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# Energy-Efficient Routing Protocols In Mobile Ad-Hoc Networks

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***Abstract:*** **An ad-hoc network is a local area network (LAN) that is built spontaneously as devices connect. Instead of relying on a base station to coordinate the flow of messages to each node in the network, the individual network nodes forward packets to and from each other. In Latin, "Adhoc" is actually a Latin phrase that means "for this purpose." It is often used to describe solutions that are developed on-the-fly for a specific purpose. In computer networking, an ad hoc network refers to a network connection established for a single session and does not require a router or a wireless base station. In this paper, the three routing protocols are studied i.e. AODV, DSR, DSDV.**

***Keywords:*** **Ad hoc networks, AODV, DSR, DSDV, mobile ad hoc networks.**

## I. INTRODUCTION

An ad-hoc network is a collection of wireless mobile hosts forming a temporary network without the aid of any stand-alone infrastructure or centralized administration. Mobile Ad-hoc networks are self-organizing and self-configuring multi-hop wireless networks where, the structure of the network changes dynamically. This is mainly due to the mobility of the nodes. Nodes in these networks utilize the same random access wireless channel, cooperating in a friendly manner to engaging themselves in multihop forwarding. The node in the network not only acts as hosts but also as routers that route data to/from other nodes in network [1]. The main limitation of ad-hoc systems is the Availability of power. In addition to running the onboard electronics, power consumption is governed by the number of processes and overheads required to maintain connectivity [2]. The disadvantage of ad hoc network is that the nodes should be in range of a base, so that these nodes can receive the information and transmit it for further devices. If these nodes are not available, the whole network would fail [1]. There is cooperation between networks so that they should all be ready to receive and transmit data. Also, a single node can receive data from multiple other nodes, without the other nodes knowing about each other. Ad hoc network is a multi-hop wireless network, which consists of number of mobile nodes [5]. These nodes generate traffic to be forwarded to some other nodes or agroup of nodes. Due to a dynamic nature of ad hoc networks, traditional fixed network routing protocols are not viable. Based on that reason several proposals for routing protocols have been presented. Ad hoc radio networks have various implementation areas. Some areas to be mentioned are military, emergency, conferencing and sensor applications. Each of these application areas has their specific requirements for routing protocols. For example in military applications low probability of detection and interception is a key factor such is routing efficiency during fading and disturbed radio channel conditions. At sensor applications low or minimum energy consumption is a precondition for an autonomous operation. In conference applications a guaranteed quality of service formultimedia services is a needed feature. All application areas have some features and requirements for protocols in common. The routing protocol overhead traffic is not allowed to drive the network to congestion nor is a local change in link not allowed to cause a massive control traffic storm throughout the network [5]. There are number of routing protocols for ad hoc networks, they are categorized into two: Proactive Routing and Reactive routing.

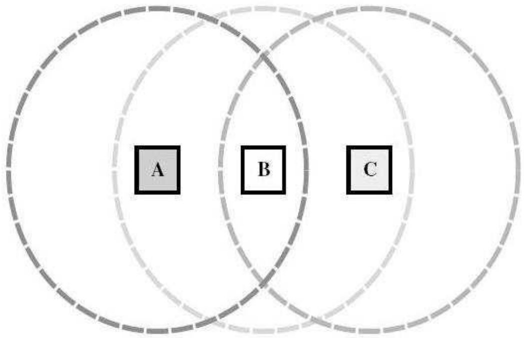


Fig 1: Simple ad hoc network

*A. Classification Of Routing Protocols:*

The routing protocols can be classified into two parts: 1.Table driven and 2. Source initiated (on demand) while depending onthe network structure these are classified as flat routing, hierarchical routing and geographic position assisted routing[2]. Flat routing coversboth routing protocols based on routing strategy.The three ad hoc routing protocols are used, AODV, DSDV and DSR. AODV and DSR is Reactive (On demand) whereas DSDV is Proactive (Table driven) Routing protocol.

*A.1. Proactive (Table- Driven) Routing Protocol*

In Proactive, nodes maintain one or more routing tables about nodes in the network. These routing protocols update the routing table information either periodically or in response to change in the network topology. The advantage of these protocols is that a source node does not need route-discovery procedures to find a route to a destination node. On the other hand the drawback of these protocols is that maintaining a consistent and up-to-date routing table requires substantial messaging overhead, which consumes bandwidth and power, and decreases throughput, especially in the case of a large number of high node mobility. There are various types of Table Driven Protocols: Destination Sequenced Distance Vector routing (DSDV), Wireless routing protocol (WRP), Fish eye State Routing protocol (FSR), Optimized Link State Routing protocol (OLSR), Cluster Gateway Switch Routing protocol (CGSR), Topology Dissemination Based on Reverse Path Forwarding (TBRPF) [3][1].

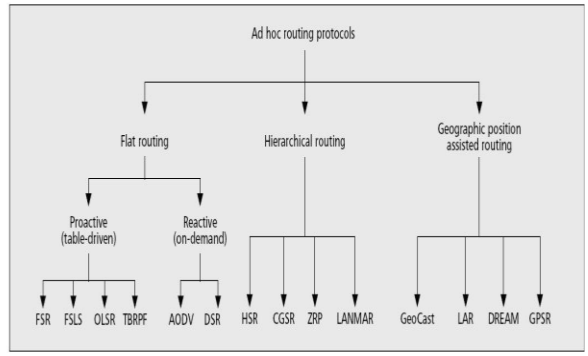


Fig 2: Adhoc Networking Protocols

*A.2. REACTIVE (On-Demand) ROUTING PROTOCOL*

Reactive routing is also known as on-demand routing protocol these protocols have no routing information at the network nodes if there is no communication. These protocols take a lazy approach to routing [3]. 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 and establishes the connection in order to transmit and receive the packet. There are various types of On-demand protocols are the dynamic source Routing (DSR), ad hoc on-demand distance vector routing (AODV).

## II. RELATED WORK

The problem of routing in MANETs has received attention among researchers, and many routing protocols devoted to MANETs have been proposed. According to their approaches for creating and maintaining routes, these protocols can be divided into two main categories; proactive protocols and reactive ones.

The proactive protocols, also called table driven, establish routes in advance, and permanently maintain them, basing on the periodic routing table exchange.

Table I: Comparison of Proactive and Reactive routing protocols

| **Proactive Protocols** | **Reactive protocols** |
|---|---|
| Attempt to maintain consistent, up-to-date Routing information from each node to every other node in the network. | A route is built only when required. |

| | |
|---|---|
| Constant propagation of routing information periodically even when topology change does not occur. | No periodic updates. Control information is not propagated unless there is a change inthe topology |
| First packet latency is less when comparedwith on-demand protocols | First-packet latency is more whencompared with table-driven protocolsbecause a route need to be built |
| A route to every other node in ad-hocnetwork is always available | Not available |

## III. DESCRIPTION OF SELECTED ROUTING PROTOCOLS

### *A. 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 inter-mediate 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 greateror 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 thedestination 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 samesequence 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).

#### *A.1. Characteristics of AODV*

- Unicast, Broadcast, and Multicast communication.
- On-demand route establishment with small delay.
- Multicast trees connecting group members maintained for lifetime of multicast group.
- Link breakages in active routes efficiently repaired.
- All routes are loop-free through use of sequence numbers.
- Use of Sequence numbers to track accuracy of information.
- Only keeps track of next hop for a route instead of the entire route.
- Use of periodic HELLO messages to track neighbors [21].

#### *A.2. Advantages and Disadvantages*

The main advantage of AODV protocol is that routes are established on demand and destination sequence numbers are used to find the latest route to the destination. The connection setup delay is less. The HELLO messages supporting the routes maintenance are range limited, so they do not cause unnecessary overhead in the network.
One of the disadvantages of this protocol is that intermediate nodes can lead to inconsistent routes if the source sequence number is very old and the intermediate nodes have a higher but not the latest destination sequence number, thereby having stale entries. Also multiple RouteReply packets in response to a single RouteRequest packet can lead to heavy control overhead [21]. Another disadvantage of AODV is that the periodic beaconing leads to unnecessary bandwidth consumption.

### *B. 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 sourcerouting 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 it owns 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 [1].

*B.1. Advantages and Disadvantages*

DSR uses a reactive approach which eliminates the need to periodically flood the network with table update messages which are required in a table-driven approach. The intermediate nodes also utilize the route cache information efficiently to reduce the control overhead. The disadvantage of DSR is that the route maintenance mechanism does not locallyrepair a broken down link. The connection setup delay is higher than in table-driven protocols. Even though the protocol performs well in static and low-mobility environments, the performance degrades rapidly with increasing mobility. Also,considerable routing overhead is involved due to the source-routing mechanism employed in DSR. This routing overhead is directly proportional to the path length.

C. Destination-Sequenced Distance-Vector 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. It eliminates route looping, increases convergence speed, and reduces control message overhead.

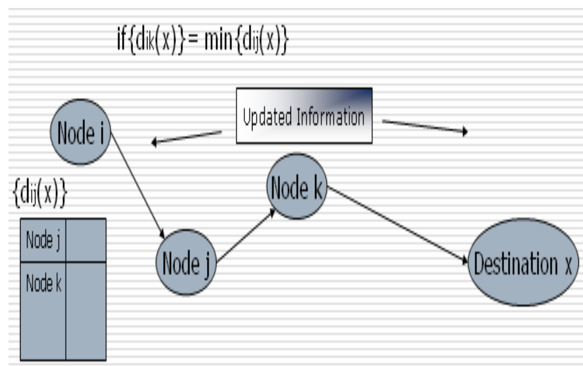


Fig 3: Illustration of DSDV [8].

In DSDV, each node maintains a next-hop table, which it exchanges with its neighbors. There are two types of next-hop table exchanges: periodic full-table broadcast and event-driven incremental updating. The relative frequency of the full-table broadcast and the incremental updating is determined by the node mobility. In each data packet sent during a next-hop table broadcast or incremental updating, the source node appends a sequence number. This sequence number is propagated by all nodes receiving the corresponding distance-vector updates, and is stored in the next-hop table entry of these nodes [6]. A node, after receiving a new next-hop table from its neighbor, updates its route to a destination only if the new sequence number is larger than the recorded one, or if the new sequence number is the same as the recorded one, but the new route is shorter. In order to further reduce the control message overhead, a settling time is estimated for each route. A node updates to its neighbors with a new route only if the settling time of the route has expired and the route remains optimal [3] [1].

*D. Comparison Between DSR, AODV, DSDV*

Table II: Comparison between AODV, DSR, DSDV.

| Sr. No. | AODV | DSR | DSDV |
|---|---|---|---|
| 1 | It is Reactive Protocol | It is Reactive Protocol | It is Proactive Protocol |
| 2 | It delivers virtually all packets at low mobility | It is very good at all mobility rates. | It performs almost as DSR, but requires transmission overheads of many packets. |
| 3 | | It has low end to end delay | It has high for pause time 0 but it starts decreasing as time increases. |
| 4 | It performs better for larger number of nodes | It performs better for larger number of nodes | It performs better for few number of nodes |
| 5 | For real time traffic AODV is preferred. | | |

## IV. SIMULATION BASED ANALYSIS USING NETWORK SIMULATOR (NS-2)

Here the tools and methodology used for analysis of ad hoc routing protocol performance i.e. about simulation tool, Simulation Setup(traffic scenario, Mobility model) performance metrics used and finally the performance of protocols is represented by using excel graph[1].

### *A. Simulation Tool*

The simulation tool used for analysis is NS-2 which is highly preferred by research communities. NS is a discrete event simulator targeted at networking research. NS provides substantial support for simulation of TCP, routing, and multicast protocols over wired and wireless (local and satellite) networks [14]. NS2 is an object oriented simulator, written in C++, with an OTcl interpreter as a frontend. This means that most of the simulation scripts are created in Tcl (Tool Command Language). If the components have to be developed for ns2, then both Tcl and C++ have to be used.

### *B. Simulation Analysis and Performance Metrics*

The network simulation is implemented using the NS-2 simulation tool [9].

Table III: NS-2 Specifications

| Simulation Parameter | Value |
|---|---|
| Simulator NS-2 | NS-2 |
| Node Movement Model | Random waypoint |
| Speed | 0-25m/s |
| Traffic Type | UDP |
| Bandwidth | 2Mb/s |
| Transmission range | 250m |

While comparing two protocols, we focused on two performance measurements such as Average Delay, Packet Delivery Fraction [8].

**(i) Packet delivery fraction**: The ratio of the number of data packets successfully delivered to the destinations to those generated by CBR sources. Packet delivery fraction = (Received packets/Sent packets)*100. Fig 5(a) & 5(b) shows a comparison between both the routing protocols on the basis of packet delivery fraction as a function of pause time and using different number of traffic sources [8].

**(ii) Average End to end delay of data packets**: The average time from the beginning of a packet transmission at a source node until packet delivery to a destination. This includes delays caused by buffering of data packets during route discovery, queuing at the interface queue, retransmission delays at the MAC, and propagation and transfer times. Calculate the send(S) time (t) and receive (R) time (T) and average it [8].

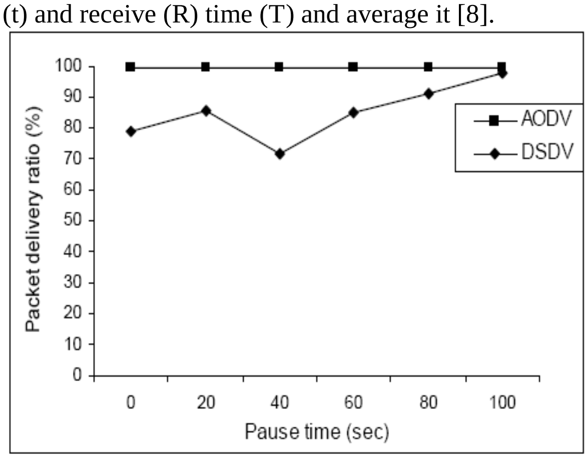


Fig 5(a): Packet delivery fraction vs. Pause time for 50-node model with 15 sources [8].

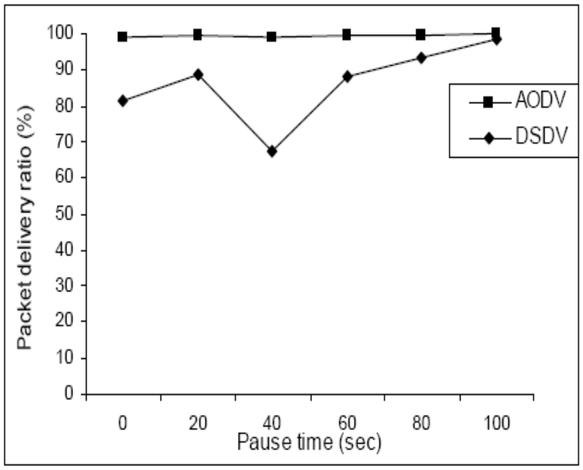


Fig 5(b): Packet delivery fraction vs. Pause time for 50-node model with 30 sources

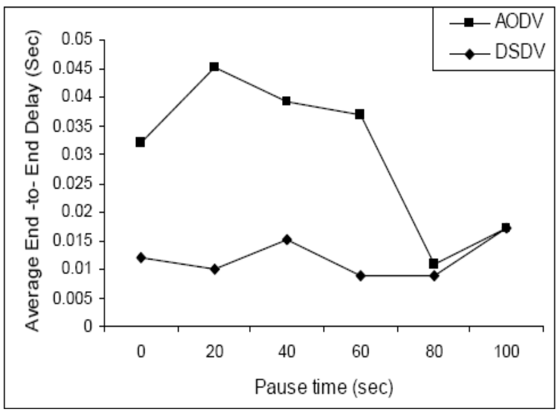


Fig 6(a): Average End-to-End Delay vs. Pause time forthe 50-node model with 15 sources[8].

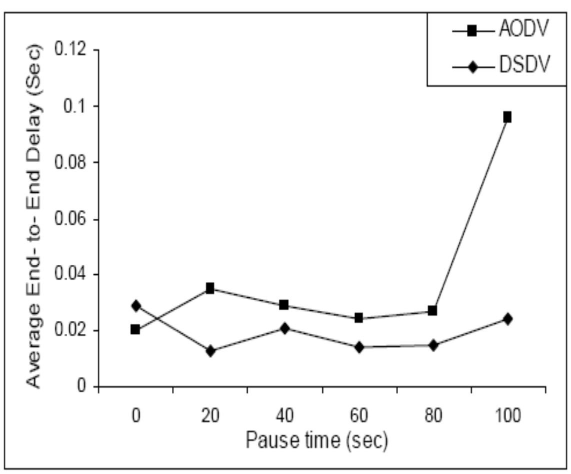


Fig 6(b): Average End-to-End Delay vs. Pause time forthe 50-node model with 30 sources[8]

## V. 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 [6].

## VI. FUTURE SCOPE

The application developed can be further enhanced to include some new features that changes with time and new technologies some of them includes the following features:

- It can be used to transfer the larger packets, length by fragmenting at the sender side and de-fragmenting at the receiver side.
- The protocols which are having poor behaviors and correcting it is not simple. It is more than complex that of writing a new protocol so in future the performance, quality gets enhanced.

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