Effects of Velocity on Performance of DYMO, AODV and DSR Routing Protocols in Mobile Ad-hoc Networks

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Abstract

A Mobile Ad-hoc Network (MANET) is a self-configuring, infrastructure-less network of mobile devices (nodes) where nodes communicate with each other using multi-hop wireless links. This paper analyses the effect of mobility on performance of three MANET on-demand routing protocols i.e. Dynamic Manet On-Demand (DYMO), Dynamic Source Routing (DSR) and Ad-hoc On-Demand Distance Victor Routing Protocol (AODV). The performance metrics for analysis consists of different parameters such as throughput, packet delivery ratio, average end-to-end delay and average jitter. We used EXata/Cyber 1.2 from scalable networks for simulation of these protocols.

Keywords: MANET; On-Demand; DYMO; DSR; AODV; EXata/Cyber 1.2

1. Introduction

With significant advancement in mobile computing and wireless communication technology, mobile devices have gained sufficient communication, computation and memory resources to be interconnected. By definition, Mobile Ad-hoc Networks (MANETs) differentiate themselves from existing networks by the fact that they do not rely on fixed infrastructure [1]. The network has no base stations, access points, remote servers, etc. Such constraints make routing a challenging task in MANET were all network functions are performed by the nodes forming the network and each node performs the functionality of host and router.

Due to mobility of nodes, path between nodes may change. Therefore, it is not possible to apply techniques of fixed network in MANET. Because of this, routing is most studied problem in MANET. A
number of routing protocols have been proposed so far in MANET. Based on routing information update mechanism routing protocols in MANET can be categorized as proactive (table driven) and reactive (on-demand). First type of protocols are not suitable for highly dynamic network due to extra control overhead involved whereas in later one, a route is created only when it is required [2]. Such protocols are more suitable for MANET therefore we have considered only on-demand protocols for our study.

To determine the relative performance of the routing protocols, a lot of work has been done, comparing protocols under various conditions and constraints [3-5]. However, due to dynamic nature of network topology, velocity of nodes may also affect the performance of protocols. The intent of this paper is to compare the performance of routing protocols and to determine whether the velocity of nodes affects the relative performance of MANET routing protocols.

The rest of the paper is organized as follows: Section 2 provides an overview of each of the routing protocols used in the study. The simulation environment and performance metrics along with results are described in Section 3. Finally Section 4 concludes the paper.

2. Overview of Routing Protocols

As each protocol has its own merits and demerits, none of them can be claimed as absolutely better than others. To see how velocity of nodes affects their performance, three On-Demand MANET routing protocols are selected for study – Dynamic Manet On-Demand (DYMO), Dynamic Source Routing (DSR) and Ad-hoc On-Demand Distance Victor (AODV)

2.1 Dynamic Manet On-Demand (DYMO)

The Dynamic Manet On-Demand (DYMO) [6] is an On-Demand and fast reactive routing protocol for multi-hop communication in MANET currently under development by the Mobile Ad-hoc Networks Working Group of Internet Engineering Task Force (IETF).

The basic operations of the DYMO protocol are route discovery and route management. During route discovery, the source node initiates a RouteRequest (RREQ) throughout the network to find a route to the destination node. During this hop-by-hop dissemination process, each intermediate node records a route to the source node. When the destination node receives the RREQ, it responds with a Route Reply (RREP) sent hop-by-hop toward the source node. Each node that receives the RREP records a route to the destination node, and then the RREP is unicast hop-by-hop toward the source node. When the source node receives the RREP, routes have then been established between the source node and the destination node in both directions.

During route management, if there is a change in the network topology, nodes maintain their routes and monitor links over which traffic is moving. When a data packet is received for a destination to which the route is broken, and then the source node is notified with a Route Error (RERR). When the source receives the RERR, it knows that it must perform route discovery if it still has packets to deliver to that destination. DYMO uses sequence numbers to avoid loop formation. Sequence numbers also enable nodes to determine the order of DYMO route discovery messages, thus stale routing information can be avoided.

2.2 Dynamic Source Routing (DSR)

Dynamic Source Routing (DSR) [7] is a beacon-less protocol. During route construction phase, RREQ is flooded in network. The destination nodes respond by RREP, which carries the route traversed.
by the RREQ packet. Each RREQ carries a sequence number generated by source which is used to prevent loop formation and to avoid multiple transmission of the same RREQ by intermediate node that receives it through multiple paths.

Main advantage of this protocol is that it is beacon-less, thus bandwidth consumption is less and each packet carries full routing information. Disadvantage of this protocol is that the route maintenance mechanism does not locally repair a broken link and stale route cache information could also result in inconsistencies during the route reconstruction phase.

2.3 Ad-hoc On-Demand Distance Victor (AODV)

Ad-hoc On-Demand Distance Vector (AODV)[8] is a routing protocol in which each node maintains a routing table, one entry per destination which records the next hop to the destination and its hop count. AODV also uses a sequence number to ensure the freshness of routes. AODV discovers a route through network-wide broadcasting. It does not record the nodes it has passed but only counts the number of hops. It builds the reversed routes to the source node by looking into the node that the route request has come. The intermediate nodes checks for fresh routes according to the hop count and destination sequence number and forwards the packets that they receive from their neighbours to the respective destinations.

AODV utilizes periodical beaconing (HELLO packets) for route maintenance. If a node does not receive a HELLO packet within a certain time, or it receives a route break signal that is reported by the link layer, it sends a route error packet by either unicast or broadcast, depending on the precursor lists (i.e. active nodes towards the destination), in its routing table. AODV avoids the stale route cache problem of DSR and it adapts the network topology changes quickly by resuming route discovery from the very beginning.

3. Simulation results and analysis

We carried out simulation on Scalable Network’s EXata/Cyber 1.2 [9] and defined the parameters for the performance evaluation of DYMO, AODV and DSR routing protocols with different maximum velocity.

3.1 Simulation Environment

The network consists of 50 nodes in a 1500meter x 1500meter rectangular field. We use the random waypoint as the mobility model. Constant bit rate (CBR) with 512 byte data packets is used. The source-destination pairs are spread randomly over the network. The MAC layer protocol is 802.11. The main parameters used in the simulations are summarized in table 1.

| Parameter                          | Value                           |
|------------------------------------|---------------------------------|
| Dimension of space                 | 1500meter * 1500meter           |
| Number of Nodes                    | 50                              |
| Maximum Velocity (meter/second)    | 10, 20, 30, 40                  |
| Traffic Source                     | CBR                             |
| Simulation Time (second)           | 300                             |
| Mobility Model                     | Random waypoint                 |
| Pause Time (second)                | 10                              |

3.2 Performance Metrics

The performance of routing protocols is compared on the basis of following performance metrics.
3.2.1 Throughput:

\[
\text{Throughput} = \frac{\text{Total amount of data received from the sender}}{\text{Time takes for the receiver to get the last packet}} \text{ (bit/sec)}.
\]

Throughput of 50 nodes is shown in figure 1(a). In our results, DYMO shows inferior throughput as compared to other two protocols, and its performance further declines with increase in maximum velocity of nodes.

![Throughput Graph](image1)

3.2.2 Packet Delivery Ratio (PDR):

\[
\text{PDR} = \frac{\text{Number of packets successfully received at application layer}}{\text{Number of packets sent from source application layer}}.
\]

It should be close to unity for better performance. PDR is shown in figure 1(b). As per our results, AODV delivers almost 75 percent of packets and less performance degradation with increase in velocity as compared to other protocols.

![Packet Delivery Ratio Graph](image2)

3.2.3 Average end-to-end Delay:

It is the average delay between the time at which the data packet is originated on the source and the time when the packet reaches the destination. Lost packets are not considered. Delays due to route discovery, queuing and retransmissions are also included. Average end-to-end delay is shown in figure 2(a). AODV shows least delay with maximum of 0.14 second at velocity of 30 meter/second. DYMO is worst performer with maximum delay.

3.2.4 Average Jitter:

Average jitter is the time variation between subsequent packet arrivals. This is caused by network congestion, timing drift, or route changes. For an efficient routing protocol, it should be as low as possible. Average jitter is shown in figure 2(b), DSR and AODV shows average jitter as compared to DYMO.
4. Conclusion

In this paper, we compared the performance of DYMO, DSR and AODV routing protocol for MANET with variable maximum velocity of nodes. We measured the average jitter, average end-to-end delay, packet delivery ratio and throughput as performance metrics. Our simulation results show that AODV is the best scheme in terms of PDR and delay, while DSR shows best performance in terms of throughput. AODV and DSR show average performers in jitters. DYMO shows worst performance for throughput and average jitter. In future study, different node placement strategy, mobility model, additional metrics such as residual energy, average packet size of routing packets and normalized routing overhead may be considered.

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