Volume 2, No. 4, July-August 2011
ISSN No. 0976-5697
International Journal of Advanced Research in Computer Science
RESEARCH PAPER
Available Online at www.ijarcs.info

RMNHR : A Robust Multiple Next Hop Routing Protocol for Ad-hoc Networks

G. S. Sreedhar*
Department of Computer Science & Engineering
K.O.R.M. College of Engineering
Kadapa, Andhra Pradesh, India
gssreedhar9@gmail.com

K. Sreenivasulu
Department of Computer Science and Engineering
Madina Engineering College
Kadapa, Andhra Prdesh, India
sreenu.kutala@gmail.com

Abstract: A Wireless Ad-hoc Network consist of mobile nodes that may move often. The mobility of nodes results in a change in routes and requires some mechanism for determining new routes. In this paper we present a robust Multiple Next Hop Routing protocol (RMNHR) , which is based on Ad hoc on demand distance vector routing protocol for ad hoc networks. The proposed RMNHR protocol establishes multiple paths during the route discovery process. This saves network bandwidth and reduces route reconstruction time when routing path fails.

Keywords: Ad hoc Network, AODV, control messages

I. INTRODUCTION

With the fast development of internet, people can get information that they want from Internet easily and quickly. Wireless networks have become more and more popular in Internet. This is because they enable mobility. Besides technology has made wireless devices smaller, less expensive and more powerful, communications anytime and anywhere is not just a dream.

There are three main challenges [1], in the design and operation of ad hoc network.

a) The lack of centralized entity: The ad hoc network is unlike other cellular wireless networks, that have centralized entity, such as a base station, a mobile switch center etc.
b) The probability of rapid platform movement: Mobility of each node will cause network topology changes which have an effect in routing.
c) All communication is carried over the wireless medium: The connections between network nodes are not guarantee, so intermittent and sporadic connectivity is quite common.

With the presence of high mobility of the mobile hosts and frequent link failures in wireless environment, traditional routing schemes for wired networks such as Distance vector routing [2], or link state routing [3] are not appropriate. This is because, the traditional routing methods assume that the network is mostly stable. They either lack the ability to quickly reflect the topology change of ad hoc networks or may cause excessive overload that degrades the network performance.

Therefore there are many routing protocols that have been proposed for ad hoc networks. These routing protocols can be divided into two types. Table Driven [6][7][8] and on demand [4] [9] [10] [11] [12] [13] [14] routing protocols.

In this paper we present an on demand routing protocol, called Robust Multiple NextHop Routing (RMNHR) protocol for ad hoc networks. We apply the concept of forward link and reverse link used in ad hoc on demand distance vector (AODV) routing protocol [4]. The main idea of RMNHR is

a) For each destination each mobile node maintains multiple next hops in its routing table. Thus RMNHR may provide multiple paths for a source – destination pair, while AODV only provides a single path.
b) Each intermediate host maintains the best routes and has to reconstruct the route if link fails. This can reduce the number of route reconstructions and control messages for the source to re-initiate a route.
c) The remainder of this paper is organized as follows. Section 2 describes the method of RMNHR routing protocol in detail. Section 3 presents the simulation results and Section 4 describes conclusions.

II. ROBUST MULTIPLE NEXTHOP ROUTING PROTOCOL (RMNHR)

Note that AODV only provides a single path when link breaks due to mobility, AODV informs source to reinitiate a new route by route request procedure. It wastes Band Width and route searching time for finding a new route in this case. Thus , if intermediate nodes can maintain another route instead of re–initiation , the connection can be recovered more faster Therefore the network band width consumed and the number of route request procedures invoked can be reduces. This is the goal of RMNHR protocol.

In order to provide multiple paths for a given destination each mobile host may have more than one next hop fields in its routing table and also a flag indicating which is the best route among all the existing routes.

When the link fails due to the movement of the intermediate nodes that detect the broken link, are responsible for finding another route using its routing table. This is the main idea of RMNHR protocol. In the following we describe the route request and route response operations of RMNHR protocol.

A. Route Request Procedure:

When the source node wants to communicate with a destination node and it has no routing information about this destination, the source node initiates a route request procedure to find the route to the destination. First the source node sends a route request(RREQ) message to its neighbors. If the neighbor knows a route to the destination node, they send a route reply (RREP) message. Otherwise they build reverse link to the node that sends RREQ message and then rebroadcasts the RREQ message to their neighbors. Each intermediate node repeats this procedure until an intermediate node knows a route to the destination or the destination is reached. Next, the node that knows a route to the destination or the destination node sends the RREP message back along the reverse links.

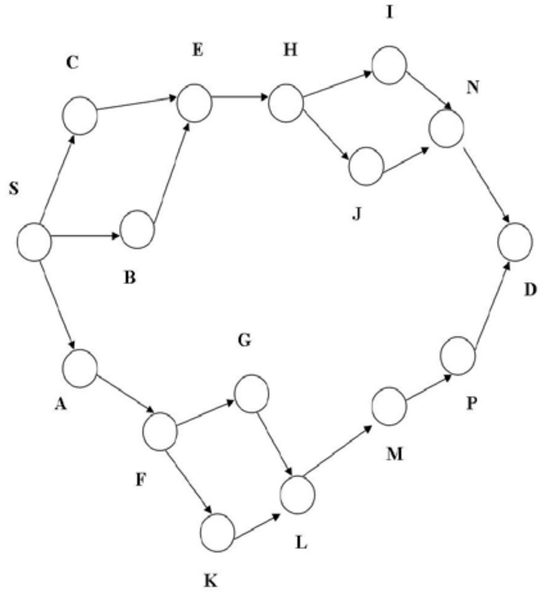

Figure-1

For example as shown in figure 1, when node S wants to communicate with node D, & it has no routing information about D in its routing table. Node S initiates a route request procedure to find the route to D. At first S broadcast the RREQ message to its neighbors A,B and C. Initially A, B and C also do not have routing information about D. They build reverse links to S and send RREQ message to their neighbors.

That is B & C send RREQ message to E , & A sends RREQ message to F. Note that E will have 2 reverse links to B &C and E will broad cast RREQ message to its neighbors once (However in AODV protocol , E only builds a reverse links to A or C and discards the RREQ message arrived later). This way, finally RREQ message will reach destination D. Also note that L and N each build two reverse links. The former builds reverse links to K and H and the later to I and J.

B. Route Reply Procedure:

Initially if there is no routing information at any of the intermediate nodes then the RREQ massage will finally reach destination node. The Destination node will send a RREP to the source along the reverse links. The RREP message contains a count field initially assigned to zero. As the RREP message travels to the source along the reverse path, at each intermediate node the count field will be incremented each of the intermediate nodes along the path follows the following steps.

a) If the RREP message is not a duplicate then, it sets up a forward link and updates its routing table along with the count field.(A smaller count filed indicates a shorter distance to the destination). If it is the source node then it starts communication.

b) If the RREP message is a duplicate, coming from a different neighbor, it sets up a forward link, updates its routing table and discards the message. Otherwise if RREP message is a duplicate, coming from the same neighbor then it is discarded.

c) If RREP message is a duplicate and the node is the source, then it creates a forward link, updates its routing table and chooses the best neighbor for communication.

If the routing information is available at the intermediate node then the RREP message would be generated by the intermediate node with the count field initialized to whatever it has in its routing table. The RREP message would travel along the reverse links. And each of the intermediate nodes would follow the same steps as above whenever they receive a RREP message.

In RMNHR, as each node may have more than one forward link while AODV has only one forward link. Also forward link entry would have a count field indicating the distance so that the best available link can be chosen for forwarding the message.

For example in figure 1 when P and N receives RREP message from destination D with count field initialized to zero. Each of P and N creates forward links to D, and updates its routing table. N sends RREP message back to I and J as well as P sends RREP message to M. Each node in the reverse path follow the same operations.(i.e. create forward link, update their routing table and send RREP message back along the reverse link)until source node S has received the RREP message and then S can start communication. Nodes that are not along the path determined by RREP message will time out after link validation time. Note that E has two next hop fields I & J in its routing table entry. Thus S has more than one route to D, such as S->B->E->H->I->N->D,S->C->E->H->J->N->D and etc. Table 1 describes the routing table entry of each mobile node to destination D.

Table 1 Routing Table entry of mobile hosts to destination D

Source	*Destination*	*(NextHop,Cost)*
S	D	(A,6), (B,5),(C,5)
A	D	(F,5)
B	D	(E,4)
C	D	(E,4)
E	D	(H,3)
F	D	(G,4),(K,4)
G	D	(L,3)
H	D	(I,2),(J,2)
I	D	(N,1)
J	D	(N,1)
K	D	(L,3)
L	D	(M,2)
M	D	(P,1)
N	D	(D,-)
P	D	(D,-)

C. Route Maintenance :

If a link break occurs, the upstream node should take appropriate action to recover. In AODV routing protocol, the upstream node sends an error message to notify the source node when link failure happens. Source node then decides to reinitiate route request procedure or not.So in this protocol much overhead is present in control messages and takes much time to establish a fresh route.

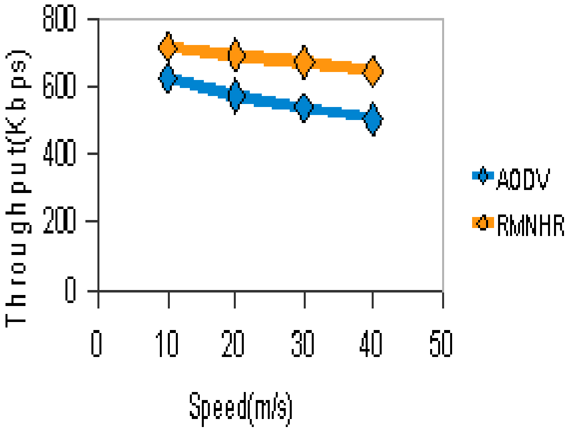

Figure. 2

In our proposed protocol, RMNHR, each host sends hello messages periodically; it knows existence of its neighbors. Thus when there is a broken link, then if the upstream node has more than one next hop entry in its routing table for the same destination then it chooses the best next hop neighbor by comparing the count filed associated with each of its neighbors ,otherwise it informs the upstream node along the reverse links. The new upstream node is in charge of reconstructing a new route. By this way the number of new route reconstruction messages can be reduced.

For example in fig 2, S has many routes to D,such as S->A->F->G->L->M->P->D,S->B->E->H->I->N->D and S>C->E->H->I->N->D etc. If H detects link fails, and then H find it has two next hops I & J to D, Node H will eliminate the invalid hop to I and chose another next hop to D immediately. If both (H,I) & (H,J) fails , H will eliminate the invalid route and informs the upstream node E. E has no route to D and so it informs the upstream nodes B and C. As each of B and C have no other route to D they inturn inform to the upstream node S , then S chooses another path through A.

III. SIMULATION RESULTS

In this section, the performance of RHNMR routing is studied. A comparison between the control messages used in RMNHR and AODV are made. Fig 3, 4 shows the number of control messages generated and the end to end delay respectively for AODV and RMNHR for a network consisting of 50 nodes. We find that initially our protocol makes more control messages to set up connections than AODV does. Also we find that RMNHR gives a better end to end delay compared to AODV. This is because of RMNHR keeps more information as time goes by.RMNHR uses less control messages than AODV.

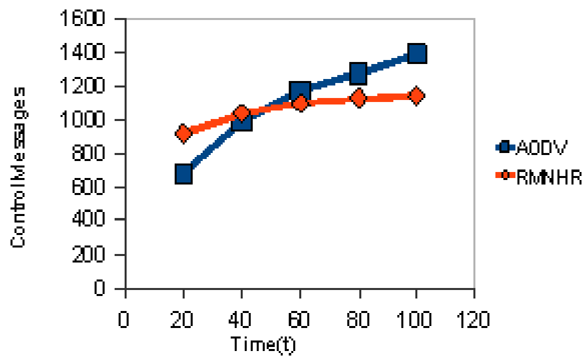

Figure-3

IV. CONCLUSION

Ad-hoc networks do not rely on the pre existing infrastructure. And because of the movement of the nodes the routing information would change rapidly. As a result the traditional routing protocols can't be employed for Ad hoc routing.

In this paper we present an Robust Multi Next Hop Routing protocol (RMNHR) based on AODV to provide robust and efficient multiple routes. Using multiple next hop information along with the best next hop information for the same destination would reduce the number of control messages as well as the end to end delay. However our simulation results shows that , initially the number of control messages and the end to end delay would be very high but as the time proceeds it is much better that AODV protocol.

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