ASTEEC Conference Proceeding: Computer Science
3rd International Conference on Information Science and Technology Innovation (ICoSTEC)
July 27, 2024, Yogyakarta, Indonesia

Evaluation of Precursor Feature in a Mobile Ad hoc Network Routing Protocol

Van Vuong Ngo

Viettel High Tech, Viettel Group, Hanoi, Vietnam
vuongvuongnvvt@gmail.com

Abstract— **The ad hoc on-demand distance vector (AODV) is a routing protocol that is usually used in the mobile ad hoc networks (MANETs) and other wireless ad hoc networks. The AODV is a reactive protocol, so a source node will use control messages to find routes to a destination node whenever there are data packets that are needed to transmit. If there is more than one route to the destination node, the source node chooses the shortest route (the route has the fewest number of hops). However, this selection is not ideal in some cases. Considering there is a defected node or unavailable node in the shortest route, the path from the source node to the destination node becomes unstable. To avoid this problem, an enhancement of the AODV is proposed. The proposed solution uses another metric besides the number of hops to find an optimized route. The new metric is the length of the precursor lists of involved nodes. The precursors of a node are the neighbour nodes that use this node as a next hop to a particular destination. The nodes that have a high number of neighbour nodes in their precursor lists are relatively more active than other nodes, and they seem to be located in the center of the network. Therefore, if they are out of commission, the network will suffer a heavy failure. The proposed solution mitigates the reliance of the network on these nodes, so the performance of the network can be optimized. In this paper, the performance of the proposed solution was evaluated using the NS-3 simulator, and the results show that the performance of the network had been improved with the proposed solution.**

Keywords— **AODV, MANET, Routing, Protocol, Simulation.**

I. INTRODUCTION

The mobile ad hoc networks (MANETs) are wireless networks that have many autonomous mobile nodes (devices) and “ad hoc” means “for this special purpose” in Latin. The nodes get together to make a self-configured network without any fixed infrastructure. The nodes in ad hoc networks can forward packets without the presence of a base station because each node can work as a router. Fig. 1 and Fig. 2 depict a wireless network with a base station and an ad hoc network.

There are some advantages of MANETs. First, it can be deployed in different environments and scenarios. Second, the process of deployment is rapid because the networks do not need pre-configured infrastructure. Moreover, the network topology can change and the number of nodes can be decreased or increased.

The ad hoc on-demand distance vector (AODV) is a routing protocol that is widely used in MANETs [1][2]. However, it still has some drawbacks. Therefore, we proposed an improvement of the AODV. In this manuscript, Section 2 gives information about MANET routing protocols and the AODV protocol. Then, we review some related works in Section 3. The proposed solution is described in the next section and the simulation results are presented in Section 5.

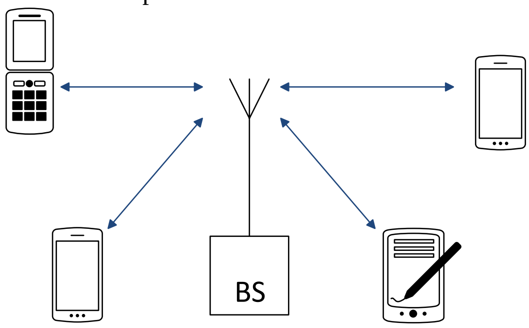

Fig. 1 Wireless network with a base station

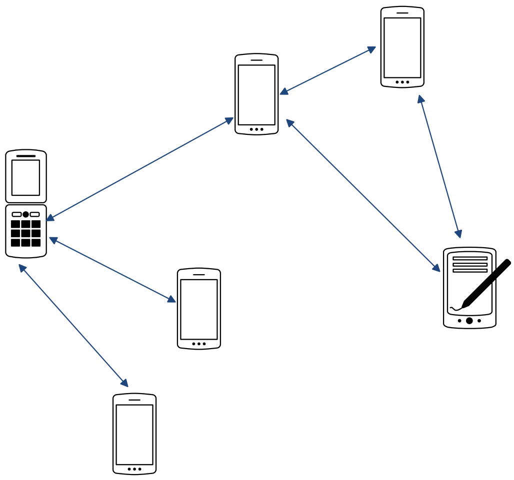

Fig. 2 Ad hoc network

II. MANETS ROUTING PROTOCOL AND AD HOC ON-DEMAND DISTANCE VECTOR PROTOCOL

A. MANETs Routing Protocol

The MANET routing protocols are classified into three categories: reactive, proactive, and hybrid.

- **Reactive protocols**: The reactive protocols do not maintain the network topology information and the route will be obtained whenever there is a request for communication. These protocols do not need to update the network topology periodically but it takes time to establish a route.
- **Proactive protocols**: These protocols always have up-to-date information of routes from each node to other

nodes in the network. The network topology is updated periodically, so if there is no communication, a huge amount of control messages is redundant.

- **Hybrid protocols**: The hybrid protocols try to use the advantages of both reactive protocols and proactive protocols. They provide different ways of routing for each level of network.

Some examples of MANET routing protocols are AODV (reactive), DSDV (proactive), and ZPR (hybrid) [3][4].

B. Ad hoc On-demand Distance Vector Protocol

The AODV is a reactive protocol, so whenever a source node needs to transmit data packets to a destination node, the source node commences a procedure to find a route to the destination node. This procedure is the route discovery process with some control packets, namely route request (RREQ), route reply (RREP), and route error (RERR). The headers of the RREQ and RREP are shown in Table. 1 and Table. 2. The RREQ packet contains the following information: message type, source address, destination address, broadcast ID, hop count, source sequence number, and destination sequence number. The RREP packet contains the following information: message type, source address, destination address, hop count, destination sequence number, and life time. The broadcast ID is used to differentiate each route discovery process, so each time a node commences a route discovery process, it will use a unique broadcast ID. Sequence number describes if the information in a node is old or not. The node will update its routing table if it receives a message that has higher sequence number than the number of it. The life time describes how will the established route should exist, afterwards the source node needs to start another route discovery process. The route discovery process is described as follows.

First, the source node broadcasts the RREQs to all of its neighbor nodes. After that, the neighbor nodes continue to broadcast the RREQs to other nodes. This process ensures there is no loop because the RREQs are discarded if the intermediate nodes receive the duplicated RREQs. When an RREQ reaches the destination node, the destination node replies with an RREP. This RREP will travel backward to the source node. After receiving the RREP, the source node starts to send data packets to the destination node because the source node now knows the path to the destination node.

Moreover, if an intermedia node also knows the path to the destination node, it can reply with an RREP to the source node. With this RREP, the source node can establish a path to the destination node. When the source node receives more than one RREP, it decides to choose the path with has the fewest number of hops.

Fig. 3 illustrates a route discovery process. The source node (node 1) wants to send data packets to the destination node (node 4). First, node 1 broadcasts RREPs to all of its neighbour nodes. Then the intermediate nodes continue to broadcast RREPs if they do not know the route to the destination node. When node 4 receives an RREQ, it replies with an RREP. Node 1 transmits the data packets as soon as it receives the RREP.

C. Precursor List

Each node maintains a routing table which contains information of how to reach other nodes. When a source node wants to transmit data to a destination node, the source node first look the address of the destination node up in its routing table. If there is the address of the destination node in the routing table, the entry with this address is used. The source node takes the IP address in the field "next hop" of the entry, then transmitting data to this next hop.

In each route entry maintained in a routing table, a node also records a list of precursors. The precursors are neighbour nodes that will use this node as a next hop to the destination node in the entry. When the upstream link of this node to the destination node is broken, this node must notify all of its neighbour nodes in the precursor list about this broken link. Therefore, the neighbour nodes can update their routing tables by deleting the route entry which relates to the broken link.

Focusing on node 2 in Fig. 3, this node has a routing table that contains paths to both node 1 and node 4. Regarding the entry to node 1 as a destination, the field "next hop" has the address of node 1, and the precursor list have one node which is node 3 (node 3 uses node 2 as a next hop to the destination node 1). Similarly, as for entry to node 4 as a destination, the precursor list contains one node which is node 1 (node 1 uses node 2 as a next hop to the destination node 4).

TABLE I
RREQ PACKET FORMAT

Type	Reserved	Hop Count
Broadcast ID		
Destination IP Address		
Destination Sequence Number		
Source IP Address		
Source Sequence number		

TABLE II
RREP PACKET FORMAT

Type	Reserved	Hop Count
Destination IP Address		
Destination Sequence Number		
Source IP Address		
Life time		

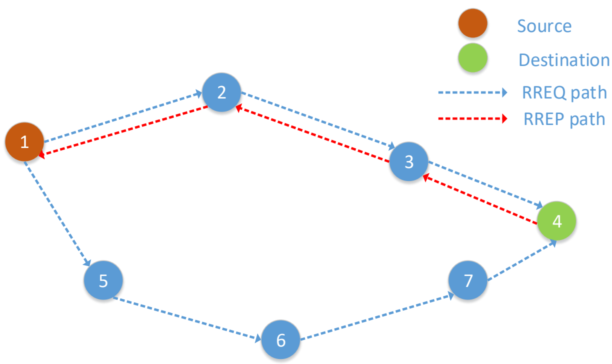

Fig. 3 Route discovery process

III. Related Works

There are some works that improve the efficiency of AODV. In R-AODV, the reverse route request (R-RREQ) is used [5]. After the destination node receives an RREQ, it floods R-RREQ to find the source node. R-AODV increases the number of control messages in the network, so it is the main drawback of this protocol. Instead of flooding R-RREQ, the destination node can reply with more than one RREP, then the overhead (the number of control messages) is not modified much.

EDA-AODV and ENH-AODV concerned about the energy of nodes in the network [6][7]. The proposed protocol in this manuscript also helps to share the load between nodes in the network. Instead of nodes which are in the center of the network, the other nodes are likely to get involved in transmissions, so a node can avoid the shortage of energy because it does not need to forward packets continuously. The technique of using multiple RREPs without flooding RREPs is also applied to the proposed solution.

IV. Proposed Solution

In AODV, the source node chooses the path with the sole metric which is the number of hops. If the source node receives multiple RREPs, it will update its routing table to the destination node with the RREP that has the smallest value in the header "Hop Count". This leads to the issue that some nodes are engaged inequitably in communications. For example, the nodes which locate in the center of the network topology are likely involved in the transmission path between the source node and the destination node. Besides, when these nodes are out of commission, many data transmission links become broken down. The alleviation of reliance on centre nodes may bring some benefits which help the networks become more stable. It can be noticed that the centre nodes have many addresses in their precursor lists. These nodes often lie on reverse paths of RREPs and they also have many neighbour nodes in their vicinity. Therefore, the neighbour nodes regard these centre nodes as the next hop to destination nodes. Fig. 4 demonstrates an example of a network topology. Node 5, node 8, and node 9 have many addresses in their precursor list. However, if node 5 is out of commission, all data links related to node 5 are broken consequently. Moreover, node 5 seems to lose its energy faster because other nodes always forward packets to it.

In order to improve the networks' stability, we proposed that the queue length of precursor list of nodes can be considered as another metric. The RREP has some reserved bits and these bits can be used to store the information of queue length in the buffer. The new metric is calculated as follows:

$$NewMetric = \alpha * HopCount + \beta * PrecursorListLength \quad (1)$$

α and β are the weight factors. They are used to determine which parameter is more important in the calculation.

$HopCount$ is the value in the header "Hop Count" of RREPs. $PrecursorListLength$ is the total sum of precursor list's length of each intermediate node. It is obvious that the route that has the smallest hops count and smallest sum of precursor list's length will be chosen by the source node.

The new metric can help to share the load between nodes of the network. The nodes that are not located in the center of the network now have chances of getting involved in the communications. The load sharing also reduces the chance in that the nodes are broken because of transmitting continuously. For example, in Fig. 4, with AODV protocol, when node 2 wants to transmit data to node 7, the path is node 2 - node 5 - node 8 – node 7. Then, node 3 desires to transmit data to node 9, so the path can be node 3 – node 2 - node 5 - node 9. Node 5 is engaged in both two data transmissions with AODV protocol. In contrast, with Proposed AODV, while the first path is still the same (node 2 - node 5 - node 8 – node 7), the second path can be node 3 - node 6 – node 15 - node 9.

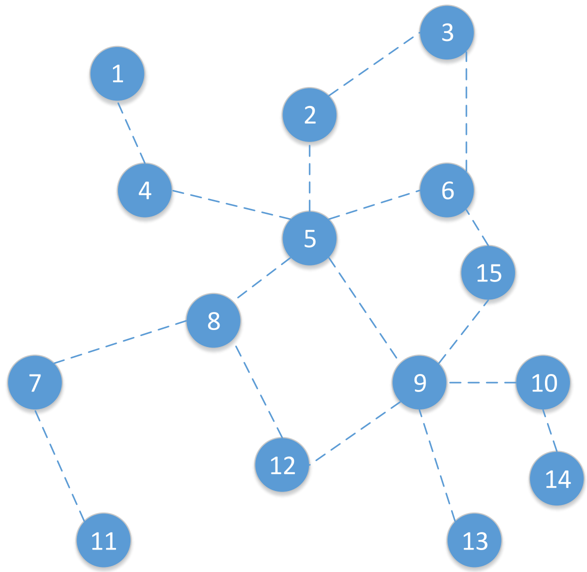

Fig. 4 An network topology

Besides new metric calculation, another technique is also implemented in the protocol. Normally, the destination node only replies with one RREP. However, in the proposed solution, the destination node replies with multiple RREPs. Every time the destination node receives an RREQ, it replies with an RREP. The more RREPs return to the source node, the more options the source node has to choose a suitable route to the destination node. This technique was often used by other researchers in their works. Fig. 5 shows an example of two RREPs response.

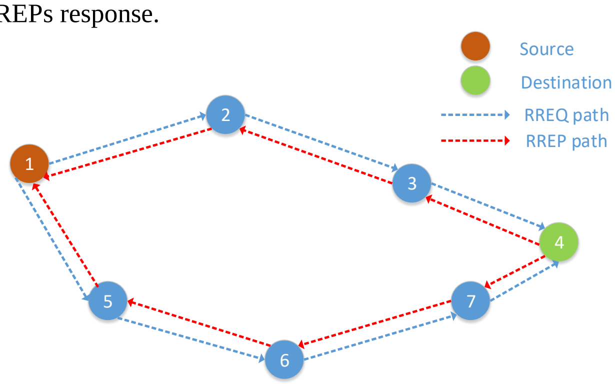

Fig. 5 Multiple RREP response

V. SIMULATION RESULTS

The simulations are implemented using Network Simulator 3 (NS-3) [8]. We conduct 2 simulation scenarios, and α and β are set to 1. The scenario 1 has 40 nodes in the networks while the scenario 2 has 50 nodes. The simulation parameters are as follows:

TABLE 3
SIMULATION PARAMETERS

Parameters	
Number of nodes	40 nodes (Scenario 1) 50 nodes (Scenario 2)
Traffic load	UDP, CBR traffic generator
Application	10/15/20 UDP links (Scenario 1) 15/20/25 UDP links (Scenario 2)
Routing protocol	AODV and Proposed AODV
Transmission time	100s
Packet rate	2048 Kb/s (4 packets/s)
Packet size	64 bytes
Node speed	20m/s

To evaluate the performance of AODV and improved AODV, we compare the number of packets received in each cases.

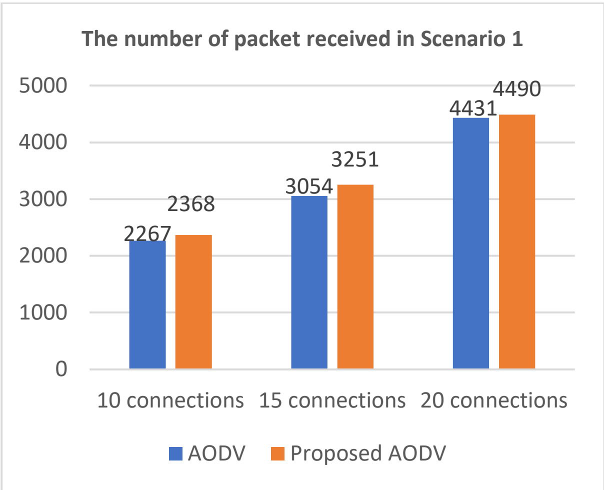

Fig. 6 The number of packet received in Scenario 1

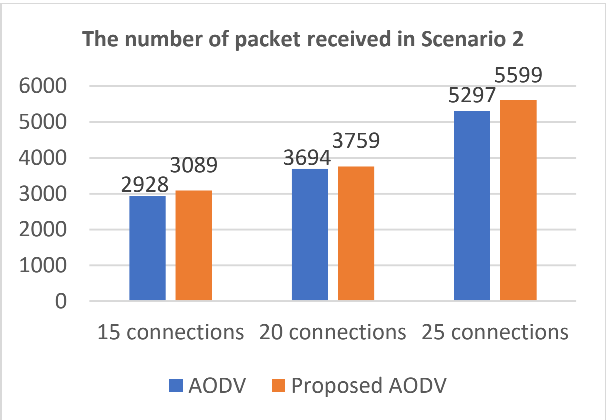

Fig. 7 The number of packet received in Scenario 2

As can be seen in Fig. 6 and Fig. 7, the improved protocol outperformed the AODV. The number of packets received of the improved protocol are higher than that of the AODV.

VI. CONCLUSIONS

We proposed the idea of using a new metric in the route discovery process of the AODV and this metric is the length of precursor list of intermediate nodes. The nodes that have many addresses in their precursor lists are likely to get involved in the new path because they are usually located in the center of the network. This solution helps to share the load equitably between nodes in the networks. The nodes which do not at the center of the network have some chances to be engaged in data transmission. We conducted some simulations to evaluate the performance of the proposed idea. The results show that the improved protocol outperformed the AODV.

REFERENCES

[1] S. Corson and J. Macker, "Mobile Ad hoc Networking (MANET): routing protocol performance issues and evaluation considerations," RFC 2501, January 1999.

[2] C. Perkins and E. Belding-Royer, "Ad hoc On-Demand Distance Vector (AODV) routing," RFC 3561, July 2003.

[3] Charles E. Perkins and Pravin Bhagwat, "Highly dynamic destination sequenced distance-vector routing (DSDV) for mobile computers," in Proc. of the SIGCOMM '94 Conference on Communications Architectures, Protocols and Applications, pp. 234-244, August 1994.

[4] Z. J. Haas, M. R. Pearlman, and Prince Samar, "The zone routing protocol (ZRP) for ad hoc networks," Internet draft, draft-ietf-manet-zone-zrp-04.txt, July 2002.

[5] H. Nishat, V. Krishna K, S. Rao, S. Ahmed, "Performance Evaluation of On-Demand Routing Protocols AODV and Modified AODV (R-AODV) in MANETS," in International Journal of Distributed and Parallel Systems (IJDPS) Vol.2, No.1, January, 2011

[6] A. Ryan, S. Nouh, T. Salem, A. Naguib, "EDA-AODV: Energy and Distance Aware AODV Routing Protocol," in International Journal of Computer Networks and Applications (IJCNA) Vol.5, Issue 5, September-October, 2018.

[7] P. Pandey, R. Singh, "Efficient Route Selection Scheme in MANET Using Enhanced AODV Protocol," in Wireless Personal Communications, March, 2022.

[8] NS-3: Network Simulator 3, http://www.nsnam.org.