Performance Evaluation and Comparison of AODV and AOMDV

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Abstract:

A Mobile Ad-hoc Network (MANET) is a dynamic wireless network that can be formed without the need for any pre-existing infrastructure in which each node can act as a router. One of the main challenges of MANET is the design of robust routing algorithms that adapt to the frequent and randomly changing network topology. A variety of routing protocols have been proposed and several of them have been extensively simulated or implemented as well. In this paper, we compare and evaluate the performance of two types of On-demand routing protocols- Ad-hoc On-demand Distance Vector (AODV) routing protocol, which is unipath and Ad-hoc On-demand Multipath Distance Vector (AOMDV) routing protocol. In this paper we note that on comparing the performance of AODV and AOMDV, AOMDV incurs more routing overhead and packet delay than AODV but it had a better efficiency when it comes to number of packets dropped and packet delivery.

Keywords: Ad-hoc networks; routing protocols; Simulation; Performance evaluation

1. Introduction

A mobile ad-hoc network or MANET is a collection of mobile nodes sharing a wireless channel without any centralized control or established communication backbone. They have no fixed routers with all nodes capable of movement and arbitrarily dynamic. These nodes can act as both end systems and routers at the same time. When acting as routers, they discover and maintain routes to other nodes in the network. The topology of the ad-hoc network depends on the transmission power of the nodes and the location of the mobile nodes, which may change from time to time [1].

One of the main problems in ad-hoc networking is the efficient delivery of data packets to the mobile nodes where the topology is not pre-determined nor does the network have centralized control. Hence, due to the frequently changing topology, routing in ad-hoc networks can be viewed as a challenge.

In table-driven or proactive routing protocols, consistent and up-to-date routing information of the network topology of all nodes is maintained at each node with respect to the time. Routes are built from each node to every other node before they are needed. Any changes occurring in topology is broadcasted through the network, notifying all the nodes of the changes. Proactive protocols hence maintain routing information about the available paths in the network even if these paths are not currently used. The major drawback of these approaches is that the maintenance of unused paths may occupy an important part of the available bandwidth if the topology changes frequently [1].

In on-demand or reactive routing protocols, the routes are created on requirement basis. To find a path from source to destination, it invokes the route discovery mechanisms. Only the routes that are currently in use are maintained, thereby maintaining low control overhead and reducing the network load since a small subset of all available routes is in use at any time. Reactive routing protocols have some inherent limitations. First, since routes are only maintained while in use, it is usually required to perform a route discovery before packets can be exchanged between communication peers. This leads to a delay for the first packet to be transmitted. Second, even though route maintenance for reactive algorithms is restricted to the routes currently in use, it may still generate an important amount of network traffic when the topology of the network changes frequently. Finally, packets to the destination are likely to be lost if the route to the destination changes [1].

The main challenge of MANETs is to route with low overheads even when conditions are dynamic. Overhead here is defined in terms of routing protocol control messages which consume both channel bandwidth as well as the battery power of nodes for communication/processing. Several studies on performance comparisons [4, 5] have shown that on-demand protocols achieve lower routing overheads in comparison to proactive protocols and position-based routing protocols are even lower than on-demand reactive routing.

Existing routing protocols in ad-hoc networks utilize the single route that is built for source and destination node pair. Due to node mobility, node failures and the dynamic characteristics of the radio channel, links in a route may become temporarily unavailable, making the route invalid [1]. The overhead of finding alternative routes mounts along with additional packet delivery delay. This problem can be solved by use of multiple paths between source and destination node pairs, where one route can be used as the primary route and the rest as backup. Performance can be adversely affected by high route discovery latency and frequent route discovery in dynamic networks. This can be reduced by computing multiple paths in a single route discovery attempt. Multiple paths can be formed for both traffic sources and intermediate nodes with new routes being discovered only when needed, reducing route discovery latency and routing overheads. Multiple paths can also balance network load by forwarding data packets on multiple paths at the same time.

In our paper, we concentrate on two on-demand routing protocols: AODV and AOMDV.

2. Background

On-Demand routing protocols work on the principle of creating routes as and when required between a source and destination node pair in a network topology. Our discussion is limited to two on-demand ad-hoc routing protocols, AODV and AOMDV, as follows.

2.1 Ad-hoc On-Demand Distance Vector Routing (AODV)

AODV is a reactive protocol that discovers routes on an as needed basis using a route discovery mechanism. It uses traditional routing tables with one entry per destination. Without using source routing, AODV relies on its routing table entries to propagate an RREP (Route Reply) back to the source and also to route data packets to the destination. AODV uses sequence numbers maintained at each destination to determine freshness of routing information and to prevent routing loops [1]. All routing packets carry these sequence numbers.

AODV maintains timer-based states in each node, for utilization of individual routing table entries, whereby older unused entries are removed from the table. Predecessor node sets are maintained for each routing table entry, indicating the neighboring nodes sets which use that entry to route packets. These nodes are notified with RERR (Route Error) packets when the next-hop link breaks. This packet gets forwarded by each predecessor node to its predecessors, effectively erasing all routes using the broken link. Route error propagation in AODV can be visualized conceptually as a tree whose root is the node at the point of failure and all sources using the failed link as the leaves [1]. The advantages of AODV are that less memory space is required as information of only active routes are maintained, in turn increasing the performance, while the disadvantage is that this protocol is not scalable and in large networks it does not perform well and does not support asymmetric links.

2.2 Ad-hoc On-demand Multipath Distance Vector Routing (AOMDV)

Ad-hoc On-demand Multipath Distance Vector Routing (AOMDV) [9] protocol is an extension to the AODV protocol for computing multiple loop-free and link-disjoint paths [1]. The routing entries for each destination contain a list of the next-hops along with the corresponding hop counts. All the next hops have the same sequence number. This helps in keeping track of a route. For each destination, a node maintains the advertised hop count, which is defined as the maximum hop count for all the paths, which is used for sending route advertisements of the destination. Each duplicate route advertisement received by a node defines an alternate path to the destination. Loop freedom is assured for a node by accepting alternate paths to destination if it has a less hop count than the advertised hop count for that destination. Because the maximum hop count is used, the advertised hop count therefore does not change for the same sequence number [1]. 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.

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 RREQs arriving via a different neighbor of the source defines a node-disjoint path. This is because nodes cannot be 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 replies to duplicate RREQs, 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 trajectories of each RREP may intersect at an intermediate node, but each takes a different reverse path to the source to ensure link-disjointness [1]. The advantage of using AOMDV is that it allows intermediate nodes to reply to RREQs, while still selecting disjoint paths. But, AOMDV has more message overheads during route discovery due to increased flooding and since it is a multipath routing protocol, the destination replies to the multiple RREQs those results are in longer overhead.

3. Performance Evaluation

Implementation of wireless ad-hoc networks in the real world is quite hard. Hence, the preferred alternative is to use some simulation software which can mimic real-life scenarios. Though it is difficult to reproduce all the real-life factors such as humidity, wind and human behavior in the scenarios generated, most of the characteristics can be programmed into the scenario.

3.1 Methodology

To compare two on-demand ad-hoc routing protocol, it is best to use identical simulation environments for their performance evaluation.

3.1.1 Simulation Environment:

We make use of ns-2.34 which has support for simulating a multi-hop wireless ad-hoc environment completed with physical, data link, and medium access control (MAC) layer models on ns-2.

The protocols maintain a send buffer of 64 packets. It contains all data packets waiting for a route, such as packets for which route discovery has started, but no reply has arrived yet. To prevent indefinite buffering of packets, packets waiting in the buffer for more than 30s are dropped. All packets sent by the routing layer are queued at the interface queue till the MAC layer transmits them. The maximum size for interface priority queue is 50 packets and it maintains it with two priorities, each served in FIFO order. Routing packets get higher priority than data packets.

Our evaluations are based on the simulation of 50 wireless nodes forming an ad hoc network, moving about over a square (1000m x 1000m) flat space for 1000s of simulated time. A square space is chosen to allow free movement of nodes with equal density. To enable fair and direct comparisons between the routing protocols, identical loads and environmental conditions had to be maintained. Each simulator run accepts an input *scenario file* describing the motion of mobile nodes and also the sequence of packets originated by the mobile node, along with time of change in motion or packet origination pattern.

3.1.2 Movement Model:

In the simulation, node movement is due to *random waypoint model*. The scenario files used for each simulation are characterized by different *pause times*. Each mobile node begins the simulation by remaining stationary for the pause time duration. On expiry of pause time, the node chooses a random destination in the 500m x 500m simulation space and moves there at a uniform speed. Upon reaching the destination, the mobile node pauses again, selects another destination and proceeds there. This behavior is repeated for the entire duration of the simulation. We ran the simulation with movement patterns generated for 7 different pause times: 0, 50, 100, 250, 500 and 1000s. A pause time of 0 seconds correspond to continuous motion and a pause time of 1000s (the length of the simulation) corresponds to no motion.

3.1.3 Communication Model:

We choose the traffic sources to be *constant bit rate* (CBR) source. The source and destination pairs were spread randomly over the network. Only 512-byte data packets were used. Varying the number of CBR traffic sources was approximately equivalent to varying the sending rate. Hence, for these simulations we choose to fix sending rate at 8 packets per second, and used 5 different communication patterns corresponding to 1, 5, 10 and 20 connections.

3.2 Performance Evaluation Metrics

We compare the performance of AODV and AOMDV according to the following performance metrics [1]:

Packet delivery fraction: the ratio of data packets delivered to the destinations to those generated by the constant bit rate.

Average End-to-End delay of data packets: this includes all possible delays caused by buffering during route discovery, queuing at the interface queue, retransmission delays at the MAC, propagation and transfer times.

Routing Overhead: the total number of routing packets transmitted during the simulation. For packets sent over multiple hops, each transmission of the packet (each hop) counts as one transmission

4. **Simulation Results**

We ran the simulation environments for 500sec for seven scenarios with pause times varying from 0 to 500 s and also maximum connections varying in between 0 and 50 connections. Packet delivery fraction, routing overhead, average end-to-end delay and number of packets dropped are calculated for AODV and AOMDV. The results are summarized below with their corresponding graphs.

4.1 Packet Delivery Fraction (PDF)

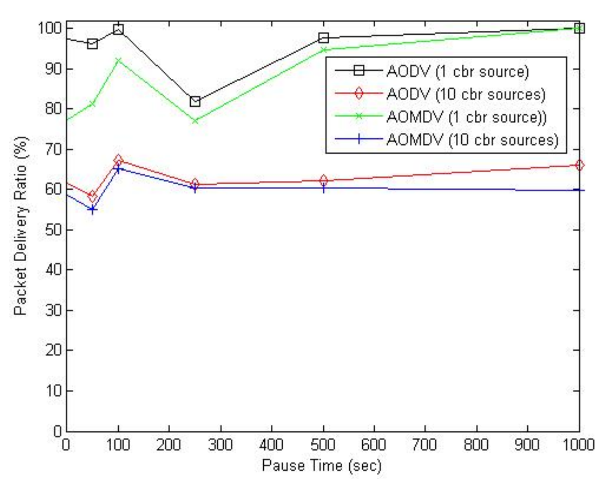

Figure 1: Comparison of AODV and AOMDV on basis of PDF

We note that AOMDV has a better PDF value when compared to AODV for each set of connections. This is because in the time waited at a node, AOMDV can find an alternate route if the current link has broken whereas AODV is rendered useless at that point. For example we note, that for AODV (fig 1 a), the performance degrades at 50 s of pause time while AOMDV (fig 1 b), waits till 100s.

4.2 *Average End-to-End delay of data packets*

AOMDV has an average delay of 194ms to AODV's average delay of 175ms. We note that AODV has a better average delay than AOMDV due to the fact if a link break occurs in the current topology, AOMDV would try to find an alternate path from among the backup routes between the source and the destination node pairs resulting in additional delay to the packet delivery time. In comparison, if a link break occurs in AODV, the packet would not reach the destination due to unavailability of another path from source to destination, since we assume in AODV only singular paths exist between a source and destination node.

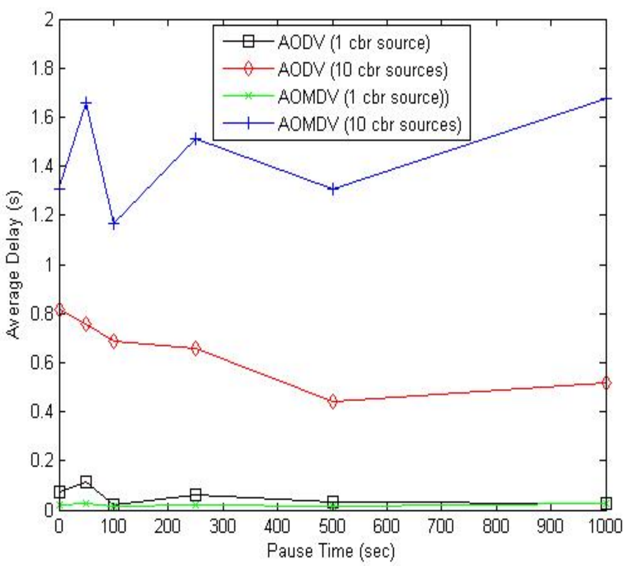

Figure 2: Comparison of AODV and AOMDV on basis of Average End-to-End delay of packets

4.3 *Routing Overhead*

From studying the figures (fig 3) for routing overhead, we see that AOMDV has more routing overhead that AODV for any range of pause time. This is attributed to the different mechanism of AODV and AOMDV. Due to AODV being a unipath routing protocol, once a link breaks the packet delivery along that route stops. But AOMDV is a multipath routing protocol and it searches for alternate paths if the current route breaks by flooding the network with RREQ packets. Hence AOMDV incurs more routing overhead than AODV.

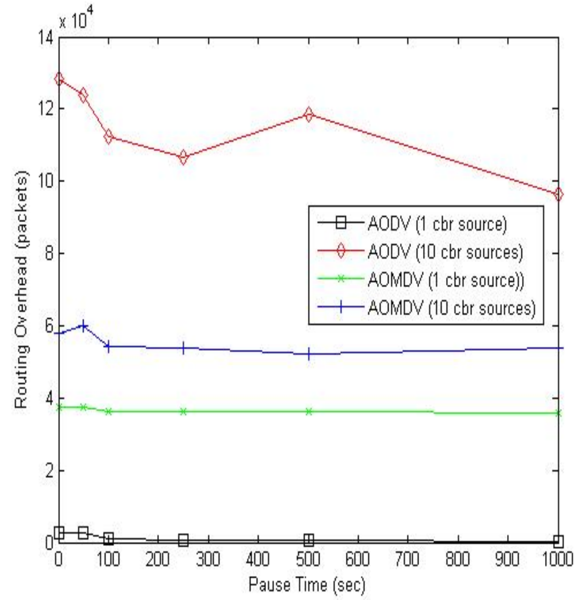

Figure 3: Comparison of AODV and AOMDV on basis of routing packets overhead

4.4 *No. of Packets Dropped*

The number of packets dropped in AODV is more than the number of packets dropped in AOMDV. This is because of the fact that due to AODV being a uni-path routing protocol, if a link is broken, the packet will not be delivered to the destination node. Thus that packet will get dropped. But due to AOMDV being a multipath routing protocol, even if the current link breaks, the network will find an alternate path from the source to the destination node and have a better chance of packet delivery; hence less number of packets will be dropped for AOMDV.

5. Conclusion

This paper evaluated the performances of AODV and AOMDV using ns-2. Comparison was based on of packet delivery fraction, routing overhead incurred, average end-to-end delay and number of packets dropped, we conclude that AOMDV is better than AODV. AOMDV outperforms AODV due its ability to search for alternate routes when a current link breaks down. Though AOMDV incurs more routing overheads while flooding the network and packet delays due its alternate route discovery mechanism, it is much more efficient when it comes to packet delivery for the same reason. Hence, in conclusion we can say that when network load tolerance is of no consequence, AOMDV is a better on-demand routing protocol than AODV since it provides better statistics for packet delivery and number of packets dropped. But if routing overhead is a concern, then AODV is preferred over AOMDV.

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