

# New Multipath Node-Disjoint Routing Based on AODV Protocol

V. Zangeneh, S. Mohammadi

**Abstract**—Today, node-disjoint routing becomes inessential technique in communication of packets among various nodes in networks. Meanwhile AODV (Ad Hoc On-demand Multipath Distance Vector) creates single-path route between a pair of source and destination nodes. Some researches has done so far to make multipath node-disjoint routing based on AODV protocol. But however their overhead and end-to-end delay are relatively high, while the detail of their code is not available too. This paper proposes a new approach of multipath node-disjoint routing based on AODV protocol. Then the algorithm of analytical model is presented. The extensive results of this algorithm will be presented in the next paper.

**Keywords**—AODV; MANET; Multipath Routing; Node-disjoint; transmission delay.

## I. INTRODUCTION

A MOBILE ad hoc network is a type of wireless that is composed of wireless mobile nodes. Each mobile node dynamically changes the network topology without relying on a wired backbone network or a fixed base station. Mobile nodes in MANETs are constrained by their limited power, processing, memory resources and high degree of mobility. In such networks, the wireless mobile nodes may dynamically join or leave the network topology. In MANETs, many routing protocols have been suggested to communicate between mobile nodes. And pertinent routing protocols are used in various network environment and application.

In conventional wired networks, each node does not frequently change the network topology. Routing protocols for wired networks are therefore inadequate for ad hoc network where the network topology changes dynamically. In a network composed of mobile nodes, changes in the network topology required the frequent rebuilding of routes, so maintaining stable routes may be infeasible. Therefore, routing protocols for MANETs consider node mobility, stability and the reliability of data transmission. Based on these criteria, various multipath routing protocols have been suggested as extensions to conventional single-path routing protocols AODV [1]. For example, the Ad Hoc On-demand Multiple Distance Vector (AOMDV [2]) protocol discovers multiple routes by recording the path over which RREQ packets have been sent, and the Ad Hoc On-demand Distance Vector Backup Route (AODV-BR [3]) and AODV-Multipath (AODVM [4]) protocols use overhearing to send RREP

packets for discovering multiple routes and GIMR [7] that uses greedy forwarding .

In this paper, we proposed a new multipath routing protocol that is based on the AODV protocol for MANETs. This protocol improves the packet transmission rate and reduces the end-to-end delay by utilizing backup route that is node-disjoint from the main route. And also, it reduces the packet transmission delay by establishing the backup route while data is transmitted.

## II. RELATED WORK

Multipath routing establishes multiple routes between source and destination nodes. For fault tolerance, even if one route failure occurs, source nodes can maintain connections by using other routes. So multiple routing protocols can reduce data transmission failures and delay times that are caused by route disconnection.

Multipath routing protocols search node-disjoint, link-disjoint or non-disjoint routes during the rout discovery process. Node-disjoint routes have completely disjoint routes where there are no nodes or links in common. Link-disjoint routes have no links in common but may have nodes in common. Non-disjoint routes may use nodes or links in common. If a node or link fails (and it is used by the main and backup route) in non-disjoint and link-disjoint routes, then main and backup routes will be disconnected at the same time. However in node-disjoint routes, main routes and backup routes use completely different nodes or links. Therefore, even though main route will be disconnected, data transmission may be available through the backup route [5].

In single-path routing protocols, route maintenance may be performed after route fail. Therefore, data transmission will be stopped while the new route is established, causing data transmission delay. On the other hand, multipath routing protocols perform the route maintenance process even if only one route fails among the multiple routes. To perform the route maintenance process before all routes fail, the network must always maintain multiple routes. This can reduce data transmission delays caused by link failure [4].

Several implementation of multipath routing are based on AODV; typical examples are AOMDV, AODVM, AODV-BR and MP-AODV [6] protocols. The AOMDV [2] protocol establishes loop-free link-disjoint paths in the network. When intermediate nodes receive the RREQ packet from the source node, AOMDV stores all RREQ packets, unlike conventional AODV, which discards duplicates. So, each node maintains a firsthop-list where information from additional field called firsthop in RREQ packet to indicate the neighbor node of the source nodes. If firsthop of received RREQ packet is

V. Zangeneh MSc of Khajeh Nasir Toosi University of Technology, Tehran, Iran (e-mail: vz.vahidzangeneh@gmail.com).

S. Mohammadi Prof. of Khajeh Nasir Toosi University of Technology, Tehran, Iran (e-mail: mohammadi@kntu.ac.ir).

duplicate from its own firsthop-list, the RREQ packet is discarded. On the other hand, the RREQ packet is not duplicate from previous RREQ packets. Then the node updates the nexthop, hopcount and advertised-hopcount in routing table. At the destination, RREP packets are sent from each received RREQ packet. The multiple routes are made by RREP packets that follow the reverse routes that have been setup already in intermediate nodes [6].

For the AODVM protocol, intermediate nodes are not allowed to send a RREP packet directly to the source node. Also, intermediate nodes do not discard the duplicate RREQ packets. But the intermediate nodes record all received RREQ packets in routing table. The destination node sends an RREP for all the received RREQ packets. An intermediate node forwards a received RREP packet to the neighbor in the routing table. Whenever a node overhears one of its neighbors broadcasting RREP packet and it removes that neighbor from its routing table, because nodes cannot participate in more than one route.

For the AODV-BR protocol, neighbor nodes overhear the RREP packets for establishing and maintaining the backup routes during the route initiation process. If part of the main route is broken, nodes broadcast error packets to neighbor nodes. When neighbor nodes receive the error packet, they establish an alternate route using information about the overheard RREP packets previously.

AOMDV has the overhead of storing multiple next hops and hop counts and the first hop list for each destination. By overhearing the neighbor's packets, AODVM may not establish alternate routes depending on the path along which the RREP packets are sent. Moreover, to speak strictly, AODV-BR is not a multipath routing protocol, because it only maintains bypass routes when the main route is broken by using the neighbor nodes around the main routes. MP-AODV protocol uses the modified RREQ and RREP packet that has additional 1bit flag 'F'. This flag distinguishes the packet into the main route (RREQ, RREP) or backup route (RREQ\_2, RREP\_2) route discovery processes. Unlike a conventional AODV, intermediate nodes that receive the RREP packet increment the RREQ ID value in the seen table. By incrementing the RREQ ID value, the protocol ensures that a backup route will not use any nodes that belong to the main route. When a source node receives the RREP packet, the main route is established, and the source node starts data transmission and broadcasts the RREQ\_2 packet (a packet with a RREQ ID value of two) for simultaneously searching a backup route. RREQ\_2 is a packet for establishing a backup route, and its flag bit F is set to one. When the RREQ\_2 packets are delivered to the intermediate nodes, the RREQ ID values in the seen table are compared with the RREQ ID values in the RREQ\_2 packets. If they are identical, the nodes discard the RREQ\_2 packet. If not, the nodes forward the RREQ\_2 packet continuously. When nodes belonging to the main route receive the RREP packet, the RREQ ID value in the RREQ\_2 packet and the RREQ ID value in the seen table are identical because the protocol has already increased the RREQ ID value in the seen table during the previous route

discovery process. After this process, the intermediate nodes belonging to the main route do not join in the backup routes. MP-AODV has high control overhead and end-to-end delay, because it uses at last five control packets to establish two node-disjoint routes.

### III. NEW MULTIPATH NODE-DISJOINT BASED ON AODV

In this paper, we propose the NMN-AODV (Multipath AODV) protocol based on AODV protocol. NMN-AODV is proposed for MANET that configures the network topology randomly because the freely moving mobile nodes. This protocol uses two node-disjoint routes between source and destination pair. NMN-AODV reduces the transmission delay using backup routes when the main route is broken but the backup route is stable.

The MP-AODV uses multipath node-disjoint for reduce end to end delay, but it produces at last five control packets for reaches two node-disjoint. In NMN-AODV, we use three control packets for setup two node-disjoint routes, which reduce control overhead in the network. In the other hand, this protocol setup backup route faster than MP-AODV, that reduces the end to end delay.

#### A. Changes of AODV Packets

Similar to MP-AODV, we add 1bit flag 'F' to AODV packets shown in Fig. 1 and Fig. 2. When intermediate nodes receive the RREQ packet, they store RREQ ID value, information about the source node and 'F' flag value to the routing table. When each node receives the RREQ packet, AODV protocol checks <Source IP, RREQ ID> pair of RREQ packet and compares with information in the routing table for rebroadcast or drop received RREQ packet. NMN-AODV protocol uses the 'F' flag in the RREQ and RREP packets for distinguishes the main route or backup route packet route discovery processes.

Type	J	R	...	D	F	Reserve d	Hop Count
RREQ ID							
Destination IP Address							
Destination Sequence Number							
Originator IP Address							
Originator Sequence Number							

Fig. 1 NMN-AODV RREQ packet

Type	R	A	F	Reserved	Prefix Size	Hop Count
Destination IP Address						
Destination Sequence Number						
Originator IP Address						
Originator Sequence Number						

Fig. 2 NMN-AODV RREP packet

*B. Route Discovery*

When a source node wants to transmit data to a destination node and if it doesn't has a path to destination node in the routing table, it broadcasts the RREQ packet (with an 'F' flag value of zero) for establish a main route. When intermediate nodes receive the RREQ packet (with an 'F' flag value of zero) and they aren't the destination that is determined in the RREQ packet, take action similar to conventional AODV protocol.

If the destination node receives RREQ packet, sends the RREP packet (with an 'F' flag value of zero) to the source node, and after NET-TRAVERSAL-TIME milliseconds sends RREQ packet (with an 'F' flag value of one and 'D' is set) to the source node. If the source node receives the RREP packet (with an 'F' flag of zero), the main route is established and starts data transmission. If the source node receives RREQ packet with an 'F' flag value of one, the backup route is established and starts data transmission with piggybacking RREP (with an 'F' flag value of one) on this path simultaneously sending data on main route. If a destination node receives RREP packet (with an 'F' flag value of one), it drops this packet. When an intermediate node receives RREQ packet (with an 'F' flag value of one) checks and compares <Source IP, Destination IP> in the RREQ packet with <Destination IP, Source IP> pairs in the itself routing table, if a match case is found and Route-flag=0, that is the node is belong of the main route, and discard RREQ packet. If a match case is not found, the node takes action similar to conventional AODV protocol. The route discovery process is shown in Fig. 4. Similar to MP-AODV, as shown in Fig. 3 we add two new fields named 'Route-flag' and 'Source' to the routing table. 'Route-flag' is used to distinguish between main and backup routes. A value of zero for 'Routing-flag' indicates the main route, and a value of one indicates the backup route. 'Source' field indicates the source node of the path in the routing table. When each node receives the RREQ packet, stores value of the 'F' flag and Source IP in the packet to the routing table as 'Routing-flag' and Source field.

Destination	...	Source	Route-flag
D	...	S	0
...	...	...	1

Fig. 3 Adding the 'Source' and 'Route-flag' fields to the routing table

In the route discovery process (Fig. 4) we assume that:  
 Des-IP: Destination IP Address in the received packet  
 Sou-IP: Originator IP Address in the received packet  
 My-IP: The current node's IP Address.  
 Des-IP-T: Destination IP Address in the routing table of the current node.  
 Sou-IP-T: Originator IP Address in the routing table of the current node.

```

Input: RREQ packet with 'F' flag
IF (packet's 'F'=0)
{
  if (packet's Des-IP ≠ My-IP)
  {
    • Conventional AODV algorithm is used
  }
  else
  {
    •The destination node sends RREP (with an 'F' flag value of zero).
    •After NET-TRAVERSAL-TIME millisecond Broadcast RREQ with an 'F' flag value of one, 'D'=1 and Des-IP=Sou-IP
  }
}
ELSE
{
  if (packet's Des-IP = My-IP)
  {
    •Transmit data packets with piggybacking RREP with an 'F' flag value of one.
  }
  else if (Sou-IP-T=Des-IP and Des-IP-T=Sou-IP and Route-flag=0)
  {
    •Discard RREQ packet.
  }
  else
  {
    • Conventional AODV algorithm is used
  }
}

```

---

```

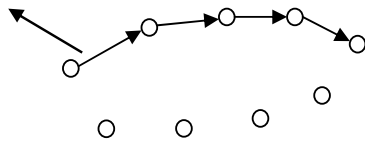
Input: RREP packet with 'F' flag
IF (packet's 'F'=0)
{
  • Conventional AODV algorithm is used
}
Else
{
  if (Sou-IP=My-IP)
  {
    •Discard RREP packet
  }
  else
  {
    • Conventional AODV algorithm is used
  }
}

```

Fig. 4 Route Discovery Process

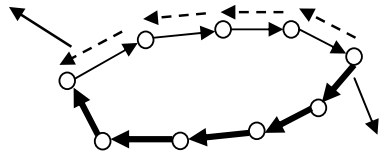
Regards to conventional AOVD when 'D' flag in the RREQ packet is set to one, indicates only the destination may respond to this RREQ. Therefore the RREQ packet is used for backup route only will be responded by the destination node (same source node). Fig. 5 illustrates the route discovery.

RREQ with F=0



a) Main Route Discovery

RREP with F=0



RREQ with F=1

b) Backup Route Discovery

Fig. 5 NMN-AODV Route Discovery

## IV. CONCLUSION

In this paper, we proposed a routing protocol that establishes two node-disjoint routes between source and destination nodes based on AODV protocol for MANETs. NMN-AODV uses three control packets for establishes two routes, but MP-AODV uses five control packets. Thus NMN-AODV has low overhead to MP-AODV. In addition, two routes will not break at the same time because the protocol uses node-disjoint multiple routes that are not duplicated between main and backup routes. NMN-AODV establishes two node-disjoint faster than MP-AODV because NMN-AODV starts to establish backup route faster than MP-AODV. Thus end-to-end delay is lower than MP-AODV. Also this protocol sends the data immediately after the main route is found by separating the main route and backup route discovery process to reduce the data transmission delay. In the future work, we will compare NMN-AODV with other multipath routing protocols based on AODV such as AOMDV, AODVM and AODV-BR.

## REFERENCES

- [1] RFC3561: Ad hoc On-Demand Distance Vector (AODV) Routing.
- [2] Mahesh K. Marina and Samir R. Das, "On-demand Multiple Distance Vector Routing in Ad Hoc Networks", *Proceedings of the International Conference for Network Protocol*, 2001.
- [3] Sung-Ju Lee and Mario Gerla, "AODV-BR: Backup Routing in Ad hoc Networks", *Wireless Communications and Networking Conference, 2000*.
- [4] Zhenqiang Ye, Strikanth V. Krishnamurthy and Satish K. Tripathi, "A Framework for Reliable Routing in Mobile Ad Hoc Networks", *IEEE INFOCOM*, 2003.
- [5] M.T.Toussaint, "Multipath Routing in Mobile Ad Hoc Networks", *TU-Delft/TNO Traineeship Report*.
- [6] Chang-Woo Ahn, Sang-Hwa Chung, Tae-Hun Kim, Su-Young Kang, "A Node-Disjoint Multipath Routing Protocol Based on AODV in

Mobile Ad-hoc Networks", International Conference on Information Technology, IEEE, 2010.

- [7] Wenjing Yang, Xinyu Yang, Guozheng Liu, Wei Yu, "An Interference Avoidance Multipath Routing Protocol based on Greedy Forwarding in MANETs", IEEE, 2010.