Scenario based Performance Analysis of AODV and OLSR in Mobile Ad hoc Networks

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Abstract

A mobile ad hoc network (MANET) is a network consisting of a set of wireless mobile nodes that communicate with each other without centralized control or established infrastructure. Routing is a critical task in MANET as the nodes are moving. We compare the performance of two prominent routing protocols in MANET: Ad hoc On-Demand Distance Vector Routing (AODV) and Optimized Link State Routing (OLSR) protocol. The performance differentials are analyzed using various metrics like packet delivery ratio, end to end delay and number of nodes and are simulated using NS2. The paper describes all the parameters used for the simulations in detail and then compares each routing protocol's simulation results before arriving at a conclusion as to which is the best one for ad hoc networks.

Index Terms— Ad hoc, AODV, OLSR, Performance comparison, Routing protocols, Simulation, NS2.

1. Introduction

A mobile ad hoc network (MANET) is a network comprising wireless mobile nodes (MNs) that communicate with each other without centralized control or established infrastructure. MNs that are within each other's radio range can communicate directly, while distance MNs rely on their neighboring MNs to forward packets. Each MN acts as either a host or router. In MANET environment, MNs are free to join or leave the network at any point of time, resulting in a highly dynamic network environment compared to wired network.

Routing protocols are divided into two categories: Proactive and Reactive. Proactive routing protocols are table-driven protocols and they always maintain current up-to-date routing information by sending control messages periodically between the hosts which update their routing tables. The proactive routing protocols use link-state routing algorithms which frequently flood the link information about its neighbors. [2] Reactive or on-demand routing protocols create routes when they are needed by the source host and these routes are maintained while they are needed. Such protocols use distance-vector routing algorithms. [1]

Our goal is to carry out a systematic performance study of two routing protocols for ad hoc networks namely Ad hoc On Demand Distance Vector (AODV) Routing protocol and Optimized Link State Routing (OLSR) protocol.

The rest of the paper is organized as follows: Section 2 gives a brief description of the routing protocols using for performance comparison. In Section 3 a review of previous literature carried out in this field is provided. In Section 4 we present the setup of the Simulation Environment. Section 5 gives the Results and Analysis of the simulation done and finally we provide the conclusion.

2. Description of Routing Protocols

2.1 Ad hoc On Demand Distance Vector Routing Protocol

This protocol performs Route Discovery using control messages route request (RREQ) and route reply (RREP) whenever a node wishes to send packets to destination. To control network wide broadcasts of RREQs, the source node uses an *expanding* ring search technique. The forward path sets up an intermediate node in its route table with a lifetime association RREP. When either destination or intermediate node using moves, a route error (RERR) is sent to the affected source node. When source node receives the (RERR), it can reinitiate route if the route is still needed. Neighborhood information is obtained from broadcast Hello packet.

As AODV protocol is a flat routing protocol it does not need any central administrative system to handle the routing process. AODV tends to reduce the control traffic messages overhead at the cost of increased latency in finding new routes. The AODV has great advantage in having less overhead over simple protocols which need to keep the entire route from the source host to the destination host in their messages. The RREQ and RREP messages, which are responsible for the route discovery, do not increase significantly the overhead from these control messages. AODV reacts relatively quickly to the topological changes in the network and updating only the hosts that may be affected by the change, using the RRER message. The Hello messages, which are responsible for the route maintenance, are also limited so that they do not create unnecessary overhead in the network. The AODV protocol is a loop free and avoids the counting to infinity problem, which were typical to the classical distance vector routing protocols, by the usage of the sequence numbers. [3]

2.2 Optimized Link State Routing Protocol

Optimized Link State Protocol (OLSR) is a proactive routing protocol, so the routes are always immediately available when needed. OLSR is an optimization version of a pure link state protocol. So the topological changes cause the flooding of the topological information to all available hosts in the network. To reduce the possible overhead in the network protocol uses Multipoint Relays (MPR). The idea of MPR is to reduce flooding of broadcasts by reducing the same broadcast in some regions in the network, more details about MPR can be found later in this chapter. Another reduce is to provide the shortest path. The reducing the time interval for the control messages transmission can bring more reactivity to the topological changes. [2]

OLSR uses two kinds of the control messages: Hello and Topology Control (TC). Hello messages are used for finding the information about the link status and the host’s neighbors. TC messages are used for broadcasting information about own advertised neighbors which includes at least the MPR Selector list.

The proactive characteristic of the protocol provides that the protocol has all the routing information to all participated hosts in the network. However, as a drawback OLSR protocol requires each host periodically to send the updated topology information throughout the entire network. This increases the protocols bandwidth usage. But the flooding is minimized by the MPRs, which are only allowed to forward the topological messages.

3. Related Work

In [6] four different routing protocols like AODV, TORA, DSDV and DSR are compared. It is shown through simulation results that DSR generates less routing load than AODV. AODV suffers from end to end delay while TORA has very high routing overhead. The better performance of DSR is because it exploits caching aggressively and maintains multiple routes to the destinations.

Performance comparison of AODV and DSR routing protocols in a constrained situation is done in [7]. The authors claim that the AODV outperforms DSR in normal situation but in the constrained situation DSR out performs AODV, where the degradation is as severe as 30% in AODV whereas DSR degrades marginally as 10%.

A comparison of Link State, AODV and DSR protocols for two different traffic classes, in a selected environment is done in [8].It is claimed that AODV and DSR perform well when the network load is moderate and if the traffic load is heavy then simple Link State outperforms the reactive protocols .

Perkins et all [10] show the performance of two on demand routing protocols namely DSR and AODV. Though both AODV and DSR use on demand route discovery, they have different routing mechanics. The authors observe that for application oriented metrics such as delay, throughput DSR outperforms AODV when the numbers of nodes are smaller. AODV outperforms DSR when the number of nodes is very large. The authors do show that DSR consistently generate less routing load than AODV.

4. Simulation Environment

4.1 Simulation Setup

The MANET network simulations are implemented using NS-2 simulator [4]. Nodes in the simulation move according to a model that we call Random Waypoint Mobility model [5]. Each node is then assigned a particular trajectory. The simulation period for each scenario is 900 seconds and the simulated mobility network area is 800 m x 500 m rectangle. In each simulation scenario, the nodes are initially located at the center of the simulation region. The nodes start moving after the first 10 seconds of simulated time. The MAC layer protocol IEEE 802.11 is used in all simulations with the data rate 11 Mbps. The transmission range is 250m. The application used to generate is CBR traffic and IP is used as Network layer protocol. The performance evaluation, as well as the design and development of routing protocols for MANETs, requires additional parameters which is addressed in RFC developed by Internet Engineering Task Force (IETF).

4.2 Mobility Metrics

We have selected the Packet Delivery Ratio, Average end-to-end delay and Protocol Control Overhead as a metrics during the simulation in order to evaluate the performance of the different protocols:

Packet Delivery Ratio: This is the number of packets sent from the source to the number of received at the destination.

Average end-to-end delay: This is the average time delay for data packets from the source node to the destination node.

Protocol Control Overhead: This is the ratio of the number of protocol control packets transmitted to the number of data packets received.

5. Results and Analysis

First, an attempt was made to compare the two protocols under the same simulation environment. For all the simulations, the same movement models were used, the number of traffic sources was fixed at 20, the maximum speed of the nodes was set to 20m/s and the pause time was varied as 100s, 200s, 300s, 400s and 500s.

5.1 Packet Delivery Ratio Comparison

The On-Demand protocol AODV performed particularly well, delivering over 85% of the data packets regardless of mobility rate. But AODV fails when the node density increases. OLSR shows consistent performance.

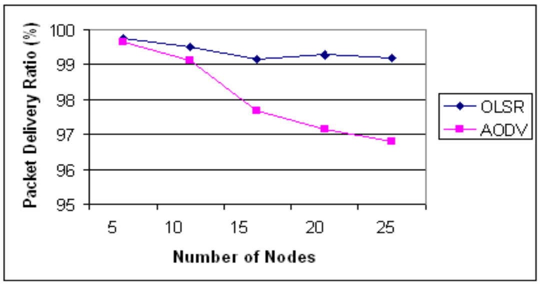

Fig 1. Packet Delivery Ratio v/s Number of Nodes.

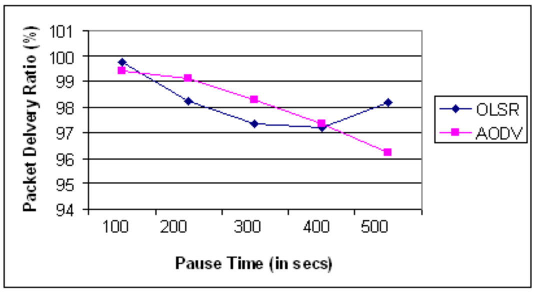

Fig 2. Packet Delivery Ratio v/s Pause Time.

Fig 1 and Fig 2 highlight the relative performance of the two routing protocols. Both the protocols deliver a greater percentage of the originated data packets when there is little node mobility (i.e. at large pause time), converging to 100% delivery when there is no node motion.

5.2 Average End to End Packet Delivery

The average end to end delay of packet delivery was higher in OLSR as compared to AODV as shown in Fig 3 and Fig 4. This observation is made while varying the nodes.

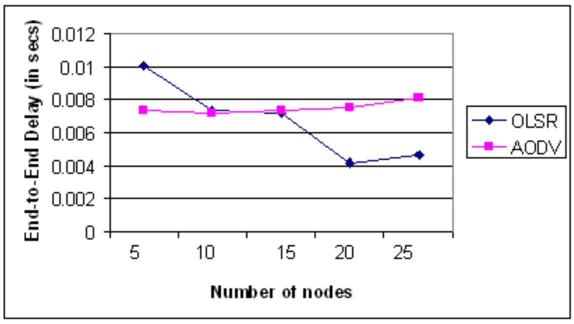

Fig 3. End to End Delay v/s Number of Nodes

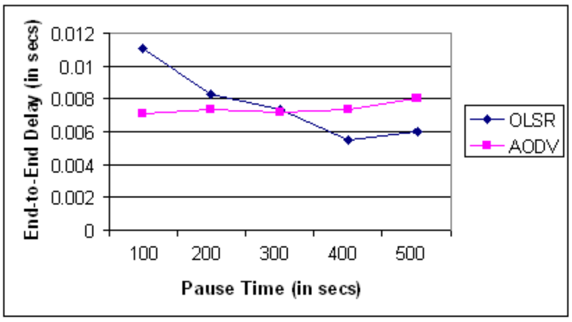

Fig 4. End to End delay v/s Pause Time

In summary On-Demand routing protocol AODV outperformed OLSR in both the cases.

Since both AODV and OLSR did better next, an attempt is made to evaluate the performance difference between the two by varying the Mobility and the Number of Nodes.

5.3 Normalized Routing Load Comparison

In all cases, AODV demonstrates significantly lower routing load than OLSR (Fig 5 and Fig 6), with the factor increasing with a growing number of nodes.

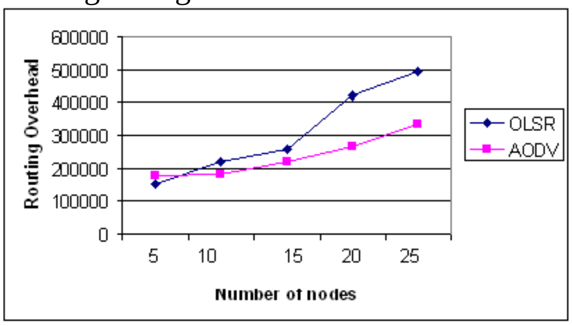

Fig 5.Routing Overhead v/s Number of Nodes

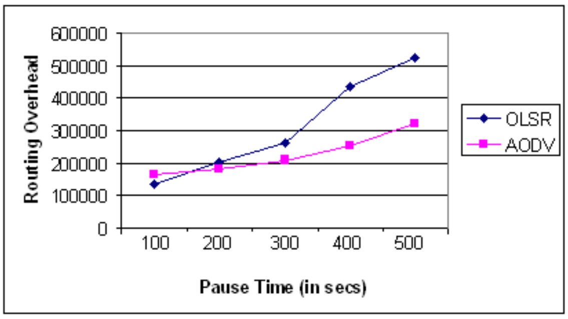

Fig 6. Routing Overhead v/s Pause time

The simulation results bring out some important characteristic differences between routing protocols.

The presence of high mobility implies frequent link failures and each routing protocol reacts differently during link failures. The different basic working mechanisms of these protocols lead to the differences in the performance.

OLSR fails to converge below lower pause times. At higher rates of mobility (lower pause times), OLSR does poorly, dropping to a 70% packet de-livery ratio. Nearly all of the dropped packets are lost because a stale routing table entry directed them to be forwarded over a broken link. As described in the earlier section, OLSR maintains only one route per destination and consequently, each packet that the MAC layer is unable to deliver is dropped since there are no alternate routes.

For OLSR and AODV, packet delivery ratio is independent of offered traffic load, with both protocols delivering between 85% and 100% of the packets in all cases.

Since OLSR uses the table-driven approach of maintaining routing information, it is not as adaptive to the route changes that occur during high mobility. In contrast, the lazy approach used by the on-demand protocols, AODV and OLSR to build the routing information as and when they are created make them more adaptive and result in better performance (high packet delivery fraction and lower average end-to-end packet delay).

6. Conclusion

In this paper the basic actions related to the two routing protocols namely AODV and OLSR were studied in detail. The AODV protocol will perform better in the networks with static traffic, with the number of source and destination pairs is relatively small for each host. It uses fewer resources than OLSR, because the control messages size is kept small requiring less bandwidth for maintaining the routes and the route table is kept small reducing the computational power. The AODV protocol can be used in resource critical environments.

The OLSR protocol is more efficient in networks with high density and highly sporadic traffic. But the best situation is when there is a large number of hosts. OLSR requires that it continuously has some bandwidth in order to receive the topology update messages. Both protocols scalability is restricted due to their proactive or reactive characteristic. In the AODV protocol it is the flooding overhead in the high mobility networks. In the OLSR protocol it is the size of the routing table and topological updates messages and their performance depends a lot on the network environment.

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