

Performance Comparison of AODV, DSDV, OLSR and DSR Routing Protocols in Mobile Ad Hoc Networks

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Mobile ad hoc networks (MANET) represent complex distributed systems that comprise wireless mobile nodes that can freely and dynamically self organize into arbitrary and temporary ad hoc network topologies. A mobile ad hoc network is a collection of nodes that is connected through a wireless medium forming rapidly changing topologies. The widely accepted existing routing protocols designed to accommodate the needs of such self-organized networks do not address possible threats aiming at the disruption of the protocol itself.

1. INTRODUCTION

Mobile Ad Hoc Network (MANET) is a collection of communication devices or nodes that wish to communicate without any fixed infrastructure and pre-determined organization of available links. The nodes in MANET themselves are responsible for dynamically discovering other nodes to communicate. It is a self-configuring network of mobile nodes connected by wireless links the union of which forms an arbitrary topology. The nodes are free to move randomly and organize themselves arbitrarily; thus, the network's wireless topology may change rapidly and unpredictably. Routing is a core problem in networks for sending data from one node to another. Wireless Ad Hoc networks are also called Mobile Ad Hoc multi-hop wireless networks is a collection of wireless mobile hosts forming a temporary network without the aid of any established infrastructure or centralized administration. Mobile Ad Hoc Networks (MANETs) are characterized by a dynamic, multi-hop, rapid changing topology. Such networks are aimed to provide communication capabilities to areas where limited or no communication infrastructures exist. MANET's can also be deployed to allow the communication devices to form a dynamic and temporary network among them. A mobile Ad Hoc network (MANET) is receiving attention due to many potential military and civilian applications. MANETs have several salient characteristics: 1) Dynamic topologies 2) Bandwidth-constrained, links 3) Energy constrained operation 4) limited physical security. Therefore the routing protocols for wired networks cannot be directly used for wireless networks. Some examples of the possible uses of ad hoc networking include students using laptop computers to participate in an interactive

lecture, business associates sharing information during a meeting, soldiers relaying information for situational awareness on the battlefield and emergency disaster relief personnel coordinating efforts after a hurricane or earthquake. A MANET uses multi-hop routing instead of a static network infrastructure to provide network connectivity. Several routing protocols have been proposed for mobile Ad Hoc networks. In this paper we present a number of ways of classification or categorization of these routing protocols and did the performance comparison of an AODV, DSR and DSDV routing protocols.

2. MANET ROUTING PROTOCOL

There are different criteria for designing and classifying routing protocols for wireless ad hoc networks. For example, what routing information is exchanged; when and how the routing information is exchanged, when and how routes are computed etc?

2.1. Proactive (Table Driven) and Reactive (On-Demand)

2.1.1. Proactive (Table-Driven) Routing Protocols

These routing protocols are similar to and come as a natural extension of those for the wired networks. In proactive routing, each node has one or more tables that contain the latest information of the routes to any node in the network. Each row has the next hop for reaching a node/subnet and the cost of this route. Various table-driven protocols differ in the way the information about a change in topology is propagated through all nodes in the network. There exist some differences between the protocols that come under this category depending on the routing information being updated in each routing table. Furthermore, these routing protocols maintain different number of tables. The proactive protocols are not suitable for larger networks, as they need to maintain node entries for each and every node in the routing table of

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every node. This causes more overhead in the routing table leading to consumption of more bandwidth. Examples of such schemes are the conventional routing schemes, Destination Sequenced Distance Vector (DSDV).

2.1.2. Reactive (On-Demand) Protocols

Reactive routing is also known as on-demand routing protocol since they don't maintain routing information or routing activity at the network nodes if there is no communication. These protocols take a lazy approach to routing. They do not maintain or constantly update their route tables with the latest route topology. If a node wants to send a packet to another node then this protocol searches for the route in an on-demand manner and establishes the connection in order to transmit and receive the packet. The route discovery usually occurs by flooding the route request packets throughout the network. Examples of reactive routing protocols are the dynamic source Routing (DSR), ad hoc on-demand distance vector routing (AODV).

2.2. Single Path vs. Multi Path

There are several criteria for comparing single-path routing and multi-path routing in ad hoc networks. First, the overhead of route discovery in multi-path routing is much more than that of single-path routing. On the other hand, the frequency of route discovery is much less in a network which uses multi-path routing, since the system can still operate even if one or a few of the multiple paths between a source and a destination fail. Second, it is commonly believed that using multi-path routing results in a higher throughput.

2.3. Table Driven vs. Source Initiated

In Table Driven Routing protocols, up-to-date routing information from each node to every other node in the network is maintained on each node of the network. The changes in network topology are then propagated in the entire network by means of updates. Destination Sequenced Distance Vector Routing (DSDV) and its scheme classified under the table driven routing protocols head. The routing protocols classified under Source Initiated On-Demand Routing, create routes only when desired by the source node. When a node requires a route to a certain destination, it initiates what is called as the route discovery process. Examples include DSR and AODV.

3. DESTINATION-SEQUENCED DISTANCE-VECTORS ROUTING (DSDV)

Destination-Sequenced Distance-Vector Routing (DSDV) is a table-driven routing scheme for ad hoc mobile networks based on the Bellman-Ford algorithm. The improvement made to the Bellman-Ford algorithm includes freedom from

loops in routing tables by using sequence numbers. It was developed by C. Perkins and P. Bhagwat in 1994. The DSDV protocol can be used in mobile ad hoc networking environments by assuming that each participating node acts as a router. Each node must maintain a table that consists of all the possible destinations. In this routing protocol, an entry of the table contains the address identifier of a destination, the shortest known distance metric to that destination measured in hop counts and the address identifier of the node that is the first hop on the shortest path to the destination. Each mobile node in the system maintains a routing table in which all the possible destinations and the number of hops to them in the network are recorded. A sequence number is also associated with each route/path to the destination. The route labeled with the highest sequence number is always used. This also helps in identifying the stale routes from the new ones, thereby avoiding the formation of loops. Also, to minimize the traffic generated, there are two types of packets in the system. One is known as "full dump", which is a packet that carries all the information about a change. However, at the time of occasional movement, another type of packet called "incremental" will be used, which will carry just the changes, thereby, increasing the overall efficiency of the system. DSDV requires a regular update of its routing tables, which uses up battery power and a small amount of bandwidth even when the network is idle. Whenever the topology of the network changes, a new sequence number is necessary before the network re-converges; thus, DSDV is not suitable for highly dynamic networks.

4. AD HOC ON DEMAND DISTANCE VECTOR (AODV)

The Ad hoc On Demand Distance Vector (AODV) routing algorithm is a routing protocol designed for ad hoc mobile networks. AODV is capable of both unicast and multicast routing. It is an on demand algorithm, meaning that it builds routes between nodes only as desired by source nodes. It maintains these routes as long as they are needed by the sources. Additionally, AODV forms trees which connect multicast group members. The trees are composed of the group members and the nodes needed to connect the members. AODV uses sequence numbers to ensure the freshness of routes. It is loop-free, self-starting, and scales to large numbers of mobile nodes. The AODV protocol uses route request (RREQ) messages flooded through the network in order to discover the paths required by a source node. An intermediate node that receives a RREQ replies to it using a route reply message only if it has a route to the destination whose corresponding destination sequence number is greater or equal to the one contained in the RREQ. The RREQ also contains the most recent sequence number for the destination of which the source node is aware. A node receiving the RREQ may send a route reply (RREP) if it is either the destination or if it has a route to the destination with corresponding sequence number greater than or equal to that

contained in the RREQ. If this is the case, it unicasts a RREP back to the source. Otherwise, it rebroadcasts the RREQ. Nodes keep track of the RREQ's source IP address and broadcast ID. If they receive a RREQ which they have already processed, they discard the RREQ and do not forward it. As the RREP propagates back to the source nodes set up forward pointers to the destination. Once the source node receives the RREP, it may begin to forward data packets to the destination. If the source later receives a RREP containing a greater sequence number or contains the same sequence number with a smaller hop count, it may update its routing information for that destination and begin using the better route. As long as the route remains active, it will continue to be maintained. A route is considered active as long as there are data packets periodically traveling from the source to the destination along that path. Once the source stops sending data packets, the links will time out and eventually be deleted from the intermediate node routing tables. If a link break occurs while the route is active, the node upstream of the break propagates a route error (RERR) message to the source node to inform it of the now unreachable destination(s).

5. DYNAMIC SOURCE ROUTING (DSR)

Dynamic Source Routing (DSR) is a routing protocol for wireless mesh networks and is based on a method known as source routing. It is similar to AODV in that it forms a route on-demand when a transmitting computer requests one. Except that each intermediate node that broadcasts a route request packet adds its own address identifier to a list carried in the packet. The destination node generates a route reply message that includes the list of addresses received in the route request and transmits it back along this path to the source. Route maintenance in DSR is accomplished through the confirmations that nodes generate when they can verify that the next node successfully received a packet. These confirmations can be link-layer acknowledgements, passive acknowledgements or network-layer acknowledgements specified by the DSR protocol. However, it uses source routing instead of relying on the routing table at each intermediate device. When a node is not able to verify the successful reception of a packet it tries to retransmit it. When a finite number of retransmissions fail, the node generates a route error message that specifies the problematic link, transmitting it to the source node. When a node requires a route to a destination, which it doesn't have in its route cache, it broadcasts a Route Request (RREQ) message, which is flooded throughout the network. The first RREQ message is a broadcast query on neighbors without flooding. Each RREQ packet is uniquely identified by the initiator's address and the request id. A node processes a route request packet only if it has not already seen the packet and its address is not present in the route record of the packet. This minimizes the number of route requests propagated in the

network. RREQ is replied by the destination node or an intermediate node, which knows the route, using the Route Reply (RREP) message. The return route for the RREP message may be one of the routes that exist in the route cache (if it exists) or a list reversal of the nodes in the RREQ packet if symmetrical routing is supported. In other cases the node may initiate its own route discovery mechanism and piggyback the RREP packet onto it. Thus the route may be considered unidirectional or bidirectional. DSR doesn't enforce any use of periodic messages from the mobile hosts for maintenance of routes. Instead it uses two types of packets for route maintenance: Route Error (RERR) packets and ACKs. Whenever a node encounters fatal transmission errors so that the route becomes invalid, the source receives a RERR message. ACK packets are used to verify the correct operation of the route links. This also serves as a passive acknowledgement for the mobile node. DSR enables multiple routes to be learnt for a particular destination. DSR does not require any periodic update messages, thus avoiding wastage of bandwidth.

Optimized Link State Routing (OLSR)

Optimized Link State Routing (OLSR) protocol is a proactive routing protocol where the routes are always immediately available when needed. OLSR is an optimization version of a pure link state protocol in which the topological changes cause the flooding of the topological information to all available hosts in the network. OLSR may optimize the reactivity to topological changes by reducing the maximum time interval for periodic control message transmission. Furthermore, as OLSR continuously maintains routes to all destinations in the network, the protocol is beneficial for traffic patterns where a large subset of nodes are communicating with another large subset of nodes, and where the [source, destination] pairs are changing over time. OLSR protocol is well suited for the application which does not allow the long delays in the transmission of the data packets. The best working environment for OLSR protocol is a dense network, where the most communication is concentrated between a large numbers of nodes. OLSR reduce the control overhead forcing the MPR to propagate the updates of the link state, also the efficiency is gained compared to classical link state protocol when the selected MPR set is as small as possible. But the drawback of this is that it must maintain the routing table for all the possible routes, so there is no difference in small networks, but when the number of the mobile hosts increase, then the overhead from the control messages is also increasing. This constrains the scalability of the OLSR protocol. The OLSR protocol work most efficiently in the dense networks.

A comparison of the characteristics of the above three ad hoc routing protocols DSDV, DSR, AODV, and OLSR is given in Table 1.

Table 1

Protocol Property	DSDV	DSR	AODV	OLSR
Multicast Routes	No	Yes	No	Yes
Distributed	Yes	Yes	Yes	Yes
Unidirectional Link Support	No	Yes	No	Yes
Multicast	No	No	Yes	Yes
Periodic Broadcast	Yes	No	Yes	Yes
QoS Support	No	No	No	Yes
Routes Maintained in Reactive	Route Table No	Route Cache Yes	Route table Yes	Route table No

6. COMPARISONS

In order to evaluate the performance of ad hoc network routing protocols, the following metrics were considered:

6.1. Packet Delivery Fraction (PDF) Result

PDF is the ratio between the numbers of packets originated by the application layer sources and the number of packets received by the sinks at the final destination. It will describe the loss rate that will be seen by the transport protocols, which in turn affects the maximum throughput that the network can support. In terms of packet delivery ratio, DSR performs well when the number of nodes is less as the load will be less. However its performance declines with increased number of nodes due to more traffic in the network. The performance of DSDV is better with more number of nodes than in comparison with the other two protocols. The performance of AODV is consistently uniform.

6.2. Average End to End Delay Result

The delay is affected by high rate of CBR packets as well. The buffers become full much quicker, so the packets have to stay in the buffers a much longer period of time before they are sent. This can be seen at the DSR routing protocol when it was reach around 2400 packets at the 0 mobility. For average end-to-end delay, the performance of DSR and AODV are almost uniform. However, the performance of DSDV is degrading due to increase in the number of nodes the load of exchange of routing tables becomes high and the frequency of exchange also increases due to the mobility of nodes.

6.3. Number of Packets Dropped

The number of data packets that are not successfully sent to the destination. In terms of dropped packets, DSDV's performance is the worst. The performance degrades with the increase in the number of nodes. AODV and DSR performs consistently well with increase in the number of nodes.

7. CONCLUSION

It is difficult for the quantitative comparison of the most of the ad hoc routing protocols due to the fact that simulations have been done independent of one another using different metrics and using different simulators. This paper does the realistic comparison of three routing protocols DSDV, AODV and DSR. The significant observation is, simulation results agree with expected results based on theoretical analysis. As expected, reactive routing protocol AODV performance is the best considering its ability to maintain connection by periodic exchange of information, which is required for TCP, based traffic. AODV performs predictably. Delivered virtually all packets at low node mobility, and failing to converge as node mobility increases. Meanwhile DSR was very good at all mobility rates and movement speeds and DSDV performs almost as well as DSR, but still requires the transmission of many routing overhead packets. At higher rates of node mobility it's actually more expensive than DSR. Compared the On-Demand (DSR and AODV) and Table-Driven (DSDV) routing protocols by varying the number of nodes and measured the metrics like end-end delay, dropped packets, As far as packet delay and dropped packets ratio are concerned, DSR/AODV performs better than DSDV with large number of nodes. Hence for real time traffic AODV is preferred over DSR and DSDV. For less number of nodes and less mobility, DSDV's performance is superior.

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