INTERFERENCE-AWARE MULTI-PATH DYNAMIC SOURCE ROUTING PROTOCOL FOR MOBILE AD-HOC NETWORKS

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Abstract- Advances in the applications of Mobile Ad hoc NETwork (MANET) has made MANET popular. In MANET mobile nodes move freely and dynamically and self-organize into randomly and temporary network topologies. Because of the dynamic structure of MANET, many challenges exist. Routing is a vital challenge. Interference is a important characteristic of MANET. The decrease of it increases the stability and reliability of the network. In this paper, we propose a node-disjoint Interference-Aware Multi-Path Routing Protocol (IA-MDSR) which is based on interference aware Dynamic Source Routing Protocol (DSR). The minimal interference path is calculated by using multiple paths with their interference intensity values generated by DSR algorithm. From simulation results, we show that the IA-MDSR packet delivery fraction is remarkably higher than the DSR. We also show that IA-MDSR throughput is higher than DSR.

I. INTRODUCTION

Advances in MANETs in applications such as defense disaster recovery, academic institutions, health care, corporate conventions/meetings, to name a few has made MANETs popular. Many on-demand and proactive multi-path routing protocols such as AOMDV, SR-MPOLSR, MP-OLSR were purposed. These protocols did not address the problem of interference from source to destination. Hence interference plays an important role for the network performance such as data loss, conflict, retransmission of packets and so on. Reduction of interference on a path is a vital problem in order to increase network performance. In MANET, interference is caused at neighbor nodes when a node data transmitted to them. There exit many definitions of interference but there have been still no common definition of it. Our aim is to initiate one definition of interference and propose a formula of interference and to build a new node disjoint multi-path routing protocol that minimizes the interference. The paper is organized as follows. Section II introduces the detail structure of IA-MDSR protocol. In section III, We compare the IA-MDSR and DSR protocols. Finally, we conclude the paper in section IV.

II. INTERFERENCE-AWARE MULTI-PATH ROUTING PROTOCOL

A. Topology information

In the DSR protocol, “Hello” messages are used for the link sensing and neighbor detection. Periodically each node broadcasts “Hello” message to each of its neighbor nodes. The packets contain information of neighbor nodes and the node current link status. “Topology Control” (TC) message is broadcasted by each node in the network for knowing network topology. Network topology information is recorded by each and every node. We proposed an interference-aware multi-path routing protocol (IA-MDSR) which takes all above characteristics. Moreover, IA-DSR also updates the location of all nodes, the interference intensity of all nodes and links.

B. Definition of interference

There are two types of radio ranges, one is the transmission range (T_r) carrier sensing range (C_t) in MANET. A node can transmit a packet successfully to other nodes without interference in transmission range but a node can receive signals but cannot correctly decode the signal in carrier sensing range. When a node transmits data the nodes within the carrier sensing range will be interfered. The intensity of the interference of a node depends on the distance from the transmitting node to the receiving node. The intensity of a node is higher when the two nodes are close to each other in the network and vice versa. The total interference at each node in the network is the sum of the received interferences from other nodes to this node. Transmission at each node is successful if total interference is less. On contrary, if the intensity of interference of a node exceeds a certain threshold, the data will be in error or lost. Hence interference is one of the most important factors affecting network performance. Therefore, reduction of interference is necessary .to improve network quality. In, the interference of each node is defined as the total useless signals transmitted by other nodes within its interference range. The interference of a link or path between transmitting node and received node is total useless signals transmitted by other nodes within their interference ranges. In other words, the interference of a given node is total interference of the nodes within its interference range. Link interference of two nodes in the network is the average of the total interference of the nodes forming the link. Interference of a given path is total interference of the links forming the path.

C. Interference Measurement

We know that interference of a given node depends on the distance from that node to neighbor nodes within its interference range. To calculate the interference of a given node, whole interference region of a node is divided into smaller interference regions. The interference calculation will be more accurate when interference area of a node is divided into smaller areas. As the calculation complexity increases we divide the interference area into three zones and calculate the interference of a node. The whole interference of a node can be considered as a circle with a radius of T_c with the node o in the centre. The three zones are determined by Z_1 , Z_2 and Z_3 as follows (Fig1).

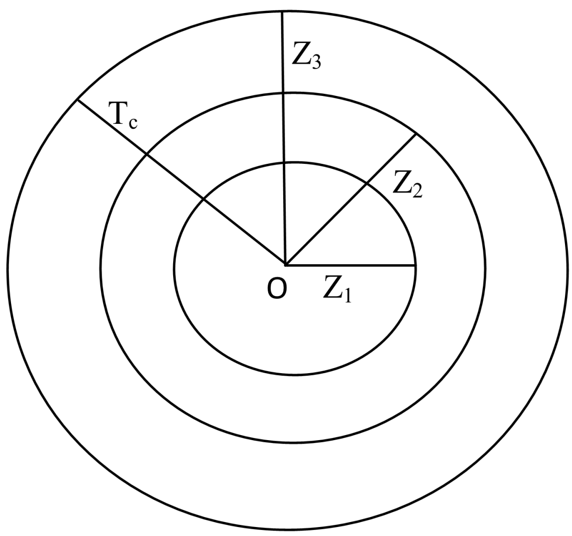

Fig 1: Interference of a node.

zone1: $0<d<=Z_1$, $Z_1=1/3T_c$

zone2: $Z_1<d<=Z_2$, $Z_2=2/3T_c$

zone3: $Z_2<d <= Z_3$, $Z_3=T_c$

Where d is the distance between transmitter and receiver. At each zone, we assign an interference weight which represents the interference intensity that a node. If the weight of interference of zone1 is 1, the interference weight of zone 2 and zone 3 are a, b respectively (b<a<1), we can calculate the interference of a node o in MANET as follows.

$I(o)=n1+ a.n2 +b.n3$ (1)where n1, n2 and n3 are the numbers of nodes in zone 1, zone 2 and zone 3 respectively. According to [9], in Two-Ray Ground path loss model, the receiving power (P_r) of a signal from a sender d meters away can be modeled as equation (1).

$$P_r = P_t\, G_t\, G_r\, H_t^2\, H_r^2/d^k \quad (1)$$

In equation (1), G_t and G_r are the antenna gains of transmitter and receiver, respectively. P_t is the transmission power of a sender node. H_t and H_r are the heights of the transmitter and receiver antenna respectively. Here, we assume that the MANET is homogeneous, that is all the radio parameters are identical at each node.

$$a=(P_tG_tG_rH_tH_r/R_2^k)/(P_tG_tG_rH_tH_r/R_1^k)=0.5^k$$
$$b=(P_tG_tG_rH_tH_r/R_3^k)/(P_tG_tG_rH_tH_r/R_1^k)=0.33^k$$

We assume that common path loss model used in wireless networks is the open space path loss which has k equal to 2. Therefore, a=0.25, b=0.11, and

$$I(o) = n1+ 0.25n2 + 0.11n3 \quad (2)$$

Based on the formula of interference of a node we can calculate the interference of a link. For a link interconnecting two nodes x and y, e=(x,y), I(x) and I(y) are the interferences of node u and node v respectively, we have:

$$I(e)=(I(x)+I(y))/2 \quad (3)$$

Based on the calculation of interference of a link, we can calculate the interference of a path P that consists of links e1, e2 ,...,en as follows.

$$I(P)=I(e1) + I(e2) + ... + I(en)$$

D. IA-MDSR protocol design

1. IA-MDSR

In order to find multiple paths with interference consideration, we determine a single minimum interference path with the interference aware DSR algorithm. A MANET can be considered as a weighted graph (Fig 2) where nodes of MANET are vertices of the graph and the edges of the graph are the links between any two neighbor nodes. We calculate the interference of each node based on the formula (2). To determine n1, n2, n3 for a node we calculate the distances from the considered node to the other nodes of the network. Then the interference of each link is determined by the formula (3). The weight of each edge is the interference of the corresponding link. Using the DSR algorithm, we can get the minimum interference path from a source to a destination.

2. Algorithm of node-disjoint multi-path

In MANET, multi-path can be divided into three following categories:

-Node-disjoint multi-path: the paths have only common source and destination.

- Link-disjoint multi-path: the paths can share a few common nodes but not links.

- Hybrid multi-path: the paths may have some common links and nodes.

To build the node-disjoint multi-path algorithm for DSR, we perform the following steps.

Step 1: Over a topology, find the single path with minimum interference based on the DSR algorithm.

Step 2: The second minimum interference path is found by applying the DSR algorithm again while avoiding all nodes between the source and destination along the path found in step 1.

Step 3: DSR algorithm is repeated for a number of times k, (k=1,.,n) while continuing to avoid the nodes between the source and destination along the paths found in the previous steps to find k-minimum interference path.

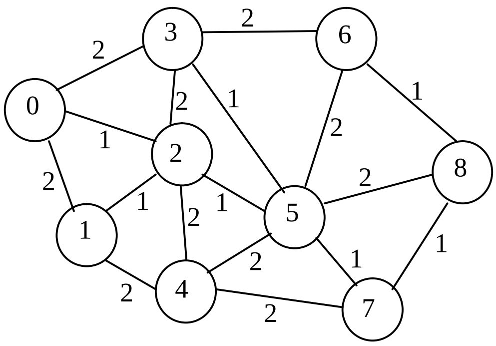

Fig 2: MANET with Intensity Interference values

We illustrate an example for a calculation of minimum path taking the example of the MANET in Fig 2, considered as a weighted graph. The intensity interference values of MANET in Fig 2 are calculated by interference measurement method (Section II) above.

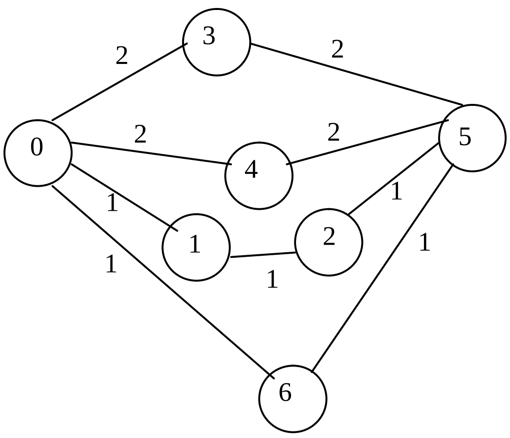

Fig 3: MANET for calculation of interference path

When using the DSR algorithm at the first time for this weighted graph with source S=0 and destination D=5 we get the minimum interference path 0-3-5 that has the path interference value of 4.Using the DSR algorithm once more, we get the second minimum interference path 0-4-5 with the path interference value of 4. We continue to apply the DSR algorithm and find the third path 0-6-5 with the interference value of 2. We continue to apply the DSR algorithm and find the fourth path 0-1-2-5 with the interference value of 3.The minimum path of these is 0-6-5 with interference value of 2. Therefore this path is selected.

3. Route recovery and packet forwarding In IA-MDSR, topology of network is always maintained and updated by each node thanks to "Hello" messages and TC messages. IA-MDSR also updates the position of all nodes, the interference levels of all nodes and links.

When a node wants to forward packets to the next hop in a found path, one more check has been conducted by sent node to confirm the received node. The packets will be transmitted without any problem. Otherwise, the node will use immediately a different path to transmit the packets. When there is no available path for a destination, the paths will be recomputed. This mechanism could help to enhance the stability and reliability of the network.

III. PERFORMANCE EVALUATION

E. Simulation environment

Both the protocols DSR and IA-MDSR are implemented using Java program. Free space and the Random Waypoint models have been used as propagation model and mobility model respectively. The number of mobile nodes varies from 100 to 500. Mobile nodes move within an area that varies from 700mx700m to 2500m x2500m. The transmission range varies from 500m to 600m.

F. Simulation results

The simulation parameter metrics used for simulation are Packet Delivery Ratio, Source Destination Pairs (SD Pairs), Throughput and number of nodes (n).

The Packet Delivery Ratio is defined as the ratio of the number of packets received successfully to the number of packets sent from source to destination.

Throughput is defined as the number of packets received by the destination node per second.

Fig 4 shows the packet delivery results for 500m transmission range.

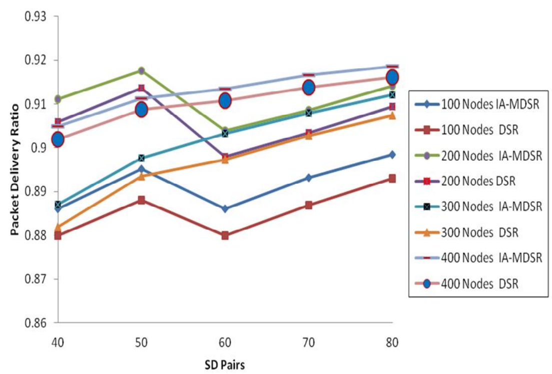

Fig 4: Packet Delivery Ratio VS SD Pairs for 500m Transmission Range

From the graph ,it shows that, for IA-MDSR the Packet Delivery Ration either increases or is constant for given SD Pairs and n when compared to DSR. Thus we say that the Packet Delivery Ratio increases..

Fig 5 shows the simulation results for 600Km transmisiion range.

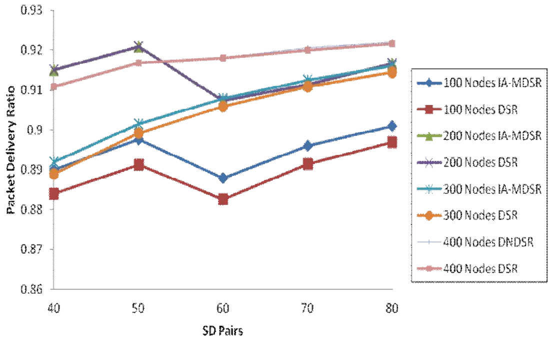

Fig 5: Packet Delivery Ratio VS SD Pairs for 600m Transmission Range

From the graph ,it shows that, for IA-MDSR the Packet Delivery Ration either increases or is constant for given SD Pairs and n when compared to DSR. Thus we say that the Packet Delivery Ratio increases. Fig 6 shows the Throughput result for 500m transmisiion range.

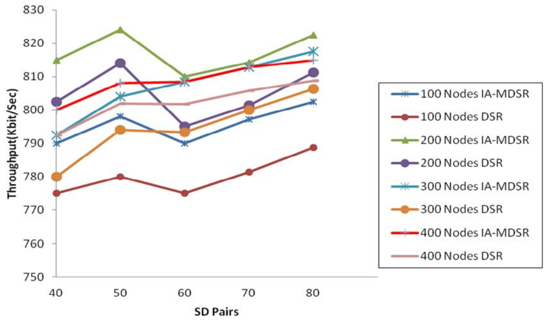

Fig 6:Throughput VS SD Pairs for 500m transmission range.

From the graph ,it shows that, for IA-MDSR the Throughput either increases or is constant for given SD Pairs and n when compared to DSR. Thus we say that the Throughput increases.

Fig 7 shows the Throughput result for 600m transmisiion range.

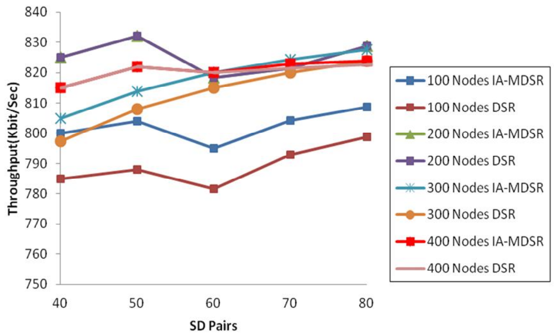

Fig 7:Throughput VS SD Pairs for 600m transmission range.

From the graph ,it shows that, for IA-MDSR the Throughput either increases or is constant for given SD Pairs and n when compared to DSR. Thus we say that the Throughput increases. Hence from graphs we conclude that the Packet Delivery Ratio and Throughput of IA-MDSR is greater that DSR for given number of SD Pairs and nodes.

CONCLUSION

In this paper, we proposed a formula and method to calculate interference and a new multi-path routing protocol IA-MDSR based on interference aware DSR for mobile ad hoc network. This protocol, IA-MDSR, uses multiple node-disjoint paths with minimal interference to increase the performance of data transmission between a source and a destination. IA-MDSR has been shown remarkably better than DSR in terms of Packet Delivery Ratio and Throughput. In future works, we seek to improve our protocol to enhance network performance.

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