Performance Analysis of AODV and AOMDV Routing Protocols on Scalability for MANETs

B. Rekha and D. V. Ashoka

Abstract In the world of computer networks, routing protocols of mobile ad hoc networks (MANETs) draw an increasing attention. One of the challenging components of routing in MANETs is accomplishing scalability which defines the performance ability of a routing protocol when one or more network parameters grow in value. In this chapter, two reactive routing protocols—Ad hoc On-demand Distance Vector (AODV) and Ad hoc On-demand Multipath Distance Vector (AOMDV) are chosen to show their performance on scalability by changing number of nodes. Also their comparative analysis is performed through simulation using ns-2 on different metrics like end-to-end delay, throughput, packet delivery fraction (PDF). Results show that AOMDV performs better to AODV when the number of nodes is increased.

Keywords MANET · AODV · AOMDV · Scalability · Performance evaluation · Delay · Throughput · PDF

1 Introduction

MANET is characterized by self-configuring, decentralized, high dynamic topology and easily broken without any infrastructural components. Each node acts both as a host and as a router. MANET is represented by distributed system with wireless mobile nodes which move freely and self-organize forming ad hoc

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V. Sridhar et al. (eds.), *Emerging Research in Electronics, Computer Science and Technology*, Lecture Notes in Electrical Engineering 248,
DOI: 10.1007/978-81-322-1157-0_19,

network topologies without pre-existing infrastructure. So each node acts both as a host and as a router. Traditionally, we find MANET applications in tactical networks, but now technologies like IEEE 802.11, Hyperlan, and Bluetooth enable commercial deployments apart from military domain. Today, we see a revolutionary change in our information society by the use of wireless communication devices such as laptops, cell phones, personal digital assistants (PDAs). Due to mobility of nodes, routing is one of the key challenges faced by researchers. In this chapter, an attempt has been made to analyze protocols performance on scalability by varying number of nodes as large-scale ad-hoc networks find applications in consumer owned networks, tactical military networks, natural disaster recovery services and vehicular networks [1].

2 Overview of MANET Routing Protocols

Based on how routing information is acquired and maintained by mobile nodes, existing MANET routing protocols are classified into three categories: proactive (table driven), reactive (on demand), and hybrid.

2.1 Proactive Routing Protocols

Proactive protocols create the routes (shortest path) periodically upon changes in topology and maintain it in their routing tables. Hence, route to a particular node is available at any moment. They maintain fresh lists of destinations and their routes by periodically distributing routing tables throughout the network. But drawbacks increased control overhead upon frequent changes in topology due to mobility of nodes, respective amount of data for maintenance, and slow reaction on restructuring and failures. Few examples in this category are Wireless Routing Protocol (WRP), Destination-Sequenced Distance Vector (DSDV) Routing Protocol, Fisheye State Routing (FSR) Protocol, and Optimized Link-State Routing (OLSR) Protocol.

2.2 Reactive Routing Protocols

Reactive protocols create the routes by discovery mechanism on requirement basis. These protocols find a route on demand by flooding the network with route request packets. After finding the route to any destination node, it is maintained until it is no longer required or destination node is unavailable. The distinct advantage is less control overhead and thus better scalability compared to proactive ones. However, source nodes experience delay in route discovery process before they send data packets, that is, high latency time in route finding, and excessive flooding can lead to network clogging. Examples include Dynamic Source Routing (DSR), AODV, AOMDV, Temporally Ordered Routing Algorithm (TORA), Dynamic MANET On-demand Routing Protocol (DYMO) are few examples of on-demand routing protocols.

2.3 Hybrid Routing Protocols

Hybrid protocols combine the advantages of proactive and of reactive routing. The routing is initially established with some proactively prospected routes and then serves the demand from additionally activated nodes through reactive flooding. Examples of hybrid algorithms include Zone Routing Protocol (ZRP), Hybrid Wireless Mesh Protocol (HWMP), Hybrid Routing Protocol for Large Scale (HRPLS) Mobile Ad Hoc Networks with Mobile backbones, etc.

3 Related Work

AODV and AOMDV in [2] and [3] are compared and found that AOMDV incurs more routing overhead and delay than AODV, but it has a better efficiency in packet drop and delivery. However, maximum connections considered are 50. Comparative analysis [4] is also given for AODV and AOMDV. Authors have chosen mean link failure rate as a function of mean node speed. They have proved that AOMDV can cope with mobility-induced route failures, reducing packet loss by 40 percent with improved delay and reduced overhead. Authors in [3, 5–8] have chosen various pause times to analyze the performance of routing protocols. However, the number of nodes is varied in the range 50–100. Comparison of these two protocols in heterogeneous hybrid cluster routing is done in [7] to show the increased performance in terms of throughput. They have concluded that AOMDV gives a better performance. However, they have chosen 50 nodes for simulation.

Since nodes keep moving with different speed in MANETs, main challenge is to route packets with low overhead and achieve high throughput and low packet loss. In this chapter, an attempt has been made to check the performance of selected two protocols in terms of scalability of the MANET along with performance metrics such as packet delivery fraction, throughput, and average end-to-end delay.

4 Overview of AODV

AODV is a single-path, reactive, loop-free distance vector routing protocol. It is capable of both unicast and multicast routing which uses route discovery approach of DSR and DSDV. A source node to find the destination initiates route discovery by flooding route request (RREQ) packets and waits for route reply (RREP) packet from destination node. Upon receiving the first copy of RREQ packet, intermediate nodes set up a reverse path to the source node by using previous hop of the RREQ as the next hop of the reverse path. If an intermediate node knows the path to the destination node, it unicasts RREP to the source node along the reverse path. Thus, AODV uses hop-by-hop routing approach. Sequence numbers are used to ensure loop freedom in AODV. Each node will have a monotonically increasing number for itself in its routing table. Whenever a node sends out any message, it increases its own sequence number [9]. The highest sequence number is maintained for each destination by each node which signifies a fresher route [9]. It determines the freshness of routing information. The node with higher sequence number has more recent information. Route error (RERR) packets are used by MANET nodes to maintain the routes. If any intermediate node detects a failure over any of its links, it invalidates all destinations which are unreachable. Then, it generates RERR packets which are propagated toward the traffic sources having a route through failed link. The source after receiving RERR initiates a new route discovery process. Figure 1 outlines the routing of AODV.

4.1 Advantages and Disadvantages

The main advantage of AODV protocol is the routes that are established on demand, and destination sequence numbers are applied to find the latest route to the destination. The connection setup delay is lower. Disadvantage of AODV protocol is that intermediate nodes can lead to inconsistent routes if the source sequence number is very old and the intermediate nodes have a higher but not the latest destination sequence number, thereby having stale entries. Also, multiple route reply packets in response to a single route request packet can lead to heavy control overhead. Another disadvantage of AODV is unnecessary bandwidth consumption due to periodic beaconing.

5 Overview of AOMDV

AOMDV [4] a reactive routing protocol, is an extension to AODV protocol. It computes multiple loop-free and disjoint paths. The routing entries for each

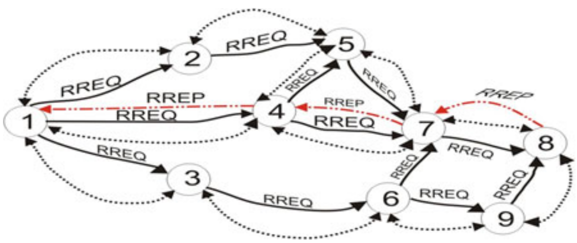

Fig. 1 Route request packets flooding from node 1 to node 8 and path establishment through route reply packets

destination contain a list of the next hops along with the corresponding hop counts, where all the next hops have the same sequence number. This helps to keep track of a route [4]. For each destination, a node maintains the advertised hop count which is the maximum hop count for all the paths. It is used to send route advertisements of the destination. The duplicate advertisement defines an alternate path to the destination. Loop freedom is ensured for a node by accepting alternate paths to destination if it has a less hop count than the advertised hop count for that destination. The advertised hop count is not changed for the same sequence number as the maximum hop count is used. When a route advertisement is received for a destination with a greater sequence number, the next hop list and the advertised hop count are reinitialized [4]. AOMDV can be used to find node-disjoint or link-disjoint routes. To find node-disjoint routes, each node does not immediately reject duplicate RREQs. Each RREQ arriving via a different neighbor of the source defines a node-disjoint path. This is because nodes cannot broadcast duplicate RREQs. So any two RREQs arriving at an intermediate node via a different neighbor of the source could not have traversed the same node. In an attempt to get multiple link-disjoint routes, the destination only replies to RREQs arriving via unique neighbors. After the first hop, the RREPs follow the reverse paths, which are node disjoint and thus link disjoint. The advantage of using AOMDV is that it ensures loop-free multiple and disjoint paths [4].

6 Simulation Environment

The simulations have been performed using network simulator ns-2 [10]. The network simulator ns-2 is discrete-event simulation software. A network of nodes placed within a 11,000 × 11,000 m area is considered. The performance is evaluated by keeping the network speed and pause time constant and varying the network size (number of mobile nodes). Figure 2 shows the network with 1,000 mobile nodes in the NAM console which is a built-in program in ns-2-allinone package.

Table 1 shows the simulation parameters used in this evaluation.

Performance Metrics

While analyzing, packet delivery fraction (PDF), average end-to-end delay, and throughput are the performance metrics which are considered in simulation.

Packet Delivery Fraction

It is a ratio of the number of packets received by the destination to the number of packets send by the source, and this illustrates the level of delivered data to the destination. The greater value of packet delivery fraction means better performance of the protocol.

PDF = Σ No. of packet received/Σ No. of packet sent

Average end-to-end delay

It is defined as average time taken by data packets to propagate from source to destination across the network. This includes all possible delays caused by

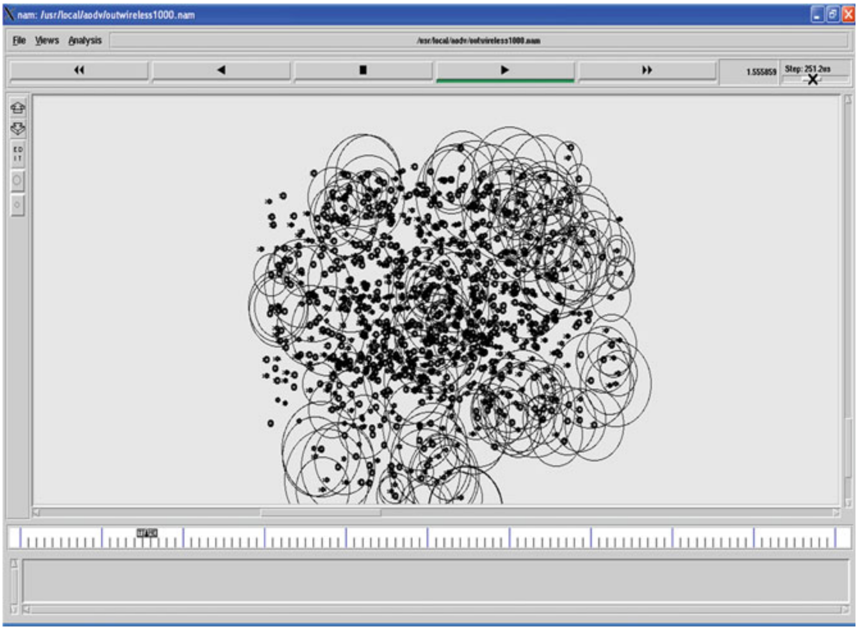

Fig. 2 MANET with 1,000 nodes

Table 1 Parameter values for simulation

Simulator	Ns-2.35
Protocols	AODV and AOMDV
Simulation duration	20 s
Simulation area	11,000 × 11,000 m
Number of nodes	500, 600, 700, 800, 900, 1,000
Movement model	Random waypoint
MAC layer protocol	IEEE 802.11
Link type	Duplex link
Queue size	50
Pause time	5 s
Packet size	1,500 bytes/packet
Application type	FTP
Agent type	TCP

buffering during routing discovery latency, queuing at the interface queue, and retransmission delays at the MAC, propagation, and transfer times; the lower value of end-to-end delay means the better performance of the protocol.

End-to-end delay = Σ (arrive time—send time)

Throughput

Throughput is the average number of messages successfully delivered per unit time, that is, average number of bits delivered per second.

Throughput = Σ Total number of received packets at destination/time taken

7 Simulation Results and Analysis

From Fig. 3, it is noted that AOMDV incurs more delay than AODV due to the fact that on link failure in AOMDV, it tries to find the alternate path from backup route which results in additional delay.

Throughput is better in AOMDV than in AODV as it is shown in Fig. 4, except at one point which is because AODV is single-path protocol. On link failure in , packets are not delivered to the destination. Since AOMDV is multipath routing protocol, it finds an alternate path and delivers the packets.

AOMDV has better PDF than *AODV* on increasing number of nodes. This is because AOMDV finds different path on link break which is seen in Fig. 5.

8 Conclusion

AODV and AOMDV routing protocols are evaluated by increasing number of nodes in the range 500–1,000 using ns-2. Comparison is based on end-to-end delay, throughput, and packet delivery fraction. By comparative study of simulation, it is found that AOMDV is preferred to AODV when throughput and PDF are concerned as it has got better throughput and PDF. But AOMDV incurs more delay when compared to AODV. Hence, when delay is concerned, AODV is

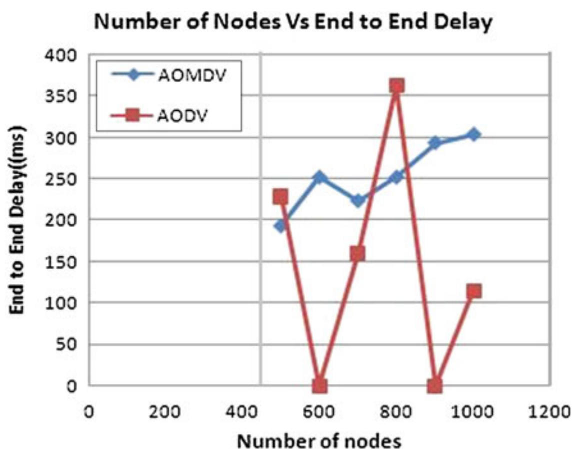

Fig. 3 End-to-end delay

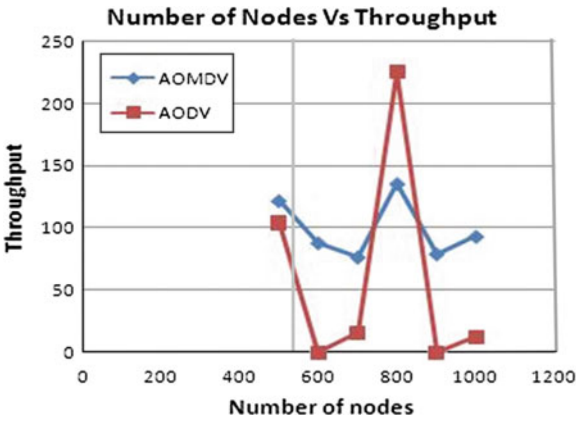

Fig. 4 Throughput

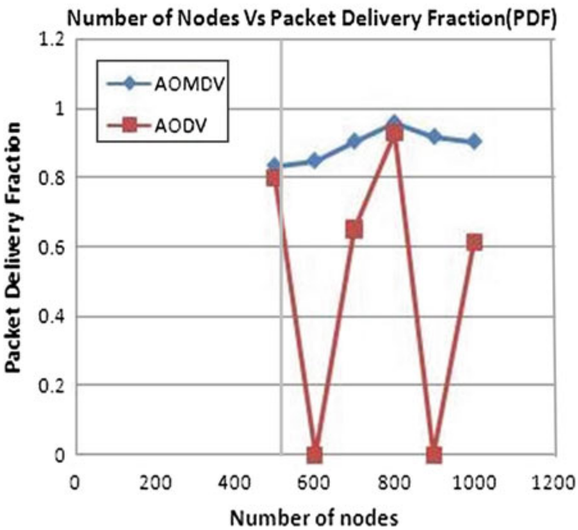

Fig. 5 Packet delivery fraction

preferred, but still in the above all cases, it can also be observed that values of AODV are inconsistent.

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