

# Dynamic Probabilistic Flooding in DSR Routing Algorithm for Wireless Network

Muneer Bani Yassein

Jordan University of Science and Technology/Department of Computer Science, Irbid, Jordan  
Email: masadeh@just.edu.jo

Qusai Abuein, Deya Alzoubi

Jordan University of Science and Technology/Department of Computer Information Systems, Irbid, Jordan  
Jordan University of Science and Technology/Department of Computer Science, Irbid, Jordan  
Email: {qabuein,daalzoubi}@just.edu.jo

**Abstract**—Broadcasting in Mobile Ad Hoc Networks (MANETs) is one of the most important operations that are used to disseminate data throughout the entire network. Simple flooding is the conventional operation that performs broadcasting in MANETs. Although flooding is a simple operation that achieves a high delivery of data, it has many disadvantages summarized by the redundant broadcasts, contention and collision, which are referred to as the broadcast storm problem. Probabilistic protocols stand to provide a good solution to the problems associated with simple flooding. This paper, presents Dynamic Probabilistic Flooding (DPF) for expand Dynamic Source Routing (DSR). The dynamic probabilistic routing protocol controls the flooding by dynamically determining the rebroadcast probability of a node based on the local knowledge of the neighbors, thus reducing a rebroadcast messages, and therefore, increasing the overall routing reliability by decreasing the routing overhead. All experiments are conducted using Network simulator 2 (NS-2). The simulations results show that the proposed protocol outperformed original DSR in terms of reducing average End-To-End delay, increased PDR and reducing routing overhead.

**Index Terms**—Mobile Ad Hoc Networks, broadcasting, flooding, Probabilistic flooding

## I. INTRODUCTION

A Mobile Ad-Hoc Network (MANET) is a collection of mobile nodes that communicate with each other via wireless means without relying on any base stations for communication [1]. In such networks, no routers are needed to perform the task of routing data between communicating nodes. Also, there is no centralized access point that is responsible for controlling communication among the nodes.

Hosts are free to move randomly and organize themselves arbitrarily. Thus, the network's topology may change rapidly and be unpredictable in manner. MANETs may operate in a standalone fashion or be connected to the larger Internet [2]. MANETs are self-organizing, rapidly deployable, decentralized, and adaptive in which the topology can change on-the-fly without the intervention of a system administrator [3, 4, 25].

### A. Fundamental Properties of MANETs

MANETs have many fundamental properties some of these properties are:

- **Dynamic network topology:** Network Topology in MANET is said to be dynamic because of nodes mobility. These nodes are free to move in all directions and arbitrarily with random speeds, thus the network topology may change randomly and continually in a hardly predictable manner [4].
- **Multi-hop routing:** is used when a node needs to communicate with another node that is not located in its transmission range, so it employs relay nodes to find the best route until reaching the destination. Thus, mobile nodes in MANET work not only as hosts but also as routers [5].

MANETs can be used in numerous situations and can provide tremendous opportunities, particularly whenever there is a need for establishing a network for a limited period of time and where a wired infrastructure maybe non-existent or very difficult to be deployed.

The applications for MANETs are widely used for military purposes, disaster recovery (i.e. earthquake), and in business environment, where the need for collaborative computing is important outside the office [26].

Broadcasting is one of the most important mechanisms that are used in MANETs, where the source node sends the same packet to all nodes in the network. There were many models designed to achieve this schema such as one-to-one model, where each transmission is directed to only one neighbor using narrow beam directional antennas or separate frequencies for each node.

Another model is the one-to-all, where transmission occurs by sending a packet from a node to reach all nodes that are within its transmission area [6, 7, 8]. In fact, broadcasting is more closed for the one-to-all model than one-to-one model. The one-to-many is another model, where frozen or changeable angular beam antennas can be used to reach several neighbors at once [6].

Flooding is one of the most deployed mechanisms that are used to perform broadcasting [9]. According to this mechanism, each node transmits the same packet many times for all its neighbors. Therefore, Redundancy, collisions and contention are the most challenging problems that are encountered by flooding. These three problems are collectively referred to as “the broadcast storm problem” [10].

One of the possible suggested solutions that could be applied to prevent such problems is to memorize the packets that are received during the flooding operation, and to prevent sending repeated copies of the same packet [11].

The main goal of this paper is to reduce the overhead resulting from flooding by dynamically determining the probability  $P$  of the rebroadcast process based on the local knowledge of the neighbors. Reducing the number of retransmissions packets that are required to transmit a message to all nodes in the network contributes significantly to reduce routing overhead and redundant packets.

## II. RELATED WORK

In the literature, many approaches have been proposed to perform broadcasting. Williams and Camp [7] have classified broadcasting protocols into: simple flooding, probabilistic-based, counter-based, distance-based, location-based and neighbor- knowledge-based schemes.

In simple flooding [12], a naïve flooding approach is performed through the entire network, where each mobile host broadcasts a received packet provided that it has not been broadcasted before. Packets that have already been received are discarded. The main advantage of flooding it is very attractive due to its simplicity and effectiveness.

Flooding approach is costly and can cause a serious problem called broadcast storm problem which was identified in [10]. This problem occurred because the flooding is likely to happen frequently in Ad-Hoc networks.

Several approaches were proposed to reduce the redundancy and control the rebroadcasting process. One of the earliest techniques used is probabilistic broadcasting in which the intermediate nodes rebroadcast the RREQ according to a certain probability.

Bani Yassein, M. Ould Khaoua and S.Papanatasiou [13] used the of fixed probabilistic concepts to rebroadcast the packet in which the intermediate node rebroadcast the packet according to a pre-determined probability  $P$  regardless of the number of neighboring nodes. Which result a high save rebroadcast and reduce the redundant packets, in literature, this probability has been chosen as 0.7.

Bani Yassein and M. Ould Khaoua [14, 15, 16] used the adjusted probabilistic algorithm to control the rebroadcasting process. In this algorithm, the probability of rebroadcasting depends on whether the node is in a dense area or in a sparse area. The methodology is to compare the number of neighbors with the average number of neighbors in the networks and then assign a low probability to the intermediate node if it's in a dense

area and assign high probability if it's in a sparse area, the results show that a great impact on the degree of reachability and the number of saved rebroadcasts achieved by the probabilistic broadcasting scheme in terms of node speed and pause time.

Abdulai, M. Ould-Khaoua, L.M. Mackenzie [17] have proposed enhanced adjusted probabilistic algorithm in which there are four values of probabilities  $P$  based on the number of neighbors of the intermediate node. The probabilities are assigned based on three values of averages: the average number of neighbors; the average number of neighbors of nodes whose number of neighbors is above the network average and; the average number of neighbors of the nodes whose number of neighbors is below the network average. The others use an initial value of  $P=0.7$  and then calculates the other values of  $P$  based on a fraction of this initial value, the result reveal a significant reduction in the overhead involved in the number of RREQs that are used in the route discovery process.

Bani Yassein, M. Bani Khalaf, A. Y. Al-Dubai [18, 19] used the concept of four  $P$ 's ( $4P$ ) in their smart probabilistic scheme to calculate the rebroadcasting probability based on local information of the neighbors. Also, they chose the value of  $P$ 's such that  $P1 > P2 > P3 > P4$  without specifying initial value of  $P$ , the simulation results made some improvements to packet collisions and contention in the network in terms of end-to-end delay and routing overhead.

A. M. Hanashi, A. Siddique, I. Awan and M. Woodward [20] proposed the concept of dynamic probabilistic rebroadcasting for AODV routing protocol in which the probability of rebroadcasting process  $P$  is calculated depending on the number of neighbors of the intermediate node. Higher value of  $P$  means higher number of redundant rebroadcast while smaller value of  $P$  means lower reachability. Also, A. M. Hanashi, A. Siddique, I. Awan and M. Woodward [21] performed a further investigation comparing dynamic probabilistic scheme with fixed probabilistic scheme and blind flooding techniques using the parameters of save rebroadcasting (SRB), relays versus mobility, relays versus connections and collisions. The result of the study shows a significant improvement by implementing dynamic probabilistic rather than a predetermined probability  $P$  regarding the above parameters.

Q. Zhang, D.P. Agrawal [22] proposed a dynamic probabilistic scheme, which is a hybrid of both probabilistic-based and counter-based approaches. It uses a counter for each node to determine whether the host node has a large number of neighbors. Although, the packet counter is used as density estimator. It means that the value of a packet counter does not necessarily correspond to the exact number of neighbors, since some of the host's neighbors may have suppressed rebroadcasts according to their local rebroadcast probability.

Another approach described by J. Cartigny, D. Simplot [23], computes the probability  $P$  based on the number of neighbor nodes and a fixed efficiency parameter  $K$ . This approach performs well in terms of reachability of

broadcast; however, it has a shortcoming in that the computation of the probability  $P$  depends on constant data, including constant efficiency parameters and local density.

In counter-based schemes [11] a specific threshold  $C$  is determined and the mobile host rebroadcasts the packet if the number of copies received by that host is only less than the threshold. Counter-based algorithms achieve better reachability and throughput; however, they suffer from relatively longer delays. Distance-based schemes [7] prevent the packet rebroadcasts when the distance between the source and destination is less than a given threshold. In a location-based scheme, a node rebroadcasts a packet with respect to additional coverage concepts. In selecting forwarding neighbors a broadcasting node elects some of its 1-hop nearest nodes as rebroadcast nodes.

### III. METHODOLOGY

Dynamic Probabilistic Flooding (DPF) Algorithm is an on-demand, broadcast based, Ad-Hoc route discovery protocol that is designed for MANETs. The proposed routing protocol controls the flooding by dynamically determining the probability  $P$  of the rebroadcast process based on the local knowledge of the neighbors, thus reducing redundant broadcasts and therefore, increasing the overall routing reliability by decreasing the routing overhead, Fig. 1 shows a description of a DPF Algorithm

A DPF algorithm sets the rebroadcast probability of a node according to number of neighbor nodes information in which the probability  $P$  of the rebroadcast process is dynamically calculated depending on the number of node neighbors. Thus each node has its own rebroadcast probability  $P$  regarding to its number of neighbors, this means that a higher value of  $P$  means a smaller number of neighbors (i.e. sparse- area), while a smaller value of  $P$  means higher number of neighbors (i.e. dense area).

To implement a dynamic probability, the nodes must have some local knowledge of the neighbors. Therefore, the technique must enable the nodes to collect a neighbor's information in a continuous manner. Hence, in this work, the researchers define HELLO message to be used with DSR algorithm.

Since, the original DSR algorithm was designed without HELLO messages, HELLO message was defined in the approach so it broadcasts periodically by nodes every fixed period of time. Therefore, any node that receives this message will indicate that the sending node is a neighbor for it and store this information in a local data structure. Consequently, when any node needs information about local knowledge of its neighbors, it retrieves the number of neighbor nodes  $N(i)$  from local data structure to calculate the rebroadcast probability  $P$ .

The algorithm works as follow; first we set the rebroadcast probability of  $P_{min}$ ,  $P_{max}$  and  $P$  by 0.4, 0.9 and 1, respectively; therefore, we use the values of maximum and minimum rebroadcast probability  $P$  that are used by the authors of [20, 21], which is between  $P_{min}$  and  $P_{max}$  as ( $P_{min} \leq P \leq P_{max}$ ).

The rebroadcast probability of  $P_{min}$  is set to 0.4 and  $P_{max}$  to 0.9 because it represents the minimum number of neighbor nodes in case of dense area for  $P_{min}$  and spare area for  $P_{max}$ .

Then upon receiving a broadcast packet  $pkt$  at node ' $i$ ' for the first time (i.e. not a duplicate packet), the node gets the number of neighbors to calculate a rebroadcast probability using the projection equation show in step 9 in the Fig. 1 [20, 21].

It is clear from this equation that rebroadcast probability  $P$  decreases as the number of neighbors increases. If the rebroadcast probability is less than the minimum rebroadcast probability, then we set it to be  $P_{min}$ . After that, node ' $i$ ' rebroadcast or drop the packet according to probability produced by RN

```

1. DPF-DSR ()
2. Set the maximum rebroadcast probability  $P_{max}$  to 0.9
3. Set the minimum rebroadcast probability  $P_{min}$  to 0.4
4. Upon receiving a broadcast packet  $pkt$  at node  $N$  do
   the following:
5. If packet  $pkt$  received for the first time, then
6. Set the rebroadcast probability  $P = 1$ 
7. Get the number of neighbor nodes of  $i^{th}$  node  $\Rightarrow N(i)$ 
8. Calculate the rebroadcast probability  $P$ 
9. 
$$P = \prod_{i=0}^{N(i)} P * P_{max}$$

10. End if
11. If rebroadcast probability  $P < P_{min}$  Then
12.  $P = P_{min}$ 
13. End if
14. If the Random Number (RN) over [0,1] for  $i^{th}$  node
     $RN > P$  Then
15. Drop the packet
16. Else
17. Rebroadcast (Relay) packet  $pkt$  with probability  $P$ 
18. End if
19. End Algorithm

```

Figure 1. : Dynamic Probabilistic Flooding algorithm

So, if node ' $i$ ' has a high rebroadcast probability  $P$  this means that it has small number of neighbors and might be retransmitted, Otherwise, if it has a low rebroadcast probability  $P$ , this means that it has large number of neighbors and might be retransmitted .

### IV. SIMULATION, RESULTS AND ANALYSIS

#### A. Simulation Environment

All experiments are implemented and evaluated using NS-2 version 2.33 running under Linux operating system [24]. The researchers have run fifteen randomly

generated mobility patterns per each DSR and DPF algorithms and the average value of their results were taken to ensure accuracy. The researchers show 95% confidence interval in all graphs of the simulation experiments.

The simulation scenarios use various mobile node numbers that are placed randomly on a terrain of 1000 X 1000 m<sup>2</sup>. Transmission ranges used of each node is 250 meter, having a bandwidth of (2) Mbps. Each simulation lasts for 900 sec. A free space propagation model was used for simulation scenarios. IEEE 802.11 was used as the MAC layer protocol. The application layer uses Constant Bit Rate generators (CBR) over (User Datagram Protocol) UDP with random source and destination pairs, using CBR grants us a strict control over the bandwidth in usage at any moment.

The data packet size was 512 bytes because it is the smallest values that could be used in the network without partition packet. The well-known mobility model Random Waypoint was used to describe the movement of the mobile nodes.

**B. Simulation Parameters**

To comprehensively measure the performance of the proposed algorithm, the researchers run simulations for different node maximum speed of 5, 10, 15 and 20 m/sec. In addition, they varied the node traffic by using CBR values of 2, 3, 4, 5 and 6 packets/ sec. In addition, they studied the effect of the number of traffic generators by assuming 4, 8, 12 and 16 CBR sources. In addition, they run simulations with different numbers of nodes 25, 50, 75 and 100. Finally, they study the effect of various mobility levels by using pause time of 0, 300, 600 and 900 sec. When the pause time is zero, a node is in continuous motion and so that a mobility is high. In contrast, when the pause time is 900 sec, a node moves only once during an entire simulation experiment, so that mobility is low. Table 1 summarizes the different configuration values that were used in all the performed simulations.

TABLE 1  
SIMULATION PARAMETERS

Parameter	Value
Routing Protocol	DSR
Area	1000*1000 m <sup>2</sup>
Simulation time	900 sec
Packet size	512 bytes
Data Traffic	CBR
Bandwidth	2 Mbps
Transmitter range	250 meters
Maximum speed	5, 10, 15 and 20 m/sec
Number of nodes	25, 50, 75 and 100 nodes
Number of connections	4, 8, 12 and 16 connections
Pause time	0, 300, 600, 900 sec
Packet generation rate	2, 3, 4, 5 and 6 packets /sec

**C. Experimental Results**

To evaluate the performance of the proposed algorithm, various simulation experiments were performed using different performance metrics such as the average End-To-End-Delay (ETED), packet delivery Ratio (PDR), and

routing overhead. The average ETED is the average elapsed time between when data packet was initially sent by the source node and when it was successfully received by the destination. Routing overhead is the total number of RREQ packets generated and transmitted during the entire simulation period. For a sent packet over multiple hops, each transmission over one hop is counted as one transmission. PDR can be defined simply as the total number of data packets received by destinations as a fraction of the total number of data packets sent by sources [15].

We generated the proper scenarios and tracing files for required experiments. In the final stage, we have made parsing for the generated tracing files using special parser in order to gain routing overhead, PDR, and average ETED values. There are two directions for the simulation. The first direction is to simulate DSR routing discovery, which is based on simple flooding as a route discovery mechanism. The second direction is to simulate the routing discovery using the proposed dynamic probabilistic scheme.

*a. Effects of Node Speed*

In this scenario, we study the effect of the maximum node speed when the number of mobile nodes is (50), the number of connections is (12) each node sends (4) packets/sec, the transmission range is (250) meter and finally the pause time is (0) sec with different maximum node speed values between (5) and (20) m/sec. The simulation results presented in Fig.s 2, 3, and 4 illustrate the average ETED ,PDR and routing overhead respectively.

*1) Average ETED*

Fig.2 illustrates that the average ETED increases as maximum node speed increases. This is because the faster the nodes are, the less stability of the links is achieved, hence, the more processing time to reaches a data packet to destination is needed. Therefore, the number of RREQs that are used in the route discovery process is reduced by preventing some nodes from receiving RREQs in route discovery process. Consequently, proposed algorithm control flooding by reducing processing times that were used during sent data packet based on the rebroadcast probability process.

*2) PDR*

As shown in Fig.3, the PDR decreases as maximum node speed increases. This is because when maximum node speed is large the number of unstable route becomes more evident than when maximum node speed is small and thus the probability of broken links increases. In addition, the number of drop packet increases and lower PDR is achieved. Consequently, proposed algorithm control flooding by reducing the number of drop packet that were used during sent data packet based on the rebroadcast probability process.

### 3) Routing Overhead

The routing overhead increases as maximum node speed increases as shown in Fig. 4. This is because the faster the nodes are, the less stable the links are. Hence, the larger reinitiate the RREQs are. Therefore, the number of RREQs that are used in the route discovery process is reduced by preventing some mobile nodes from receiving RREQs during the route discovery process and the retransmission of control traffic. Consequently, proposed algorithm outperformed DSR because it tends to control flooding by reducing the number of RREQs that were sent during the route discovery process based on the rebroadcast probability process.

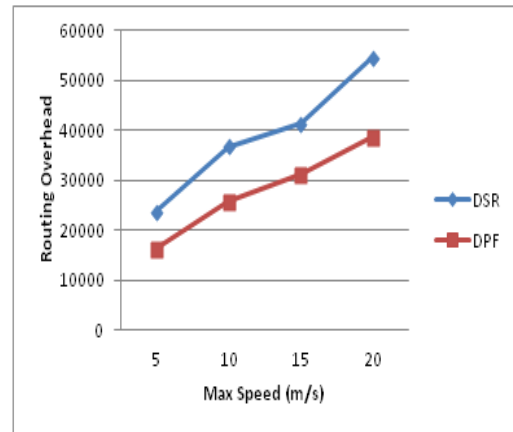


Figure 4. : Routing Overhead vs. Maximum speed

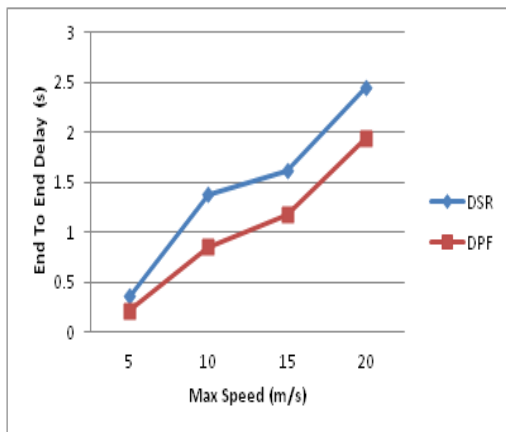


Figure 2. : Average ETED vs. Maximum speed

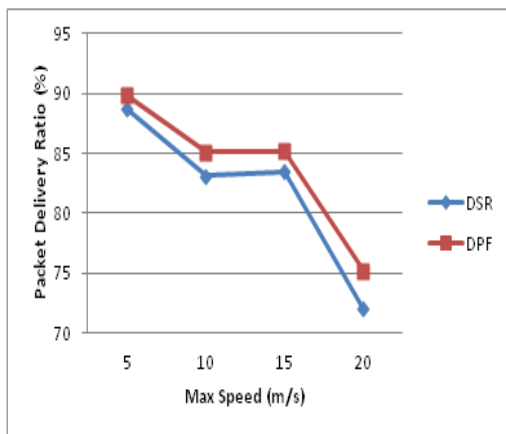


Figure 3. PDR vs. Maximum speed

### b. Effects of Number of Nodes

In this scenario, we study the effect of number of nodes when the number of connections is (12) each node sends (4) packets/sec, the transmission range is (250) meter, the maximum node speed is 10 m/sec and finally the pause time is (0) sec with different numbers of mobile node values between (25) and (100) mobile nodes. The simulation results presented in Figs 5, 6 and 7 illustrate the average ETED, PDR and routing overhead respectively.

#### 1) Average ETED

The average ETED increases as number of nodes increases as depicted in Fig. 5. The reason is when number of nodes is large the processing time that is requested for a data packet to reach its destination is increased. The processing time increases due to buffering and initiation of a new route discovery process. Therefore, the number of RREQs that are used in the route discovery process is reduced by preventing some nodes from receiving RREQs. Consequently, the proposed algorithm control flooding by reducing processing time that were used during sent data packet based on the rebroadcast probability process.

#### 2) PDR

Fig. 6 plots that the PDR decreases as number of nodes increased. This is because when number of nodes is large the redundancy, contention and collision of data packets increased, thus the probability of drop packet increased and thus the lower PDR will be. Consequently, the proposed algorithm control flooding by reducing the number of drop packet that were used during sent data packet based on the rebroadcast probability process.

#### 3) Routing Overhead

Fig. 7 shows that the routing overhead increased as the number of nodes increased too. This is because when the number of nodes is large this will cause redundancy, contention and collision in RREQs which is more than

when the number of nodes is small. Therefore, the number of RREQs that is used in the route discovery process is reduced by preventing some mobile nodes from receiving RREQs during the route discovery process and the retransmission of control traffic. Consequently, proposed algorithm control flooding by reducing the number of RREQs that were sent during the route discovery process based on the rebroadcast probability process.

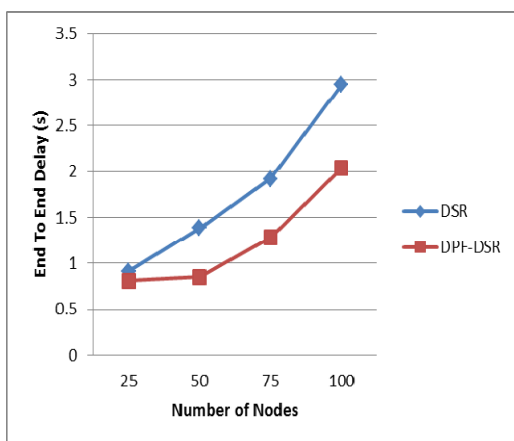


Figure 5. : Average ETED vs. Number of Nodes.

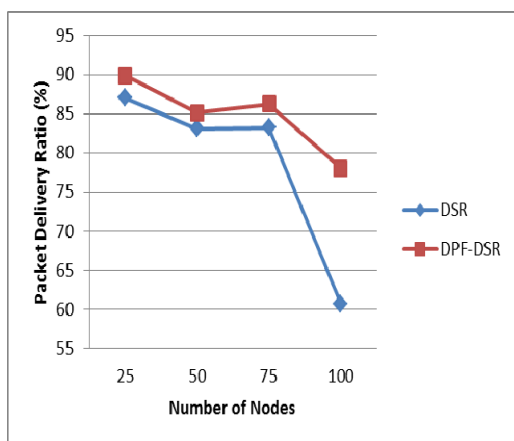


Figure 6. : PDR vs. Number of Nodes.

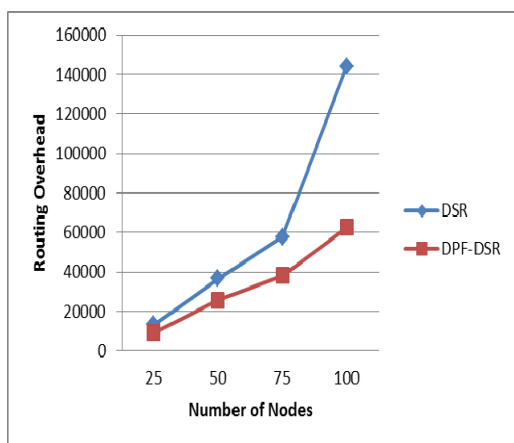


Figure 7. : Routing Overhead vs. Number of Nodes.

c. Effects of Number of Connections

In this scenario, we study the effect of number of connections when the number of mobile nodes is (50), the maximum node speed is 10 m/sec, the transmission range is (250) meter, the traffic load is (4) packets/sec and finally the pause time is (0) sec with different number of connections values between (4) and (16) connections. The simulation results presented in Figs 8, 9 and 10 illustrate the average end to end delay, PDR and routing overhead respectively.

1) Average ETED

As shown in Fig. 8, the average ETED increases as number of connections increased too. This is because when number of connections is large a needed for more processing time to reaches a data packet to distention is increase such as buffering and initiate new route discovery process in case of breakage route links because redundancy, contention and collision in RREQs more than when number of connections is small. Therefore, the number of RREQs that are used in route discovery process is reduced by preventing some nodes from receiving RREQs in route discovery process. Consequently, proposed algorithm tend to control flooding by reduces processing time that were used during sent data packet based on the rebroadcast probability process.

2) PDR

As depicted in Fig. 9 the PDR decreases as number of connections increased. This is because when number of connections is large the number of unstable route becomes more evident than when number of connections is small because redundancy, contention and collision in data packets, thus the probability of broken links increase, therefor the number of drop packet increase and thus lower PDR will be. Consequently, proposed algorithm tend to control flooding by reduces the number of drop packet that were used during sent data packet based on the rebroadcast probability process.

3) Routing Overhead

Fig. 10 shows that the routing overhead increase as number of connections increased too. This is because when number of connections is large this will cause redundancy, contention and collision in RREQs more than when number of connections is small since a large number of packets disseminate through network. Therefore, the number of RREQs that is used in route discovery process is reduced by preventing some mobile nodes from receiving RREQs during the route discovery process and the retransmission of control traffic. Consequently, proposed algorithm tend to control flooding by reduces the number of RREQs that were sent during route discovery process based on the rebroadcast probability process.

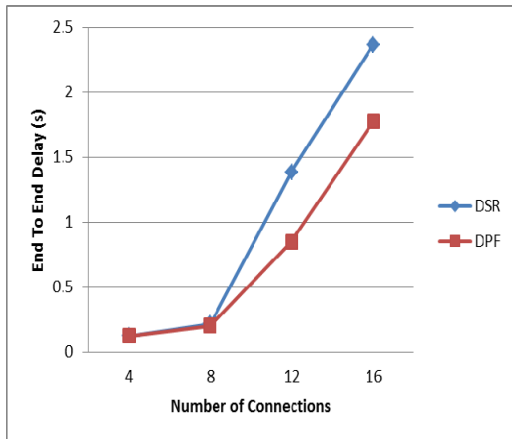


Figure 8. : Average ETED vs. Number of Connections.

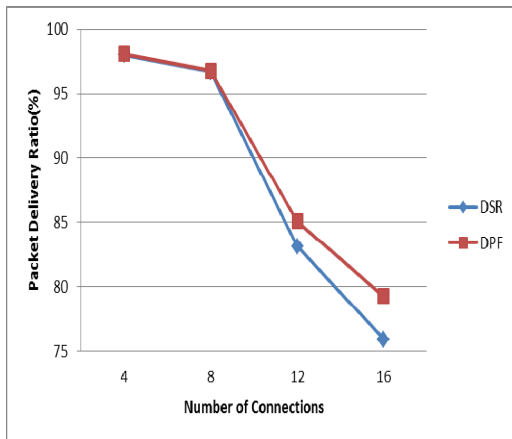


Figure 9. : PDR vs. Number of Connections.

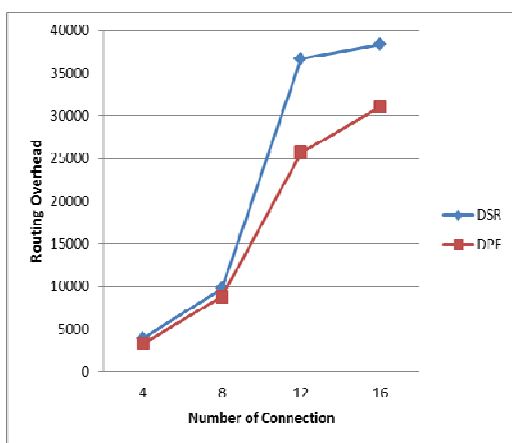


Figure 10. : Routing Overhead vs. Number of Connections.

*d. Effects of Nodes Mobility*

In this scenario, we study the effect of nodes mobility when the number of mobile nodes is (50), the maximum node speed is (10) m/sec, the transmission range is (250)

meter and the number of connection is (12) each sends (4) packets/sec with different mobility values between (0) and (900) sec. The simulation results presented in Fig.s 11, 12 and 13 illustrate the average ETED , PDR and routing overhead respectively.

*1) Average ETED*

Fig. 11 plot that the ETED increases as pause time decreased. This is because the faster the nodes, the less stable the links are, hence, the more processing time to reaches a data packet to distention. Therefore, the number of RREQs that are used in route discovery process is reduced by preventing some nodes from receiving RREQs in route discovery process. Consequently, the proposed algorithm tend to control flooding by reduces processing time that were used during sent data packet based on the rebroadcast probability process.

*2) PDR*

Fig. 12 depicted that the PDR decrease as pause time increased. This is because when pause time is small the number of unstable route becomes more evident than when pause time is large, thus the probability of broken links increase and therefor the number of drop packet increase and thus lower PDR will be. Consequently, the proposed algorithm tend to control flooding by reduces the number of drop packet that were used during sent data packet based on the rebroadcast probability process.

*3) Routing Overhead*

As polt in Fig. 13, the routing overhead increase as pause time decreased. This is because the faster the nodes, the less stable the links are, hence, the larger reinitiate the RREQs are. Therefore, the number of RREQs that is used in route discovery process is reduced by preventing some mobile nodes from receiving RREQs during the route discovery process and the retransmission of control traffic. Consequently, the proposed algorithm tend to control flooding by reduces the number of RREQs that were sent during route discovery process based on the rebroadcast probability process.

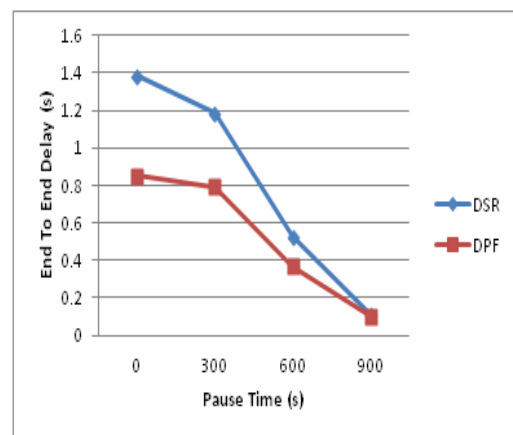


Figure 11. : Average ETED vs. Pause Time.

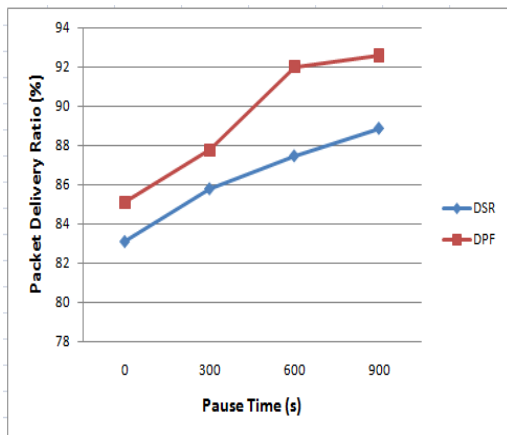


Figure 12. : PDR vs. Pause Time

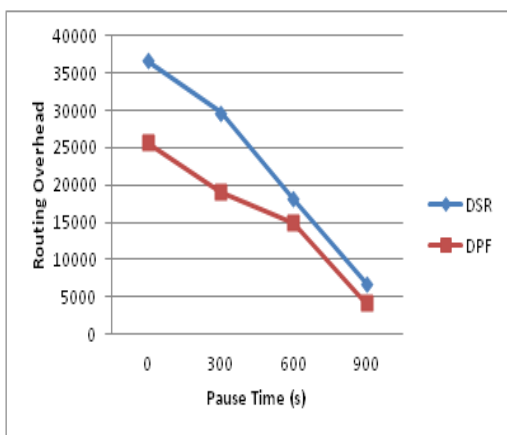


Figure 13. : Routing Overhead vs. Pause Time.

*e. Effects of Traffic Load*

In this scenario, we study the effect of traffic load when the number of mobile nodes is (50), the maximum node speed is (10) m/sec, the number of connections is (12), the transmission range is (250) meter and finally the pause time is (0) s with different traffic load values between (2) and (6) packets/sec. The simulation results presented in Figs 14, 15 and 16 illustrate the average end to end delay, PDR and routing overhead respectively.

*1) Average End-To-End Delay*

Fig. 14 polt that the average ETED increases as traffic load increased too. This is because when traffic load is large a needed for more processing time to reaches a data packet to distention is increase such as buffering and initiate new route discovery process in case of breakage route links because redundancy, contention and collision in RREQs more than when traffic load is small. Therefore, the number of RREQs that are used in route discovery process is reduced by preventing some nodes from receiving RREQs in route discovery process. Consequently, proposed algorithm tend to control flooding by reduces processing time that were used

during sent data packet based on the rebroadcast probability process.

*2) PDR*

Fig. 15 shows that the PDR decrease as traffic load increased. This is because when traffic load is large the number of unstable route become more evident than when traffic load is small because redundancy, contention and collision in RREQs, thus the probability of broken links increase, therefor the number of drop packet increase and thus lower PDR. Consequently, proposed algorithm tend to control flooding by reduces the number of drop packet that were used during sent data packet based on the rebroadcast probability process.

*3) Routing Overhead*

Fig. 16 depicted that the routing overhead increase as traffic load increased too. This is because when traffic load is large this will cause redundancy, contention and collision in RREQs more than when traffic load is small. Therefore, the number of RREQs that is used in route discovery process is reduced by preventing some mobile nodes from receiving RREQs during the route discovery process and the retransmission of control traffic. Consequently, proposed algorithm tend to control flooding by reduces the number of RREQs that were sent during route discovery process based on the rebroadcast probability process.

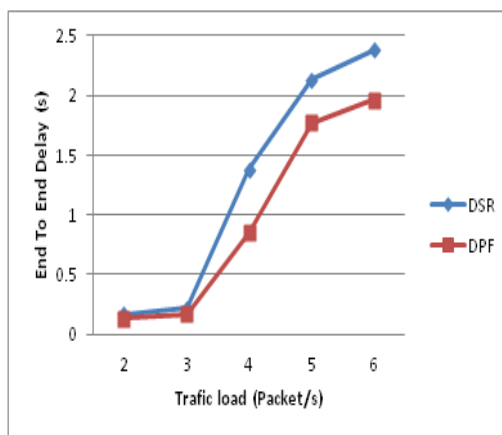


Figure 14. : Average ETED vs. Traffic Load.

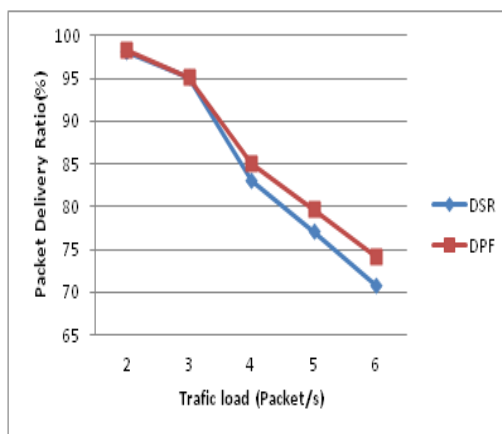


Figure 15. : PDR vs. Traffic Load.



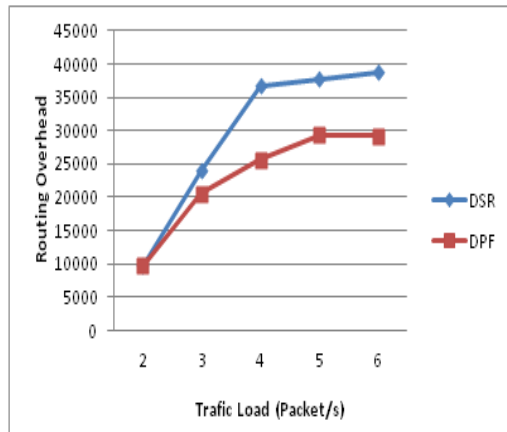


Figure 16. : Routing Overhead vs. Traffic Load.

## V. CONCLUSION

Simple flooding is one of the mechanisms that are used to spread data over networks. This technique is suffering many challenges such as redundancy, contention and collision. Previous studies suggested solutions to this problem using probability flooding broadcast. This paper proposed a reactive broadcast-based route discovery protocol for mobile Ad-Hoc network. Applying this mechanism, the proposed protocol achieves lower Average End-To-End delay, lower routing overhead and higher PDR. Simulations were carried out with Network Simulator (NS-2) version 2.33. The simulation experiments show that the proposed dynamic probabilistic routing protocol outperformed DSR in terms of reducing routing overhead, average End-To-End Delay and increasing PDR by up to 56.5, 40.9 and 28.54 % respectively.

For future works, it would be interesting to compare the performance of the proposed protocol with a dynamic probabilistic algorithm on Ad-Hoc on Demand Distance Vector Routing (AODV).

## ACKNOWLEDGMENT

We would like to thank the staff of the Faculty of Computer and Information Technology, Jordan University of Science and Technology (JUST) for their great effort and continuous support

## REFERENCES

- [1] N. Enneya, M. El Koutbi, A. BERQIA. "Enhancing AODV Performance based on Statistical Mobility Quantification". The IEEE International Conference on Information & Communication Technologies: from Theory to Applications (2006) pp.2455 – 2460
- [2] Y. Zhang and W. Lee, "Intrusion Detection in Wireless Ad-Hoc Networks", ACM MOBICOMM, (2000) pp. 275-283.
- [3] S. Basagni, M. Conti, S. Giordano, and I. Stojmenovic. "Mobile Ad Hoc Networking ",New Jersey: IEEE Press, (2004) pp. 205 - 229.

- [4] R. Timo, K. Blackmore, L. Hanlen. "On Entropy Measures for Dynamic Network Topologies: Limits to MANET "( 2005) pp.89-94.
- [5] Dr.S.Karthik,S.Kannan,Dr.V.P.Arunachalam,Dr.T.Ravichandran, Dr.M.L.Valarmathi, "An Investigation about Performance Comparison of Multi-Hop Wireless Ad-Hoc Network Routing Protocols in MANET", IJCSI International Journal of Computer Science (2010) pp. 35-41.
- [6] S.-Y. Ni, Y.-C. Tseng, Y.-S. Chen, and J.-P. Sheu, "The broadcast storm problem in a mobile ad hoc network, Wireless Networks", (2002) pp. 153-167.
- [7] B. Williams, T. Camp, "Comparison of broadcasting techniques for mobile ad hoc networks". Proceeding of ACM Symposium on Mobile Ad Hoc Networking & Computing (2002) pp. 194–205.
- [8] M. Bani Yassein, M. Ould-Khaoua S. Papanastasiou, A.Al-Ayyoub, "On the Effect of Mobility and Density on Probabilistic Flooding in MANETs". Proc. INT. Working Conference on Performance Modeling and Evaluation of Heterogeneous Networks (2004) pp. 63/1- 63/9.
- [9] P.Rongers, N.Abu-Gazaleh , " Robustness of network-wide broadcast in MANET" . IEEE International Conference on Mobile Adhoc and Sensor Systems Conference, Washington DC, (2005) pp. – 185.
- [10] S.-Y. Ni, Y.-C. Tseng, Y.-S. Chen, J.-P. Sheu," The broadcast storm problem in a mobile ad hoc network", Wireless Networks (2002) 153–167.
- [11] Y. Sasson, D. Cavin, A. Schiper, "Probabilistic broadcast for flooding in wireless mobile ad hoc networks", Proc. IEEE Wireless Communications & Networking Conference (2003) pp. 1124-1130.
- [12] C. Perkins, E. BELDing-Royer and S. Das," Ad hoc On-demand Distance Vector (AODV) routing". IETF Mobile Ad Hoc Networking Working Group, internet draft version 13, (2003).
- [13] M. Bani Yassein, M. Ould Khaoua and S.Papanastasiou," On the Performance of Probabilistic Flooding in Mobile Ad Hoc Networks". 11th International Conference on Parallel and Distributed Systems - Workshops (2005) pp.125-129.
- [14] M. Bani Yassein and M. Ould Khaoua," Application of Probabilistic Flooding in MANETs". Ubiquitous Computing and Communication Journal. 1 (2007) pp.1-5.
- [15] M. Masadeh Bani Yassein, M. Ould Khaoua, L. M. Mackenzie and S.Papanastasiou, "Performance Evaluation of Adjusted Probabilistic Broadcasting in MANETs". Proceedings of the 2nd IEEE International Symposium on Dependable, Autonomic and Secure Computing (2006) pp.245-249.
- [16] M. Bani-Yassein, M. Ould-Khaoua, L. M. Mackenzie, S. Papanastasiou and A. Jamal, "Improving Route Discovery In On-Demand Routing Protocols Using Local Topology Information in MANETs". Proceedings of the Ninth ACM/IEEE International Symposium on Modeling, Analysis and Simulation of Wireless and Mobile Systems (2006) pp.95-99.
- [17] J. Abdulai, M. Ould-Khaoua, L.M. Mackenzie, "Improving Probabilistic Route Discovery in Mobile Ad Hoc Networks", 32nd IEEE Conference on Local Computer Networks (2007) pp.739-746.
- [18] M. Bani Yassein ,M. Bani Khalaf ,A. Y. Al-Dubai , "A Performance Comparison of Smart Probabilistic Broadcasting of Ad hoc Distance Vector (AODV)", 25th UK Performance Engineering Workshop (2009) pp.6-7.
- [19] M. Bani Yassein and M. Bani Khalaf , " A Performance Comparison of Smart Probabilistic Broadcasting of Ad hoc

Distance vector (AODV)". Proceeding of the IEEE International conference on Communications, Propagation and Electronics (2009) pp.6-8

[20] A. M. Hanashi, A. Siddique, I. Awan and M. Woodward , "Performance Evaluation of Dynamic Probabilistic Flooding Under Different Mobile Model in MANETs". 13th International Conference on Parallel and Distributed Systems (2007) pp. 1-6

[21] A. M. Hanashi, A.Siddique, I. Awan and M. Woodward." Dynamic Probabilistic Flooding Performance Evaluation of On-demand Routing Protocols in MANETs". Proceedings of the 2008 International Conference on Complex, Intelligent and Software Intensive Systems, (2008) pp.200-204.

[22] Q. Zhang, D.P. Agrawal, "Dynamic probabilistic broadcasting in MANETs", Proceedings of Journal of Parallel and Distributed Computing (2005) 220–233.

[23] J. Cartigny, D. Simplot, "Border node retransmission based probabilistic broadcast protocols in ad-hoc networks", Telecommunication Systems (2003) pp.189–204.

[24] The Network Simulator Site. [Online] [Accessed 2010 January]. Available from URL, <http://www.isi.edu/nsnam/ns>

[25] Muneer Bani Yassein, Saher S. Manaseer and Ahmad A. Momani," Adaptive Backoff Algorithm for Wireless Internet," International Journal of Emerging Technologies in Web Intelligence, Volume 4, Number 2, Pages 155-163, 2012

[26] Deepika Chaudhary, " Bee-Inspired Routing Protocols for Mobile Ad HOC Network (MANET)", International Journal of Emerging Technologies in Web Intelligence, Volume 2, Number 2, Pages 86-89, 2010



**Muneer O. Bani Yassein** is an Associate Professor, Vice Dean of Faculty of Computer Information Technology at Jordan University of Science and Technology (JUST). Dr. Bani Yassein completed his PhD from Department of Computing Science in the University of Glasgow, His current research interests include networking protocol development and analysis the performance probabilistic flooding in mobile ad hoc networks.



**Qusai Abuein** received his B.Sc. in computer science from Yarmouk University /Jordan in June 1993. Abuein has joined the Yarmouk University as a programmer and system analyst for five years. Abuein completed his master and Ph.D. in computer science from Japan and currently he is an assistant professor in Computer Information Systems Department at Jordan University of Science and Technology. His research interests are in computer cryptography, information retrieval and web technologies.



**Deya Alzoubi** received his B.Sc. degree in Computer Science from Jordan University of Science and Technology, Jordan in 2007 and M. Sc. in Computer Science, from Jordan University of Science and Technology, Jordan in 2010. His main area of research is Computer Networks and Data Mining. Currently he is teaching in Computer Science Department in Jordan University of Science and Technology.