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Performance of AODV Protocol for H-MANETs

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ABSTRACT

As per need of recent applications, new research aspects related to scalability, heterogeneity, and power consumption have been arisen. These problems are supposed to be fixed for better utilization of MANETs. MANET nodes interact through multi-hop routing. AODV is a commonly used on-demand protocol for routing in MANETs. In the existing literature, AODV has been analyzed a number of times but heterogeneity of the nodes has not been addressed. Heterogeneity may be defined as diversity among the nodes in resources or capability. The environment is usually heterogeneous in case of constraint fluid dynamic environment of MANET. In this paper we are analyzing the routing performance as well as energy efficient behavior of AODV routing protocol in both homogeneous and heterogeneous MANETs (H-MANETs), using performance parameters like ratio of delivered packets, throughput, average delay, average power consumption, energy of alive nodes, etc. Heterogeneity has been introduced in terms of different initial energy for all the nodes, unlike the homogeneous scenario. The simulation work has been done using network simulator (NS-2). This work will be helpful to get insight of effects of heterogeneity on energy efficiency and other performance metrics of AODV.

Keywords : MANET, H-MANET, Routing, AODV, Heterogeneity, Energy

I. INTRODUCTION

Mobile Ad-hoc Network (MANET) [1] consists of wireless mobile nodes that dynamically organize themselves in random network structures. There is no pre-installed infrastructure, which can facilitate the forwarding of packets from one host to another. In MANETs, the forwarding of packets has to be taken care by mobile nodes, alive in the network. Therefore, each of the member nodes operates as a host as well as a router.

Routing in mobile ad-hoc networks [2, 3] is characterized as multi-hop routing, because multiple nodes participate in the routing process due to limited propagation range of wireless nodes. The main objective of a MANET routing protocol is to setup an efficient route between the nodes in order to deliver the messages in a timely manner. Since nodes in the network do not have a prior knowledge of topology, so they have to discover it. Moreover, the nodes tend to move freely and randomly, routes often get disconnected even after discovery. So it is the routing protocol which controls the discovery and maintenance of the routes between computing devices in a

MANET. The basic idea of a routing protocol is that a new node would announce its presence and it would listen and response to announcements made by its neighbors.

Three types of routing protocols [3, 4] are there in MANETs: Proactive, Reactive and Hybrid Routing Protocols. Proactive (table-driven) protocols [3, 4] are proactive in nature, as the routing information is maintained, regardless of its need. Each and every node in the network maintains routing information about every other node in the network. Proactive routing protocols are not suitable for the large network scenarios, since a lot of information is needed to be maintained. DSDV, CGSR, WRP, OLSR, FSR, are some of the examples.

Reactive (On Demand) protocols [3, 4] don't maintain routing information, if there is no communication on a route. If a node wants to communicate with another node then on-demand protocols search for the route and then establish the connection in order to communicate. AODV [2], DSR, TORA, ABR are few example of on- demand protocols. Hybrid routing protocols [3, 4, 6] have the characteristics of both proactive and reactive routing protocols. ZRP, SHARP, ZHLS, DST are the examples of hybrid routing protocols.

In this paper, the performance of one of the very well accepted on demand routing protocols i.e. AODV is evaluated over the performance metrics like throughput, end to end delay, packet delivery ratio and energy related metrics with varying network size.The objective is to observe the behavior of AODV routing protocol for both homogeneous and heterogeneous network environments, which would be subsequently helpful in real life applications having heterogeneity of nodes.

The paper is organized in several sections. Section II describes the working of AODV protocol followed by an overview of the challenges posed by heterogeneity in MANETs in Section III. Different parameters of simulation work are mentioned in Section IV. The simulation results are shown in Section V. Section VI represents the concluding remarks.

II. AODV ROUTING PROTOCOL

AODV is a reactive, distributed and deterministic routing protocol. The routes are only setup when needed. AODV [2] was proposed with the objective to minimize the broadcasts by on demand routing. AODV supports unicast, multicast and broadcast communication. It reduces the problem of loops in routing, as it uses the concept of packet sequence numbering. The link breakages, if occurred, can be repaired locally. AODV can support the large number of nodes in a network scenario. The protocol has the provision for the nodes to join or leave the network arbitrarily. A route is used only when packets travel from the source to the destination along that path.

Working of AODV:

Route discovery is done only when a source node does not have a valid path to a destination, where the message has to be sent. AODV [2] uses three kinds of messages during entire routing process viz. RREQ, RREP and RERR. If a node does not have a route to destination then it forwards RREQ to the neighbor node(s) adding its own address to the packet. A node produces a RREP iff it is itself the destination or it has a route to the destination. The RREP is sent back to the source along the path already established by the RREQ. For this, AODV supports the use of symmetric links only. After receiving RREP, the source records the route and now it can start sending data to the destination. In case of multiple RREPs, source node selects the shortest route.

The Route Maintenance takes place, if any node moves or depleted its energy. Route discovery is re-initiated if the source node moves. In case of intermediate node movement, the upstream neighbor propagates link failure message to all active upstream neighbors. Upstream nodes in turn forward the message to their upstream neighbors, until the source node is reached. Then route discovery is re-initiated.

Periodic hello messages are also used to maintain the connectivity of a node.

III. HETEROGENEITY IN MANETS

Wireless ad hoc networks are now being used in numerous applications like infrastructure monitoring or providing connectivity to remote locations. Effective communication is the need of the hour. It is assumed usually that the mobile devices present in the network are capability wise homogeneous. However, the nodes can be heterogeneous in real application scenarios [5, 6, 9]. The devices may differ in their communicational aspects, such as initial energy, power consumption in transmission, type of antenna, etc. [14]. Few challenges are imposed in the network due to heterogeneity of the nodes [6, 7, 9], like need for proper device classification, device identification and addressing. Some other major issues such as mobility patterns, energy constraints, traffic handling, QoS, security and node cooperation are needed to be addressed.

In this work, the mobile nodes have been provided with randomly distributed initial energy in order to imitate heterogeneity. This would help to understand the impact of energy constrained heterogeneous environment on the behavior of on-demand routing.

IV. IV. SIMULATION METHODOLOGY

To compute and compare the AODV routing protocol performance in homogeneous and heterogeneous environments, we are using different conventions - AODV

(for homogeneous network scenario) and AODV_H (for heterogeneous network scenario). The performance evaluation has been done considering varying number of nodes. In homogeneous network scenario the initial energy of each node has been given a fixed value. In heterogeneous network scenario, different initial energy values have been given to different nodes.

The simulation based analysis has been done using Network Simulator (ns-2.34) [15]. NS-2 simulation environment is an open source framework with rich built-in library and can be extensively used for network related studies. For NS-2 simulation, we need to input topology configuration, traffic information. The traces produced as simulation output are analyzed for computing different parameters and to plot the results in form of graphs. In this paper, an inbuilt Wave LAN energy model is used for generating traces with energy values [12, 13]. The different parameters for simulation are given in Table I:

TABLE I. SIMULATION PARAMETERS

Parameters	**Values**
Area	1000 x 1000 m^2
Time of simulation	500 Sec
Protocol	AODV
Mobility Model	Random Waypoint
MAC	IEEE 802.11
Network size	10, 15, 20, 25, 30, 35, 40, 45 nodes
Pause time	100sec
Traffic	CBR
Number of Connections	50% of the network size
Initial Energy	100 Joules (for Homogeneous Nodes) 50 to 90 Joules (for Heterogeneous Nodes)
Data Rate	2 Mbps

It is worth noticeable that several simulations have been executed and results are drawn. In the next section, we are presenting the obtained results in graphical form.

V. RESULT ANALYSIS

The performance evaluation has been done using different metrics like Packet delivery ratio, end to end delay, throughput, energy consumed by alive nodes, average energy etc. The results are shown in Fig. 1-7

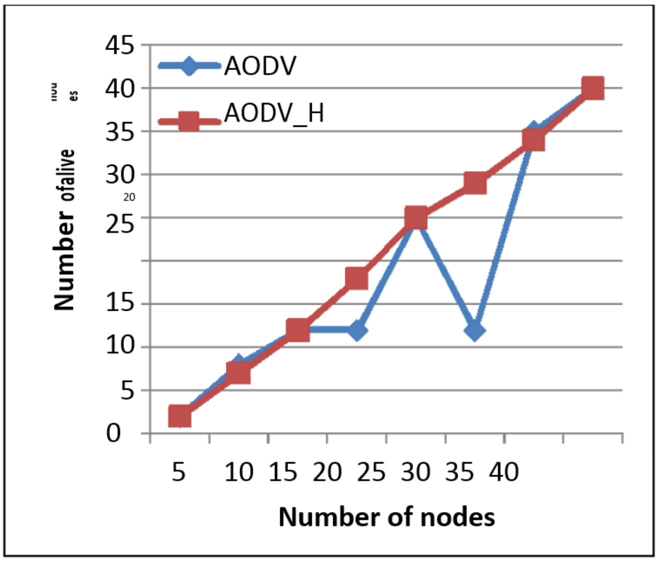

Fig. 1. Nodes versus No. of Alive Nodes

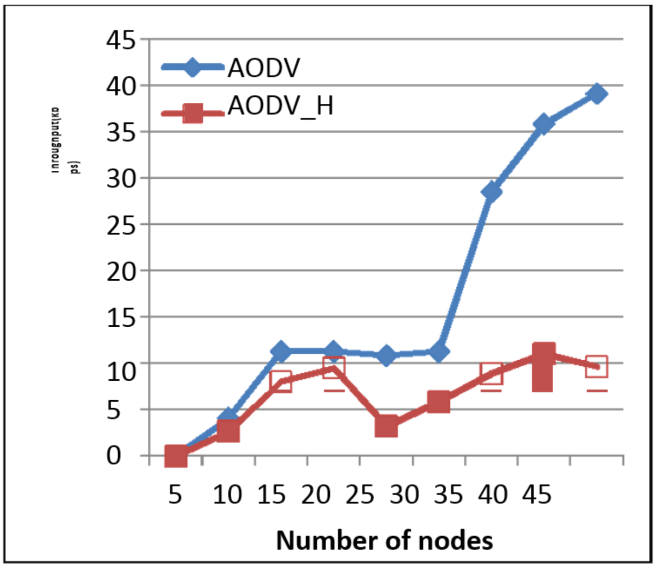

Fig. 2. Nodes versus Throughput

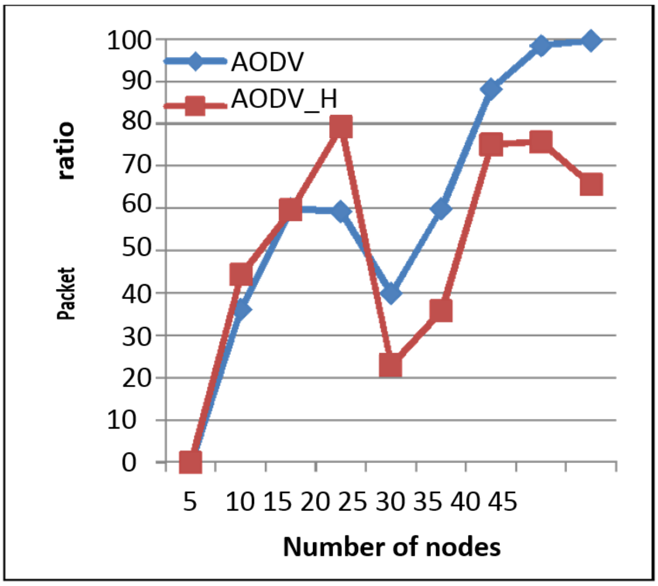

Fig. 3. Nodes versus Packet Delivery Ratio

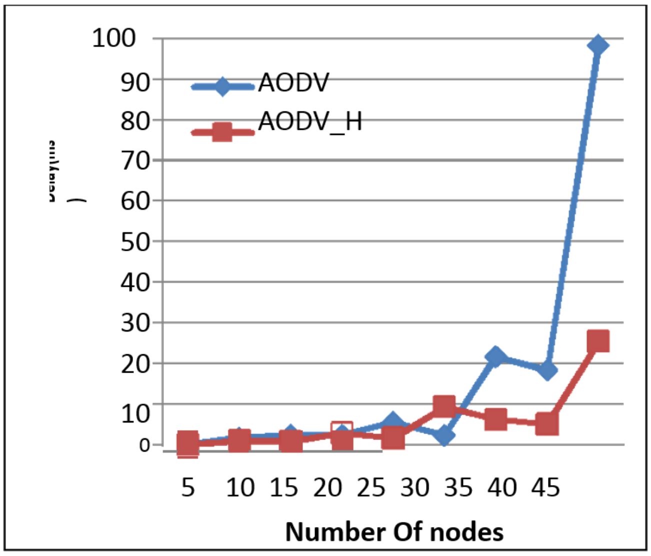

Fig. 4. Nodes versus Packet Delay

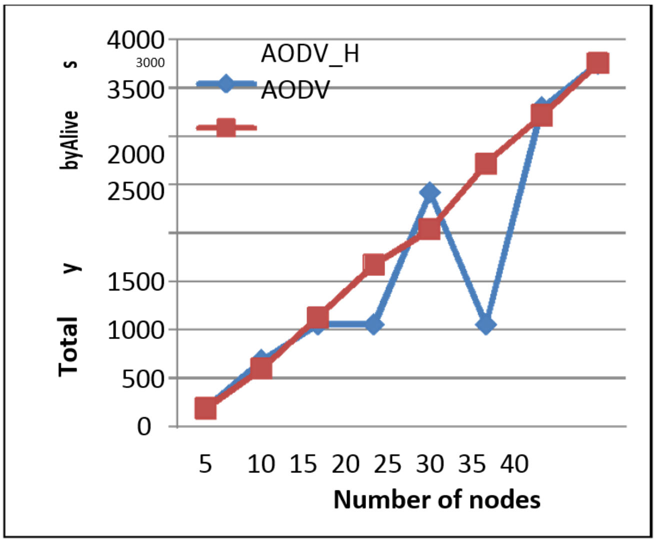

Fig. 5. Nodes versus Energy of Alive Nodes

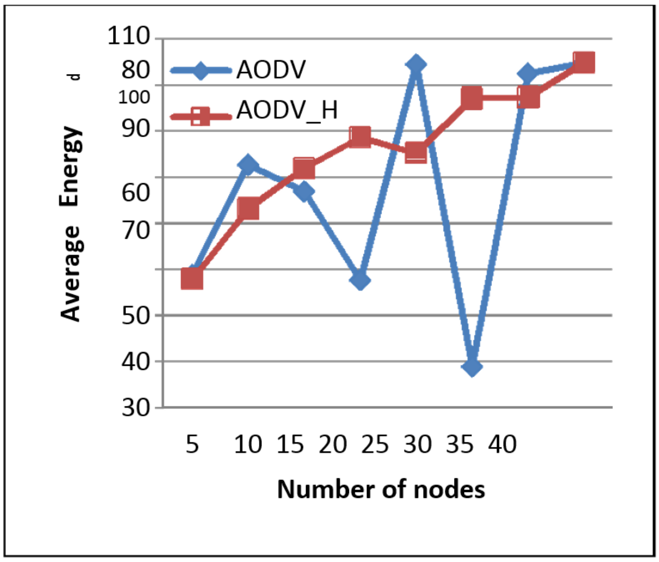

Fig. 6. Nodes versus Average Energy Consumed

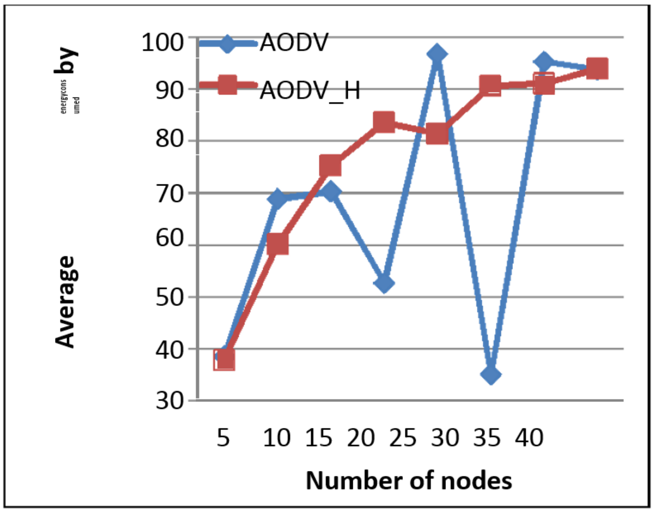

Fig. 7. Nodes versus Average Energy Consumed by Alive Nodes

VI. Result Analysis

As the number of nodes gets increased in the network, the average end to end delay remains range bound in case of heterogeneous network, but in case of homogeneous nodes, the delay increases abruptly, as the number of nodes increase after a certain limit. The value of throughput and PDR for AODV in homogeneous environment is better in comparison to heterogeneous environment. Average energy consumption is also increasing with the increase in number of nodes for heterogeneous network environment. But in case of AODV (homogeneous), the average energy consumption is not range bound. Total energy consumption of alive nodes is greater in case of heterogeneous network.

VII. CONCLUSION

In this work, the behavior of AODV for both homogeneous and heterogeneous network scenarios, with respect to varying network size from 10 nodes to 45 nodes network was analyzed. The results clearly indicate the difference between the two environments. Routing simulations discussed in the literature so far like [8, 10-13], have not considered heterogeneity of the nodes in a mobile ad-hoc network. In view of real applications, simulation studies of networks having heterogeneous nodes are essential. This work will motivate researchers to analyze more aspects of heterogeneous MANETs. The results indicate that the performance of AODV varies with the variation in node configuration and the network size. The relative performance also depends on the mobility and traffic conditions.

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