Performance Evolution of Multiple Probabilities of Ad-hoc On Demand Distance Victor Protocol (AODV)

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ABSTRACT

Recently, a probabilistic approach to flooding has been proposed as one of most important suggested solutions to solve the broadcast storm problem, which leads to the collision, contention and duplicated messages. It has been shown in the literature that, there are many enhancements has done on probabilistic scheme, one of them, is using more than probability with different values instead of using fix probability. This paper by extensive simulation, analysis the effect of using more than probability on the performance of Ad-hoc On Demand Distance Victor protocol (AODV), in term of different metrics, such as, normalized routing load, end-to-end delay and routing overhead..

***Keywords**: MANET, Overhead, Flooding, Simulation, AODV, probability.*

1. Introduction

The Mobile Ad hoc Network (MANET) is a collection of wireless movable devices, where transferring data between them is done by intermediate devices independently from any base station. It is a self-configuring network of mobile hosts connected by wireless links with arbitrary topology where nodes randomly move and organize themselves arbitrarily; thus, the wireless topology network may change itself rapidly and unpredictably. Such a network could run individually; or it may be connected to the Internet [3].

MANET is used in many areas, and it has a lot of features, such as, no fixed infrastructure, no dependency on any base station and no slowness to configure itself quickly, all of these features make MANET suitable in many applications. Military operations are one of the most important applications that MANET can be used, especially, in battlefield to deduct enemy or to exchange information between soldiers. But it is difficult to establish these operations using a network that depends on fixed infrastructure [2].

Because all of these characteristics of MANET, which were mentioned above make designing and developing an efficient routing protocol one of the most essential challenges in context of dynamic network such as MANET. For this, more extensive work has been done,

and quite a lot of routing protocols has proposed [4-7].In general, the existing routing protocol for MANET can be classified in two classes, *proactive* and *reactive*. On the one hand, *proactive* protocols like DSDV [7] every node should know every other nodes' routs, whether they are actually used or not. These protocols require to continuously updating the information routs for every node in the network. On the second hand, in the *reactive* protocol the rout is requested only on-demand like AODV [3].

Broadcasting scheme is a basic procedure used to send out information messages between mobile devices in MANET, and it's also the basic method for many protocols like AODV [3]. Although the broadcasting scheme is presumable to distribute messages between all nodes, it has several problems that decrease efficiency and performance in MANET, such as, duplicate transmission, collision and contention, these problems are called broadcast storm problem [2].

In many covenantal on-demands routing protocol like AODV [3], a mobile host floods Rout Request control packets (RREQ) to its surrounding neighbors in order to discover a rout to explicit destination, then each neighbor rebroadcasts the RREQ control packets until the path between mobile source and required destination is established.

Recently, a probabilistic approach to flooding has been proposed to solve the broadcast storm problem, as one of most important suggested solutions [1, 4]. In the traditional probabilistic scheme, the mobile host will rebroadcast a broadcast message which is received for the first time with probability *p*. in this scheme; the rebroadcast decision is mad without any information about the network topology and the surrounding node neighbors.

The rest of the paper is organized as follow:
Section 2 presents related work on some route discovery techniques. Section 3 provides a brief overview of on-demand route discovery process in AODV [3]. Section 4 presents different versions of Smart Probabilistic Broadcast mechanism (SPB). Section 5 shows the Performance Evaluation. Section 6 conducts Simulation Environment and Scenario. Section 7 conducts performance results of SPB. Finally, Section 8concludes this study and outlines some directions of future research work

2. Related work

The direct method which uses the broadcasting is flooding, where every mobile host receives a broadcast message for the first time and retransmits it to all nodes in network, so this costs n broadcast equals n-1 host in network. Flooding protocol has several drawbacks. Firstly, when a node is about to rebroadcast a broadcast message, all its neighbors could have this message, so this problem is called redundant rebroadcast. Secondly, when nodes are to rebroadcast the message, a contention may happen between them. Finally, because there is no Collision Detection (CD) mechanism, collision is more likely to occur and cause more damage. All of these drawbacks called the broadcast storm problem [2].

A comprehensive study has been made about the different methods, flooding, probability-based, distance-based, counter-based, and location-based and neighbor knowledge schemes, which are directed to solve the broadcast storm problem [2].

Zone Routing Protocol (ZRP) [4] is another technique which uses a combination of two protocols, *proactive* and *reactive; it* takes the advantages of both Protocols in order to solve the flooding of RREQ control packets. . In case of *proactive*, route information is available when it is needed; as a result, a node can immediately send a data packet to required destination in little delay prior to data transmission. But in case of *reactive*, because route formation is not available, a significant delay is produced in order to determine a route. The rout discovery procedure in ZRP is established as follow, if the destination inside the zone of the source which is called *Interzone Routing*, the source already knows the rout to destination, since the *Interzone Routing* uses proactive protocols. Otherwise, the source node will *bordercasting* RREQ control packets to its peripheral nodes instead of blind flooding, since the path between nodes in different zones use reactive protocol.

The distributed clustering algorithm [5] has also been proposed to handle and control the RREQ control packets. In such algorithm each group of nodes selects a *clusterhead* which is responsible for flooding RREQ control packets to another *clusterhead* in different group through Connected Dominating Set (CDS) which is defined as *a dominating set D(S) of a set S is a set of nodes such that each node from S either belongs to D(S) or has a neighboring node that belongs to D(S).* Although the CDS reduces the overhead during rout discovery, the construct minimal dominating set is NP-hard problem.

Qi.Zhang and Dharma have implemented approach that uses the concept of gossip and CDS, but the construct minimal dominating set is not required. Instead of that, categorizes mobile hosts into four groups according to their neighborhood information. for each group, there are a specified value of probability so the nodes with more neighbors are given higher probability, while the nodes with fewer neighbors are given lower probability [6].

In [7] Q. Zhang and Agrawal have implemented dynamic probabilistic broadcasting which combines the advantages of both counter-based and probabilistic methods. This algorithmic adjusts the value of *p* based on the value of the packet counter which indicates the number of RREQ control packet over a period of time, but it has drawbacks since the decision to rebroadcast is done after a random delay time, and the probability is decreased or increased according to small constant *d* which is not explicitly specified.

M. Bani Yassein et. al. [4] have proposed an improvement on the probabilistic flooding by using multiple values of p (high, medium and low) which are set according to the local neighbors information. This improvement has been applied on the pure broadcasting in term of *reachability* and *saved rebroadcast*.

3. Overview of AODV

In general, the on demand routing protocols set up the routing path to the destination only on demand or when it is changed to send data packets in the network.

3.1 on demand rout discovery

A node broadcasts a RREQ packets to its neighbor whenever it needs a rout to destinations, but it is currently not exist (the rout to destination is expired or it is unknown to such nod), each neighbor in turn flood the RREQ packet until it reaches to destination. During rout discovery operation, each node broadcasts RREQ, creates reverse path to the source node. When the required destination reaches, it is immediately unicasting a RREP packet along the reverse path which is created by RREQ packet.

3.2 on demand rout maintains

The routing table entry which is used in AODV maintains a route expiry time, which indicates the valid time for the current route. When the route used to forward a data packet, its expiry time is updated to be the current time plus ACTIVE_ROUTE_TIMEOUT [3]. A routing table entry is become invalid if it is not used within its expiry time. AODV uses a "Hello" packet which is flooded every one second in order to keep an active neighbor node list for each routing entry to keep track of the neighbors that are using the entry to route data packets. This packet contains the node's IP address and its current sequence number. The "Hello" packets have a TTL value equal 1 which means that this packet will keep track only one hop neighbor.

4. Smart Probabilistic Broadcast Mechanism

In the traditional AODV [3], all RREQ packets which have been received for the first time will flooded by the intermediate node. If the intermediate node dose not have a valid rout to destination, and N is the total nodes in the network, the number of possible broadcasts of an RREQ packet in AODV is N -2 (the source and destination will not retransmit a receive a RREQ that is being generated) [9].

4.1 Smart Probabilistic Broadcast: AODV-SPB.

A brief outline of the AODV-SPB algorithm is presented in Fig.1 and operates as follows. On hearing a broadcast RREQ control packet at node *X*, the node rebroadcast a packet according to a high probability if the packet is received for the first time, and the number of neighbors of node *X* is less than average number of neighbors typical of its surrounding environment. Hence, if node *X* has a low degree (in terms of the number of neighbors), retransmission should be likely. Otherwise, if *X* has a high degree its rebroadcast probability is set low. The AODV-SPB-2P for probabilistic broadcasting algorithm for each node is presented below:

***Smart Probabilistic Broadcast: AODV-SPB* ()**

On hearing a broadcast RREQ packet at node x .

Get the number of neighbor N_x at node x .

Get the values of avg .

If packet RREQ received for the first time **then**
    If $N_x < avg$ **then**
        Node X has a low degree: the high rebroadcast probability $p = p_1$ **;**
    Else $N_x \geq avg$
        Node X has a high degree: the low rebroadcast probability $p = p_2$ **;**
    End_if
End_if

Generate a random number *RN* over [0, 1].
If $RN \leq p$ **then**
Rebroadcast the received RREQ.
Else
Drop it

End_algorithm

Figure 1: Description of the algorithm.

4.2 Adjusted Smart Probabilistic Broadcast mechanism: AODV-ASPB.

A brief outline of the AODV-ASPB algorithm is presented in Fig.2. This algorithm is a further improvement to that presented in Fig.1 and operates as follows. When a broadcast RREQ packet is received by a node for the first time, it is rebroadcast according to a probability distribution which depends on the node's degree N_x. The packet is re-broadcast with probability p_1 if the node is inside a sparse node population. Similarly, it is re-broadcast with probability p_2 if the degree denotes a medium density node population. Finally, in dense population, the node rebroadcasts the packet with a lower probability p_3. Sparse, medium and dense populations correspond to avg, avg_1 and avg_2 threshold values which we have been determined through extensive simulations. The AODV-ASPB is presented below:

***Adjusted Smart Probabilistic Broadcast: AODV-ASPB* ()**

On hearing a broadcast RREQ packet at node x.

Get the number of neighbor N_x at node x.

Get the values of three thresholds, avg, avg_1 and avg_2.

If packet RREQ received for the first time **then**
  If $N_x < avg$ **then**
    Node X has a low degree: the high rebroadcast probability p= p_1;
  Else If $N_x > avg_1$ and $N_x < avg_2$ **then**
    Node X has a medium degree: the medium rebroadcast probability p=;
  Else If $N_x > avg_2$ **then**
    Node X has a high degree: the low rebroadcast probability p= ;
  End_if
Generate a random number RN over [0, 1].
If $RN \leq p$ **then**
Rebroadcast the received RREQ.
Else
Drop it

End_algorithm

Figure 2: Description of the algorithm

4.3 Highly Adjusted Smart Probabilistic Broadcast mechanism: AODV-HASPB.

A brief outline of the AODV-HASPB in Fig.3. On hearing a broadcast RREQ packet at node X for the first time, the node compared its neighbor by avg, avg_1 and avg_2, if the node has number of neighbor N_x less than avg_1, this implies that the node is in a low sparse region, the node rebroadcasts the packet according to probability p_1. But the probability p_2 is selected if the number of neighbors N_x are such that $avg_1 \leq N_x < avg$, this implies that the node is in a medium sparse region. The value of probability p_3 is chosen if the node is a medium density region and the number of neighbors N_x are such that $avg \leq N_x < avg_2$. Finally, the value of probability p_4 is chosen if the number of neighbors N_x are such that $N_x \geq avg_2$, this implies that the node is in a high density region. The values of p_1, p_2, p_3 and p_4, respectively, will be $p_1 > p_2 > p_3 > p_4$.

***Highly y Adjusted Smart Probabilistic Broadcast: AODV-HASPB* ()**

On hearing a broadcast RREQ packet at node x.

Get the number of neighbor N_x at node x.

Get the values of three thresholds, avg, avg_1 and avg_2.

If packet RREQ received for the first time **then**
  If $N_x < avg_1$ **then**
    Node *X* has a low degree (i.e. Low sparse region)
    The high rebroadcast probability $p = p_1$
  Else if $avg_1 \leq N_x < avg$
    Node *X* has a low degree (i.e. Medium sparse region)
    The medium high rebroadcast probability $p = p_2$;
  Else if $avg < N_x \leq avg_2$
    Node *X* has a high medium degree (i.e. medium dense region)
    The medium low rebroadcast probability $p = p_3$;
  Else if $N_x \geq avg_2$
    Node *X* has a high degree (i.e. High dense region)
    The low rebroadcast probability $p = p_4$
    End_if
  End_if
  Generate a random number *RN* over [0, 1].
  If $RN \leq p$
    Rebroadcast the received RREQ.
  Else
    Drop it.

End_algorithm

Figure 3: Description of the algorithm.

5. Performance Evaluation

The traditional AODV protocol which use blind flooding during rout discovery, has been modified by replaced the blind flooding with new adjusted probabilistic scheme. AODV is already implemented in NS-2 packet level simulator. The aim is to reduce the flooding of RREQ packets during the rout discovery operation, and as a result reduces the broadcast storm problem. The net effect is that overall network improved by reduced the average end-to-end delay and as well as routing overhead.

Since the decisions of the nodes are independent, the total number of possible rebroadcasts of an RREQ packet, N_b [9], using the three proposed algorithms is :

$$N_b = \sum_{i=1}^{2} p_i N_i \text{ for the AODV-SPB.} \quad (5.1)$$

$$N_b = \sum_{i=1}^{3} p_i N_i \text{ for the AODV-HASPB.} \quad (5.2)$$

Where N_i is the number of nodes that chose p_i. If N is the total number of nodes in the network then, the total number of rebroadcasts of an RREQ packet in AODV-SPB, AODV-ASPB, AODV-HASPB, AODV-FP and AODV-BF are respectively related as follows [9]:

$$\sum_{i=1}^{4} p_i N_i < \sum_{i=1}^{3} p_i N_i < \sum_{i=1}^{2} p_i N_i < p \times (N-2) < N-2 \quad (5.3)$$

The value of fixed probability that used in AODV-FP is set at $p = 0.7$. [3, 5] has shown that this probability value enable fixed probabilistic flooding to achieve a good performance.

6. Simulation Environment and Scenario

Ns-2 is used as the simulation platform. Ns-2 is a discrete event simulator, it is designed by researcher at Berkeley University and targeted at networking research, Ns-2 provides substantial support for simulation of TCP, routing, and multicast protocols over wired and wireless networks. The simulation scenarios consist of different mobile nodes moving in different network area; each node has 250 meter transmission range and having bandwidth of 2Mbps. Each data point in the simulation results represents an average of 30 randomly generated mobility patterns in order to achieve a 95% confidence interval in the collected statistics.

The MAC layer protocol is IEEE 802.11. The nodes move according to the random waypoint model. This mobility model is used to simulate 30 topologies. The speed varies 2 to 16 m/sec and pause time 0 sec. The main parameters used in the simulations are summarized in Table 4.

Parameter	**Value**
Transmitter range	250
Bandwidth	2Mbit
Interface queue length	50 messages
Simulation time	900 sec
Pause time	0 sec
Packet size	512 bytes
Topology size	$500 \times 500\ m^2$
Nodes speed	2,4,8,12,16 m/sec
Number of node	25,50,75,100 nodes
Data traffic	CBR
Mobility model	Random Way-Point
Hello packet	64 bytes
Number of trials	30 trial
Confidence interval	95%

Table1: Summery of the parameters used in the simulation experiments.

7. Performance results

The following performance metrics have been used to evaluate the algorithms:

- The average end-to-end delay: of data packets includes all possible delays caused by buffering during routing discovery, queuing at the interface queue, retransmission at the MAC layer, propagation, and transfer time.
- The routing overhead: the number of RREQ packets transmitted for the purpose of routing data packets during the whole simulation time.

The normalized routing load: represents the number of routing packets transmitted per data packet delivered at the destination.

7.2. Effect of network density

7.2.1 Routing Overhead

Fig. 4 shows the performance of the five protocols in terms of routing overhead versus network density.

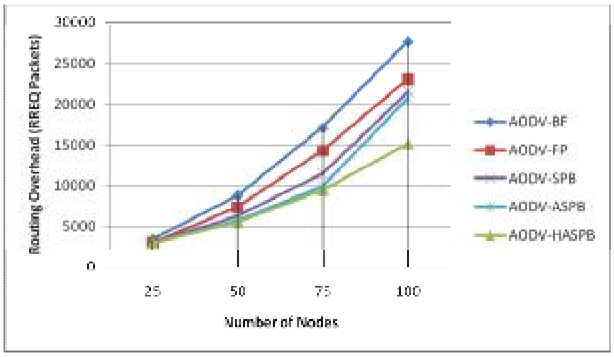

Figure 4: Routing Overhead vs. Number of Nodes placed over 500x500 area.

The RREQ Packets increased as the number of nodes is increase. The routing overhead generated by AODV-SPB, AODV-ASPB, and AODV-HASP is lower compared by AODV-FB and AODV-BF.

7.2.2 Normalized Routing Load

Fig. 4 demonstrates the effects of network density on the performance of all the five protocols in terms of normalized routing load. The AODV-SPB, AODV-ASPB, AODV-HASP has superior performance over AODV-BF and AODV-FP. For example, at high network density (e.g. 100 nodes) the normalized routing load for three protocol: AODV-HASPB, AODV-ASPB, AODV-SPB, AODV-FB and AODV-BF is reduced by about 0.5, 0.68, 0.71, 0.7 and 0.9, respectively.

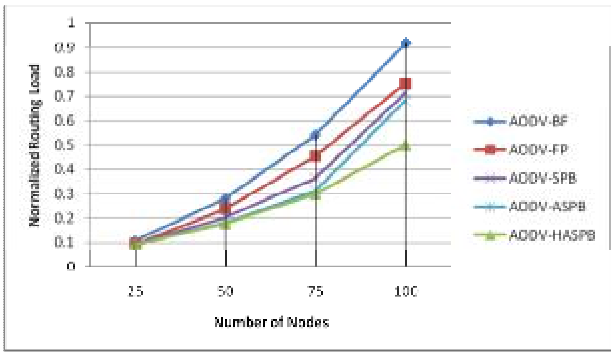

Figure 5. Normalized Routing Load vs. Number of Nodes placed over 500x500 area.

7.2.3. Average end-to-end delay (latency)

Fig.9 reveals that the delays incurred by all the five protocols. When network density increase, the number of duplicated RREQ packets which generated by nodes is also increased, and this is icreased the number of droped packets. As a result, , packets experience high latencies in the interface queues.

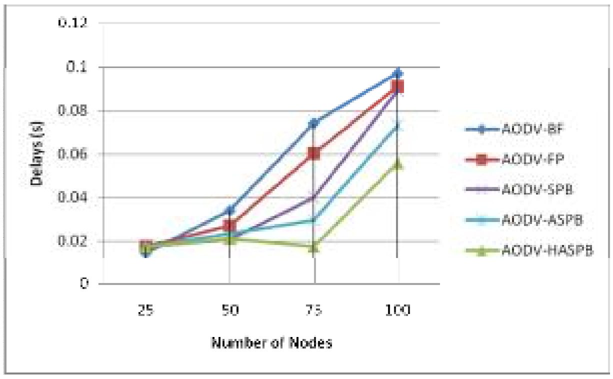

Figure 6: delay vs. Number of Nodes placed over 500x500 area.

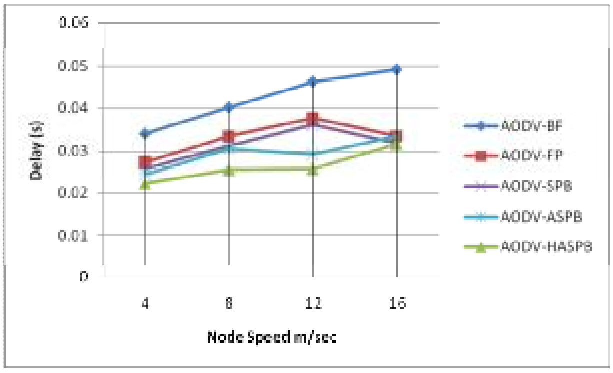

Figure7: Delay vs. node speed for a network size of 50 node and 10 connections.

8. Conclusions and Future works

In this paper, the simulation results show that new adjusted probabilistic flooding algorithm AODV-SPB with more than probability has superior performance over than traditional AODV-BF and AODV-FP. The AODV-SPB generates much lower routing overhead and end-to-end delay, as a consequence, the packet collisions and contention in the network is reduced. The results have also shown that although the traffic load increased, the normalized routing load is still low.

As a continuation of this research in the future, we plan to combine the AODV-SPB with different approach which suggested to solve the broadcast storm problem, and analysis the effect of this improvement on the performance of DSR.

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