simulator is being used by most researchers in the field, since such tool is a free and open source. Besides, all the experiments are simulated over wireless networks (MANET). Even though the proposed algorithms may applicable to work in another network such as VANET, the implementation of the proposed algorithms over other network lie beyond the scope of this thesis.

1.8 Research Significance

Certainly, as mentioned previously, in harsh and constrained situation after natural disasters such as fire, flood, or earthquake MANET is one among limited available options of wireless networks due to important reasons, which are: such network can be configured in short time, its cost is too low compared to infrastructure network, and such network can be connected to another network easily, such as the Internet. Therefore, the significant of this work arises from the need for an efficient routing algorithm, which is able to automatically adjust the network setting and reduces the extra messages broadcasted. As result, the network performance improves in terms of end to end delay, and the packet delivery ratio. All the mentioned facts emphasize the importance of conducting this research. Besides, the proposed work can be used to enhance the performance of other network such Vehicle Area Network (VAN).

1.9 Thesis Organization

The rest of this thesis is organized as follows:

Chapter 2 first presents the MANET and OSI Model, routing in MANET and classifications of the most significant routing protocols. Then, it discusses the broadcasting mechanism used in a numerous number of routing protocols, and its advantages and the drawbacks. Finally, the chapter concluded with the currently available open issues.

Chapter 3 it presents the methodology used in this thesis. The chapter first discusses the existing simulation tools and identifies the definition and the conventions used throughout the whole thesis. Then, it presents the research framework, experimental setup, network topology and finally the evaluation method.

Chapter 4 presents a novel routing algorithm called DCFP aimed at replacing the preset variables of the network parameter (total number of nodes) through a new connectivity metric. Furthermore, it discusses the DCFP algorithm, its main components and provides analytical analysis behind the main idea used to develop the new formula and dynamic connectivity factor. The chapter is concluded by the performance evaluation and results of the proposed algorithm with one of the states of art algorithms and the stander algorithm.

Chapter 5 this chapter started by giving background of a new routing protocol called SNBR and its components, then it describes the parameter setting and the their relationship. In addition, the rest of the chapter presents the results of the proposed algorithm along with states of art algorithms under different scenarios includes a varied number of nodes and varied traffic load.

Chapter 6 presents a background of a novel routing algorithm namely, NDAR. Then, it describes NDAR mechanism and the impact of RREQ on the system performance. The chapter also provides the details of density aware formula and NDAR. Finally, the performance evaluation and results of the proposed algorithm is presented, along with two important algorithms as benchmarks.

Chapter 7 concludes the thesis and recommends some promising directions for future research.

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