Performance Analysis of On-Demand Routing Protocols for Wireless Ad-hoc Network: A Survey

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Abstract—This MANET (Mobile Ad-Hoc Network) is a collection of autonomous wireless nodes without any centralized entity and without infrastructure. This paper presents a survey with an objective to compare Ad-Hoc routing protocols AODV and DSR taking into consideration different network parameters performed using simulation. Various researchers over time have analyzed the performance of AODV and DSR routing protocols based on the different test parameter and environment. AODV and DSR have been mostly studied through simulation. The objective of this survey is to review the AODV and DSR protocols based on the performance metrics such as mobility pattern, packet delivery ratio, average end to end delay, throughput, packet drop rate, routing overhead, node density and in different test environments.

Key words: MANET, AODV, DSR

I. INTRODUCTION

In ad-hoc network, mobile nodes communicate with each other using Multihop wireless links. There is no stationary infrastructure; for instance, there are no base stations. Each node in the network also acts as a router, forwarding data packets for other nodes. A central challenge in the design of ad hoc networks is the development of dynamic routing protocols that can efficiently find routes between two communicating nodes [8].

The wireless networks are classified as Infrastructured or Infrastructure less. In Infrastructured wireless networks, the mobile node can move while communicating, the base stations are fixed and as the node goes out of the range of a base station, it gets into the range of another base station. In Infrastructure less or Ad Hoc wireless network, the mobile node can move while communicating, there are no fixed base stations and all the nodes in the network act as routers. In the Ad Hoc network, mobile nodes dynamically establish routing among themselves to form their own network "on the fly".

MANET is a wireless network and self-configuring network of moving routers associated with wireless network. The routers are free to move randomly and organize themselves arbitrarily, thus, the network's wireless topology may change rapidly and unpredictably. Mobile Ad-Hoc network is an infractureless network due to mobile routers. Each node or router must forward the packets unrelated to its own use. Main challenges to maintain the Mobile Ad-Hoc network are: Limited power ability, no central controlling authority, for properly route traffic the information is continuously maintains. Figure-1 is showing the network of five mobiles connecting with wireless link. Every node will discover the routing path by using route request and route reply packets. Route maintenance is also required as the node changes its position so its route also. Mobile ad-hoc network is presently applicable everywhere in real life like in business meetings outside the offices, in Bluetooth, Wi-Fi Protocols etc. [6]

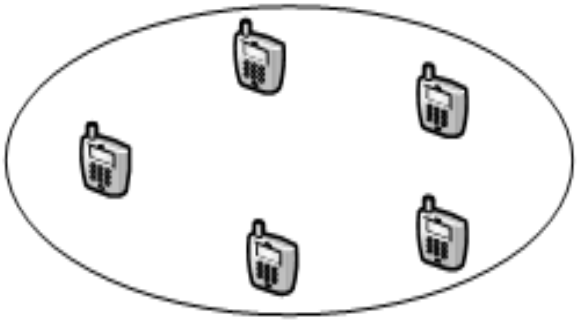

Fig. 1: Infrastructure less Network [6]

This infrastructure less network is managed using the routing protocols. Routing is the process of selecting paths in a network along which to send data or physical traffic. Routing directs the passing of logically addressed packets from their source toward their ultimate destination through intermediary nodes. So routing protocol is the routing of packets based on the defined rules and regulations. Every routing protocol has its own algorithm on the basis of which it discovers and maintains the route. In every routing protocol, there is a data structure which stores the information of route and modifies the table as route maintenance is requires. A routing metric is a value used by a routing algorithm to determine whether one route should perform better than another. Metrics can cover such information as bandwidth, delay, hop count, path cost, load, reliability and communication cost. The routing table stores only the best possible routes while link-state or topological databases may store all other information as well[6].

II. ROUTING PROTOCOLS DESCRIPTION

A routing protocol is needed whenever a packet needs to be transmitted to a destination via number of nodes and numerous routing protocols have been proposed for such kind of ad hoc networks. These protocols find a route for packet delivery and deliver the packet to the correct destination. The routing protocols can be classified into three types as: Table Driven (Proactive) Protocols, On-Demand (Reactive) Protocols and Hybrid protocol. In Table Driven (Proactive) routing protocols each node maintains tables containing routing information to every other node in the network. All nodes keep on updating these tables when

network topology change. Some existing table driven protocols are DSDV, CGSR, and WRP etc. In on-demand (Reactive) routing protocols, routes are created when it required. Some existing on demand routing protocols are: AODV, DSR, TORA etc. The emphasis in this research paper is concentrated on the study of mobility pattern and performance analysis of two prominent on-demand routing Protocols i.e. DSR and AODV. Based on combination of both table and demand driven routing protocols, some hybrid routing protocols (i.e. ZRP) are proposed to combine advantage of both proactive and reactive protocols. A brief review of AODV and DSR is presented here.

A. Dynamic State Routing (DSR)

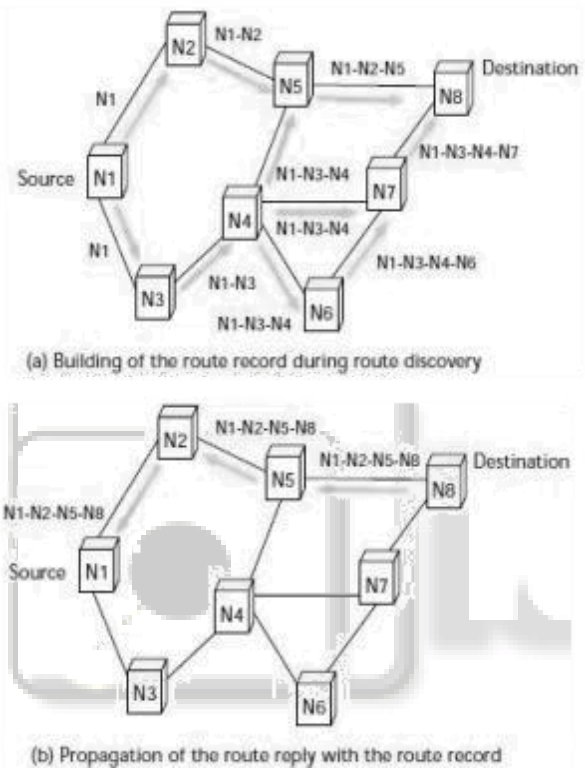

Fig. 2: DSR Path Discovery Process [9]

DSR [4] is proactive routing protocol which is source-initiated rather than hop-by-hop and is based on the theory of source-based routing rather than table-based. This is particularly designed for use in multi hop wireless ad hoc networks of mobile nodes. Basically, DSR protocol does not need any existing network infrastructure or administration and this allows the Network to be completely self-organizing and self-configuring. This Protocol is composed of two essential parts of route discovery and route maintenance. Every node maintains a cache to store recently discovered paths. When a node desires to send a packet to some node, it first checks its entry in the cache. If it is there, then it uses that path to transmit the packet and also attach its source address on the packet. If it is not there in the cache or the entry in cache is expired (because of long time idle), the sender broadcasts a route request packet to all of its neighbors asking for a path to the destination. The sender will be waiting till the route is discovered. During waiting time, the sender can perform other tasks such as sending/forwarding other packets. As the route request packet arrives to any of the nodes, they check from their neighbor or from their caches whether the destination asked is known or unknown. If route information is known, they send back a route reply packet to the destination otherwise they broadcast the same route request packet. When the route is discovered, the required packets will be transmitted by the sender on the discovered route. Also an entry in the cache will be inserted for the future use. The node will also maintain the age information of the entry so as to know whether the cache is fresh or not. When a data packet is received by any intermediate node, it first checks whether the packet is meant for itself or not. If it is meant for itself (i.e. the intermediate node is the destination), the packet is received otherwise the same will be forwarded using the path attached on the data packet. Since in Ad hoc network, any link might fail anytime. Therefore, route maintenance process will constantly monitors and will also notify the nodes if there is any failure in the path. Consequently, the nodes will change the entries of their route cache. The path discovery process of DSR is shown in figure 2.

B. Ad-hoc On Demand Distance Vector Routing (AODV)

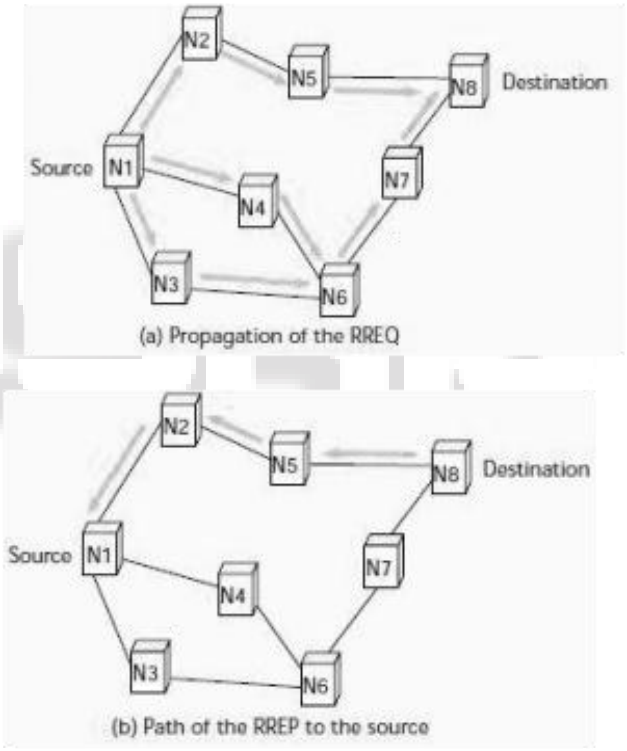

Fig. 3: AODV Path Discovery Process [9]

AODV [4] is a variation of Destination-Sequenced Distance-Vector (DSDV) routing protocol which is collectively based on DSDV and DSR. It aims to minimize the requirement of system-wide broadcasts to its extreme. It does not maintain routes from every node to every other node in the network rather they are discovered as and when needed & are maintained only as long as they are required. The algorithm used by AODV for establishment of unicast routes is explained as. When a node wants to send a data packet to a destination node, the entries in route table are checked to ensure whether there is a current route to that destination node or not. If it is there, the data packet is forwarded to the appropriate next hop toward the destination. If it is not there, the route discovery process is

initiated. AODV initiates a route discovery process using Route Request (RREQ) and Route Reply (RREP). The source node will create a RREQ packet containing its IP address, its current sequence number, the destination's IP address, the destination's last sequence number and broadcast ID. The broadcast ID is incremented each time the source node initiates RREQ. Basically, the sequence numbers are used to determine the timeliness of each data packet and the broadcast ID & the IP address together form a unique identifier for RREQ so as to uniquely identify each request. The requests are sent using RREQ message and the information in connection with creation of a route is sent back in RREP message. The source node broadcasts the RREQ packet to its neighbour and then sets a timer to wait for a reply. To process the RREQ, the node sets up a reverse route entry for the source node in its route table. This helps to know how to forward a RREP to the source. Basically a lifetime is associated with the reverse route entry and if this entry is not used within this lifetime, the route information is deleted. If the RREQ is lost during transmission, the source node is allowed to broadcast again using route discovery mechanism. Maintenance of routes is done using Local route repair scheme. The path discovery process of AODV is shown in figure 3.

C. Advantages and Drawbacks of DSR

DSR protocol has certain advantages:

1) It use reactive approach which eliminates the need of periodically flood the network with table update message, which required in a table driven approach.
2) The routes are maintained only between nodes that need to communicate.
3) The intermediate nodes utilize the route cache information efficiently to reduce the control overhead.

DSR protocol has also certain drawbacks:

1) The route maintenance mechanism does not locally repair a broken link.
2) Stale cache information could also result in inconsistencies during the route reconstruction phase.
3) The connection setup delay is higher than table driven protocol.
4) It performs well in static and low mobility environment, the performance degrades rapidly with increasing mobility.
5) Routing overhead in involved due to the source routing mechanism employed in DSR, this routing overhead is directly proportional to the path length.

D. Advantages and Drawbacks of AODV

AODV protocol has certain advantages:

1) It is used to find latest route to destination.
2) Its connection setup delay is less.
3) It favors the least congested route instead of shortest route.
4) It supports unicast and multicast packet transmissions.

AODV protocol has also certain drawbacks:

1) The intermediate nodes can lead to inconsistent route if the source sequence number is very old and the intermediate node have a higher but not the latest destination sequence number, thereby having stale entries.
2) Multiple route reply packets in response to a single route request packet can lead to heavy control overhead.
3) Periodic beaconing leads to unnecessary bandwidth consumption.

III. PERFORMANCE METRICS

There is various performance metrics that can be used to evaluate the performance of ad-hoc routing protocol. This metrics play a significant role while comparing two different protocols or ad-hoc routing protocols in terms of speed, number of packets sent, area, density, pause time etc. Few performance metrics are briefly discussed below:

1) Throughput: Ratio of the packets delivered to the time taken for deliver the packets.
2) Packet Delivery Ratio: It is the ratio of the number of packets sent by sources to the number of packets received by destination.
3) Routing Overhead: Routing overhead is the total number of transmissions routing packets transmitted during the simulation. For packets sent over multiple hops, each transmission of the packet (each hop) counts as one transmission.
4) Packet Loss Rate: The ratio of the data packets originated by the sources failure to deliver to the destination.
5) Average End-to-End Delay: Time taken for the packets to reach the destination.
6) Normalized routing load: The sum of the routing control messages such as RREQ, RREP, RRER, HELLO etc, counted by k bit/s.
7) Simulation Time: The time for which simulations will be run i.e. time between the starting of simulation and when the simulation ends.
8) Network size: It determines the number of nodes and size of area that nodes are moving within. Fewer nodes in the same area mean fewer neighbors to send request to, but also smaller probability of collision.
9) Pause time: It can be defined as time for which nodes waits on a destination before moving to other destination.

IV. RELATED WORK

In [2], the authors will simulate the environment used for analyzing, evaluating and implementing AODV, DSR and DSDV routing protocols in MANET, to analyze the performance of above said protocols based on Packet Delivery Fraction, Average End-to-End Delay and Number of dropped data packets. Authors have compared these three protocols on the basis of two traffic sources and these are TCP and CBR. For our simulation we had used a discrete event simulator known as NS2. From Simulation results, overall performance of on-demand protocols is better in terms of average end-to-end delay, packet delivery fraction. The both reactive protocols DSR and AODV use on-demand route discovery, but different routing mechanics.

In [3] the authors compare the performance of two prominent on-demand reactive routing protocols: DSR and AODV, and proactive DSDV protocol in TCP (Transmission Control Protocol) and UDP (User Datagram Protocol) environments. The performance matrix includes

Throughput of Received Packets, Throughput of Dropped Packets, End to End Delays, Packet Delivery Fraction and Routing Load. For UDP environment simulation results shows that AODV gives better performance in term of Throughput of Received Packets, Throughput of Dropped Packets and it gives higher end to end delay. DSR gives better packet delivery fraction and Throughput of Dropped Packets. For TCP environment DSR gives better performance than other protocol but gives higher end to end delay. AODV and DSR have almost same packet delivery fraction.

In [4], the authors compare the performance of two on-demand routing protocols i.e. DSR and AODV on the basis of packet delivery ratio with varying number of mobile nodes. It has been analyzed that both protocols are good in performance in their own categories. Still the emphasis of better routing can be on AODV as it performs better in denser mediums. DSR is steady in Sparse mediums but it just losses some ground in denser environment and that too when more connections are available and packet are in TCP mode. It is worth mentioning that in the future MANET's denser mediums will be used with increasing applications, so it can be generalized that AODV is better choice for routing in terms of better packet delivery.

In [5], the authors perform the three MANET routing protocols AODV, DSR and DSDV using variable number of nodes and constant pause times. Authors were to compare the three protocols, not to find the optimal performance but observe that the mobility pattern does influence the performance of MANET routing protocols. In these studies that compared different ad hoc routing protocols, there is no clear winner among the protocols in these cases, since different mobility patterns seem to give different performance rankings of the protocols. Packet delivery ratio is important as it describes the loss rate that will be seen by the transport protocols, which in turn affects the maximum throughput that the network can support. This metric characterizes both the completeness and correctness of the routing protocol, Routing overhead is an important metric for comparing these protocols, as it measures the scalability of a protocol, the degree to which it will function in congested or low-bandwidth environments, and its efficiency in terms of consuming node battery power. Protocols that send large numbers of routing packets can also increase the probability of packet collisions and may delay data packets in network interface transmission queues, Normalized Routing Load which calculated by as sum of the routing control messages such as RREQ, RREP, RRER, HELLO etc, counted by k bit/s, Average end to end data delay a metric which includes all possible delays caused by buffering during routing discovery latency, queuing at the interface queue, and propagation and transfer times.

In [6], the authors compare Mobile Ad-Hoc network routing protocols DSDV, AODV and DSR. The performance metrics includes PDR (Packet Delivery Ratio), Throughput, End to End Delay, Routing overhead. They are comparing the performance of routing protocols when packet size changes, when time interval between packet sending changes, when mobility of nodes changes. From this study result shows DSDV protocol is not good as throughput is very low and routing load is very high as compared to AODV and DSR protocols. AODV performed good in some situations than DSR protocol but overall DSR is performing better than AODV protocol like if compare average end to end delay. There is no effect on the performance of DSDV protocol if packet size varies. AODV and DSR protocols perform better at less packet size. Performance of all three protocols decrease as mobility of nodes increase.

In [7], the authors compare AODV, DSR and DSDV using NS2 simulation tool. The performance metrics he performance of these routing protocols is analyzed in terms of their average throughput, average delay and maximum packets in queue. The main objective of this study is to create a choice guide of routing protocol for a given network scenario, based on the relative performance of the protocols under various scenarios. The performance analyzed with of 5 nodes and the observations are made with variation in node speed in network. After analysis in different situations of network it can be practical that AODV perform glowing than DSDV and DSR in terms of throughput and average delay while DSR is proved to be best in case of Packet delivery ratio. By considering all the aspect, AODV is better.

V. CONCLUSIONS

In this survey it was found that AODV and DSR protocols outperformed each other in different scenarios. Most often DSR protocol was preferred in small network and less mobility while AODV performed better when node density and mobility is high. The combination of these protocols could be the better solution adapting to the changing environment and scenarios.

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