جامعة آل البيت

Al al-Bayt University

MANET Broadcasting Scheme Based on Relative Speed of Neighbors

السرعة النسبية للعقد المجاورة على اعتماداً المتحركة الخاصة الشبكات في البث خوارزمية

By:

Tamer Naiem Alghmmaz

تامر نعيم الغماز

Supervisor:

Prof. Ismail Mohammad Ababneh

This Thesis Was Submitted in Partial Fulfillment of the Requirements for the Master's Degree of Computer Science

Deanship of Graduate Studies

Al al-Bayt Universi

نموذج رقم (1)

جامعة آل البيت

عمادة الدراسات العليا

نموذج تفويض

أنا تامر نعيم قاسم الغماز

افوض جامعة آل البيت بتزويد نُسخ من رسالتي، للمكتبات أو المؤسسات أو الهيئات أو الأشخاص عند طلبهم حسب التعليمات النافذة في الجامعة.

التوقيع: .... التاريخ: 2019/1/3

II

نموذج رقم (2)

جامعة آل البيت
عمادة الدراسات العليا

نموذج اقرار والتزام بقوانين جامعة آل البيت وانظمتها وتعليماتها لطلبة الماجستير والدكتوراه.

انا تامر نعيم قاسم الغماز　　　　الرقم الجامعي: 1320901019

تخصص: علم الحاسوب　　　　كلية: الامير الحسين بن عبدالله الثاني لتكنولوجيا المعلومات

أعلنُ بأني قد التزمت بقوانين جامعة آل البيت وانظمتها وتعليماتها وقراراتها السارية المفعول المتعلقة بإعداد رسائل الماجستير والدكتوراه عندما قمت شخصياً بإعداد رسالتي بعنوان:

MOBILE AD-HOC NETWORK BROADCASTING SCHEME BASED ON RELATIVE SPEED OF NEIGHBORS

خوارزمية البث في الشبكات الخاصة المتحركة اعتماداً على السرعة النسبية للعقد المجاورة.

وذلك بما ينسجم مع الأمانة العلمية المتعارف عليها في كتابة الرسائل والأطاريح العلمية. كما أنني أُعلن بأن رسالتي هذه غير منقولة أو مستلة من رسائل أو أطاريح أو كتب أو أبحاث أو أي منشورات علمية تم نشرها أو تخزينها في أي وسيلة اعلامية، وتأسيساً على ما تقدم فأنني اتحمل المسؤولية بأنواعها كافة فيما لو تبين غير ذلك بما فيه حق مجلس العمداء في جامعة آل البيت بإلغاء قرار منحي الدرجة العلمية التي حصلت عليها وسحب شهادة التخرّج مني بعد صدورها دون أن يكون لي الحق في التظلم أو الأعتراض أو الطعن بأي صورة كانت في القرار الصادر عن مجلس العمداء بهذا الصدد.

التوقيع ....　　　　التاريخ: 3/1/2019

Committee Decision

This Thesis (MOBILE AD-HOC NETWORK BROADCASTING SCHEME BASED ON RELATIVE SPEED OF NEIGHBORS) was Successfully Defended and Approved on 3rd Jan. 2019.

Examination Committee	**Signature**
Prof. Ismail Mohammad Ababneh, (Supervisor) Dep. of Computer Science, Al al-Bayt University ismael@aabu.edu.jo	....
Prof. Saad Oqlah bani-mohammad, (Member) Dep. of Computer Science, Al al-Bayt University bani@aabu.edu.jo	....
Dr. Akram Aref Hamarsheh, (Member) Dep. of Computer Science, Al al-Bayt University hamarshi@aabu.edu.jo	....
Prof. Samer 'Mohammad Jameel' Samarah (External Member) Dep. of Computer Information Systems, Yarmok Univesity samers@yu.edu.jo	....

Dedication

To My Greatest Father and Mother, For their Support and Effort and Patience

To My Beloved Three Sisters, For Encouragement

To My Lovely Niece "Zaina" the Cutest Baby Girl Ever, For Adding Joy and Happiness to My Life

To All My Family, For Their Support

ACKNOWLEDGMENTS

First and foremost forever, I would like to thank God for his blessings and gifts. I convey my gratitude to Prof. Ismail Ababneh for having accepted to be my thesis advisor and for his guidance and assistance which are the reasons for what I have reached at this moment.

Also, I would like to thank the examination committee members for their presence and for their valuable comments that have contributed to this work.

Table of Contents

LIST OF FIGURES

TABLE OF ABBREVIATION

Abbreviation	Meaning
MANET	Mobile Ad-hoc NETwork
RSB	Relative Speed-Based Broadcast Scheme
BCNS	Broadcast-Based Covering Neighbors Scheme
BKNS	Broadcast-Based K-Neighbor Scheme
TCP/IP	Transmission Control Protocol/Internet Protocol
AODV	Ad Hoc On-Demand Distance Vector
PAN	Personal Area Networks
STAR	Source Tree Adaptive Routing
GSR	Global State Routing
WRP	Wireless Routing Protocol
FSR	Fisheye State Routing
ABR	Associativity-Based Routing
ARA	Ant-Colony Based Routing Algorithm
TORA	Temporally Ordered Routing Algorithm
GPS	Global Positioning System
RREQ	Route Request Packet
RERP	Route Reply Packet
RERR	Route Error Packet

CBR	Constant Bit Rate
GFDA	Greedy Flooding Via Dense Areas
AVON	Adaptive Velocity Of Nodes
VA-AODV	Velocity-Aware Ad Hoc On-Demand Distance Vector
MDAODV	Mobility Aware Modified AODV
RS	Relative Speed
NNT	Near Neighbors Table
GloMoSim	Global Mobile Information System Simulator
PDR	Packet Delivery Ratio
MAC	Medium Access Control.

LIST OF TABLES

MANET Broadcasting Scheme Based on Relative Speed of Neighbors

A Master Thesis By

Tamer Naiem Alghmmaz

Supervisor:

Prof. Ismail Mohammad Ababneh

Department of Computer Science, Al al-Bayt University, 2019

Abstract

Flooding is a common approach in Mobile Ad-hoc NETworks (MANETs) that is widely used in the route discovery process between a source (S) and a destination (D). Although it is simple, and can achieve a high delivery ratio, flooding suffers from some disadvantages, such as packet duplication and high overhead, which can cause contention, collision, and communication delay. In this work, we propose a novel broadcasting scheme which is the Relative Speed-Based Broadcast (RSB) scheme, which depends on the relative speed between nodes to find better routes to the destination. RSB uses the covering set concept to find the nodes with minimum relative speed between each other and select them to forward the routing request instead of flooding the requests to all nodes in the network.

The results of the simulation experiments show that RSB achieves better performance than the previous policies BCNS

and AODV in terms of overhead, packet delivery ratio, and end to end delay. More details of the results are illustrated in chapter four.

Keywords: MANET, Wireless Networks, Broadcast Scheme, Routing Protocol, Relative Speed, Hybrid Broadcast Scheme

خوارزمية البث في الشبكات الخاصة المتحركة اعتماداً على السرعة النسبية للعقد المجاورة

رسالة ماجستير قُدمت من قبل

تامر نعيم الغماز

المشرف:

أ.د. اسماعيل محمد عبابنه

قسم علم الحاسوب، جامعة آل البيت، 2019م

الملخص

يعتبر الاغراق (Flooding) من احد الطرق المتعارف عليها في الشبكات المتحركة الخاصة ويتم استخدامه بشكل واسع في عملية ايجاد المسار بين العقدة المرسلة والعقدة المستقبلة. على الرغم من انه يمتاز بالبساطة ويمكن ان يحقق نسب توصيل بيانات عالية إلا انه يعاني من بعض السلبيات مثل تكرار حزم البيانات المرسلة وارتفاع اعباء الشبكة مما قد يؤدي إلى زيادة الازدحام والاصتدام بين حزم البيانات المرسلة والتأخر في وقت الاتصال في الشبكة.

لقد قمنا في هذا البحث باقتراح الية للتحكم في عملية ارسال البيانات بين العقد الموجودة في الشبكة بأسم "الية ارسال مبنية على السرعة النسبية" (Relative Speed-Based Broadcast (RSB) scheme) والتي تعتمد على السرعة النسبية (relative speed) بين العقد الموجودة في الشبكة وذلك لإيجاد افضل مسار إلى العقدة المستهدفة. في هذه الالية يتم استخدام مفهوم "مجموعة التغطية" (covering set) لإيجاد العقد التي لها اقل سرعة نسبية ومن ثم اختيارها لتكون هي المسؤولة عن ارسال "طلب استكشاف المسار" (Routing Request) بدلا من اغراق الشبكة بهذا الطلب.

اظهرت نتائج عملية المحاكاة ان الالية المقترحة تحقق اداء افضل من الاليات التي تمت المقارنة بها في مجالات أعباء الشبكة، نسب توصيل البيانات، والوقت المستغرق بأرسال هذه البيانات.

CHAPTER ONE

Introduction

Networking is an important concept in both real life and the computing world. In the computing world, networking is abut connecting two or more devices together to exchange data via network links. These links can be wired or wireless. The wired links are traditional, while wireless links are relatively new and are becoming more and more important. Wireless technology provides solutions for the problems of needing cables and fixed lines. The configuration of wireless networks is faster, easier, and cheaper (Chlamtac, Conti and Liu, 2003) and supports mobility. Since the 1990s, the MANET has received a growing interest in the research field because of its features such as the lack of infrastructure and decentralization.

A MANET could be defined as: “an autonomous collection of mobile devices (laptops, smart phones, sensors, etc.) that communicate with each other over wireless links and cooperate in a distributed manner in order to provide the necessary network functionality in the absence of a fixed infrastructure” (Hoebeke et al., 2004). A node in a MANET acts as host and router (Cadger et al., 2016), which could be used to reach the nodes that are out of the transmission range of the source node via intermediate nodes between the source and the destination. Figure 1.1 shows a simple MANET of three nodes A, B, and C. Nodes A-C and C-B are within the communication range of each other, so they can exchange data directly, but if node A wants to send data to node B, then, node C will be considered as an intermediate node and forwards the data to B on behalf of node A.

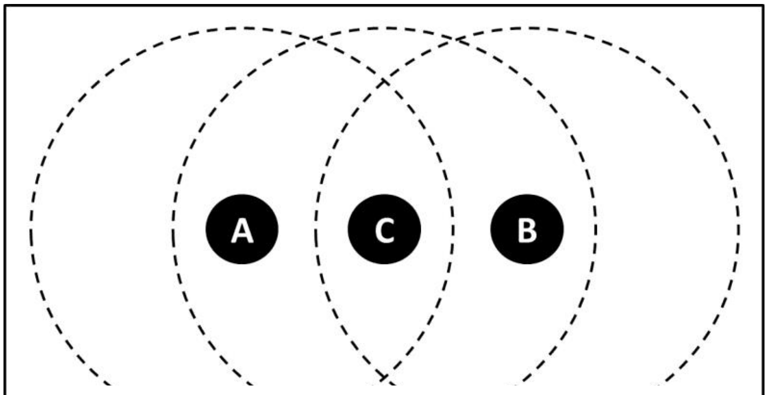


Figure 1.1 simple 3 nodes MANET

A MANET typically uses the TCP/IP protocol in order to allow the nodes to communicate with each other, but because of mobility, the traditional wired network protocols are not suitable for MANETs, so TCP/IP needs to be modified to take into consideration the mobility issue (Abolhasan, 2003), (Conti and Giordano, 2014).

Due to mobility in MANETs, the node(s) can move freely in any direction, so the network topology changes dynamically; also each node is limited to a specific transmission range (Cadger et al., 2016). As a result of mobility, the links connecting the nodes can be broken often (for example, if the node doesn't have any nodes in its transmission range).

Therefore, there is a need that the routing protocol be able to maintain the route between S and D as long as possible in order to provide efficient, reliable, and stable communication. Figure1.2 shows how the mobility feature changes the topologies in MANETs. In Figure 1.2 (a), all nodes are in the transmission range of each other and the data can be exchanged directly. In 1.2 (b), node A has moved and it goes out side of the transmission range of nodes B and C. In this case, it will be considered as an isolated node and it cannot be reached. While in 1.2 (c), node A has moved but remained within node B transmission range and the data can be transferred directly from B to it. Though, node C can reach node A by sending the data to node B in order to forward it to node A on behalf of node C.

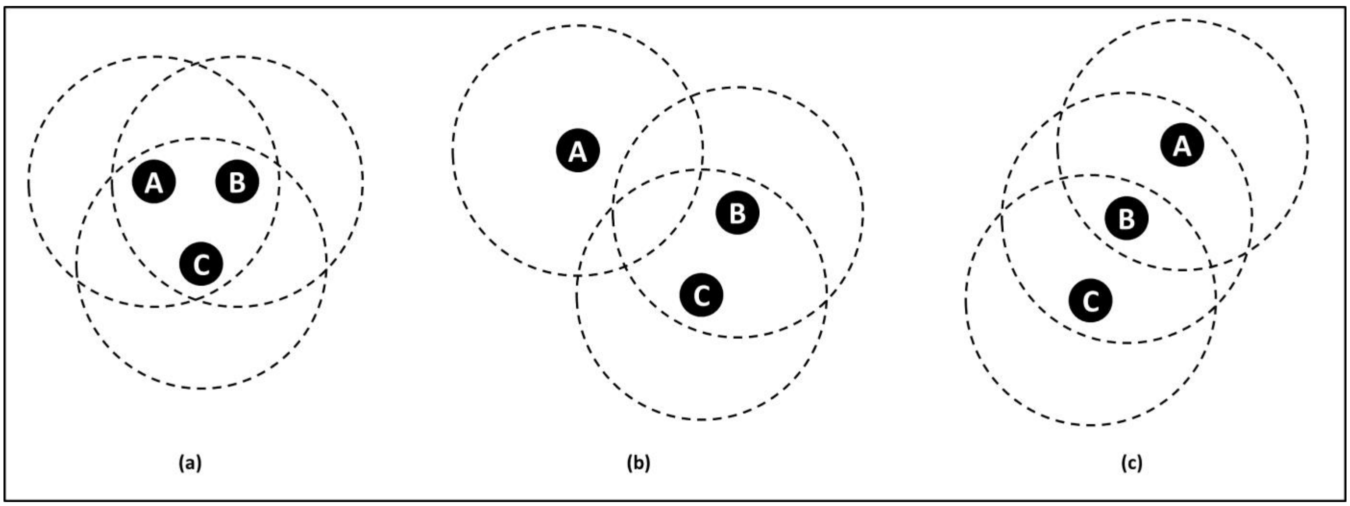


Figure 1.2 Mobility effect on MANET's topology

Nodes in a MANET could have varying densities, ranging from low to high (Ababneh, Mardini, and al-Hassan, 2010). If the number of node's neighbors is greater than the average number node neighbors, the node is considered to be in a dense area; otherwise, it is considered to be in a sparse area.

1.1 MANET Applications:

A MANET can be used in many situations because it is easy to install and costs less than traditional -fixed- networks. MANETs can be applied in the following fields:

Personal applications: MANETs appear in Personal Area Networks (PANs), where a collection of personal devices collaborate with each other to exchange the data between them.

Military applications: MANETs can be used in military applications for their ability to adapt to the rapid changes that is crucial in such environment.

Emergency applications: MANETs can be used in the natural disaster situations and in the search and rescue operations due to their features such as being infrastructure-less and easy to install.

1.2MANET Routing Protocols Categories (CLASSES)

Routing is an essential operation to establish a route between the source and the destination. Routing in ad hoc networks faces some challenges such as node mobility, where the nodes can move in any direction at various speeds, which means that the nodes get in and out of each other's ranges. Therefore, there is a need for MANET routing protocols that are able to adapt themselves to the network's dynamic topologies in order to discover and maintain the routes to ensure the data exchange between the nodes.

In MANETs, there are three main routing protocol categories that cover the routing discovery process: proactive, reactive, and hybrid.

Proactive (Table-Driven) Routing Protocols

In proactive routing protocols, nodes try to maintain updated and consistent routing information for the whole network by maintaining a routing table that contains an entry for each source-destination pair in the network. This has the advantage of finding a route in a very short time. However, these protocols suffer from some problems, such as high route maintenance overhead (Ababneh, Mardini, and al-Hassan, 2010), low message throughput, high contention, and high power consumption (Alhosban, Ababneh and Malik, 2012). Examples of proactive protocols are the Source Tree Adaptive Routing (STAR) (Garica-Luna-Aceves and Spohn, 1999), Global State Routing (GSR) (Chen and Gerla, 1998), Wireless Routing Protocol (WRP) (Murthy and Garcia-Luna-Aceves, 1996), and Fisheye State Routing (FSR) (Pei, Gerla and Chen, 2000) protocols.

Reactive (Source-Initiated, On-Demand Driven) Routing Protocols

In reactive routing protocols, the nodes do not have a routing table. When it needs to find a route to a destination, the source node initiates a routing discovery process by broadcasting a Route Request (RREQ) packet to its neighbors. The neighbors also rebroadcast the RREQ again (if they receive it for the first time) until the RREQ reaches the destination node. When the destination node receives the RREQ, it sends a Route Reply (RREP) packet containing the path back to the source node. The source node saves the path in its cache along with a timestamp. This means that there are no pre-stored routes, which reduces the network overhead, but this increases the route discovery latency. Some examples of MANET reactive routing protocols are the Ad-hoc On-Demand Distance Vector (AODV) (Das, Belding-Royer and Perkins, 2003), Associativity-Based Routing (ABR) (Toh, 1997), Ant-colony-based routing algorithm (ARA) (Gü, Sorges and Bouazizi, 2002), and Temporally Ordered Routing Algorithm (TORA) (Park and Corson, 1997) protocols.

Hybrid Routing Protocols

This type of routing protocols combines the proactive and reactive routing protocols. Due to the variety in MANET applications, there is no single protocol that can work efficiently for all of them; therefore, there is a need to use hybrid protocols that benefit from the advantages of both proactive and reactive protocols.

Proactive routing protocols are more efficient in the low mobility network, on the other hand; the reactive routing protocols are more efficient in the high mobility network.

1.3Ad-hoc On-demand Distance Vector (AODV) Routing Protocol

The AODV (Das, Belding-Royer and Perkins, 2003) routing protocol is considered as one of the best reactive routing protocols in MANETs because of its advantages such as its low overhead and maturity (Alhosban, Ababneh and Malik, 2012). As a reactive routing protocol, AODV depends on the source node to start the route discovery process to communicate with the destination node if there is no link between them. The way that AODV discovers a path to the destination can be summarized as follows:

AODV Route Discovery

When a node requests to send a packet to a destination, it checks to determine if it has a current route to the destination, if yes, it forwards the packet to the next hop node on the route to the destination, if no, it initiates a route discovery process.

The route discovery process begins with the broadcasting of an RREQ control message that has a unique sequence number, which is initiated by the source node. The control message contains (source ID, destination ID, and request ID (sequence number)).

Once an intermediate node on the route to the destination receives a RREQ, it checks the sequence number of the RREQ message. If it had been previously received, it will be dropped, otherwise the node re-broadcasts it, and stores the node ID from which it received the request for establishing a reverse route back to the source node.

The previous steps will be repeated until the RREQ reaches the destination node, which responds by sending a RREP back to the source node using unicasting through the reverse path.

AODV Route Maintenance

The route Maintenance in AODV is the process of detecting link breakages (failure) between the nodes. This is accomplished by listening to the HELLO MESSAGE from its neighbors. If the node detects a link failure, then it broadcasts a Route Error packet (RERR) to inform the source about the breakage, in order to make the source send a new RREQ to discover a new path (Seetan, Ababneh, and Dalal'ah, 2009)

1.4Research Statement and Motivation

Flooding is one of the most common strategies that have been used in MANETs protocols for discovering routes between sources and destinations. Flooding is able to find paths, but it has severe problems that reduce network efficiency. Also, the mobility nodes significantly influences the performance of the network, especially for high speed movement, where link failures occur more frequently causing more overhead.

We propose the RSB broadcasting scheme that aims to discover stable routes in order to reduce route discovery overhead by using intermediate nodes with lower relative speed among them, where we aim to achieve the following goals:

Reduce the route discovery and maintenance overhead in the network

Increase the packet delivery ratio

Decrease the end to end delay

The proposed broadcasting scheme can be used as an alternative route discovery scheme to that proposed in many on-demand routing algorithms, in order to achieve superior performance compared with existing MANET reactive routing protocols.

CHAPTER TWO

Related Work

Many researchers have proposed various routing protocols for MANETs to manage the packet broadcasting during the route discovery process. Because of mobility, topology changes, and the dynamic nature of the MANET, nodes always updating and maintaining its routing table which causes a congestion because of the huge number of transferred requests, these protocols are typically aims to find an efficient routes between MANET's nodes in order to reduce the flooding of RREQ packets where more stable routes can reduce the network overhead, increase the delivery ratio, and provides better network performance.

2.1GFDA: Route Discovery Algorithms for On-Demand Mobile Ad Hoc Routing Protocols

Researchers proposed two new route discovery algorithms that have for goal reducing communication delay. The first algorithm is Greedy Flooding via Dense Areas (GFDA) (Alhosban, Ababneh and Malik, 2012). By using the Routing Set, GFDA determines at each step the neighboring nodes that have the largest number of neighbors, assuming that a node maintains a neighbors-table that contains a list of the neighboring nodes and their number (degree), and also the time at which a node has become a neighbor, where the degree is the number of node's neighbors.

The second algorithm is Greedy Flooding via Dense Areas using Flooding (GFDAF) (Alhosban, Ababneh and Malik, 2012), and it was proposed to address the problem that in GFDA the destination may not be reached. GFDAF attempts route discovery using flooding if the source does not receive a reply within a specified timeout period.

2.2Adaptive Velocity-Based Route Discovery in Mobile Ad Hoc Networks

Researchers have proposed an Adaptive Velocity of Nodes (AVON) scheme (Ababneh, Mardini, and al-Hassan, 2010), where the forwarding nodes are chosen based on their speed and number of neighbors. AVON uses node density to determine the speed threshold value. In dense areas, small node velocity threshold values are utilized to reduce packet duplication and contention, while achieving good reachability and route stability. In sparse areas, large thresholds will be better so as to be able to reach the destination. AVON compared with VON has significantly superior performance in terms of control overhead and average end-to-end delays, without degrading the ability to deliver packets.

2.3Performance Evolutions of Velocity-Aware Routing Protocol for Mobile Ad hoc Networks

Researchers have proposed a Velocity-aware Ad hoc On-demand Distance Vector (VA-AODV) protocol (Yassein, Alslaity and Ababneh, 2012) has been proposed. VA-AODV periodically computes the mobility of the nodes in order to take the neighbors' mobility into consideration by picking the nodes with lower mobility. Each node computes its mobility periodically using a (GPS), and informs its neighbors of its mobility status every Hello_Interval. Each node updates its neighbors' table that is sorted in ascending order based on node's velocity. Then the CoveringSet is applied in the route discovery process. VA-AODV improves the performance of the original AODV protocol in terms of reduced overhead and increased packet delivery ratio.

2.4Adaptive Velocity and Distance Based Routing Protocol for MANET

In (Ahmed et al., 2012), researchers have proposed a MOBILITY AWARE MODIFIED AODV (MDAODV) protocol. MDAODV using weight function (fij) which depends on distance, relative velocity and hop count in order to select stable routes between the source and the destination and so, reducing the control message overhead and increases the life time of route. Simulation results show that the MDAODV protocol has higher data package delivery ratio compared to AODV.

2.5Enhancements in AODV Routing Using Mobility Aware Agents

In (Idrees et al., 2005), authors have proposed a mobility-aware scheme. The proposed scheme uses the Hello Packets to enhance mobility awareness in AODV in order to reduce link breakage. When a node receives a Hello Packet and with the assistance of the GPS coordinates of the source node of the packet, a lightweight mobility aware agent on each node of the network compares these coordinates with previous ones and determines information about the mobility of the originator node. When a node receives a RREQ packet, and if that node is the destination, it will sends the RREP back by using the mobility awareness to choose the best neighbor which is not moving frequently (low mobility). This process of selecting a best neighbor is done at each intermediate node from source to destination. As a result, the path with the maximum number of low mobile nodes will form the route between the source and destination.

2.6Enhancing AODV Performance based on Statistical Mobility Quantification

In (Enneya, El Koutbi, and Berqia, 2006), researchers have proposed a mobility-aware method for improving AODV performance. They define mobility metric and use it in both route discovery and route maintenance for selecting more stable routes. In route discovery they replace the hop-count metric with a combination of two mobility parameters: average and mean of the “calculated mobility” along the path between the source and the destination. In route maintenance, they extend the local repair mechanism in order to avoid sending RERR packets. An alternative route starting from the node that detects a broken link is selected based also on the mobility metric. This aims to reduce the use of RERR packets and avoid re-initiating the route discovery process.

2.7Neighborhood-based Route Discovery Protocols for Mobile Ad hoc Networks

Researchers have proposed two flooding control schemes. The first one is called (BKNS) (Alwidian, Ababneh, and Yassein, 2013), and is an on-demand, broadcast-based ad hoc route discovery protocol that has for main goal alleviating the flooding problem by reducing redundant broadcasts, which reduces the routing overhead. In BKNS, each node X maintains a parameter degree(X), which is the number of its neighbors. A node has a table called neighbors table (nbrTable(X)) that contains its neighboring nodes sorted in the decreasing order of their degrees. The first K-neighbors (where $k = \left\lceil \frac{n}{3} \right\rceil$), are selected to receive the RREQ from a node, and then rebroadcast it further. The second scheme is called BCNS. It uses a density based covering set heuristic to find a subset of the 1-hop nodes, named CoveringSet(X) that covers all of the 2-hop neighbors of nodes, named SuperSet(X). Neighboring nodes are sorted based on their degree. Only the nodes in the covering set will receive the RREQ and broadcast it to their neighbors. Both proposed schemes achieves high delivery ratio and reduce overhead as compared with AODV.

An issue with BCNS is that it does not take the relative speed into consideration, so it can choose very fast nodes, which means selecting unstable and unreliable routes. In our proposed work, we will consider the relative speed as a basis for the selected routes, and we will use the covering set principle proposed in (Alwidian, Ababneh, and Yassein, 2013). In our proposed scheme, the covering set will be constructed based on the relative speed, where the covering set in BCNS is constructed based on density. Our proposed scheme will be evaluated and compared with BCNS and AODV.

CHAPTER THREE

Proposed Scheme

Broadcasting is used in MANET in many routing protocol in the rout discovery process. The need of the broadcasting is coming from the dynamic nature of the MANETs topology where the routing tables need to be updated frequently because the nodes are mobile randomly. However, flooding is the simplest, common and widely used form of broadcasting in MANET but it suffers from some problems which may cause a huge degradation in the network performance as where the overhead increased as well as the delay, especially when the number of nodes increases, so there is a need of a routing protocol that controls the broadcasting (flooding) operation in order to efficiently reduce the disadvantages mentioned above.

In flooding, the source node will broadcast the packet to all its neighbors, then each neighbor will check the status of the packet upon receive it whether it has been received previously, so it will be discarded, otherwise it will rebroadcast it to its own neighbors as shown in figure 3.1.

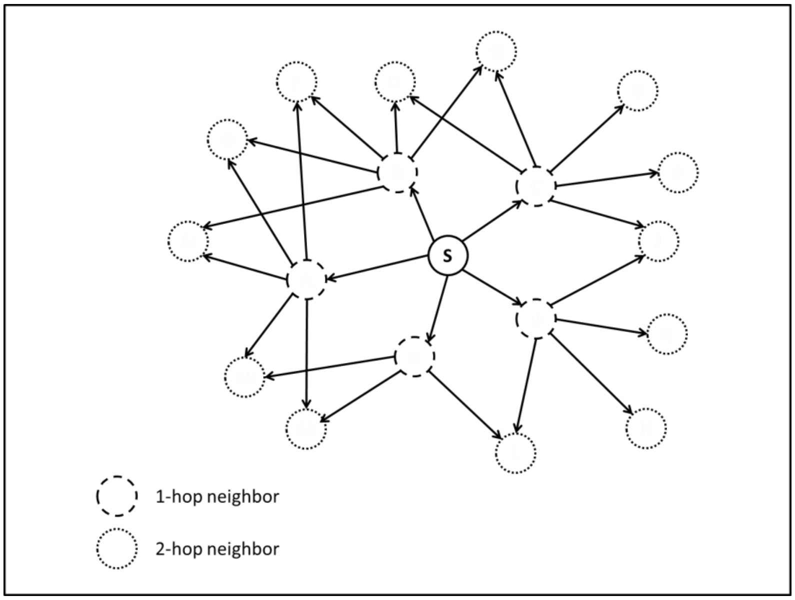
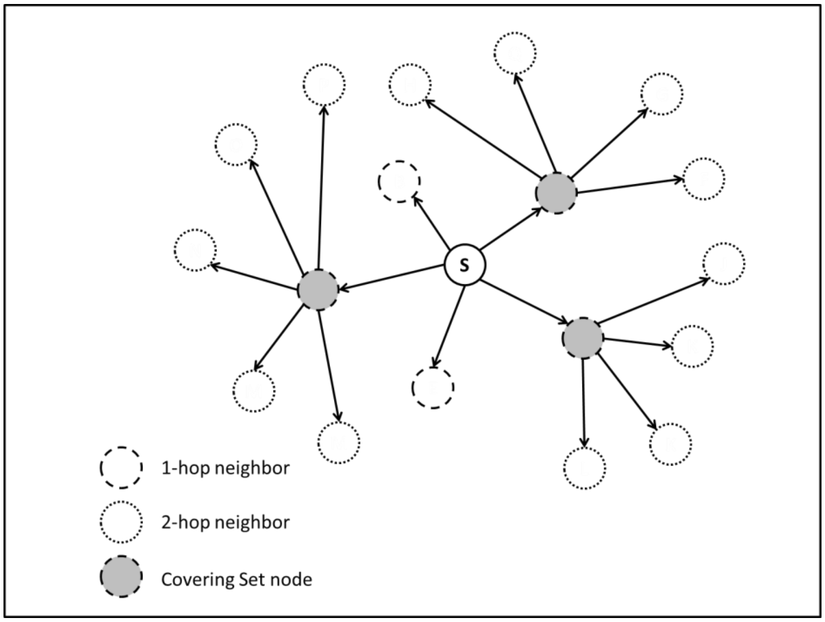


Figure 3.1 Rebroadcasting in Flooding

In our work, we proposed a broadcasting scheme, RSB, that depends on the relative speed between neighboring nodes along the route from source to destination, where only the neighboring nodes that have been selected from the covering set are involved in the rebroadcasting operation as shown in figure 3.2. The proposed scheme depends on the reactive routing protocols concepts, basically on AODV routing protocol, because it is better in performance than the other reactive routing protocols (Ababneh, Mardini, and al-Hassan, 2010).

Figure 3.2 Rebroadcasting in RSB



3.1Relative Speed (RS)

Node mobility is one of MANET's routing discovery factors, which affects the routing discovery process because the nodes in the network are freely to move in different directions with different speeds where that may be lead to link breakage, resulting on unstable and unreliable routes, which is undesirable.

To control the mobility between the nodes in the network, there is a need to use, either, a localization system like Global Positioning System (GPS) or by analyzing the received signal (Ahmed, Mohamed, and Mohamed, 2012), from which we can obtain the distances between the nodes to calculate their relative speed since the time between every periodically broadcasted “HELLO_ MESSAGE” between the nodes can be used and considered as a fixed (uniform) period of time.

Node Speed is depending on two variables which are they the distance (d) and the time (t), from which the speed could be calculated in order to be used afterward in the route discovery process. Distance between nodes could be obtained from the (x, y) coordinates of nodes, and the time could be obtained from the time of the HELLO_MESSAGE, which each node send it to its neighbors every HELLO_INTERVAL which could be obtained by calculating the time difference between the former HELLO_MESSAGE denoted as (t1) and the next HELLO_MESSAGE denoted as (t2) as shown in equation 1:

$$\boldsymbol{\Delta t = t2 - t1} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(1)}$$

Where (Δt) is the difference in time between the former and the next HELLO_MESSAGE.

To estimate the distance between two nodes (A, B), (x, y) coordinates are used to obtain the position as node A= (x1, y1) and B = (x2, y2), as shown in equation 2:

$$\boldsymbol{d = \sqrt{(x2 - x1)^2 + (y2 - y1)^2}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(2)}$$

Notice that (d) should be calculated at the time (t1) and also at the time (t2).

$$\boldsymbol{\Delta D = d_{t2} - d_{t1}} \quad \text{...(3)}$$

Where (Δd) is the difference in distance between d1 and d2 at the time t1 and t2 respectively.

The estimated relative speed (RS) between A and B could be obtained as shown in equation 4:

$$\boldsymbol{RS = \frac{\Delta d}{\Delta t}} \quad \text{.. (4)}$$

Relative speed is commonly denoted as (RS) and it represents the difference in speeds between two nodes. This difference generally has three cases which specified the relation between the estimated nodes as follows:

If RS = 0, it means that the link between the nodes is static.

If RS > 0, it means that the nodes move outward.

If RS < 0, it means that the nodes move inward.

In case 1, nodes are reserved an equal distance from each other which explain why the value of RS = 0 because there is no speed differences between the nodes. While in case 2, RS has a positive value indicating that the nodes are moving apart from each other, which increases the link breakage possibilities

and, in turn, threatening the stability of the route. In case 3, when RS has a negative value ,which considered as the wanted situation, where the life time of the link is longer since the nodes are moving inward to each other which provides more stable and reliable route.

3.2Covering Set Heuristic

In our proposed work, the heuristic covering set algorithm proposed in (Alwidian, Ababneh, and Yassein, 2013) will be used. However, the sorting of neighbors nodes will be done based on RS between them in an ascending order.

In MANETs, the idea of the covering set for a specific node X, is to find a set of X's 1-hop neighbors (i.e. CoveringSet(X)) that covers all the 2-hop neighbors (i.e. SuperSet(X)) of that node. The challenge is to keep the covering set as small as possible in order to reduce the route discovery overhead (Alwidian, Ababneh, and Yassein, 2013). Figure 3.3 illustrate 1-hop and 2-hop neighbors and figure 3.4 show the implementation of Coverings Set heuristic.

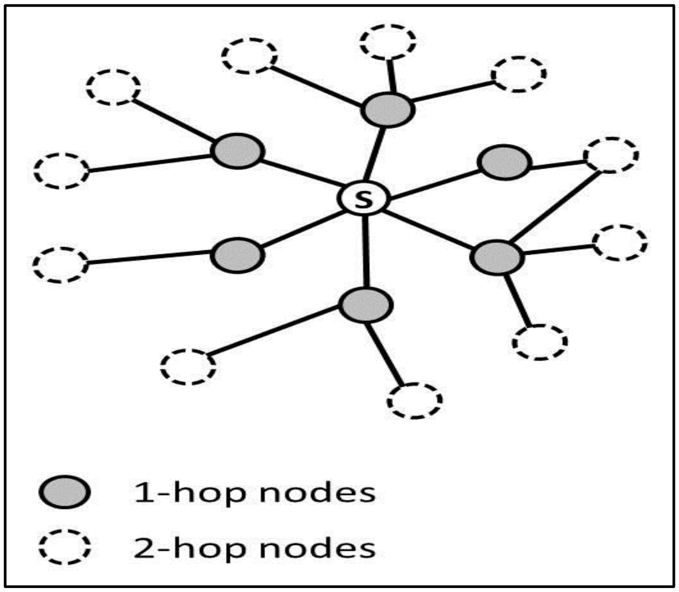

S
1-hop nodes
2-hop nodes

Figure 3.3: 1-hop neighbors and 2-hop neighbors

```
Input: the sorted NNT(X)based on Relative Speed
Output: CoveringSet(X).
if 2-hop(X)==NULL
return (0)
else
SuperSet(X) = ∪ ∀ i ϵ 2-hop (Y)

initialize CoveringSet(X) to NULL.
for each node in the sorted 1-hop(X) do:
check if it has a path to some nodes in the SuperSet(X) and add it to
CoveringSet(X).
repeat until all nodes in the original SuperSet(X) computed in 4 are covered
by CoveringSet(X).
return (CoveringSet(X)).
```

Figure 3.4 Covering Set Heuristic

In our work, we will compare the performance of the proposed algorithms against BCNS and AODV. AODV is a well-known and promising routing algorithm, and is considered as one of the best reactive routing protocols in MANETs because of several advantages, such as low overhead and maturity (Alhosban, Ababneh and Malik, 2012). Numerous improvements to AODV have been proposed in the literature [7, 19, 20].

3.3Relative Speed-Based Broadcast scheme (RSB)

The Relative Speed-Based Broadcast scheme RSB is our proposed scheme to control the flooding. RSB is basically build based on AODV reactive routing protocol. RSB aims to control the flooding by selecting a subset of the neighboring nodes based on their relative speed to be participated in the request packet forwarding process rather than other nodes, where the selected nodes from the 1-hop nodes cover all the nodes from the 2-hop nodes. The list of the1-hop nodes and 2-hop nodes obtained from the Hello Massages that the nodes broadcast it every hello interval.

RSB depends on the relative speed between neighboring nodes to construct the covering. The RREQ will be forwarded only to the selected nodes in the covering set in an attempt to reduce the overhead and increase the packet delivery ratio.

In RSB, every hello interval the neighboring nodes of node S will inform it about its own neighbors by sending the 2-hop neighbors list and the position of these nodes in the hello message and append them in the Near Neighbors Table (NNT). On receiving the hello message, node S will update its NNT so that to contain the 1-hop neighbors addresses, the value of RS between S and 1-hop nodes, and the 2-hop addresses. After updating the NNT, the values of RS will be sorted in an ascending order.

Now if S need to communicate with a destination D, and S does not have a route to that destination, then RSB will initiate a route discovery process by sending a RREQ packet. The covering set heuristic will be initiated based on RS values in NNT. The RREQ will be sent only to the 1-hop nodes addresses in the covering set that are covering all the 2-hop nodes which are included in the RREQ header. This step is repeated until reach the destination. In the worst case, if the nodes do not find the rout to the destination, then the original AODV will be applied. The lower the relative speed, the more stable the link between the nodes is. The overall complexity is O(n log n). The implementation of RSB shown in Figure 3.5 below:

Periodically, every HELLO_INTERVAL, broadcast a HELLO message containing own address, position and list of addresses of 1-hop neighbors.
On receiving a HELLO message at a node X:
update NNT((X), so that it will contain <1-hop neighbor's addresses, 1-hop neighbor's RS to X, 2-hop neighbor's addresses >.
sort the NNT(X) in an ascending order according to the RS field.
if X needs to communicate with a destination D, the following actions take place:
If a route exist to the destination.
Use it
else
Find a subset of 1-hop neighbors that cover all 2-hop neighbors by applying the heuristic in Figure 3.4
prepare a RREQ message; append the addresses of the nodes in the CoveringSet(X) to the header of the RREQ message.
Upon receiving an RREQ message, the following actions take place:
if the recipient node is the destination.
done.
else
only those intermediate nodes whose addresses are in the RREQ message will process the RREQ and rebroadcast it further.
if the destination is not found and the RREQ_RETRIES timer expires
flood RREQ message to all nodes.

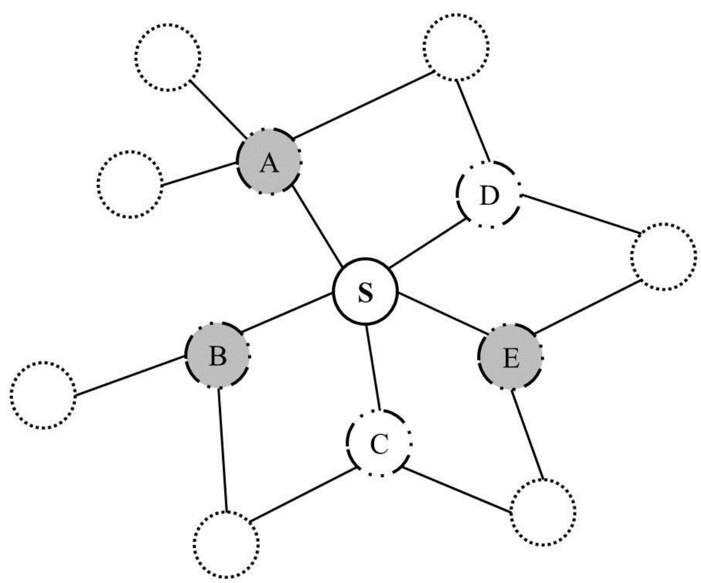
Figure 3.5: RSB broadcasting Scheme Implementation

Example: In figure 3.6 we assume that the source node (S) has 5 neighbors (A, B, C, D, and E) with the RS values 6, 1, 8, 15, and -3 m/s respectively. First, the nodes will be sorted in the ascending order of their relative speed with respect to S, as shown in Figure 3.6(a). Then, the nodes with the lowest RS values that cover all 2-hop neighbors, which are E, B, and A, will be selected to forward the RREQ packet, as shown in Figure 3.6(b). The above nodes E, B, and A, were chosen because they are the 1-hop nodes with minimum RS values that covers all the 2-hop nodes. Noticed that the priority is for the nodes that have the lowest RS values and in ascending order

Noticing the lower the RS the stable the link will be. These steps will be repeated until the RREQ packet reaches the destination.

Node	*Vr*
E	-3
B	1
A	6
C	8
D	15

(a)



(b)

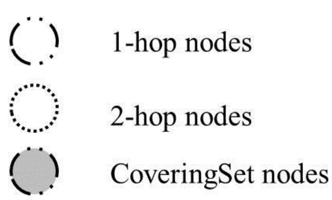


Figure 3.6: RSB concept example

CHAPTER FUOR SIMULATION ENVIROMENT and RESULTS DISCUSSION

Network simulators are usually used in the networking field to mimic the way the network works. Many network simulators have been widely used such as NS2, NS3, GloMoSim, OMNeT++, and QualNet.

In our work, we used the "Global Mobile Information System Simulator" (GloMoSim) network simulator version 2.03 to evaluate the performance of the RSB routing protocol and compare it with BCNS and AODV. The simulator already contains an implementation of AODV. GloMoSim is a commonly used simulation environment for wireless and wired networks systems (Jorge, 2004). GloMoSim uses a parallel discrete-event simulation capability provided by Parsec. The reasons why we choose GloMoSim is first its scalability as GloMoSim can simulate large scale models of up to million nodes (Jorge, 2004). Second, it is free and it is easy to find the material, user manual, and technical support in general. Third, it supports parallel simulation environments so it reduces the simulation execution time (Bajaj et al., 1999).

4.1Simulation parameters

Our proposed broadcasting scheme was added and implemented in the GloMoSim 2.03 simulator. It is worth mentioning that in our simulation experiments we have been taken the parameters values from (Alwidian, Ababneh, and Yassein, 2013) which we compare our work with it in order to insure a fair comparison. We model a MANET where the nodes are located in rectangular flat area, and each simulation experiment ran for 300 seconds repeated 10 times with different random seeds. The transmission ranges for all nodes are 250 meters. We implement experiments in four main categories:

Experiment 1 evaluates the effect of node speed on the performance using different numbers of CBR generators, where the number of Constant Bit Rate (CBR) generators is set to 10, 15, and 20 sources and the maximum speed of nodes is set to 1, 5, 10, 20, 600x600 meters area dimension and 50 m/s with a fixed node number of nodes of 20 for all scenarios.

Experiment 2 evaluates the effect of node speed on the performance, using different numbers nodes, where the number of nodes are 10, 20, and 50 nodes, the maximum nodes speed is set to 1, 5, 10, 20, 600x600 meters area dimension and 50m/s with fixed CBR generator of 10 sources for all scenarios. When the number of nodes is 10 the network is considered sparse, and when the number of nodes is 50 the network is considered dense.

Experiment 3 evaluates the effect of different traffic loads on the performance using different number of the nodes, where the number of nodes are 10, 20, and 50 nodes, the traffic loads are 1, 2, 4, 6, 8 packet/s with fixed CBR generator of 10 sources and 600x600 meters area dimension for all scenarios. The rest of simulation configurations and parameters values are illustrated in table 5.1.

Experiment 4 evaluates the effect of different area dimensions on the performance, where the dimensions are 1400x1400, 1600x1600, 1800x1800, 2000x2000, and 2200x2200 meters, with fixed number of nodes of 50 nodes, the traffic load is 8 packet/s with fixed CBR generator of 20 sources for this scenario, and the maximum node speed is 50m/s.

Parameter	Value
Simulator	GloMoSim 2.03
Routing Protocols Evaluated	RSB, BCNS, AODV
Simulation Time	300 Seconds
Number Of Nodes	10, 20, and 50 Nodes
Simulation Area	600m × 600m, 1400m×1400m, 1600m×1600m, 1800m×1800m, 2000m×2000m, 2200m×2200m
Transmission Range	250 m
Movement Model	Random Waypoint
Minimum Speed	0 m/s
Maximum Speed	1, 5, 10, 20, and 50 m/s
Number Of Sources	10, 15, and 20 Sources
Packet Rate	1, 2, 4, 6, and 8 packets/sec
Traffic Type	CBR
Pause Time	0 second
Data Payload	512 bytes/packet
MAC Layer Communication	IEEE 802.11
Link Bandwidth	2 Mb/s
Node Placement	Random

Table 4.1 Simulation parameters values

4.2Simulation performance metrics

To evaluate the performance of our broadcasting scheme in order to compare it to BCNS and AODV, we use the common performance metrics that have been used mostly in network models comparisons such as packet delivery ratio, routing overhead, and average end-to-end delay. These metrics are used to evaluate the tested protocols where identical scenarios are applied. Following is a brief explanation of each one of them.

Packet Delivery Ratio (PDR):

PDR is the ratio of total number of the data packets that are received in the destination to the number of the data packets that are sent from the source node. PDR is calculated by the following equation:

$$\textit{Percentage Change} = \frac{\textit{number of recived data packets}}{\textit{number of sent data packets}} \times 100\%$$

Routing Overhead:

Routing overhead represents the ratio of the sent control packet number to the number of received data packet. Routing overhead is calculated by the following equation:

$$\textit{Routing overhead} = \frac{\textit{number of resent control packets}}{\textit{number of recieved data packets}}$$

Average End-To-End Delay:

The Average End-To-End Delay represents the average delay between the time that the data packets were originated in the source node and the time when the packets arrives to the destination node (all the nodes in the network).

4.3Simulation Results and Analysis

In this chapter, we evaluate the proposed protocol in terms of overhead, packet delivery ratio, and end-to-end delay performance metrics. The proposed scheme, RSB, has been evaluated and compared to AODV protocol, and Broadcast-based Covering Neighbors Algorithm (BCNS) proposed in (Alwidian, Ababneh, and Yassein, 2013). The simulation experiments are divided into three main phases that investigate the effect of the following scenarios on the performance of the three protocols:

Several speeds with varies number of source generators.

Several speeds with varies number of nodes.

Several traffic loads with varies number of nodes.

The percentage of change for the proposed protocol over the others protocols are measured according to the following equation. The detailed percentages of changes for all experiments are illustrated in appendix A.

$$\text{Percentage } Change = \frac{Old\ Value - New\ Value}{Old\ Value} \times 100\%$$

4.4Effect of Speed and the number of Traffic Generators

The purpose of the simulation in this section is to study the effect of the nodes speed, and the number of CBR traffic generators on the performance of the three examined protocols. All the experiments in this section have a maximum node speed from 1 m/s up to 50 m/s. These experiments investigate the effect of a very low-speed node (speed = 1 m/s), and the effect of a very high-speed node (speed = 50 m/s) on the performance of the examined protocols. The simulation parameters for these experiments are set as follows:

Number of nodes: 20 nodes.

Packet rate: 2 packet/second.

Maximum speed of nodes: 1, 5, 10, 20, and 50 m/s.

Number of traffic generators (sources): 10, 15, and 20 CBR generators.

Different Node Speeds with 10 Sources

The simulation results presented in Figure 4.1, Figure 4.2, and Figure 4.3 illustrate the overhead, packet delivery ratio, and end-to-end delay respectively. The number of CBR generators is 10, and the node speed varies from 1 m/s up to 50 m/s.

Figure 4.1 shows that the proposed protocol has a significant reduction in the network overhead. The proposed protocol reduced the overhead by 68.5%, and 37% compared to AODV, and BCNS respectively at low nodes speed (1 m/s). At high maximum nodes speed (50 m/s) the proposed approach reduced the overhead by 79%, and 36% compared to AODV, and BCNS respectively. This overhead reduction caused by the fact that only the neighboring nodes that have been selected from the covering set are involved in the rebroadcasting operation.

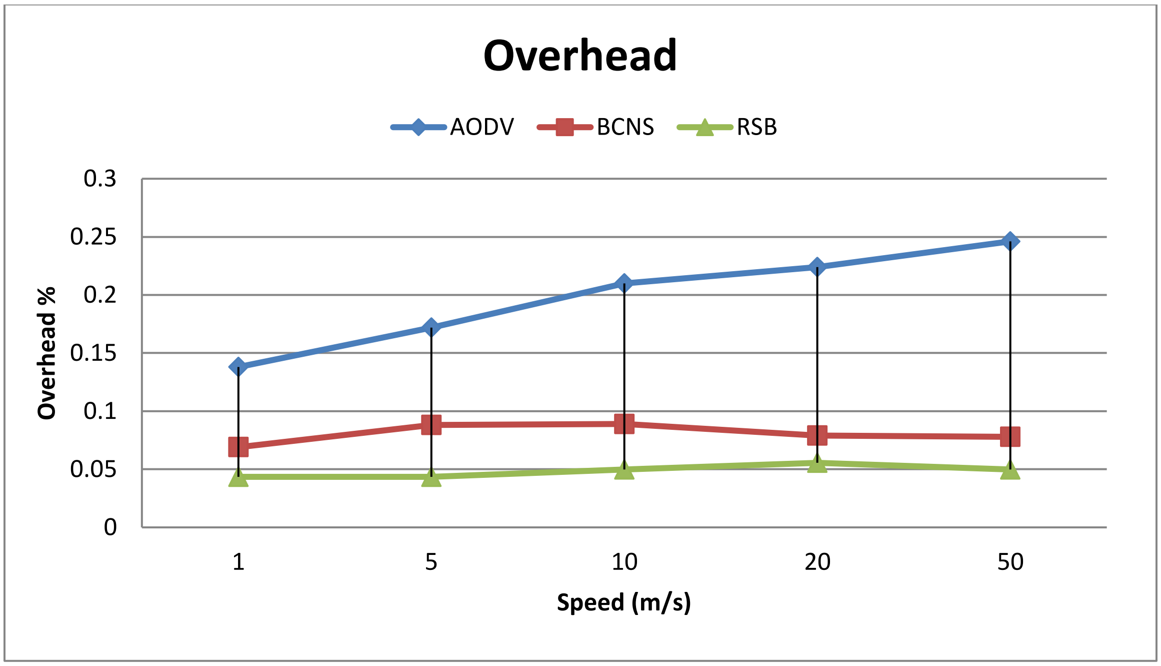


Figure 4.1: Overhead results with 10 CBR generators and varies node speeds.

Figure 4.2 shows the packet delivery ratio results of the three examined protocols. As the figure shows that the proposed protocol has a higher delivery packet ratio over the other protocols, almost all the packets have been received to their destinations. Compared to the AODV protocol the proposed protocol has 2.8%, and 6.6% enhancement ratio for low nodes speed, and for high nodes speed respectively.

Also, the RSB protocol has enhanced the packet delivery ratio approximately by 2.4% compared to BCNS protocol. The enhancement of PDR for the proposed protocol caused by the selection method of nodes (covering set) with regards to their relative speed.

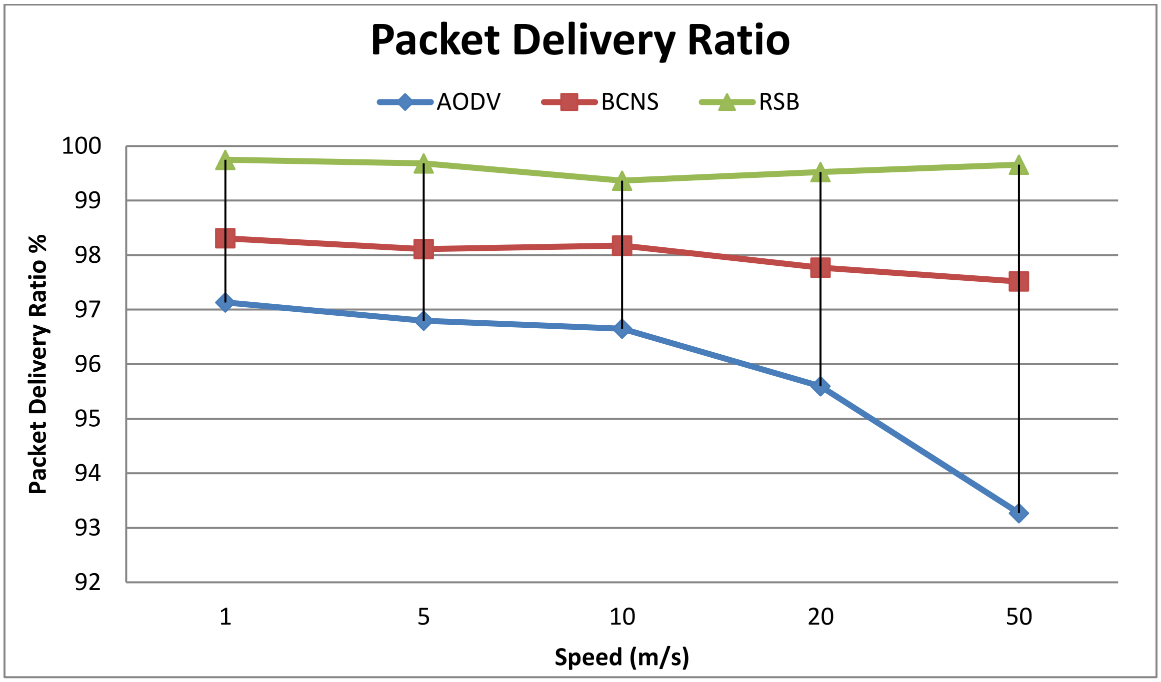


Figure 4.2: Packet Delivery Ratio with 10 CBR generators and varies nodes speed.

Figure 4.3 illustrate end-to-end delay results of the three examined protocols. As the figure shows that the AODV has the worst results in terms of delay compared to the other protocols. RSB, and BCNS have approximately the same end-to-end delay at low-speed nodes, while the RSB has a better end-to-end delay at high-speed nodes, this regards to the node selection method that affects the delay.

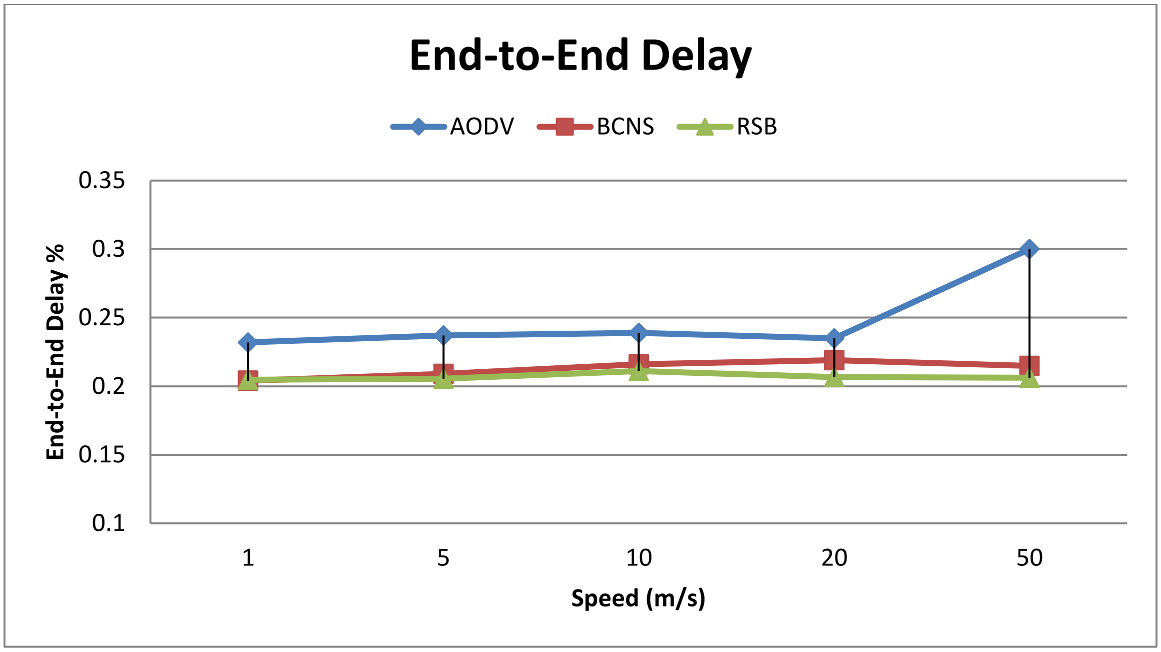


Figure 4.3: End-to-End Delay results with 10 sources and varies nodes speed.

Different Node Speeds with 15 Sources

The simulation results presented in Figure 4.4, Figure 4.5, and Figure 4.6 illustrate the overhead, packet delivery ratio, and end-to-end delay respectively. The number of CBR generators is 15, and the node speed varies from 1 m/s up to 50 m/s.

Figure 4.4 show that the proposed protocol has a significant reduction in the network overhead. The proposed protocol reduced the overhead by 76.2%, and 65.7% compared to AODV, and BCNS respectively at low nodes speed (1 m/s). At maximum nodes speed (50 m/s) the proposed approach reduced the overhead by 88.3%, and 65.6% compared to AODV, and BCNS respectively.

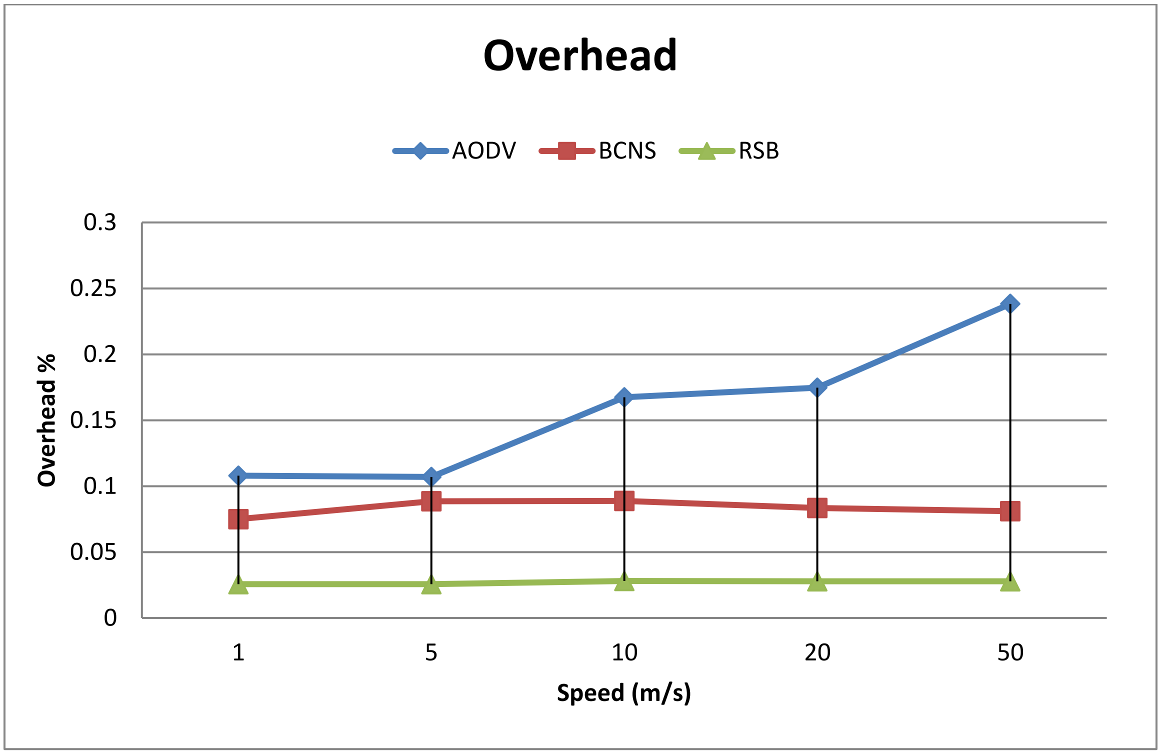


Figure 4.4: Overhead results with 15 CBR generators and varies node speeds.

Figure 4.5 shows the packet delivery ratio results of the three examined protocols. As the figure shows that the proposed protocol has achieved a good delivery packet ratio. Compared to the AODV protocol, the proposed protocol has 3.7%, and 6.9% enhancement ratio for low nodes speed, and for high nodes speed respectively. Also, the RSB protocol has enhanced the packet delivery ratio approximately by 3.6% compared to BCNS protocol.

Figure 4.6 illustrates end-to-end delay results of the three examined protocols. As the figure shows that the AODV has the worst results in terms of delay compared to the other protocols. RSB have the best end-to-end delay ratio compared to the other protocols. RSB has a better end-to-end delay by 15% than BCNS, and 31% enhancement of delay than AODV.

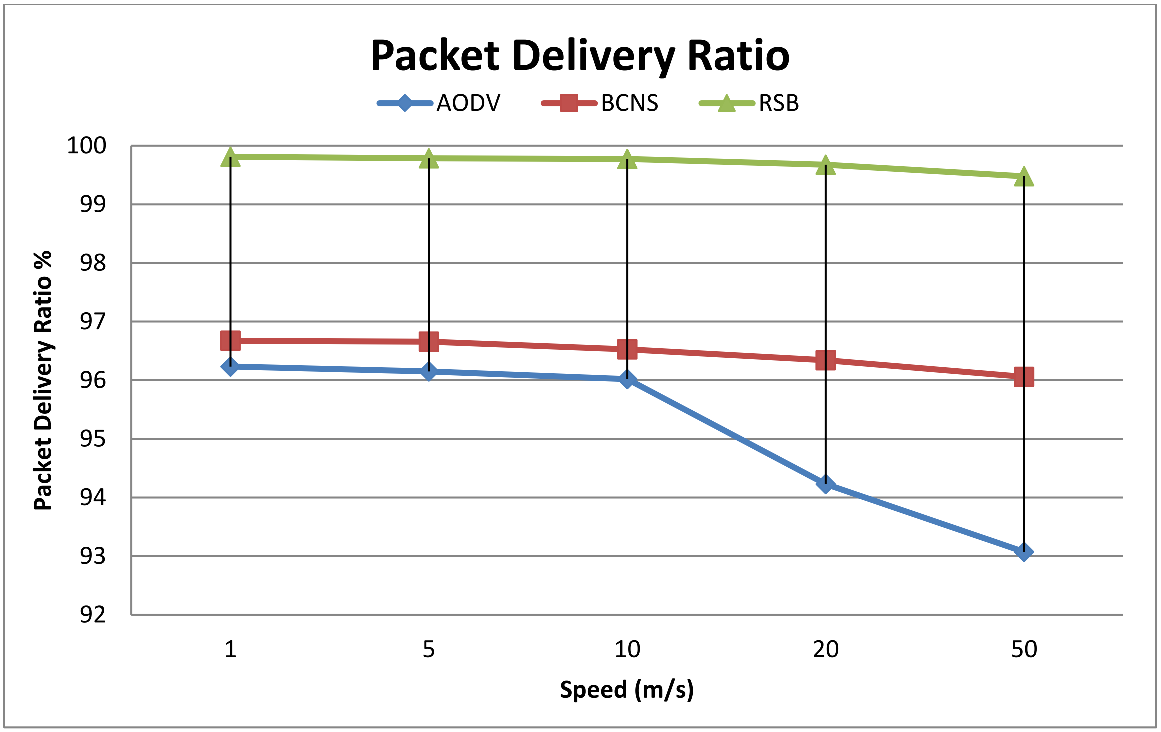


Figure 4.5: Packet Delivery Ratio with 15 CBR generators and varies nodes speed.

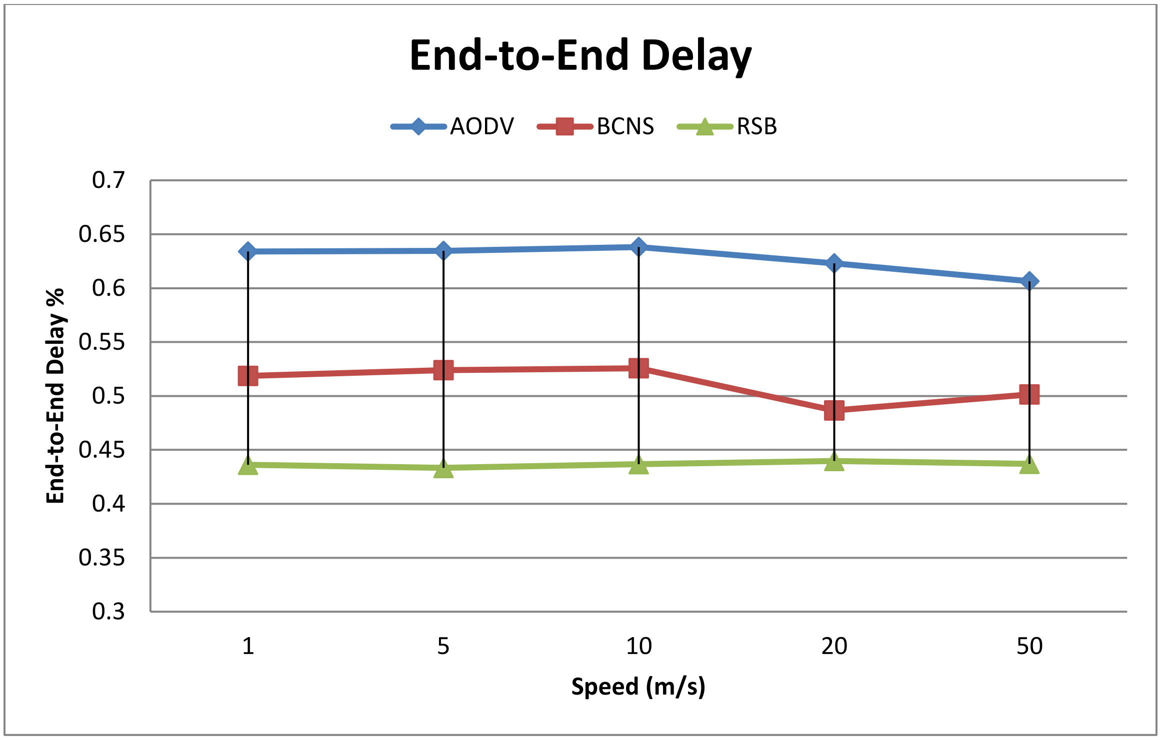


Figure 4.6: End-to-End Delay results with 15 sources and varies nodes speed.

Different Node Speeds with 20 Sources

The simulation results presented in Figure 4.7, Figure 4.8, and Figure 4.9 illustrate the overhead, packet delivery ratio, and end-to-end delay respectively. The number of CBR generators is 20, and the node speed varies from 1 m/s up to 50 m/s.

Figure 4.7 illustrates the overhead results for the three examined protocols with 20 CBR generators. As the figure shows that the proposed protocol has a significant reduction in the network overhead. The proposed protocol reduced the overhead by 81.8%, and 67% compared to AODV, and BCNS respectively at low nodes speed (1 m/s). At high nodes speed (50 m/s) the proposed approach reduced the overhead by 90.2%, and 64.5% compared to AODV, and BCNS respectively.

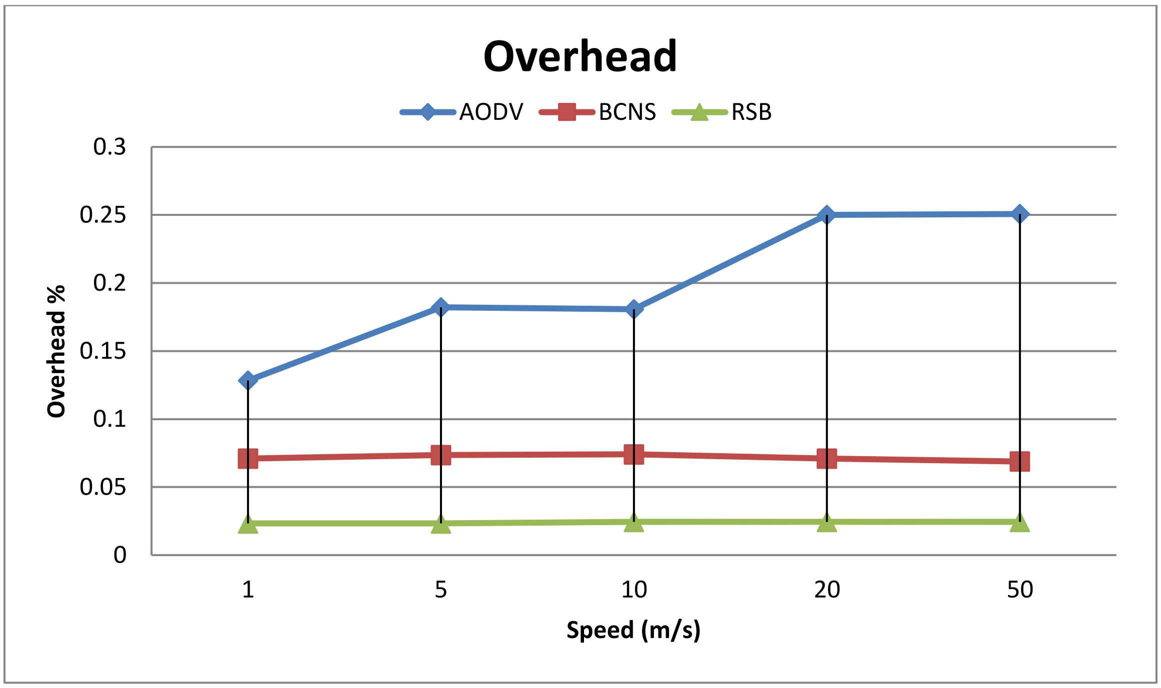


Figure 4.7: Overhead results with 20 CBR generators and varies node speeds.

Figure 4.8 presents the packet delivery ratio results of the three examined protocols. As the figure shows that the proposed protocol has a higher delivery packet ratio over the other protocols. Compared to the AODV protocol the proposed protocol has 6.2%, and 6.7% enhancement ratio for low nodes speed, and for high nodes speed respectively.

Also, the RSB protocol has enhanced the packet delivery ratio approximately 4.2% compared to BCNS protocol.

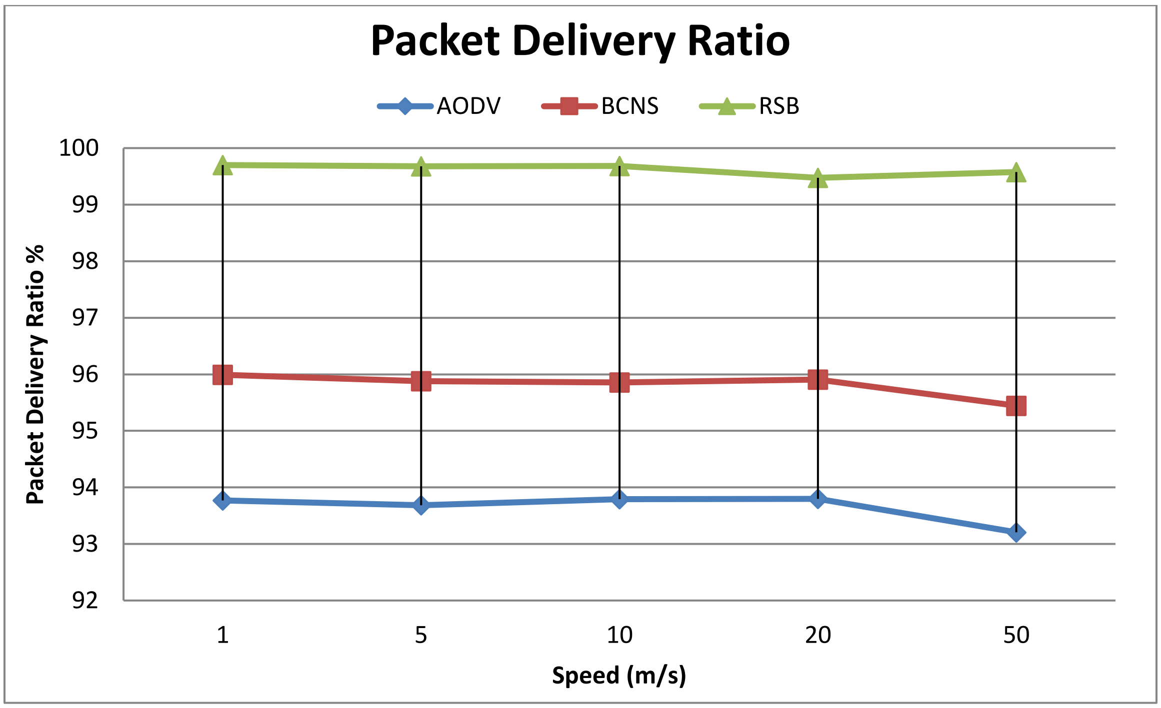


Figure 4.8: Packet Delivery Ratio with 20 CBR generators and varies nodes speed.

Figure 4.9 illustrates the end-to-end delay results of the three examined protocols. As the figure shows that the AODV has the worst results in terms of delay compared to the other protocols. RSB has a better end-to-end delay ratio than BCNS by 3%.

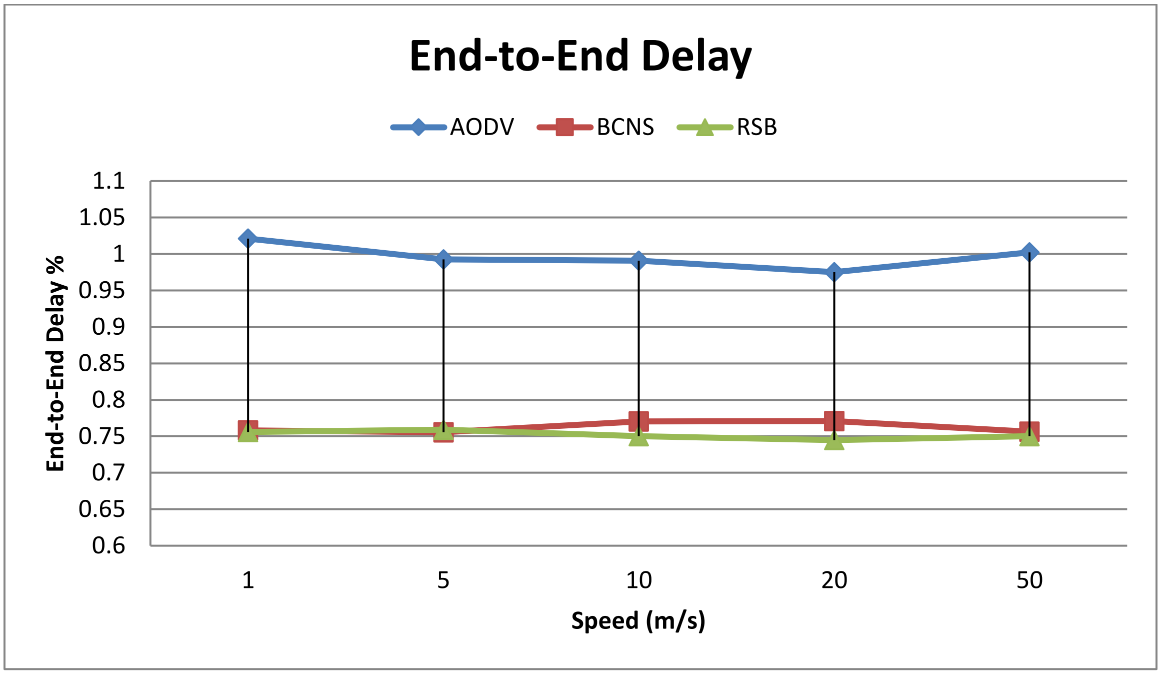


Figure 4.9: End-to-End Delay with 20 CBR generators and varies nodes speed.

4.5Effect of Speed and Number of Nodes

The purpose of the simulation in this section is to study the effect of the nodes speed, and the number of nodes on the performance of the three examined protocols. All the experiments in this section have a maximum node speed from 1 m/s up to 50 m/s. These experiments investigate the performance of the examined protocol in sparse network (number of nodes = 10 nodes), and in dense network (number of nodes = 50 nodes). All the experiments hold in simulation area of 600 x 600 dimensions. The simulation parameters for these experiments are set as follows:

Number of nodes: 10, 20, and 50 nodes.

Packet rate: 2 packet/second.

Maximum speed of nodes: 1, 5, 10, 20, and 50 m/s.

Number of traffic generators (sources): 10 CBR generators.

Different Node Speeds in Sparse Network (Number of Nodes =10)

The simulation results presented in Figure 4.10, Figure 4.11, and Figure 4.12 illustrate the overhead, packet delivery ratio, and end-to-end delay respectively. The number of nodes is 10, and the nodes speed varies from 1 m/s up to 50 m/s.

Figure 4.10 shows that the proposed protocol has a significant reduction in the network overhead. The proposed protocol reduced the overhead by 71.9%, and 53.3% compared to AODV, and BCNS respectively at low nodes speed (1 m/s). At high maximum nodes speed (50 m/s) the proposed approach reduced the overhead by 70.5%, and 37% compared to AODV, and BCNS respectively.

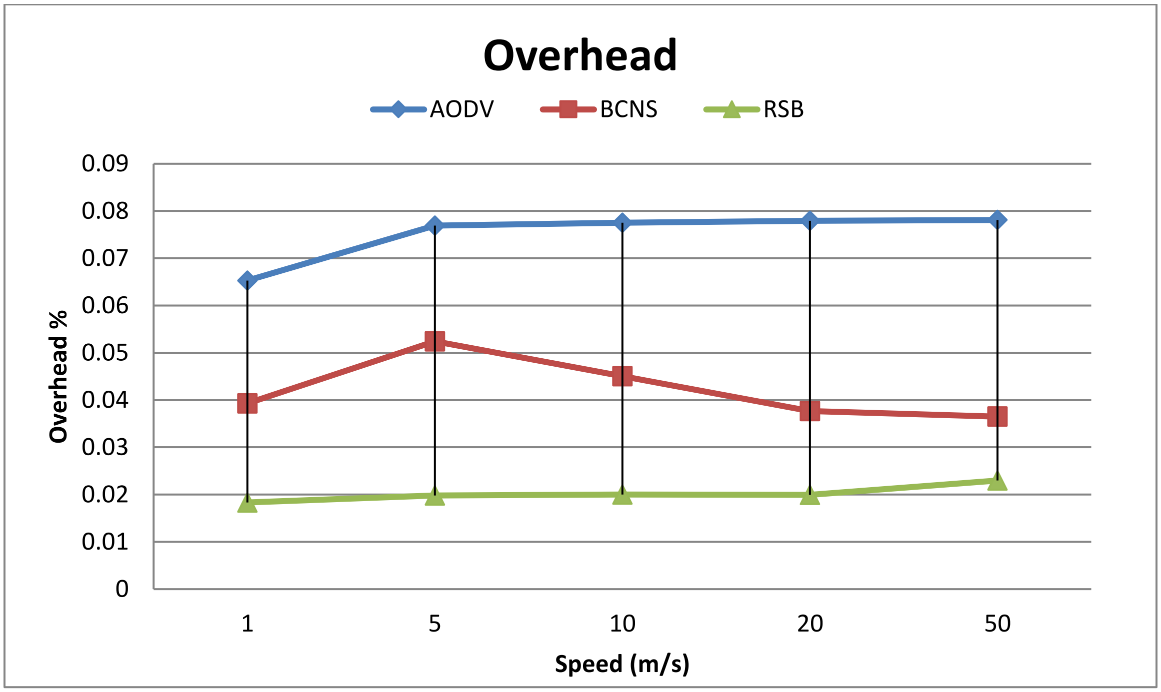


Figure 4.10: Overhead results with 10 nodes and varies node speeds.

Figure 4.11 shows the packet delivery ratio results of the three examined protocols. As the figure shows that the proposed protocol has the better delivery packet ratio than the other protocols. Compared to the AODV protocol the proposed protocol has 9.6%, and 11.77% enhancement ratio for low nodes speed, and for high nodes speed respectively.

Also, the RSB protocol has enhanced the packet delivery ratio approximately by 5.2% compared to BCNS protocol.

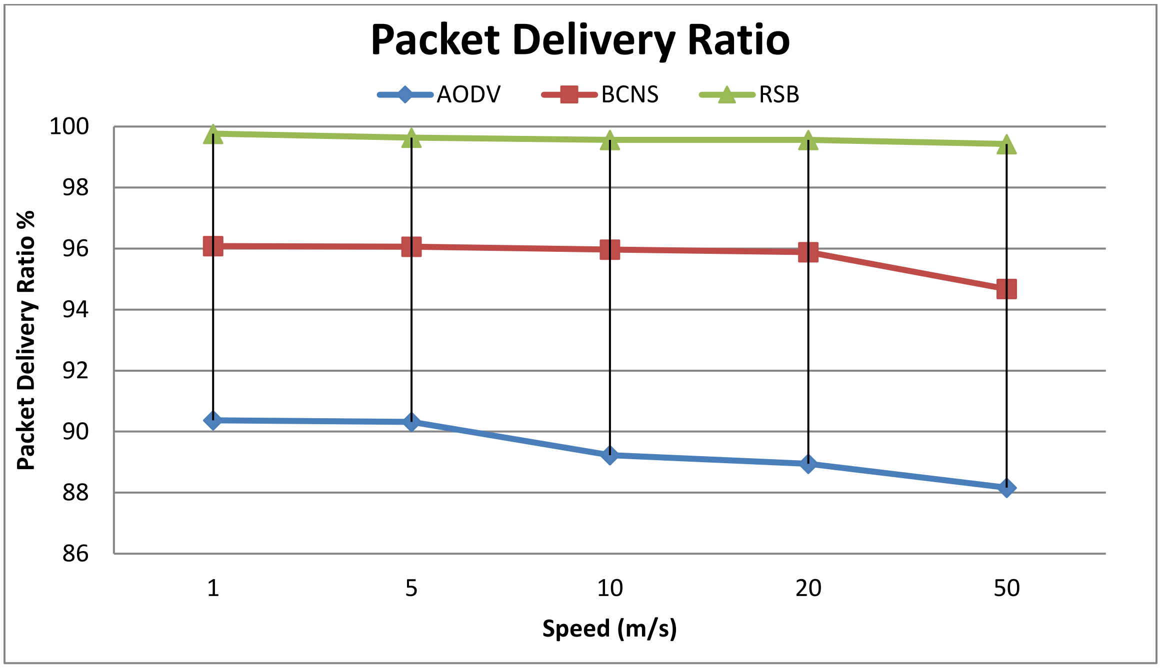


Figure 4.11: Packet Delivery Ratio with 10 nodes and varies nodes speed.

Figure 4.12 illustrates end-to-end delay results of the three examined protocols. As the figure shows that the RSB has the best results in terms of end-to-end delay compared to the other protocols. The RSB reduce the end-to-end delay by 74% and 71% for AODV and BCNS respectively.

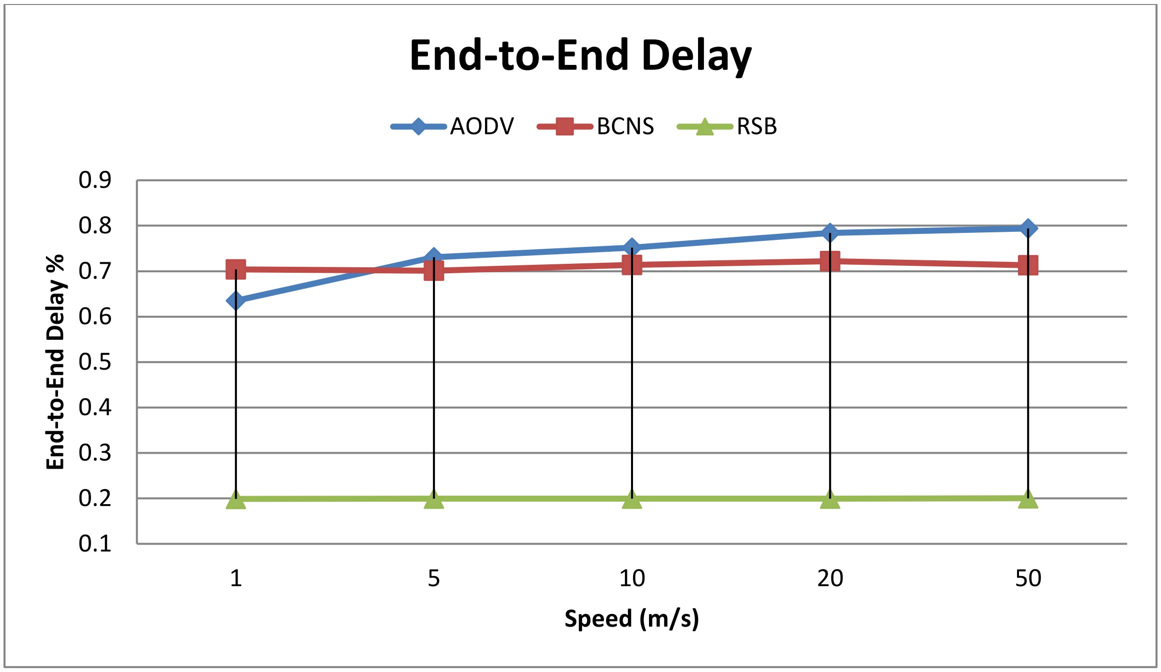


Figure 4.12: End-to-End Delay results with 10 nodes and varies nodes speed.

Different Node Speeds with 20 nodes

The simulation results presented in Figure 4.13, Figure 4.14, and Figure 4.15 illustrate the overhead, packet delivery ratio, and end-to-end delay respectively. The number of nodes is 20, and the node speed varies from 1 m/s up to 50 m/s.

Figure 4.13 presents the overhead results for the three examined protocols with 20 nodes. As the figure shows that the proposed protocol reduced the overhead in this experiment by 69%, and 42.25% compared to AODV, and BCNS respectively at low nodes speed (1 m/s). At high maximum nodes speed (50 m/s) the proposed approach reduced the overhead by 64.4%, and 22.3% compared to AODV, and BCNS respectively.

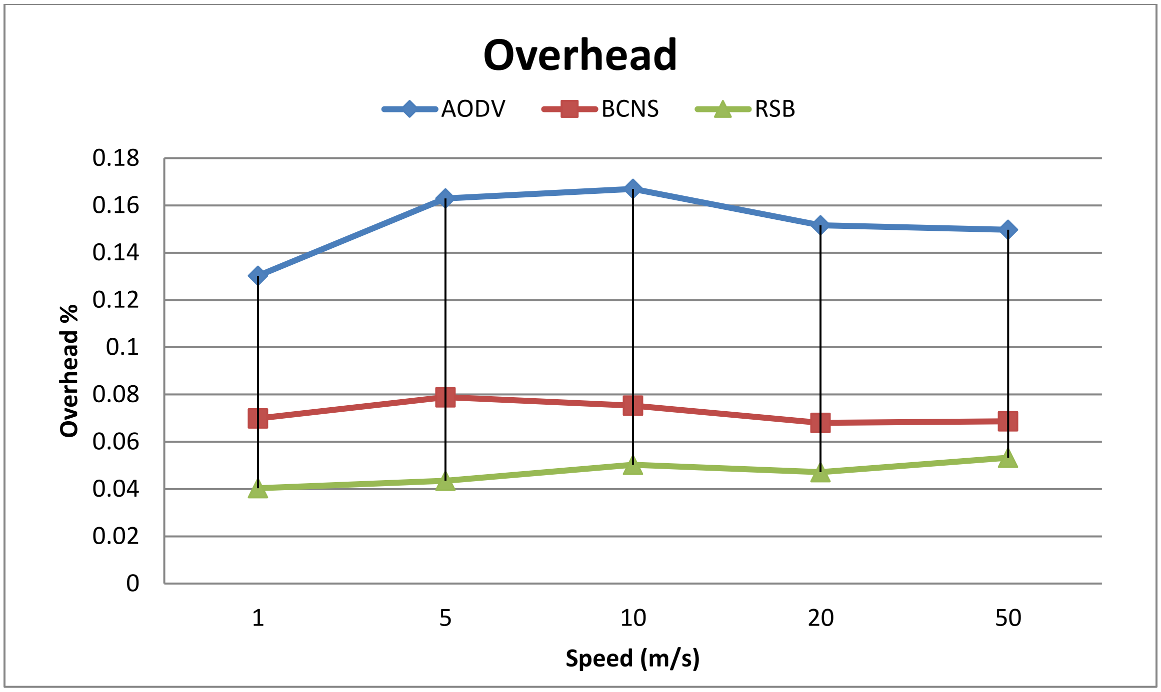


Figure 4.13: Overhead results with 20 nodes and varies nodes speed.

Figure 4.14 shows the packet delivery ratio results of the three examined protocols. As the figure shows that the delivery packet ratio of the proposed protocol is outperform the other protocols,. Compared to the AODV protocol the proposed protocol has 6.19%, and 8.1% enhancement ratio for low nodes speed, and for high nodes speed respectively. Also, the RSB protocol has enhanced the packet delivery ratio approximately by 4.03% compared to BCNS protocol.

Figure 4.15 illustrate end-to-end delay results of the three examined protocols. As the figure shows that the RSB has a significant reduction of end-to-end delay compared to the other protocols. The RSB reduce the end-to-end delay by 80% and 73.5% for AODV and BCNS respectively.

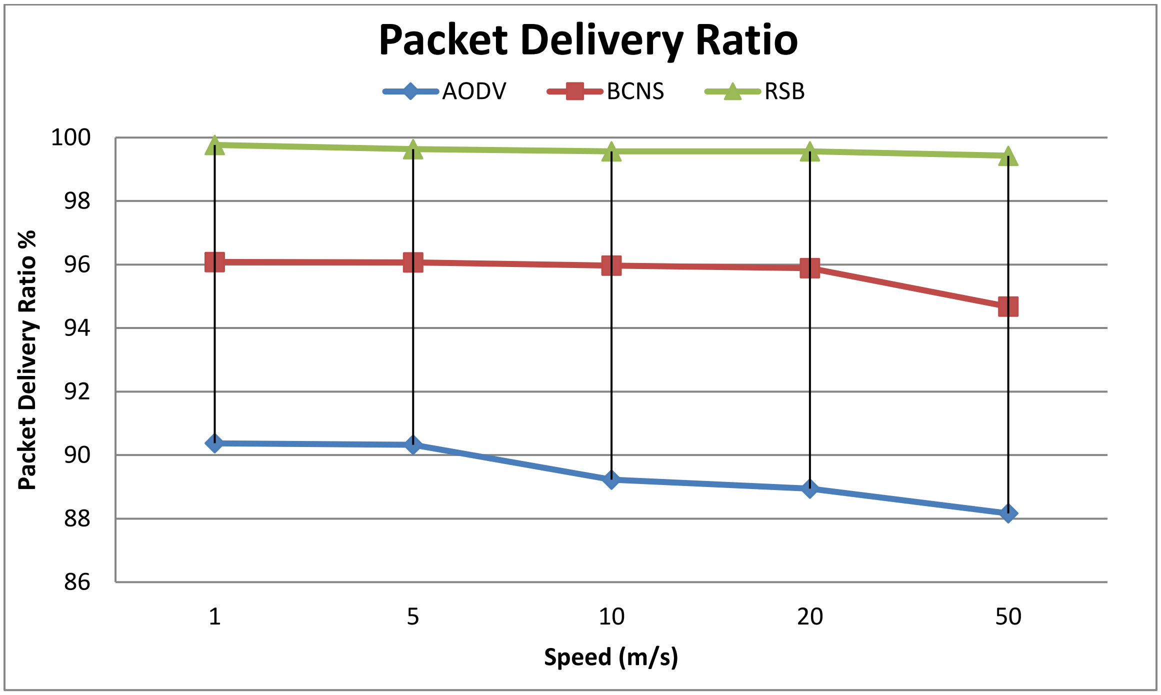


Figure 4.14: Packet Delivery Ratio with 20 nodes and varies nodes speed.

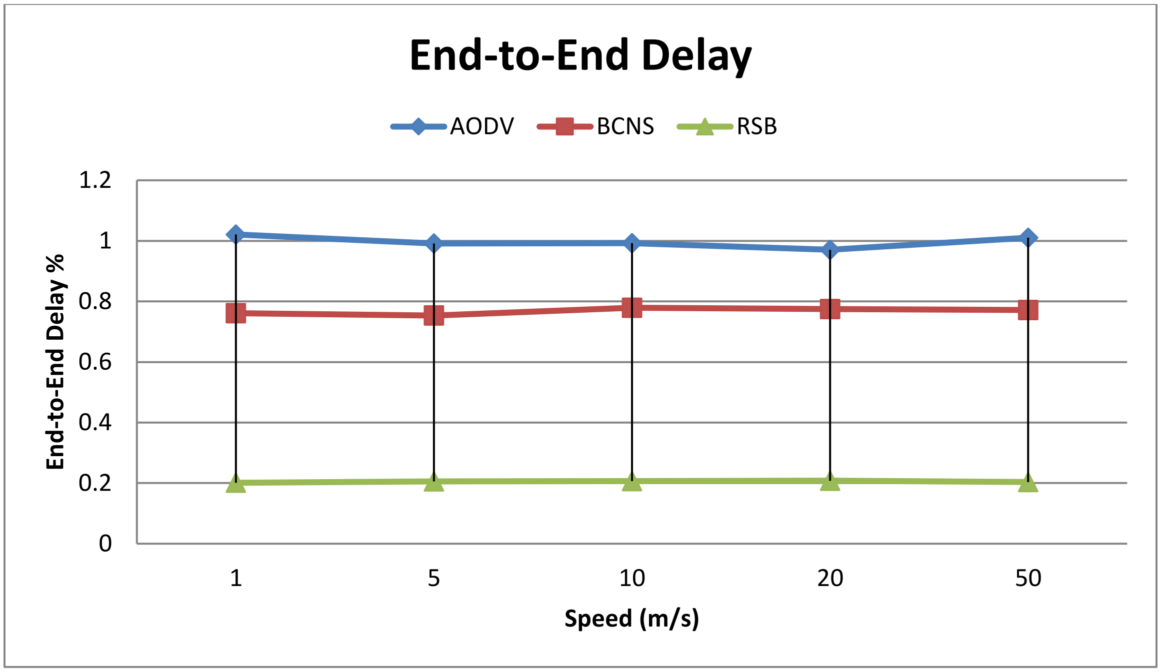


Figure 4.15: End-to-End Delay results with 20 nodes and varies nodes speed.

Different Node Speeds in Dense Network (Number of Nodes = 50 Nodes)

In this section, we evaluate the performance of the RSB protocol in a dense network against the AODV, and BCNS protocols. The simulation area dimensions were 600 x 600, and the number of nodes is 50. Figure 4.16, Figure 4.17, and Figure 4.18 present the overhead results, packet delivery ratio, and the end-to-end delay respectively.

Figure 4.16 illustrates that both RSB and BCNS protocols have a significant reduction of network overhead compared to the AODV protocol. RSB has a lower overhead than BCNS.

Figure 4.17 shows the result of packet delivery ratio for the examined protocols. In comparison to AODV, the RSB increased the packet delivery ratio by 5.6% at low nodes speed, and by 6.8% at high nodes speed, while increased the packet delivery ratio by 2.5% compared to BCNS.

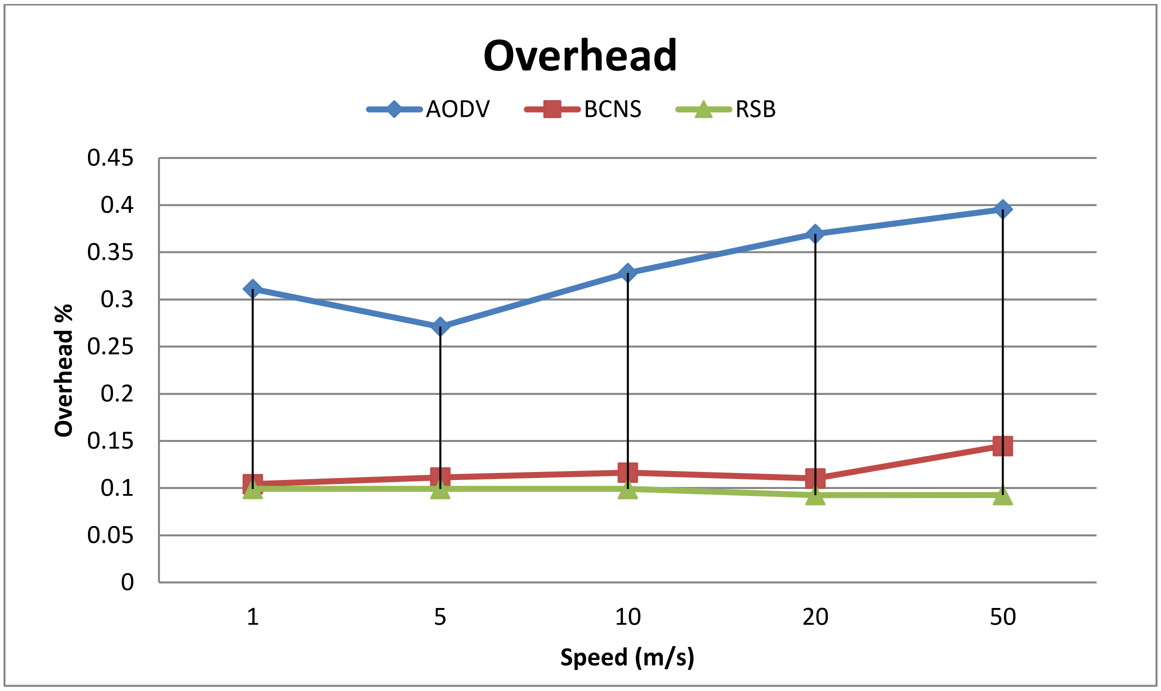


Figure 4.16: Overhead results for dense network with varies nodes speeds.

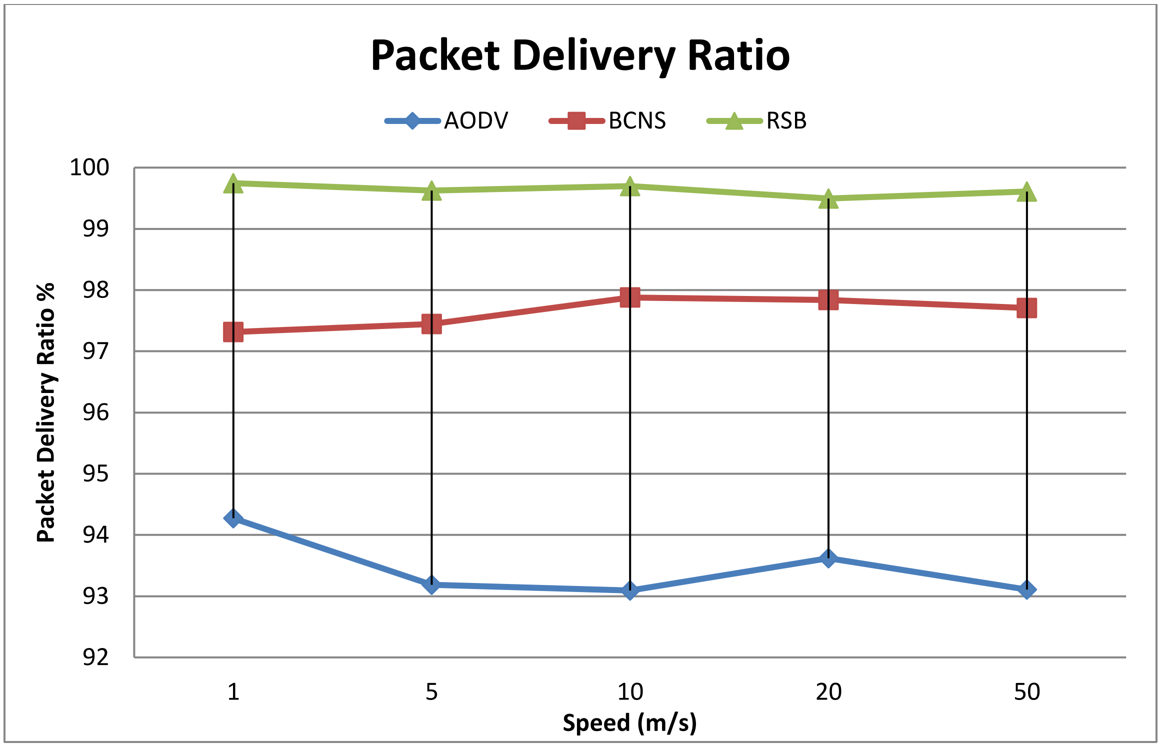


Figure 4.17: Packet delivery ratio for dense network with varies nodes speeds.

Figure 3.18 presents the end-to-end results for dense network over varies nodes speeds. As the figure shows, the RSB protocol has the lowest End-to-End delay in the dense network. With comparison to AODV, the RSB protocol reduces the end-to-end delay by 87.95%, 86.94% at low nodes speed, and high nodes speed respectively. Compared to BCNS, the RSB reduces the end-to-end delay by 74.1%, and 73.1% for low nodes speed, and high nodes speed respectively.

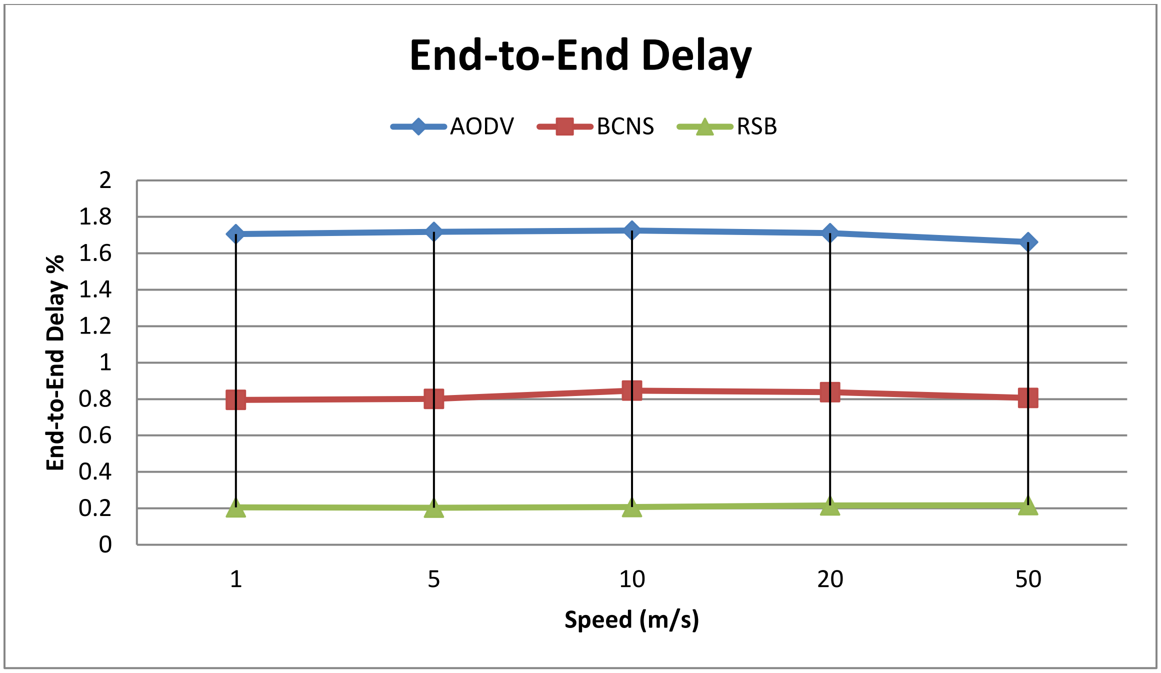


Figure 4.18: End-to-End delay for dense network with varies nodes speeds.

4.6Effect of Traffic Load and the Number of Nodes.

The purpose of the simulation in this section is to study the effect of the traffic load, and the number of nodes on the performance of the three examined protocols. The traffic load for all experiments in this section varies: 1, 2, 4, 6, and 8 packet/second. These changes in the traffic load are investigated at sparse and dense networks. The simulation parameters for these experiments are set as follows:

Number of nodes: 10, 20, and 50 nodes.

Packet rate: 1, 2, 4, 6, and 8 packets/second.

Maximum speed of nodes: 50 m/s.

Number of traffic generators (sources): 10 CBR generators.

Node pause time = 0 second.

Different Traffic Load in Sparse Network (Number of Nodes =10)

The simulation results present in Figure 4.19, Figure 20, and Figure 21 illustrate the overhead, packet delivery ratio, and end-to-end delay respectively. The number of nodes is 10, and the packet rate varies from 1, 2, 4, 6, and 8 packets/second.

The overhead results presented in Figure 4.19 illustrate that by increasing the packet rate, the network overhead reduced using RSB protocol. Also, the RSB protocol has a significant reduction in network overhead by 95.2% in high packet rate compared to AODV, and by 90.8% compared to BCNS.

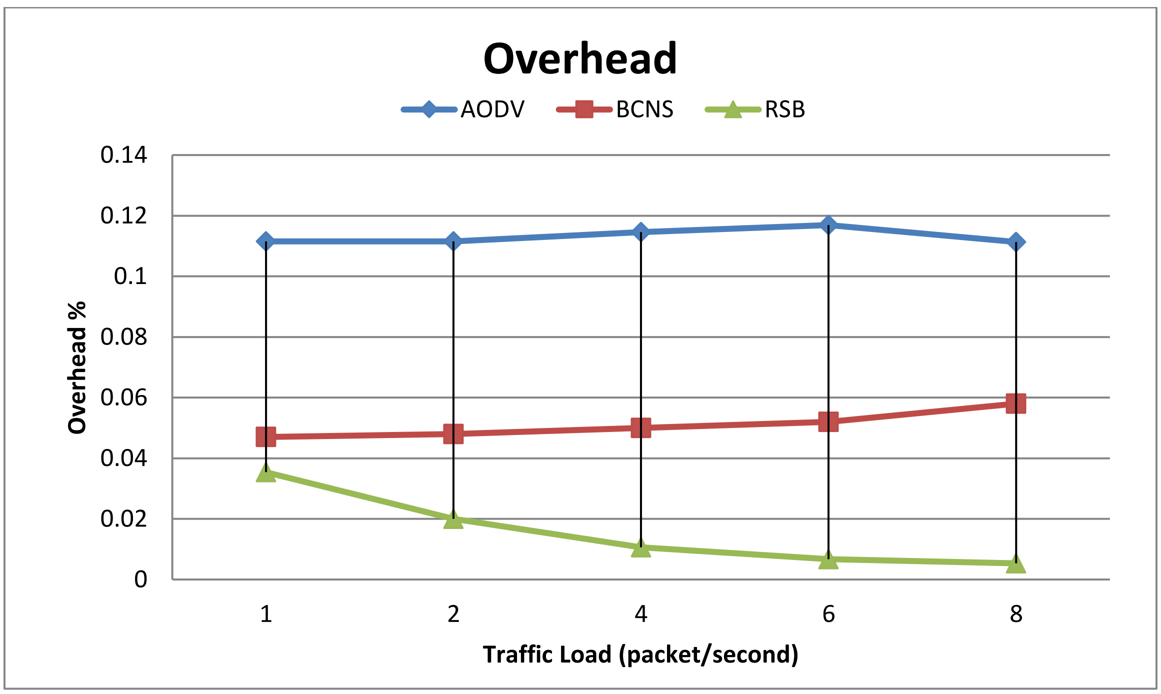


Figure 4.19: Overhead results for 10 nodes with different packet rate.

Figure 4.20 shows the results for packet delivery ratio for the three examined protocols. As the results show that whenever the packet rate increased, the packet delivery ratio decreased for both AODV and BCNS protocols. While the packet delivery ratio for the RSB remains the highest through all the packet rates.

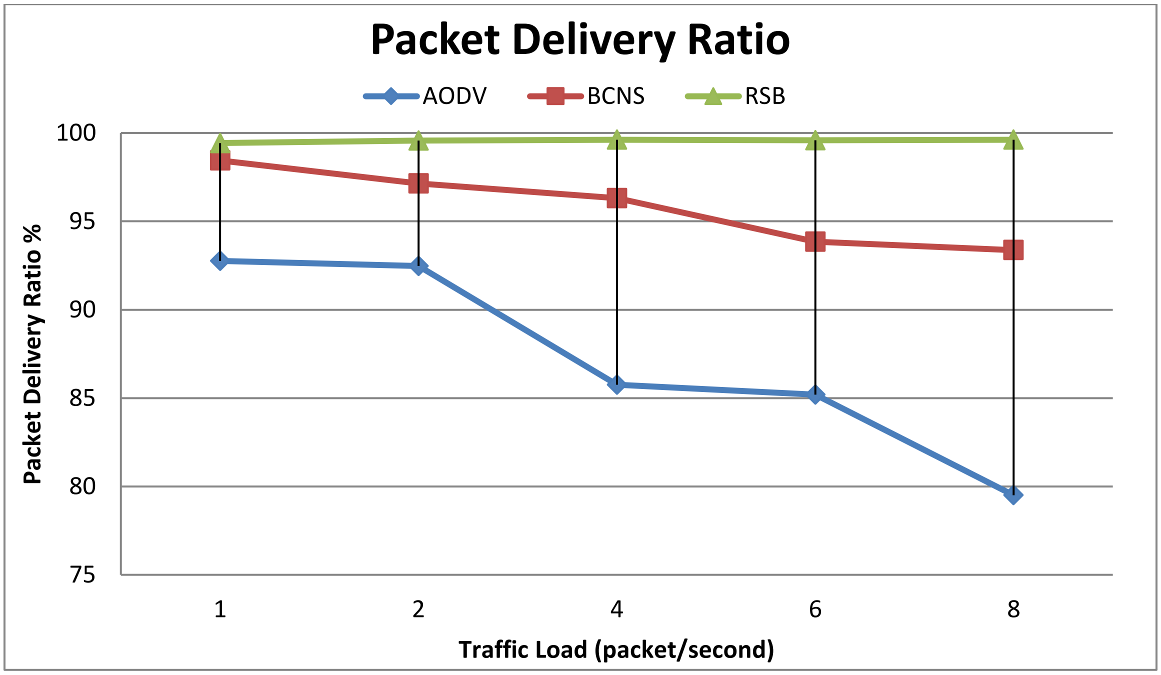


Figure 4.20: Packet delivery ratio for 10 nodes with different packet rate.

The results present in Figure 4.21 illustrate the end-to-end delay for the three protocols with 10 nodes, and different packets rate. The RSB protocol reduces the end-to-end delay by 83.2%, and 82.9% compared to AODV, and BCNS with low packet rate respectively. Also, RSB protocol reduces the end-to-end delay by 73.2%, and 75.5% compared to AODV, and BCNS with high packet rate respectively.

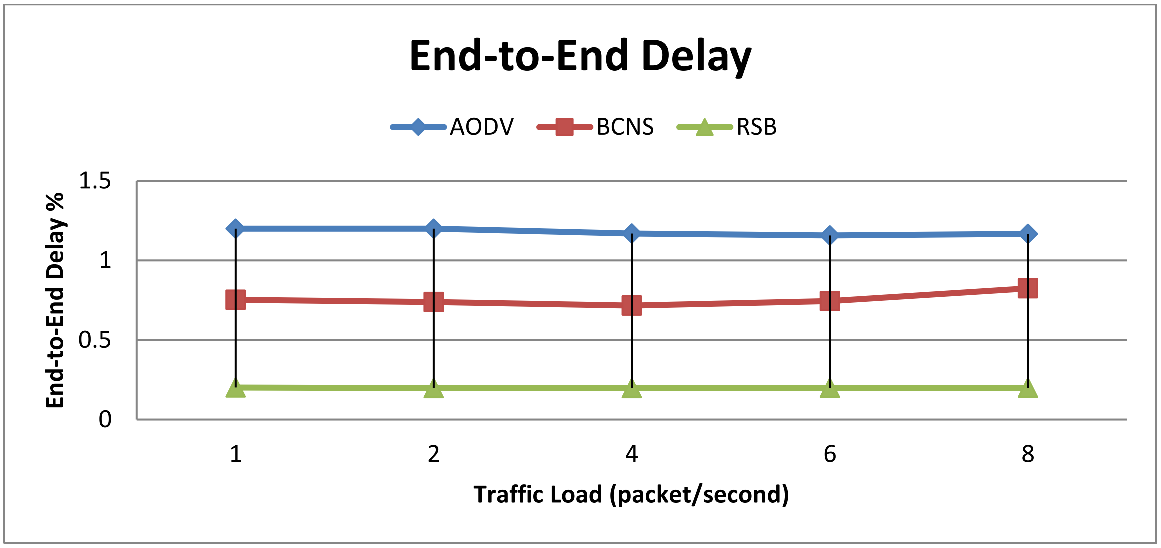


Figure 4.21: End-to-End delay for 10 nodes and different packet rate.

Different Traffic Load with Number of Nodes =20

The simulation results presented in Figure 4.22, Figure 4.23, and Figure 4.24 illustrate the overhead, packet delivery ratio, and end-to-end delay respectively. The number of nodes is 20, and the traffic load varies from 1, 2, 4, 6, and 8 packets/second.

Figure 4.22 presents the overhead results for the three examined protocols with 20 nodes. As the figure shows that the proposed protocol reduced the network overhead whenever the packet rate increased, whereas AODV and BCNS increased the network overhead, whenever the packet rate increased.

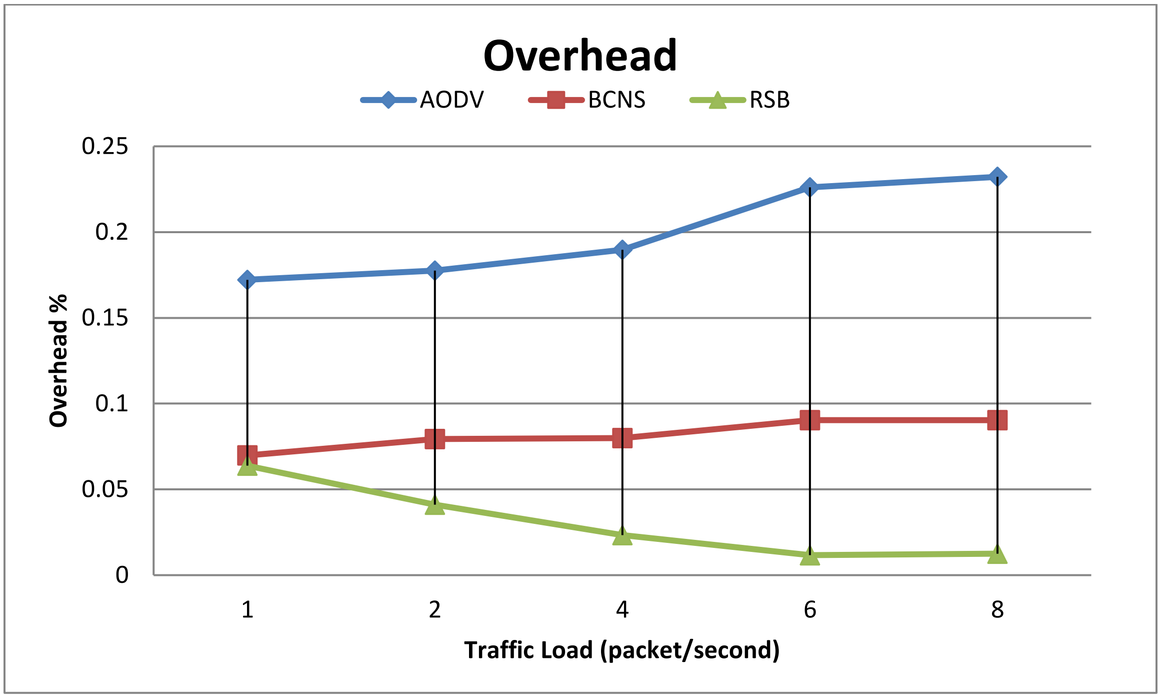


Figure 4.22: Overhead results for 20 nodes with different packet rate.

Figure 4.23 shows the results for packet delivery ratio for the three protocols. As the results show that at low packet rate, the packet delivery ratio for all protocols were convergent but with a preference for the RSB protocol over other protocols, whereas at high packet rate the different become larger. The packet delivery ratio by RSB improved by 29% compared to AODV, and by 6.1% compared to BCNS.

The results present in Figure 4.24 illustrate the end-to-end delay for the three protocols with 20 nodes, and different packets rate. The RSB protocol reduces the end-to-end delay by 82.7%, and 73% compared to AODV, and BCNS with low packet rate respectively. Also, RSB protocol reduces the end-to-end delay by 84.6%, and 71.38% compared to AODV, and BCNS with high packet rate respectively.

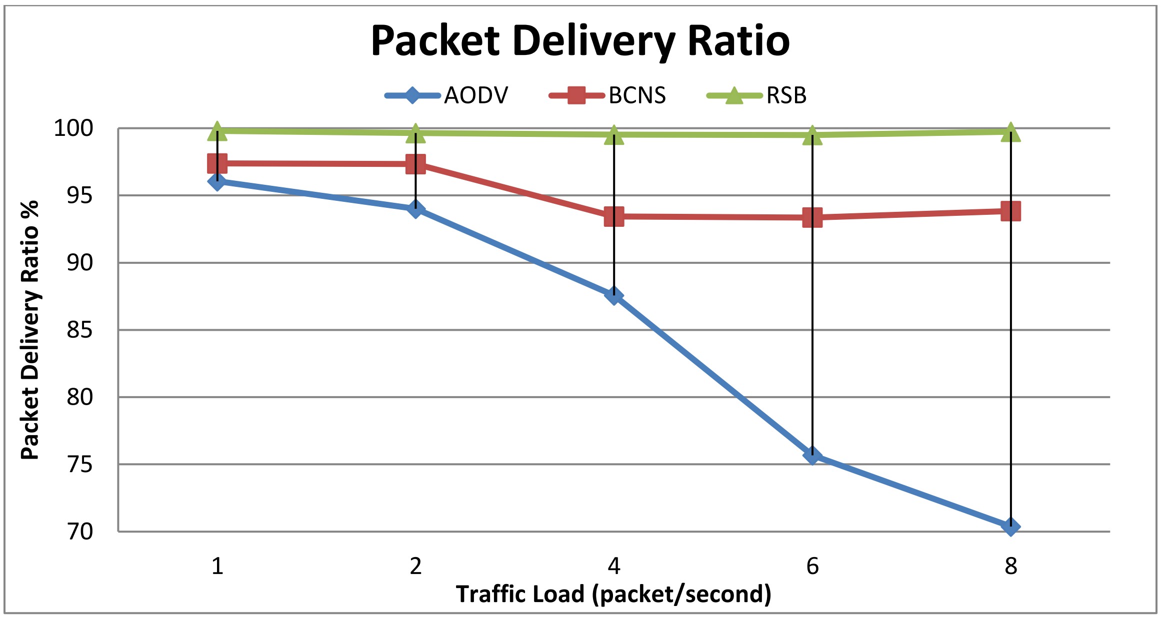


Figure 4.23: Packet delivery ratio for 20 nodes and different packet rate.

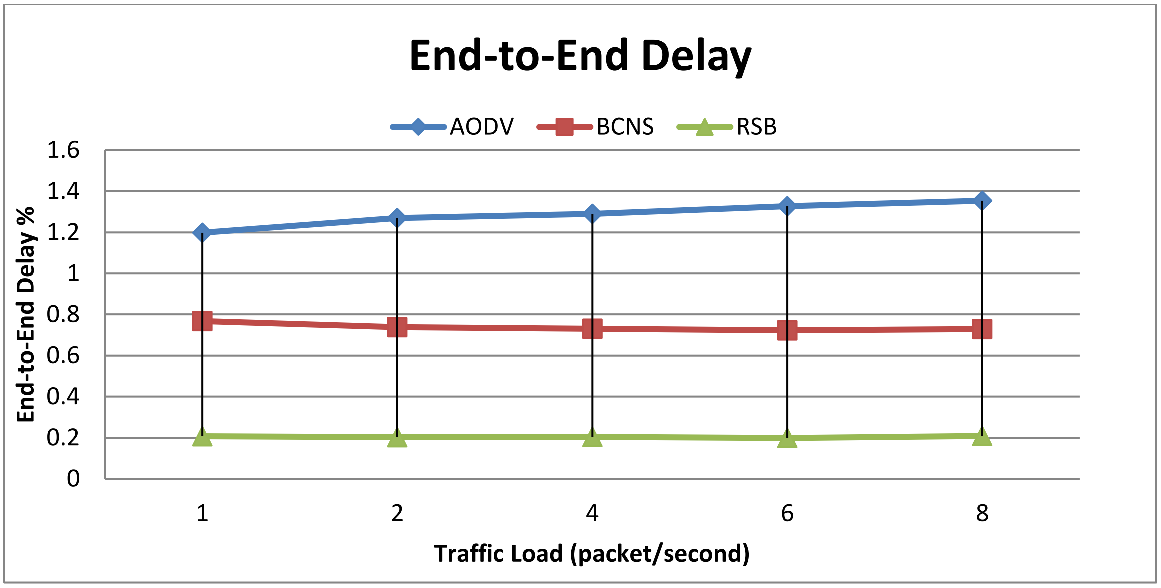


Figure 4.24: End-to-End delay for 20 nodes and different packet rate.

Different Traffic Load in Dense Network (Number of Nodes = 50)

In this section, we evaluate the performance of the RSB protocol in a dense network against the AODV, and BCNS protocols. The simulation area dimensions were 600 x 600, and the number of nodes is 50.

Figure 4.25, Figure 4.26, and Figure 4.27 present the overhead results, packet delivery ratio, and the end-to-end delay respectively.

Figure 4.25 illustrates that both RSB, and BCNS protocols have a significant reduction of network overhead compared to the AODV protocol. RSB have a lower overhead than BCNS at high packet rate.

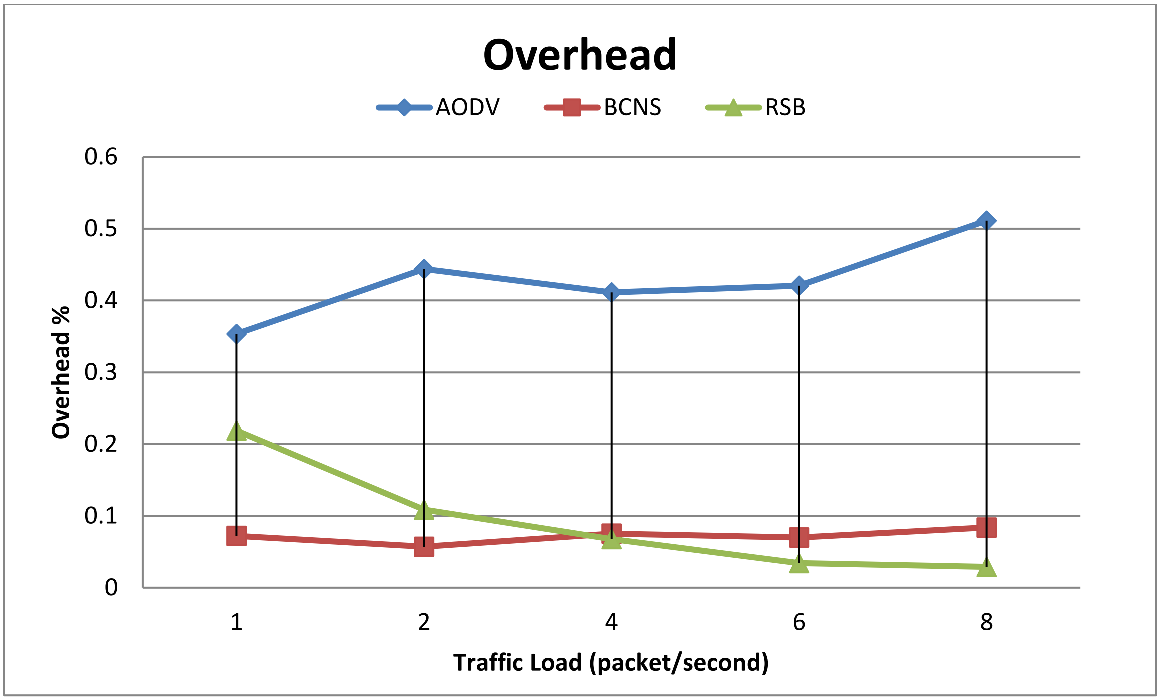


Figure 4.25: Overhead results in dense network with different packet rate.

The result of packet delivery ratio in Figure 4.26 shows that RSB outperformed the other two protocols. In comparison to AODV, the RSB increased the packet delivery ratio by 2.8% at low nodes speed, and by 24.08% at high nodes speed, while increased the packet delivery ratio by 2.1% at low packet rate, and by 5.4% at high packet rate as compared to BCNS.

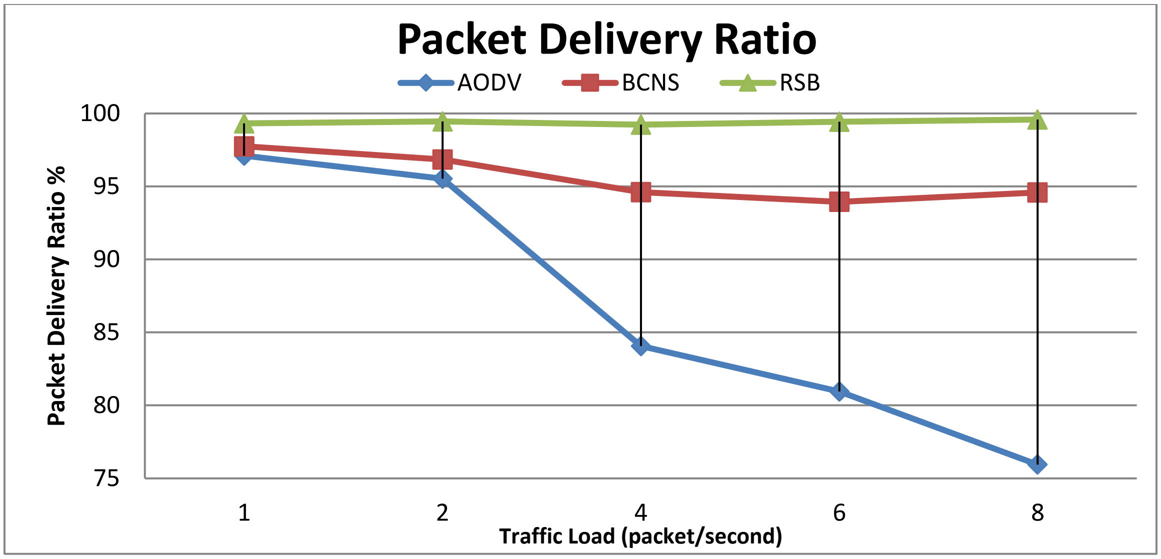


Figure 4.26: Packet delivery ratio for dense network with different packet rate.

Figure 4.27 illustrates the results of end-to-end delay for the three protocols in a dense network, and different packets rate. The results show that with increasing the packet rate, the end-to-end delay for the RSB protocol remains the approximately the same, while the end-to-end delay increased with increasing the packet rate for both AODV, and BCNS protocols. The RSB protocol reduces the end-to-end delay by 84.1%, and 92.6% compared to AODV, and BCNS with low packet rate respectively. Also, RSB protocol reduces the end-to-end delay by 75.4%, and 84.75% compared to AODV, and BCNS with high packet rate respectively.

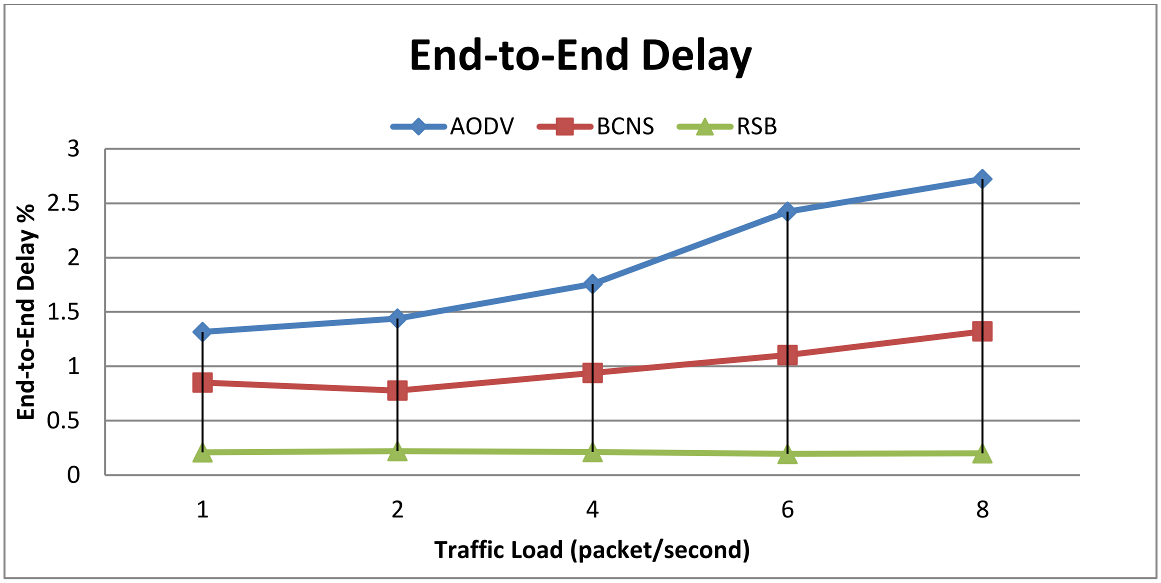


Figure 4.27: End-to-End delay results with different packet rate.

4.7Effect of different area dimensions

The purpose of the simulation in this section is to study the behavior of the RSB protocol when the simulation area becomes larger. The dimensions of the experiments in this section are: 1400x1400, 1600x1600, 1800x1800, 2000x2000, and 2200x2200 meters. The simulation parameters for these experiments are set to 50 nodes, 8 packets/second, 50 m/s maximum speed of nodes, and 20 CBR generators.

In the results of this experiment, we noticed that the overhead of the RSB protocol is increased when the area dimension becomes larger. The result of packet delivery ratio shows a degradation regarding to the RSB protocol over the different area dimension. The results present higher end-to-end delay for the RSB protocol whenever the area dimension getting larger. The reason of that is since the area dimension getting larger and larger, the distances between the nodes also increased which increased the probability of link breakage, so the overhead will be increased because of the routing discovery operations so the end-to-end delay became higher.

In summary, we noticed that with increasing the number of CBR generator, the overhead reduction for the RSB over the other protocols become larger. The packet delivery ratio increased whenever the maximum node speed increased. The end-to-end delay improvement of the RSB protocol over the other protocols increased by reduced the number of CBR generators. In the large area experiments, the results shows a downgrade in the performance of the RSB protocol with larger area diminutions.

From the conducted results, the enhancement achieved by the proposed protocol in terms of overhead, PDR, and end-to-end delay explained by the following:

The network overhead reduction caused by the fact that the RREQ forwarded to the selected nodes in the covering set only.

The PDR enhancement caused by that the covering set that selected to be included in the candidate route contains the nodes depend on their relative speed toward the route.

The end-to-end delay enhanced by the fact that the nodes that have a relative speed outside the route were excluded from the covering set. This eliminates the link breakage which affects the end-to-end delay.

CHAPTER FIVE

Conclusion and Future Work

5.1Conclusion:

In this work we present our broadcasting based scheme for MANET and illustrate the performance by using the GloMoSim network simulator, and we found the following contributions regarding to our study:

The RSB is a reliable broadcast scheme that excludes the disadvantages of the flooding, so the overhead is reduced, and avoiding the rebroadcasting storm problem by selecting a subset of the nodes to participate in the rout request process.

RSB outperform both BCNS and AODV in terms of overhead, packet delivery ratio, and end-to-end delay, where significant improvement has been achieved in low and high speed scenarios and also with deferent data packets loads.

In the large area experiment, we noticed degradation in the performance of the RSB where the packet delivery ratio is decreased, the overhead increased and the end to end delay increased with larger area dimensions. Nevertheless, it achieves better performance than the AODV protocol.

5.2Future work

In this work, we present a solution for flooding problem by using the covering set principle and the relative speed between the nodes, however there is some area for more development in each field, and the following are some suggested ideas:

Relative Speed and Density Broadcast Scheme:

This suggested scheme combines the density and the relative speed between the nodes as basis for determining the covering set. Below are some specific approaches for selecting the covering set:

Use a threshold value, which is empirically determined to decide either the node is in a dense or sparse area, and construct the covering set based on the relative speed if the node is located in a dense area.

The covering set will be constructed based on node density rather than the relative speed if the node is located in a sparse area. Furthermore, the source node can apply flooding in case the RREQ cannot reach the destination.

Another approach is to change the order of the sorted nodes based on RS. For example, if there are two nodes that have almost the same number of neighbors but there is a big difference in RS values, the node that has the lower RS will be re-sorted ahead of the other node so as to avoid the link breakage problem. Example, if a node has two neighbors A and B, and the node A has 7 neighbors and a RS of 10, and the node B has 6 neighbors and a RS of 2, then node B will be placed before node A.

References

Hoebeke, J., Moerman, I., Dhoedt, B. and Demeester, P., 2004. An overview of mobile ad hoc networks: applications and challenges. Journal-Communications Network, 3(3), pp.60-66.

Abolhasan, M., 2003. Scalable routing strategies for mobile ad hoc networks., Doctor of Philosophy thesis, School of Electrical, Computer and Telecommunications Engineering, University of Wollongong, 2003. http://ro.uow.edu.au/theses/1958.

Alhosban, A., Ababneh, I. and Malik, Z., 2012. GFDA: Route Discovery Algorithms for On-demand Mobile Ad Hoc Routing Protocols. Procedia Computer Science, 10, pp.70-77.

Ababneh, I., Mardini, W. and al-Hassan, A.A., 2010. ADAPTIVE VELOCITY-BASED ROUTE DISCOVERY IN MOBILE AD HOC NETWORKS..

Alwidian, S.A., Ababneh, I.M. and Yassein, M.O.B., 2013. Neighborhood-based route discovery protocols for mobile ad hoc networks. International Journal of Mobile Computing and Multimedia Communications (IJMCMC), 5(3), pp.68-87.

Conti, M. and Giordano, S., 2014. Mobile ad hoc networking: milestones, challenges, and new research directions. IEEE Communications Magazine, 52(1), pp.85-96.

Yassein, M.O.B., Alslaity, A. and Ababneh, I., 2012, September. Performance Evolutions of Velocity Aware Routing Protocol for Mobile Ad hoc Networks. In Proceeding of the Sixth International Conference on Mobile Ubiquitous Computing, Systems, Services and Technologies (UBICOMM 2012,-Barcelona, Spain.

Das, S.R., Belding-Royer, E.M. and Perkins, C.E., 2003. Ad hoc on-demand distance vector (AODV) routing.

Garica-Luna-Aceves, J.J. and Spohn, M., 1999, October. Source tree adaptive routing. In Proc. International Conference on Network Protocols.

Chen, T.W. and Gerla, M., 1998, June. Global state routing: A new routing scheme for ad-hoc wireless networks. In Communications, 1998. ICC 98. Conference Record. 1998 IEEE International Conference on (Vol. 1, pp. 171-175). IEEE.

Murthy, S. and Garcia-Luna-Aceves, J.J., 1996. An efficient routing protocol for wireless networks. Mobile Networks and applications, 1(2), pp.183-197.

Pei, G., Gerla, M. and Chen, T.W., 2000. Fisheye state routing: A routing scheme for ad hoc wireless networks. In Communications, 2000. ICC 2000. 2000 IEEE International Conference on (Vol. 1, pp. 70-74). IEEE.

Toh, C.K., 1997. Associativity-based routing for ad hoc mobile networks. Wireless Personal Communications, 4(2), pp.103-139.

Gü, M., Sorges, U. and Bouazizi, I., 2002, August. ARA—the ant-colony based routing algorithm for MANETs. In null (p. 79). IEEE.

Park, V.D. and Corson, M.S., 1997, April. A highly adaptive distributed routing algorithm for mobile wireless networks. In INFOCOM'97. Sixteenth Annual Joint Conference of the IEEE Computer and Communications Societies. Driving the Information Revolution., Proceedings IEEE (Vol. 3, pp. 1405-1413). IEEE.

Chlamtac, I., Conti, M. and Liu, J.J.N., 2003. Mobile ad hoc networking: imperatives and challenges. Ad hoc networks, 1(1), pp.13-64.

Ahmed, B., Mohamed, R. and Mohamed, O., 2012. Queue length and mobility aware routing protocol for mobile ad hoc network. International Journal of Communication Networks and Information Security (IJCNIS), 4(3).

Enneya, N., El Koutbi, M. and Berqia, A., 2006, April. Enhancing AODV performance based on statistical mobility quantification. In Information and Communication Technologies, 2006. ICTTA'06. 2nd (Vol. 2, pp. 2455-2460). IEEE.

Ahmed, B., Zytoune, O., Nourddine, E., Mohamed, R. and Mohamed, O., 2012. ADAPTIVE VELOCITY AND DISTANCE BASED ROUTING PROTOCOL FOR MANET. Journal of Theoretical & Applied Information Technology, 45(2).

Idrees, M., Yousaf, M.M., Jaffry, S.W., Pasha, M.A. and Hussain, S.A., 2005, September. Enhancements in AODV routing using mobility aware agents. In Emerging Technologies, 2005. Proceedings of the IEEE Symposium on(pp. 98-102). IEEE.

Cadger, F., Curran, K., Santos, J. and Moffet, S., 2016. Location and mobility-aware routing for improving multimedia streaming performance in MANETs. Wireless Personal Communications, 86(3), pp.1653-1672..

Seetan, R., Ababneh, I. and Dalal'ah, A., 2009, June. Congestion-Aware Routing Protocols for Ad Hoc Networks. In The 4th International Conference on Information Technology (ICIT 2009), al-Zaytoona University, Amman, Jordan.

Jorge Nuevo, "A Comprehensible GloMoSim Tutorial", INRS - University du Quebec nuevo@inrs-telecom.uquebec.ca, March-2004

Bajaj, L., Takai, M., Ahuja, R., Tang, K., Bagrodia, R. and Gerla, M., 1999. Glomosim: A scalable network simulation environment. UCLA computer science department technical report, 990027(1999), p.213.