Randomized Energy-Based AODV Protocol For Wireless Ad-Hoc Network

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***Abstract*—MANET is one kind of non-infrastructure network which is composed of various mobile nodes. Due to the battery energy constraints in MANET, energy efficiency is an important factor while designing ad hoc wireless networks. Previous works tried to optimize the AODV protocol by proposing different schemes. In this paper, two solutions have been proposed to control the congestion problem of wireless ad-hoc network in MANET. Some changes have been made in the RREQ packet to calculate the drop factor. The energy-based proposed scheme has been simulated with network simulator 2.35. It is seen from the result that the solutions proposed has performed comparatively better than the traditional AODV with respect of packet delivery ratio, throughput and delay.**

***Index Terms*—MANET, Mobile Ad-hoc Network, Wireless Ad-hoc Network, Routing Protocol, On Demand Routing Protocol.**

I. Introduction

Mobile Ad-hoc Network (MANET) is formed by a group of mobile nodes that are connected via wireless links with no pre-established network infrastructure [1]–[3]. As nodes move randomly in the network, it causes rapid changes and the network topology becomes unpredictable. The frequent movement of nodes in MANET makes routing in the network a challenging problem. MANETs can be applied in different fields, such as collaborative and distributive computing, emergency operations, disaster management etc.

MANET comprises of many mobile nodes that operate with limited battery power. So, energy efficiency is an important criteria to take into account for designing routing protocols in MANET.

There exist many solutions [4]–[6] for efficient AODV routing. Some of the proposals [7]–[9] are related to energy efficient AODV protocol design. Shahin Tajik proposed WAODV [10] where stable path is selected by sending *Hello* packets. Chonggun Kin proposed R-AODV [11] which deals with the node mobility problem by sending multiple RREPs. K. R. Shobha proposed named E-AODV [12] where blind flooding of RREQ message is avoided.

A. Objective

Our *objective* of this paper is to propose new solutions to ensure efficient routing. We have presented two solutions of AODV protocol efficient routing.

Fig. 1: Wireless ad-hoc network

B. Contributions

Contribution of this work contains: (i) proposing a new energy based AODV protocol. (ii) proposing a new hello message based AODV protocol for better route stability.

The organization of rest of this paper is as follows. In Section IV, new proposed AODV modified algorithm is explained. Section V outlines the network topology, simulation parameters and performance metrics. Section VI presents an analysis of all the results that we simulated. Finally, the paper comes to conclusion in Section VII.

II. Background

A. Routing Protocol Types

According to route discovery, routing protocols are basically classified into three categories.

- Re- active (On Demand) Routing Protocols
- Pro- active (Table Driven) Routing Protocols
- Hybrid Routing Protocols

Re-active or On demand routing protocols follow on demand route requsting mechanism. These protocols store only active routes. [13], [14] So, memory requirement is reduced. Here, source node invokes route discovery mechanism when it

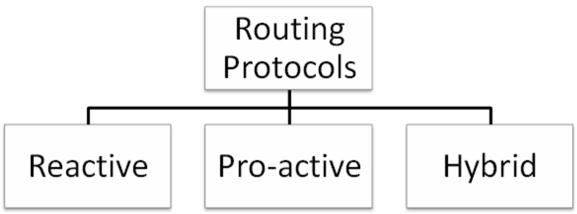


Fig. 2: Different types of Routing Protocols

needs to communicate with destination. In pro-active or table driven protocols, nodes maintain routes in routing tables and these tables are shared periodically. Nodes search the table to find routes from source to destination. Hybrid protocols combine the advantages of both on demand and table driven routing protocols.

III. Ad hoc On Demand Distance Vector Routing Protocol

Ad-hoc On Demand Distance Vector Routing Protocol, in short AODV [15] is a widely used routing protocol that is bi-directional reactive in nature. It is an enhancement over Destination Sequenced Distance Vector (DSDV)routing protocol. As it is a re-active protocol, the path of communication is established when it is needed. In AODV, nodes maintain routes only if they are used by source node. This protocol uses sequence number to keep up fresh routing information and to prevent formation of routing loops. There are mainly three kinds of packets in AODV protocol.

- Route Request (RREQ) Packet:To send out a packet from source to destination, originating node starts a path discovery process and sends RREQ packet containing destination address to its neighbor nodes to find a path to the corresponding destination node. When a node receives RREQ, a reverse data transmission path from destination node to source node is created in its routing table. Whenever a RREQ packet with identical source address with broad cast Id is received by a node , the redundant RREQ packet is dropped by the corresponding node. A reverse routing path from source node to destination node is formed by the above mentioned process.
- Route Reply (RREP) Packet: When the RREQ packet reaches to the destination node or to an intermediate node that knows route to the destination node, a reply packet named RREP is sent back to the corresponding source node via the nodes which were used to forward the RREP packet.
- Route Error (RERR) Packet: Many link breakages can occur because of the dynamic movement of nodes in ad-hoc network. This breakages result packet drop and a message named RERR is generated. These messages are sent to those neighbors or a local repair will take place.

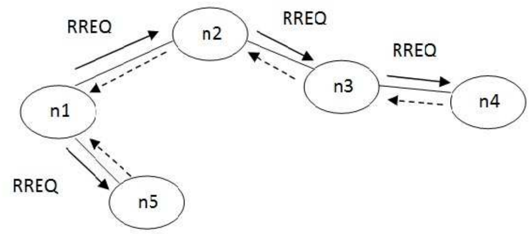


Fig. 3: RREQ packet traversal

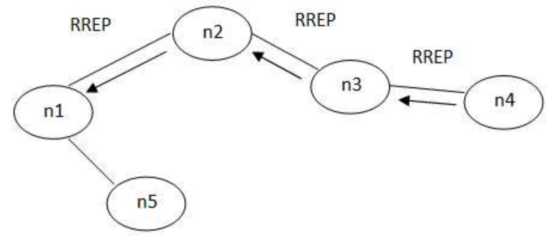


Fig. 4: RREP packet traversal

The working of AODV protocol is illustrated using Fig. 3. Suppose n1 wants to send data to n4. So, n1 needs a path for communication with n2. To discover the path, n1 will send RREQ to its neighbors n2 and n5. n2 and n5 will build a reverse path by making their destination n1, next hop n1, hop count 1. n2 does not know any path to n4. So, it will forward the RREQ packet to n3. n3 knows the path to destination n4.

RREP works in the following manner as shown in Fig. 4. n5 sends a RREP packet to n3, n3 then forwards the packet to n2 and n1.

IV. Proposed Modification

A. *Using Hello Packet*

Nodes in MANET may change their position from time to time. Hello packets are used for determining connectivity information of neighbor nodes. By default, this connectivity information is achieved in AODV by Link Layer Detection mechanism. Failure of reception of hello message means the node is not in the range of communication. According to our proposed scheme, all nodes will listen some predefined time intervals say c to count the number of Hello packets.The size of each interval will be say d seconds. Getting more hello packets from the i th node for (i+1)th node means it will stay longer in transmission range of (i+1)th node. So, the node is stable for communication. After c intervals, (i+1)th node divides number of total received Hello packets by c. This value will be the node in range factor which will be a number between 0 and d. Nodes in MANET are highly unstable. So, this node in range factor will determine, which nodes to send RREQ so that unnecessary RREQ packet delivery will be reduced. As some RREQ packet is dropped, network congestion will be lower. The algorithm is given below.

```
1.Calculate node in range factor.
2.Generate a random number between 0 and d.
3.If (random_value > node in range factor)
4.then broadcast/forward RREQ_packet,
5.else  drop RREQ_packet.
```

B. Using Energy Based Parameter

Nodes in MANET rely on batteries. So, designing a routing protocol based on energy criteria can be an optimized solution for MANET. During route discovery process, every node decides either to forward RREQ packet or drop it. All nodes contain a certain energy. A new field will be added in the RREQ for calculating transmission energy. The format of the new RREQ will be

<source_address, dest_sequence_id, source_sequence_id, broadcast_id, dest_address, hop_count, transmission_energy>

After each transmission, nodes will lose some energy. A transmission loss value will be deducted after each transmission. Prior to forward a packet, each and every node calculates a drop factor. This factor is calculated by dividing the remaining energy and total energy. This **drop factor** is in the range 0 to 1. Every node also generates a random number. If generated random number is greater than calculated drop factor, then RREQ packet is forwarded. Otherwise this packet is dropped. When the velocity of node is increased, then number of redundant RREQ packet is increased. So, the goal of our algorithm is to decrease number of redundant RREQ packets as much as possible. As some RREQ packet is dropped, so network congestion will be lower and throughput will be higher in this protocol. The modified algorithm is given below.

```
1.Calculate  drop factor d for every transmitting node.
2.Generate a random number between 0 and 1.
3.If (random_value > drop factor)
4.then broadcast/forward RREQ_packet,
5.else  drop RREQ_packet.
```

V. Simulation

In this section, we have explained the topology, parameters used in our simulation and the performance metrics that were measured for our proposed schemes and traditional AODV protocol.

A. Simulation Topology

The topology of 10 nodes in our simulation is shown in Fig. 5.

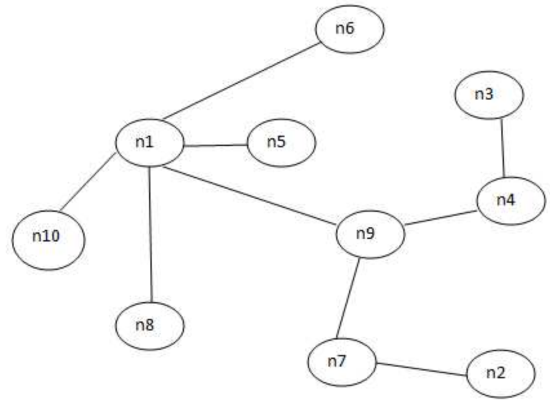


Fig. 5: Simulation topology.

B. Simulation parameters

For measurement of the performance of the proposed AODV protocol, we have used NS-2.35 [16] is used to simulate the idea with AODV protocol. We defined a scenario with $900m \times 400m$. Every node has an omnidirectional antenna and propagation model is used TwoRayGround. The average velocity of node is 20 m/s. We have used CBR (Constant Bit Rate) traffic at every node and UDP protocol in the transport layer. The simulation time is 200s. Table describes the parameters for 10 nodes of a scenario.

TABLE I: Simulation Parameters

Simulation Parameters	**Values**
Ns-2 Version	ns-2.35
Channel	WirelessChannel
Propagation	TwoRayGround
Model	Random Waypoint Model
Network Interface Type	Phy/WirelessPhy
Mac Type	Mac/802_11
Interface queue type	Queue/DropTail/PriQueue
link layer type	LL
Antenna Model	Antenna/OmniAntenna
Number of Nodes	10
Routing Protocol	AODV
Interface Queue Length	50
Simulation Time	200s

C. Performance Metrics

The energy-based solution is evaluated. The source-destination is selected randomly over the network. Each node starts from an arbitrary position and selects a destination. Simulation result is obtained by averaging several trial runs. Several performance metrics have been considered to evaluate the algorithm [17].

- *Packet Delivery Fraction (PDF)*: The rate of data packet conveyed to destination generated by CBR source.
- *Throughput*: The ratio of amount of packets successfully received by the nodes to the amount of packets sent by the nodes in a communication network.
- *Delay*: This includes all possible delays comprising re-transmission delay, route discovery latency, etc.

VI. Results

We have compared conventional AODV with the proposed modified AODV protocols in terms of packet delivery fraction, throughput and delay. We varied number of nodes and mobility rate while comparing tradional AODV with the proposed schemes.

A. Varying Mobility

It can be observed that the delay is reduced in the proposed modified protocol. When higher mobility is added, the protocol shows better performance. As speed of the node increases, RREQ packet is frequently generated, causing network congestion but the new protocol drops some additional redundant RREQ packets. Packet delivery fraction decreases as the amount of packets successfully reaching to destination decreases (if mobility rate is increased). Fig. 6 shows packet delivery fraction of the traditional AODV and the proposed schemes.

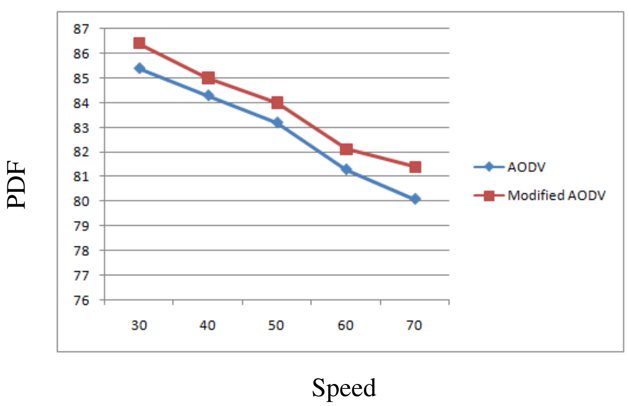


Fig. 6: Packet delivery ratio vs. speed.

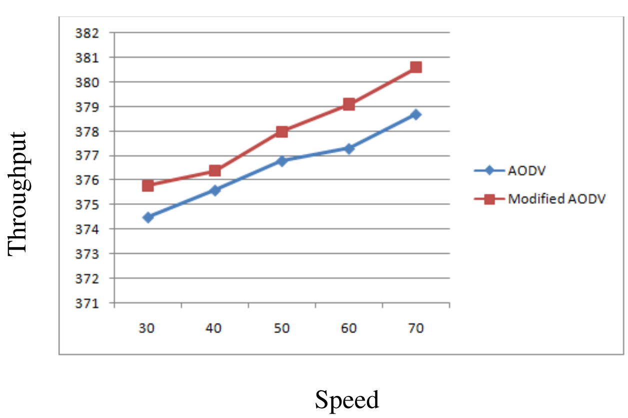


Fig. 7: Throughput vs. speed.

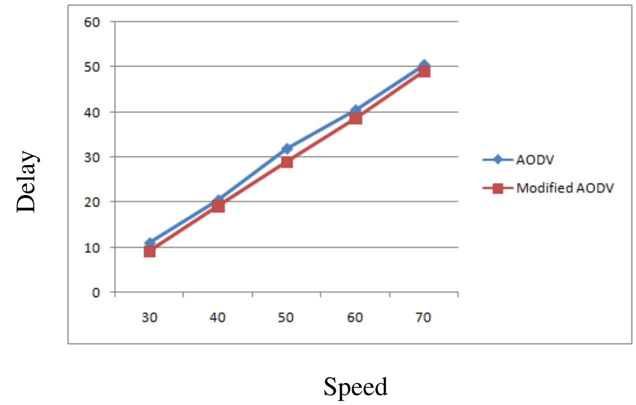


Fig. 8: Average end-to-end delay vs. speed.

Fig. 7 and Fig. 8 compare AODV and the proposed scheme in terms of throughput and delay, respectively. The modified protocol shows better performance with respect of these two performance metrics.

B. Varying Number of Nodes

Obviously, as number of node increases, delay also increases. The proposed scheme has higher packet delivery ratio than traditional AODV. We can see from Fig. 10 that as the network size grows, throughput declines.

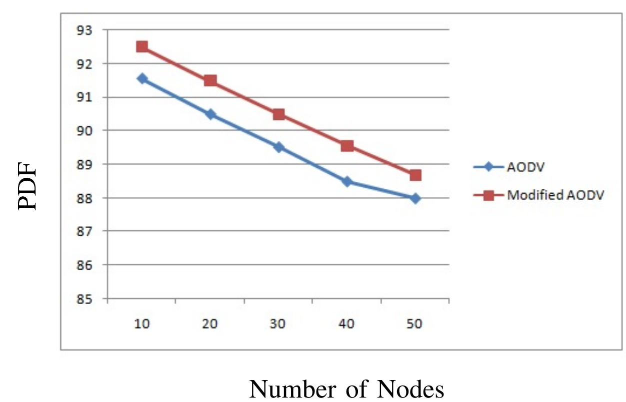


Fig. 9: Packet delivery ratio vs. number of nodes.

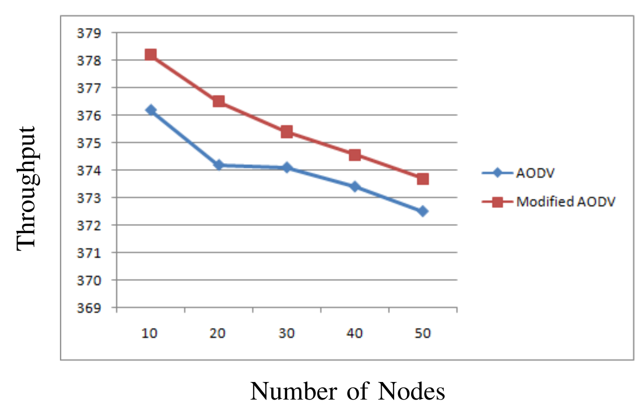
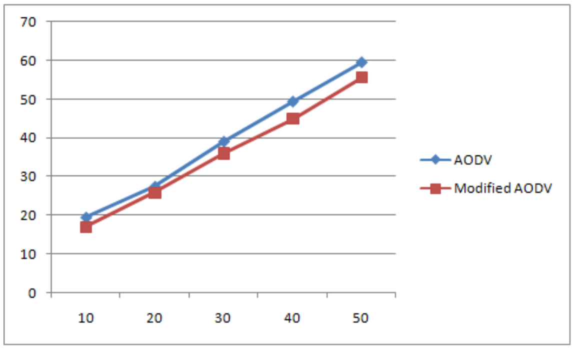


Fig. 10: Throughput vs. number of nodes

Delay



Number of Nodes

Fig. 11: Delay vs Number of Nodes

We can see that the modified energy based solution gives us better throughput than AODV since this protocol reduces network congestion and ensures successful message delivery by dropping redundant RREQ packets.

VII. Conclusion

In this paper, several new schemes for effective AODV routing protocol are proposed. But these solutions suffer from increasing network lifetime problem. We have simulated the energy based proposed scheme using ns-2.35 [16]. According to the simulation, our proposed scheme showed better performance than traditional AODV [15] in terms of throughput, average end-to-end delay and packet delivery fraction.

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