A Novel Interference Aware Optimized Link State Routing Protocol for Power Heterogeneous MANETs

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***Abstract*-Mobile Ad Hoc network is a self-configuring infrastructure less network, without centralized infrastructure. Power heterogeneity is common in mobile ad hoc network. In MANET, interference significantly reduces the network performance such as data loss, conflict, retransmission and so on. Interference is one of the problems in research. In this paper, apply a formula to calculate the interference of a node, a link, a path and an Interference-Aware OLSR protocol (IA-OLSR) based on Optimized Link State Routing protocol for mobile ad hoc network. IA-OLSR has the minimal interference from a source node to a destination node. The more difference between IA-OLSR and other protocols is that our protocol looks for the next hop based on calculating the interference between the current node and its neighbor nodes by taking into account of the geographic distance instead of hop-by-hop. The results shows that IA-OLSR'normalized routing load and routing overhead are lower than the corresponding results from the original OLSR and OLSR feedback.**

Keywords: **Mobile Ad Hoc Networks, Routing Protocol, OLSR, Interference**

I.INTRODUCTION

The Internet Engineering Task Force currently has working group named mobile ad-hoc network (MANET) is a kind of wireless ad-hoc network and is a self-configuring network of mobile routers (and associated hosts) connected by wireless links and the union of which form an arbitrary topology. The routers are free to move randomly and organize themselves arbitrarily. The network's wireless topology may change rapidly and unpredictably. Each device in a MANET is free to move independently in any direction, and will therefore change its links to other devices frequently. Each must forward traffic unrelated to its own use, and therefore be a router. The primary challenge in building a MANET is equipping each device to continuously maintain the information required to properly route traffic. Such networks may operate by themselves or may be connected to the larger Internet. MANETs are a kind of Wireless ad hoc network that usually has a routable networking environment on top of a Link Layer ad hoc network. The main objective were to developed network algorithms to support a network that can scale to tens of thousands of nodes and withstand security attacks like low-cost, low-power radios that could support sophisticated packet radio protocols.

MANET has many potential applications including disaster recovery situations, defence (army, navy, air force), healthcare, academic institutions, corporate conventions/meetings. In MANET, routing protocols are divided into three categories:

Proactive (tabledriven):Each node maintains the necessary routing information and topology of network. The advantage of these protocols is that a path to the destination is immediately available, so no delay is experienced when an application needs to send packets. Some proactive protocols are OLSR [1], DestinationSequenced DistanceVector (DSDV) [3] . Contrary to proactive protocols, ondemand Routing protocols only calculate a path before data transmission. Some ondemand protocols are AODV [4], DSR [5], TORA [8]. And the third category is hybrid protocols that use both periodic and ondemand routing, for example, the Zone Routing Protocol (ZRP) [12] .

Data transmission in MANET cannot avoid influence of interference. Interference causes data loss, conflict, retransmission and so on. Therefore,

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interference is one of the factors that has the greatest impact on network performance. Reducing interference on the path is a critical problem in order to increase the network performance. Currently, there are not many routing protocols about interference for MANET and they are only the hop-by-hop protocols. In this paper, we propose a formula of interference of a node, a link, a path and a novel interference aware routing protocol based on the geographic distance between nodes in order to minimize the interference impact to the data transmission.

This paper is organized as follows. Section II introduces the detail structure of IA-OLSR. Section III we compare the IA-OLSR to the original OLSR [1], OLSR feedback (OLSRFB) [7] and conclusion in section IV.

II. INTERFERENCEAWARE ROUTING PROTOCOL

A. Topology information

In the OLSR protocol, the link sensing and neighbor detection are performed by "Hello" message. Each node periodically broadcasts "Hello" message containing information about neighbor nodes and the node' current link status. Each node in the network broadcasts the "Topology Control" (TC) message about the network topology. The information of network topology is recorded by every node. OLSR minimizes the overhead from flooding of control traffic by using only selected nodes, called Multipoint Relays (MPRs), to retransmit control messages.

B. Interference

In a MANET, each node has two radio ranges, one is the transmission range (R_t) and the other is carrier sensing range (Rcs). Transmission range is the range that a node can transmit a packet successfully to other nodes without interference. The carrier sensing range is the range that a node can receive signals but cannot correctly decode the signal.

When a node transmits data, all nodes within the carrier sensing range will be interfered. The level of the interference of a node depends on the distance from the transmitting node to the received node.

The more two nodes in the network are close to each other, the more interference is high and vice versa. The total interference on one node in the network is the sum of the received interferences from other nodes to this node. If the total interference are small enough, the node can expect a successful transmission.

If the interference level of a node exceed a certain threshold, the data will be in error or lost so, the interference is one of the most important factors affecting network performance. Therefore, interference reduction need to be considered to increase network quality and performance. In [2], the interference of a node is defined as the total useless signals that is transmitted by other nodes within its interference range. The interference of link or path is total useless signals transmitted by other nodes within their interference ranges. In other word, the interference of a node is total interference of the nodes within its interference range. Link interference of network is the average of the total interference of the nodes forming the link. Interference of a path is total interference of the links forming the path.

C. Measurement of interference

Interference of a node depends on the distance from the node to other nodes within the its interference range. To exactly calculate the interference of a node, a link and a path we divide the whole interference region of a node into smaller interference regions. The interference calculation will be more precise when we divide interference area of a node into smaller areas. However, the calculation complexity increases. To calculate the interference of a node, divide the interference area into four zones. The whole interference of a node can be considered as a circle with a radius of Rcs with the node in the centre. The four zones are determined by R_1, R_2, R_3 and R_4 as follows (Figure1).

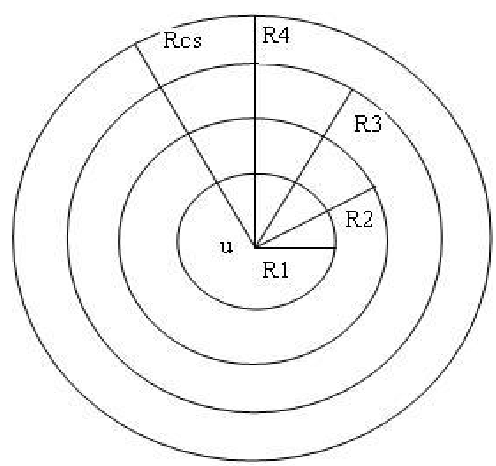

Figure 1. Illustration of radii of interference

zone1: $0<d<=R_1$, $R_1=1/4Rcs$
zone2: $R_1<d<=R_2$, $R_2=2/4Rcs$
zone3: $R_2<d <= R_3$, $R_3=3/4Rcs$
zone4: $R_3<d <= R_4$, $R_4=Rcs$

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where d is the distance between transmitter and receiver. For each zone, we assign an interference weight which represents the interference level that a node present in this zone causes to the considered node in the center. If the weight of interference of zone1 is 1, the interference weight of zone2, zone3 and zone4 are α, β, ɣ respectively (ɣ<β<α<1). We can calculate the interference of a node u in MANET as follows:

$$I(u) = n1 + \alpha.n2 + \beta.n3 + \gamma.n4$$

where n1, n2, n3 and n4 are the number of nodes in zone 1, zone 2, zone 3 and zone 4 respectively.

D. IAOLSR protocol design

1,Specifying n1, n2, n3, and n4

Each node of MANET has a coordinate (x,y). Supposed that the coordinate of u, v is (x1,y1), (x2,y2), respectively.

$$\sqrt{(x1-x2)^2 + (y1-y2)^2}$$

The above formula is used to calculate the distances between u and all other nodes in MANET. After comparing those distances to R_1, R_2, R_3, and R_4 we will have the number of nodes in zone1, zone2, zone3, and zone4 of node u. In IAOLSR, topology information of MANET is maintained and updated by each node. When any node changes its status, its information and position are updated. The distances between it and other nodes are recalculated. Therefore, interference of nodes and links is recomputed too.

2)Modelling MANET as a weighted graph

MANET can be considered as a weighted graph (Figure 2) where nodes of MANET are vertices of the graph and the edges of the graph are any two neighbor nodes. The weight of each edge is the interference level of the corresponding link. This graph is dynamic. The edges and the weight of them are changed when any node changes its status.

3)Using Dijsktra's algorithm

Applying Dijsktra's algorithm to the weighted graph above we will have the minimum interference path from a source to a destination.

In the Figure 2, we illustrate an example for MANET that is considered as a weighted graph. The weight of each edge is set on the edge.

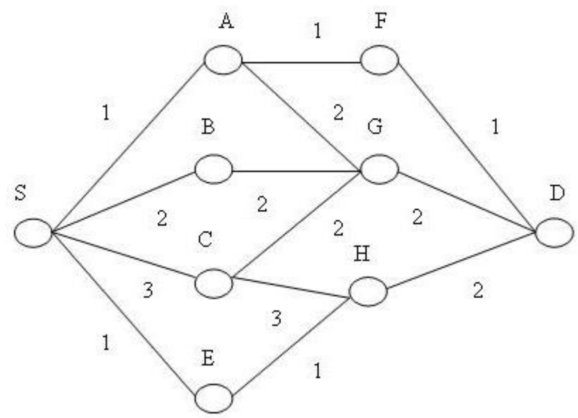

Figure 2. IAOLSR example

III. PERFORMANCE EVALUATION

A. Simulation environment

The 802.11 channels. The traffic source is Constant protocol is implemented in NS2 with 10Mbps Bit Rate (CBR). The distributed coordination function (DCF) of IEEE 802.11 for wireless LANs is used as the MAC layer. The TwoRay Ground and the Random Waypoint models have been used as propagation model and mobility model, respectively.

B. Simulation results

In the simulations, we compare the performance between IA-OLSR, the original OLSR and OLSRfeedback (OLSRFB) for:

1Packet delivery fraction (PDF)
2Routing overhead
3Normalized routing load(NRL)

As shown in Figure 3, the PDF of IAOLSR can be about 34% higher than that of the original OLSR and that of OLSRFB. The PDF of IAOLSR is higher than the original OLSR and OLSRFB because IAOLSR has lower interference.

Routing overhead of IAOLSR is about 8% lower than that of the original OLSR and that of OLSRFB as shown in Figure 4. For the reason that the number of the lost packets of the original OLSR and OLSRFB is higher than those of IA-OLSR therefore retransmissions of the original OLSR and OLSRFB increase.

Figure 5 shows that the NRL of IAOLSR has the ability to decrease about 43% compared to that of the original OLSR and to that of OLSRFB. That is because routing overhead of IAOLSR is lower and the number of packets of IAOLSR is lost less than those of the original OLSR and OLSRFB.

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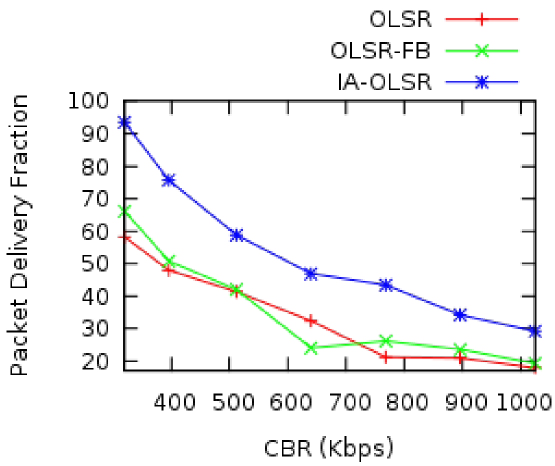

Figure 3. Packet delivery fraction

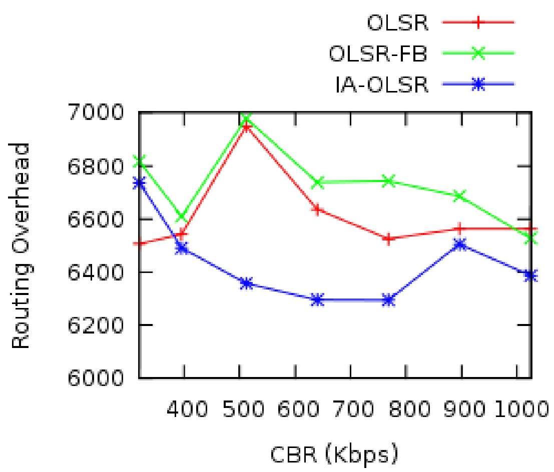

Figure 4. Routing overhead

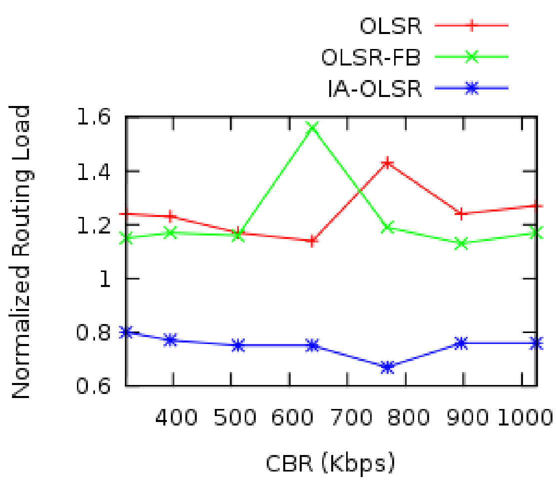

Figure 5. Normalized routing load

IV. CONCLUSION

Interference is one of the most important factors affecting the network performance. In this paper, we proposed a formula of interference and a novel InterferenceAware Routing protocol(IAOLSR) for MANET. IAOLSR calculates interference between nodes by the geographic distance and it is significantly better than the original OLSR and OLSRfeedback for the packet delivery fraction, routing overhead and normalized routing load. In the next work, we will do more research in interference and build a multipath routing protocol.

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