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Simulation Based Performance Comparison of Adhoc Routing Protocols

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ABSTRACT
Ad Hoc network is a collection of wireless mobile hosts forming a temporary network without the aid of any centralized administration, in which individual nodes cooperate by forwarding packets to each other to allow nodes to communicate beyond direct wireless transmission range. Routing protocols of Mobile Ad-Hoc Network (MANET) use different approaches from existing Internet protocols because of dynamic topology, mobile host, distributed environment, less bandwidth, and less battery power. Adhoc routing protocols can be divided into two categories: table-driven (proactive schemes) and on-demand routing (reactive scheme) based on when and how the routes are discovered. In this paper**,** MANET routing protocols DSDV, AODV and DSR are compared using network simulator NS-2.34.
Keywords- MANET, Routing Protocols, AODV, DSR, DSDV and Throughput.

I. INTRODUCTION

Wireless network has become very popular in the computing industry. Wireless network are adapted to enable mobility. There exist three types of mobile wireless networks: Infrastructure Based Networks, Ad-Hoc Networks and Hybrid Networks. Fig 1 shows an Infrastructure Based Network that consists of wireless mobile nodes and one or more bridges, which connect the wireless network to the wired network. These bridges are called Base Stations (BS). A mobile node within the network searches for the nearest BS (e.g. the one with the best signal strength), connects and communicates with it. The important fact is that all communication is taking place between the wireless node and the base station but not between different wireless nodes.

Fig 1: An Infrastructure Based Network with Two Base Stations

On the other hand, the mobile node travels around and all of a sudden gets out of range of the BS, a handover to a new BS will let the mobile node communicate seamlessly with the new BS. In contrary to Infrastructure Based Networks, an Ad-Hoc Network lacks any infrastructure. There are no BSs, no fixed routers and no centralized administration as shown in Fig 2. Mobile Ad-Hoc Network is an infrastructure-less network because all the mobile nodes work as routers. Each node forwards the packets unrelated to its own use [1] [2] [3].

Fig 2: A Mobile Ad-Hoc Network

All nodes move randomly and connected dynamically to each other. Therefore, all the nodes operate as a router and need to discover and maintain routes between source and destination in the network and to propagate packets accordingly. MANETs may be used in the areas with little or no communication infrastructure like emergency searches, rescue operations or places, where people wish to quickly share information.

II. ADHOC ROUTING PROTOCOLS

A routing protocol is needed whenever a packet needs to be transmitted to a destination via number of nodes. Numerous routing protocols have been proposed for such kind of ad-hoc networks. These protocols find a route for packet delivery and deliver packet to the right destination. Basically, routing protocols can be broadly classified into three types as A) Table-Driven (Proactive Routing) Protocols, B) On-Demand (Reactive Routing) Protocols, C) Hybrid Routing Protocols as shown in Fig 3.

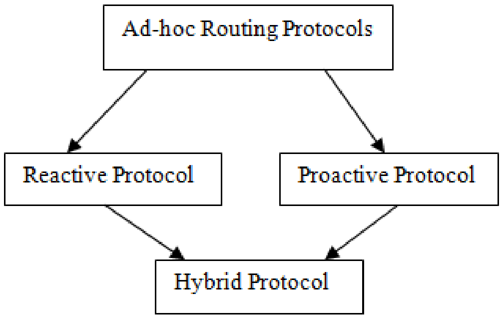

Fig 3: Types of Routing Protocols

2.1 Table-Driven (Proactive Routing) Protocols: Every node maintains the network topology information in the form of routing tables by periodically exchanging routing information. Routing information is generally flooded in the whole network whenever routing table of any node is updated. It runs an appropriate path-finding algorithm on the topology information it maintains. Some of the existing table-driven protocols are DSDV, WRP, CGSR, OLSR, STAR, FSR, and GSR.

A.) Destination Sequenced Distance Vector (DSDV) Routing Algorithm- DSDV is a traditional table-driven protocol for MANET [4] based on the classical Bellman-Ford routing mechanism [5]. The improvements made to the Bellman-Ford algorithm include freedom from loops in routing tables. DSDV guarantees loop free paths at all instants. In proactive protocols, routes to all the nodes in the network are discovered in advance. Each node maintains a routing table, which contains entries for all the nodes in the network. Each entry consists of:

- the destination's address
- the number of hops required reaching the destination (hop count)
- the sequence number as stamped by the destination

Table maintained by all the nodes are broadcast after a fixed interval of time independent of any route changes or not. This increases the overhead and so decreases the throughput of network using DSDV protocol [12] [13] [14] [15].

The sequence numbers enable the mobile nodes to distinguish stale routes from new ones, thereby avoiding the formation of routing loops. Routing table updates are periodically transmitted throughout the networking order to maintain table consistency. The routing updates can be "Event Driven" or "Time Driven". These routing table updates can be sent via "full dump" or "incremental updates". In incremental updates, only that information's are sent which has change since last updates. Full Dump means sending whole routing table [16]. This type of packet carries all available routing information and can require multiple network protocol data units (NPDUs). During periods of occasional movement, these packets are transmitted infrequently. Smaller incremental packets are used to relay only that information which has changed since the last full dump. Each of these broadcasts should fit into a standard-size NPDU, thereby decreasing the amount of traffic generated. The mobile nodes maintain an additional table where they store the data sent in the incremental routing information packets. New route broadcasts contain the address of the destination, the number of hops to reach the destination, the sequence number of the information received regarding the destination, as well as a new sequence number unique to the broadcast [6]. The route labeled with the most recent sequence number is always used. In the event that two updates have the same sequence number, the route with the smaller metric is used in order to optimize (shorten) the path.

2.2 On-Demand (Reactive Routing) Protocols: Protocols that fall under this category do not maintain the network topology information. They obtain the necessary path when it is required, by using a connection establishment process. Hence these protocols do not exchange routing information periodically. Some of the existing routing protocols that belong to this category are DSR, AODV, and TORA.

A.) Ad-Hoc On-Demand Distance Vector (AODV) Routing: The AODV protocol is an improvement of the DSDV [7]. DSDV has its efficiency in creating smaller ad-hoc networks. Since it requires periodic advertisement and global dissemination of connectivity information for correct operation, it leads to frequent system-wide broadcasts. Therefore the size of DSDV ad-hoc networks is strongly limited. When using DSDV, every mobile node also needs to maintain a complete list of routes for each destination within the mobile network. The advantage of AODV is that it tries to minimize the number of required broadcasts. It creates the routes on a on-demand basis, as opposed to maintain a complete list of routes for each destination. Therefore, the authors of AODV classify it as a pure on-demand route acquisition system [8].

Path Discovery Process

When trying to send a message to a destination node without knowing an active route [9] to it, the sending node will initiate a path discovery process. A route request message (RREQ) is broadcasted to all neighbors, which continue to broadcast the message to their neighbors and so on. The forwarding process is continued until the destination node is reached or until a intermediate node knows a route to the destination that is new enough. To ensure loop-free and most recent route information, every node maintains two counters: sequence number and broadcast_id. The broadcast_id and the address of the source node uniquely identify a RREQ message. broadcast_id is incremented for every RREQ the source node initiates. An intermediate node can receive multiple copies of the same route request broadcast from various neighbors. In this case –if a node has already received a RREQ with the same source address and broadcast_id – it will discard the packet without broadcasting it furthermore. When an intermediate node forwards the RREQ message, it records the address of the neighbor from which it received the first copy of the broadcast packet. This way, the reverse path from all nodes back to the source is being built automatically. The RREQ packet contains two sequence numbers: the source sequence number and the last destination sequence number known to the source. The source sequence number is used to maintain "freshness" information about the reverse route to the source while the destination sequence number specifies what actuality a route to the destination must have before it is accepted by the source [8].

When the route request broadcast reaches the destination or an intermediate node with a fresh enough route, the node responds by sending a unicast route reply packet (RREP) back to the node from which it received the RREQ. So actually the packet is sent back reverse the path built during broadcast forwarding. A route is considered fresh enough, if the intermediate node's route to the destination node has a destination sequence number which is equal or greater than the one contained in the RREQ packet as shown in Fig 4. As the RREP is sent back to the source, every intermediate node along this path adds a forward route entry to its routing table. The forward route is set active for some time indicated by a route timer entry [10]. If the route is no longer used, it will be deleted after the specified amount of time. Since the RREP packet is always sent back the reverse path established by the routing request, AODV only supports symmetric links.

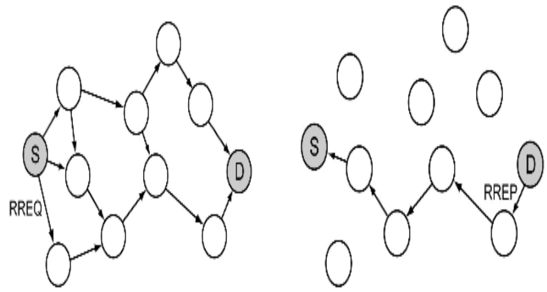

Fig 4: AODV Path Discovery Process

Maintaining Routes

If the source node moves, it is able to send a new RREQ packet to find a new route to the destination. If an intermediate node along the forward path moves, its upstream neighbor notices the move and sends a link failure notification message to each of its active upstream neighbors to inform them of the erasure of that part of the route as shown in Fig. 5. The link failure notification is forwarded as long as the source node is not reached. After having learned about the failure, the source node may reinitiate the route discovery protocol. Optionally a mobile node may perform local connectivity maintenance by periodically broadcasting hello messages [8].

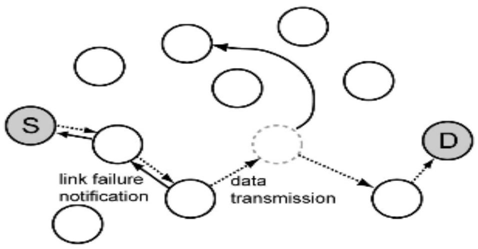

Fig 5: AODV Route Maintenance by Using Link Failure Notification Message

B.) Dynamic Source Routing (DSR): The DSR protocol is an on-demand routing protocol based on source routing. In the source routing technique, a sender determines the exact sequence of nodes through which to propagate a packet.

The list of intermediate nodes for routing is explicitly contained in the packet's header. In DSR, every mobile node in the network needs to maintain a route cache where it caches source routes that it has learned. When a host wants to send a packet to some other host, it first checks its route cache for a source route to the destination. In the case a route is found, the sender uses this route to propagate the packet. Otherwise the source node initiates the route discovery process. Route discovery and route maintenance are the two major parts of the DSR protocol.

Route Discovery

For route discovery, the source node starts by broadcasting a route request packet that can be received by all neighbor nodes within its wireless transmission range. The route request contains the address of the destination host, referred to as the target of the route discovery [11], the source's address, a route record field and a unique identification number. At the end, the source host should receive a route reply packet containing a list of network nodes through which it should propagate the packets, supposed the route discovery process was successful. During the route discovery process, the route record field is used to accumulate the sequence of hops already taken as shown in Fig 6. First of all the sender initiates the route record as a list with a single element containing itself. The next neighbor node appends itself to the list and so on. Each route request packet also contains a unique identification number called request_id. request_id is a simple counter which is increased whenever a new route request packet is being sent by the source node. So every route request packet can be uniquely identified through its initiator's address and request_id. When a host receives a route request packet, it is important to process the request in the order as described below:

1. If the pair 〈source node address, request_id〉 is found in the list of recent route requests, the packet is discarded.
2. If the host's address is already listed in the request's route record, the packet is also discarded. This ensures removal of later copies of the same request that arrive by using a loop.
3. If the destination address in the route request matches the host's address, the route record field contains the route by which the request reached this host from the source node. A route reply packet is sent back to the source node containing a copy of this route.
4. Otherwise, add this host's address to the route record field of the route request packet and rebroadcast the packet.

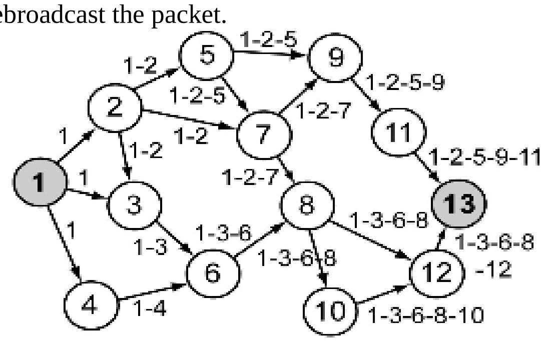

Fig 6: Building of the Route Record

A route reply is sent back either if the request packet reaches the destination node itself, or if the request reaches an intermediate node which has an active route [10] to the destination in its route cache. The route record field in the request packet indicates which sequence of hops was taken.

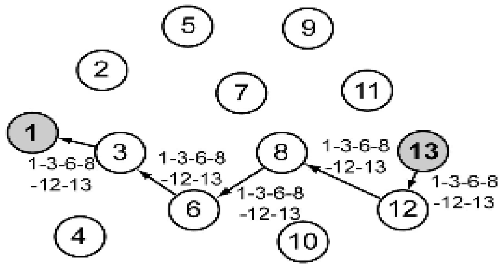

Fig 7: Propagation of the Route Reply

If the node generating the route reply is the destination node, it just takes the route record field of the route request and puts it into the route reply. If the responding node is an intermediate node, it appends the cached route to the route record and then generates the route reply as shown in Fig 7**.** If the responding node is an intermediate node, it appends the cached route to the route record and then generates the route reply. Sending back route replies can be accomplished in two different manners: DSR may use sym-metric links, but it is not required to. In the case of symmetric links, the node generating the route reply just uses the reverse route of the route record. When using unidirectional (asymmetric) links, the node needs to initiate its own route discovery process and piggyback the route reply on the new route request.

Route Maintenance

Route maintenance can be accomplished by two different processes:

- Hop-by-hop acknowledgement at the data link layer
- End-to-end acknowledgements

Hop-by-hop acknowledgement at the data link layer allows an early detection and retransmission of lost or corrupt packets. If the data link layer determines a fatal transmission error (for example, because the maximum number of retransmissions is exceeded), a route error packet is being sent back to the sender of the packet. The route error packet contains two parts of information: The address of the node detecting the error and the host's address which it was trying to transmit the packet to. Whenever a node receives a route error packet, the hop in error is removed from the route cache and all routes containing this hop are truncated at that point. End-to-end acknowledgement may be used, if wireless transmission between two hosts does not work equally well in both directions. As long as a route exists by which the two end hosts are able to communicate, route maintenance is possible. There may be different routes in both directions. In this case, replies or acknowledgements on the application or transport layer may be used to indicate the status of the route from one host to the other. However, with end-to-end acknowledgement it is not possible to find out the hop which has been in error.

2.3 Hybrid Routing Protocol: Protocols belong to this category combine the best features of the above two categories. Nodes within a certain distance from the node concerned or within a particular geographical region are said to be within the routing zone of the given node. For routing within this zone a table-driven approach is used and for the nodes that are located beyond this zone an on-demand approach is used. Some of the protocols in this category are CEDAR, ZRP, and ZHLS.

III. PERFORMANCE ANALYSIS

NS2.34 is the simulator used for simulating the three routing protocols. NS2 is a Network Simulator which is used to simulate all type of networks and can be easily understandable by anyone. The following one quantitative performance metric is used for this study.

Throughput-The ratio of the total amount of data that reaches a receiver from a sender to the time it takes for the receiver to get the last packet is referred to as throughput. It is expressed in bits per second or packets per second. Factors that affect throughput in MANETs include frequent topology changes, unreliable communication, limited bandwidth and limited energy. A high throughput network is desirable.

Throughput = no. of packets delivered/unit time

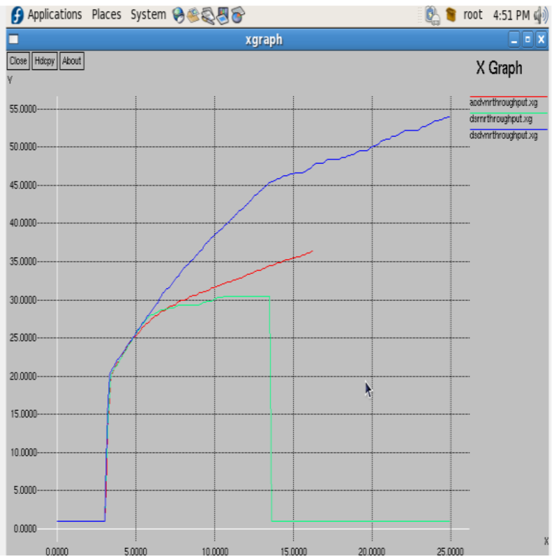

Fig 8: Throughput of AODV, DSR, DSDV Routing Protocol for 25 Nodes

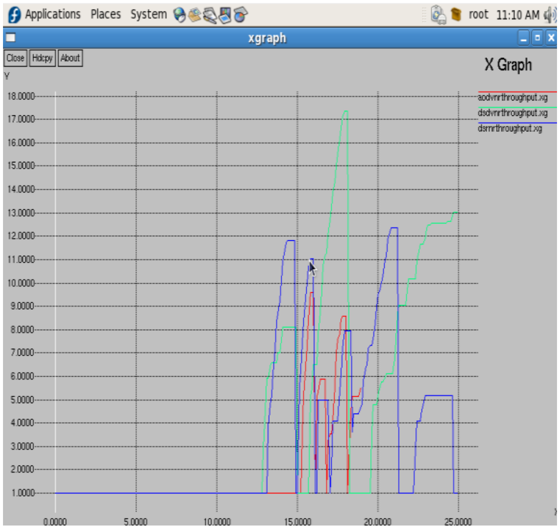

Fig 9: Throughput of AODV, DSDV DSR Routing Protocol for 40 Nodes

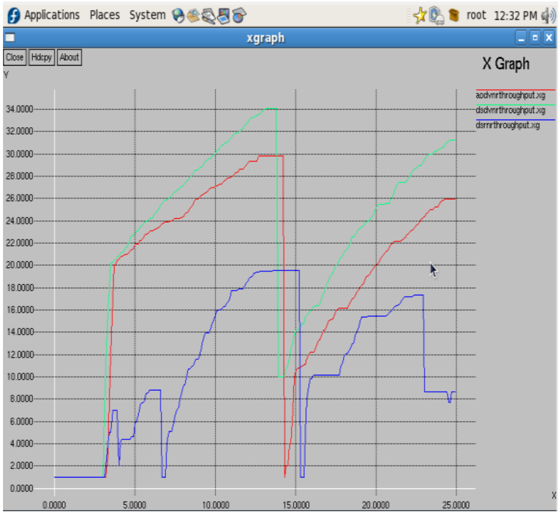

Fig 10: Throughput of AODV, DSDV, DSR Routing Protocols for 100 Nodes

Fig 8 shows that the throughput of DSDV decrease for limited number of nodes. But as the number of nodes increases the throughput value of DSDV increases as shown in Fig 9 and Fig 10. DSDV is a proactive routing protocol and suitable for large number of nodes with low mobility due to the storage of routing information in the routing table 1 at each node.

Table 1: Simulation Parameters

PARAMETER	VALUE
Traffic Type	TCPNewreno
Number of Nodes	25,40 and 100
Area Covered	1000 X 1000
Routing Protocols	AODV, DSDV and DSR
Simulation Time	25ms

IV. CONCLUSION

Routing protocol DSDV uses proactive "table driven" routing, while AODV and DSR use reactive "on-demand" routing. Protocol DSDV periodically updates its routing tables, even in cases when network topology doesn't change. AODV protocol has inefficient route maintenance, because it has to initiate a route discovery process every time network topology changes. Both protocols, AODV and DSR, use route discovery process, but with different routing mechanisms. In particular, AODV uses routing tables, one route per destination, and destination sequence numbers as a mechanism for determining freshness of routes and route loops prevention. On the other hand, DSR uses source routing and route caching, and doesn't depend on any periodic or time-based operations.

The performance of the three Routing protocols was analyzed using NS-2 Simulator. When comparing the routing throughput by each of the protocols, DSDV has the high throughput. It measures of effectiveness of a routing protocol. The throughput values of DSDV, AODV and DSR Protocols for 25, 40 and 100 Nodes. Based on the simulation results, the throughput value of AODV slowly increases initially and maintains its value when the time increases. AODV performs well than DSR since AODV is an on-demand protocol. The throughput value of DSR increases at lower pause time and grows as the time increases. Hence, DSDV shows better performance with respect to throughput among these three protocols.

V. FUTURE WORK

A comparison or routing protocols AODV, DSR and DSDV has been carried out. It is proposed to compare all other routing protocols considering the same simulation parameters so that an exhaustive comparison of various routing protocols can be made. Also, it would be interesting to observe the behavior of these protocols by varying other network parameters like Simulation time, Simulation areas, Traffic type etc. More performance metrics can also be considered. These protocols can also be compared with their existence & the work presented here can be used as a reference for future.

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