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Route discovery by farthest intermediate link distance reliability cost based for MANETs through cross layer approach

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***ABSTRACT**:* MANETs are self-configuring network of mobile routers and associated hosts connected by wireless links, the union of which form an arbitrary topology. The routers are free to move randomly and organize themselves arbitrarily, thus the network wireless topology may change rapidly and unpredictably. MANETs may also be defined as a network formed without any central administration which consists of mobile nodes that use a wireless interface to send packet data or MANET is a collection of mobile nodes with no fixed infrastructure, where some intermediate nodes should participate in forwarding data packets. MANETs have attracted a lot of researchers [1], [2] because of the growing popularity of mobile computing devices. The integration of mobile ad-hoc networks (MANETs) with the Internet and infrastructure based wireless networks have become an essential part of ubiquitous networking and has drawn the attention of researchers from industry and the networking community. Research on cross layer design in ad-hoc networks has recently attracted in significant interest [3], [4]. Initially, MANETs scenarios are deployed at places like business associates sharing information during meeting, military personnel coordinate emergency effort's relief personnel coordinating efforts after a natural disaster such as hurricane, earthquake or flooding. Today, MANETs are required to support increasing demand for multimedia communication. The proposed research scheme FILDRC improves the end to end delay, throughput and also reduces the overhead to some limit. Traditional protocol selects the route with the smallest hop count. This can be implemented in military environment. It is observed that when load density is low, the link distance should be short; otherwise the link distance is large. Link distance is adjusted according to the network load. In this research paper we are concentrating mainly link distance on networks, end-to-end delay, and throughput in multi hop wireless networks.

Keywords*:* MANET, End-to-End Delay, Multi hop, FILDRC, Ubiquitous Network, Load Density.

I. INTRODUCTION

Ad-hoc networks are revolutionize wireless communication in the present years. One of the fundamental tasks of any ad-hoc network is that it must perform routing. Since the network is in general multi-hop, a routing protocol is needed in order to discover and maintain routes between far away nodes, allowing them to communicate allowing multi-hop paths. Most of the approaches proposed here are focused on the packet forwarding phase of a routing protocol. The route to the destination is already known and the goal is to identify strategies that motivate nodes to forward packets along this route. Relatively little attention has been devoted to the problem of simulating cooperation in the route discovery phase of a routing protocol. Some of the important factor that need to be considered in designing a routing protocols for MANETs are energy efficiency, minimum delivery latency, higher probability of packet delivery, adaptability and scalability. Several routing protocols for MANETS have been proposed to cope with similar problems and meet various application requirements. For instance, traditional proactive routing protocol eliminated the initial route discovery delay, but could not perform efficiently in specific ad-hoc conditions [2] [3]. The reason is that they waste the limited system resources to discover route that are not needed. On the other hand reactive routing protocols have been proposed as an effective solution to the problems. The main advantage is that route discovery is

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performed only when there is request for communication between two network nodes. This issue is crucial in the design of new routing protocols. To design such protocols, we have to look away from the traditional minimum hop routing schemes. Traditional routing protocols designed for multi-hop wireless networks, e.g., the mobile ad-hoc network (MANET), select a route with the smallest hop count. The end-to-end throughput in the route may not be the maximum when the network has multiple link data rates, as a small hop number implies a large geographic distance (link distance) for each hop. Due to the radio signal attenuation, this results in a low SNR at the receiving node and consequently, a low available link data rate. Reducing the link distance by using routes with more hop counts can increase the link data rate. However, this may not necessarily improve the end-to-end throughput because more nodes have to be included in the routes. Analysis and simulation results show that changing the link distance affects the network throughput.

Improving end-to-end throughput is required particularly for high-data-rate multimedia applications in multi-hop wireless networks. However, it remains as one of the major challenges. Traditional multi-hop routing protocols are designed for having the least hop count for an end-to-end connection. This reduces the contending parties that have to share the upper-bounded bandwidth and, therefore, improves the throughput. The examples are ad-hoc on-demand routing protocols, such as ad-hoc distance vector (AODV) routing protocol [5] and dynamic source routing (DSR) [6], or position-aided routing protocols, such as greedy perimeter stateless routing (GPSR) [7]. The least-hop strategy works if a fixed link data rate is used, because a smaller number of contending nodes means each of the nodes may have a longer channel occupation time, which normally results in a higher network throughput. There have been existing works that improve throughput in multi-hop networks by selecting routes according to metrics other than hop counts. Link delay has been used in [8] and [9]. In [10], the probability of a successful packet delivery in each hop is the major metric. In [11] cross layer design between PHY and MAC layer for power conversation based on the transmission power control is used. Shortest path scheme is the most common criteria adopted by the conventional routing protocols proposed for MANETS. The problem is that nodes along shortest paths may be used frequently and the batteries may exhaust faster. The consequence is that the network may become disconnected leaving disparity in the energy and disconnect the networks. Therefore the shortest path is not the most suitable metric adopted for routing decision.

II. THE PROPOSED METHOD

In this section, we explore the idea of Farthest Intermediate Link Distance Reliability Cost (FILDRC) Based Cross Layer Route Discovery for MANETS. The proposed FILDRC works on on-demand principle of route discovery and is part of cross layer framework. FILDRC makes use of new cross layer interface, designed to combine the functionality of the Routing layer with Application, Medium Access Control (MAC) and Physical (PHY) layer parameter to provide the routing algorithm. FILDCR is evaluated by simulation to show how this scheme improves the network throughput. In this paper, we first investigate and analyse the impact of link distance on end-to-end throughput in multi-rate multi-hop wireless networks. Analysis and simulation results show that changing the link distance affects the network throughput. To achieve a high network throughput, a proper link distance requirement has to be set for each hop, depending on different parameters such as load density. Our target network is mobile ad-hoc network with low mobility. Link distance has been considered for power savings in [12], [13], and [14]. In this paper, we focus on improving the network end-to-end throughput from the link distance point of view. However, link distance highly depends on network topology and it is difficult to control the actual link distance in a route. To make the research results applicable for network protocol design, we further define the link distance requirements as the maximum length for the link distance of a hop and evaluate the throughput when the link distance requirements are set as different values. Since a hop can be included in a route only if its link distance is no more than this value, in this paper, the link distance requirement is also called the maximum link distance or the maximum geographic hop distance.

We have considered the network that is less mobile and that has high density of nodes. For convenient analysis we assume that every node in the network has the same radius. Every node knows the geographical position of itself and its neighbours in its transmission radius which can be gained by using the global positioning systems (GPS). Messages exchanged during transmission or receptions have a unique identity number which also consist of additional information sender id and timestamps etc. MAC and the physical layer information are explored for routing. Here we have concentrated on Link Distance [15] and Link Cost for the selection of the best routes. Link distance here is based on the data rates. By this we select the routes with proper geographical distance between the nodes at the two ends of the hop. Link Distance and Link Cost both are different because link distance highly depends on the network topology

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and it is difficult to control the actual link distance in a route. A hop can be included in a route only if its link distance is no more than a defined value. Link cost is based on the cross layer design that rejects the paths with nodes having less battery support than the specified threshold i.e. nodes below the battery support of 50 %. There have been lots of researches to improve throughput in multi-hop network by selecting routes according to the metrics other than the hop counts. Link delay has been used as the metric for calculation of the routes in [16], [17]. A simple cross layer design between PHY and MAC layers for power conservation based on transmission power control is proposed in [18].

Extensive researches have been done for developing core protocols at MAC and network layers since past few years. Nodes depend on the batteries, so energy constraints have been focused a lot in MANETS. In [19] authors have proposed a new mechanism to reduce the power consumption, while increasing channel utilization. This approach tries to adapt the power level used by a mobile host to transmit data packets as a function of the relative distance to the target node according to the strengths at which RTS/CTS packets are received. In [20] routing protocol has been proposed for minimum energy broadcasting dedicated to static MANETs. The MTPR (Minimum Total Transmission Power Routing) [13] was developed to minimize the total transmission power consumption of the nodes participating in the route, while in [21] Min-Max Battery Cost Routing (MMBCR) considers the remaining power of the nodes as the metrics for acquiring routes in order to prolong the lifetime of each node. In [23], [24] authors have used the concept of sending the packets to the maximum farthest intermediate nodes only, once the route is discovered. In this research work, for data transmission we are using the concept of [22], [23].

III. SMALL NETWORKS

Two cases occur that will effect end-to-end throughput when the network size is small or large. In a network nodes are randomly located, some node that wants to send data acts as the source and receiver node is the destination. In small size network it may be possible that the source want to send data to destination node and that destination is in the radio range of the source node. So the data can be sent directly to that destination node. First of all the possible routes are discovered to reach the destination. All these routes may have different link distance; we first select the routes that have the minimum link distance and calculate the corresponding end-to-end throughput. This value is not more than mobile ad-hoc transmitting range. The link distance is equal to the geographic distance between the source and the destination divided by the minimum number of farthest intermediate node. In a network that has i connections, let N = {N1, N2... Ni} be the geographical distances between the sources and their destinations for these i connections. Let h = {h1, h2... hi} be the number of intermediate hops in each connection, which is also the vector of the number of transmitting (contending) nodes in the routes. Since every node is within the CZ (carrier sense zone) of any other node in the network, the overall number of nodes that will contend for the channel is D. Let d = {d1, d2... di}, where dj is the link distance for each intermediate hop in the connection j, and dj = Dj / hj. Let c = {c1, c2,...., ci} be the set for all the data rates for these connections. Using Shannon‘s theory and the two-ray ground radio propagation model, the highest available data rate in every link for this connection (which is defined as cj) is

$$C_j = W \log_2 \left\{ 1 + k P_{tr} / n_{rj} \, d_j^4 \right\} \quad (1)$$

As CSMA is used, when a node is transmitting a packet, all other nodes can sense it and they will not attempt to transmit. Therefore there is no chance of channel interference. Packets with different size have different transmitting rate and time taken. The amount of time a node occupies a channel for its purpose depends on the data rate. The end to end throughput is defined as the number of bits that are successfully transmitted by any node in the connection.

IV. LARGE NETWORKS

In this section we are briefly discussing about the effect of the link distance on the end to end throughput when the network size is large. In this case the source and the destination are located far away. The route that is discovered has large number of hops and therefore large number of farthest intermediate nodes. A source that has data to forward i.e. active node has to contend with all other active nodes within its carrier sense range to access the channel. As the distance between the source and destination is large, most of the active nodes in its carrier sense are farthest intermediate node. As the number of connection increases throughput decreases as number of connection in the network increases. It can be concluded that when the network size is small and it is lightly loaded, it is possible to improve the through put by reducing the link distance, because the data could be send directly to the destination node without the help of the intermediate node. In large network size (heavily loaded) it is more important to keep the number of contending nodes small by using the concept of sending the data to the farthest intermediate node in the radio range of the sender.

V. FILDRC ROUTING

It is assumed that initially all the batteries are fully charged. When the source node wants to transmit data, it broad cast the route request message once and maintains its routing table, due to which when the source node sends the data packet it only needs to know its neighbour node. As the paths are discovered whenever they are needed it reduces the overhead. Although some information is needed to be calculated to store the record in the routing table the energy expense is less as compared to the transmit and receive energy. The format of the route request message (R-REQ) is shown in Table 1. The Source ID contains the node ID of the message to destination, Sequence Number is the packet sequence, Link Distance (Hop Count) is the number of nodes between the source and the destination node, Energy threshold gives information about the energy level for the node to take part in transmission and reception, i.e. every node should have battery support above 50% then only it can take part in routing. Signal strength threshold is the minimum distance the node selected for data transmission has to be located in order to receive all the data transmitted to that particular node. Destination ID is node where the data has to reach.

Table 1 : Route request message (R-REQ) frame format

Source ID	Sequence Number	Link Distance(Hop Count)	Link Cost (Energy Threshold)	Signal Strength Threshold	Destination ID

For data transmission source node S wants to transmit to destination node D. If the destination node is in the transmission range of Source S then, as the source node has the information about the neighbour, it can send the data directly to that node. If the destination node is not in the sensing range, source S broadcast the route request message RREQM. Then the shortest path to reach the destination is obtained from the concept of paper [22]. After establishing the different paths, the paths are stored in the routing table as shown in table 2.

Table 2 : Routing Table

Fields	Description
Destination	Address of destination node
Sequence Number	Sequence number of the previous message
Next Hop	Next node address
Hop Count	No. of hops between S and D
Lifetime	Validity of the route

When we have discovered all possible paths from S to D, initially we consider the shortest path for data transmission. In the traditional routing shortest path is considered for transmission without any checks on that route, which may create problems like if node battery deplete or any problem like change of topology, the guarantee that data would successfully reach destination decreases. Shortest path concept also introduces problems that due to again and again use of the same route it will heavily load those nodes on the path even when there exist other feasible paths. We have tried to find a much feasible path instead of just the shortest path. For feasibility analysis we check for link cost i.e. battery support of all the node for the selected route. The route that is selected for data transmission all the nodes in that route should have remaining battery support more than 50 %. Those nodes whose remaining battery supports less than 50% are dropped and that route will not be considered as feasible path. Traditional shortest path routing may create problem

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whereas heavily loaded nodes and feasible routing algorithm necessarily use long path. This scheme is divided into three major steps

- Receiver in the transmission range of sender
- All possible route discovery, calculation of link distance
- Link Reliability Cost Analysis : Reliability analysis and Cost Analysis

A. ALGORITHM FOR FILDRC

The algorithm can be laid down as under:

1. If receiver is in the transmission range of sender.
    1.1 Send data to the receiver.
2. Discover all possible routes.
3. End-if.
4. Compute the link distance.
5. Choose the route that has minimum link distance.
6. Does it pass the cost analysis and reliability analysis?
    6.1 Send the data.
7. Go to step 4 to choose the next higher link distance
8. End while.

B. RECEIVER IN THE RADIO RANGE OF SENDER

Suppose the source S has data to send to the destination D. If the receiver is in the radio range or sensing range of the sender, then without opting for using the intermediate range, source S would directly send the data to D node.

C. ALL POSSIBLE ROUTE DISCOVERY, CALCULATION OF LINK DISTANCE

Link distance is the distance from the source node to first farthest intermediate node in the radio range. It would be termed as 1st link distance. We calculate to reach from source to destination how many link distances are required. It can be well understood from figure 1a given: From figure 1a we can observe that for source node {a} the other node in the radio range are {c, d, b, g}, but we send the data to the farthest intermediate node {g} and it is denoted as the 1st link distance. Now {g} sends data to {f} and it is called the 2nd link distance. In this way when the node wants to send the data first the entire possible route to reach the destination node is calculated. Then the link distance is calculated. The link with minimum link distance is chosen for transmission. When the destination is not in the radio range of the sender, intermediate nodes strategy is to be chosen to send the data. The entire possible route is discovered to reach the destination and then the link distance is calculated. After the calculation of link distance, the route that has the minimum link distance is chosen to forward the data after cost and reliability analysis. We have considered the network that is less mobile. Mac and the physical layer information are explored for routing. Link Cost and Link distance both are different because link distance highly depends on the network topology and it is difficult to control the actual link distance in a route. The link distance for different routes can be different. The next node is selected not only based on whether a node can process a packet most closely to the destination but also on whether the node is reliable and battery capacity is not low. In the figure 1b Source A wants to send data to the destination X. Different routes are searched. We are comparing 2 routes in the below diagram. Route 1 has link distance 4 = {A, Z, P, W, X} & Route 2 has link distance 5 = {A, Y, O, P, W, X}. So we select route 1 which has the minimum link distance. This calculation takes comparatively more time but at the same time it increases the guarantee for successful data delivery chances. After that, on that route, reliability and cost analysis is performed.

D. LINK RELIABILITY ANALYSIS

Here route request from the source is accepted by a node only if its reliability is high, otherwise it is discarded. In addition to the other advantage this approach decreases number of packet loss during transmission. Reliability (R) level of each node has to be calculated. We mainly concentrate on the reliability check for those farthest intermediate

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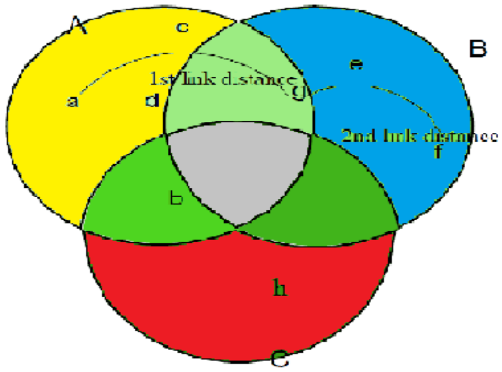
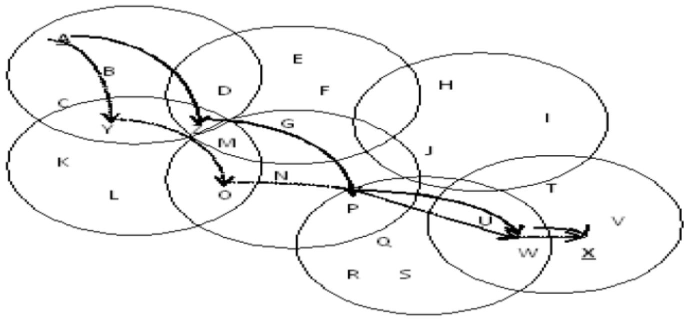


Fig. 1a Calculation of Link distance



Fig,1b. Comparison of two different routes in reference to link distance

nodes because they would be forwarding the data, therefore they should have high reliability. Reliability is calculated based on the remaining energy of the node periodically. We are not considering idle and sleep mode. After every transmission the remaining energy is calculated. When the remaining energy goes below 50 %, that particular node would be discarded. The consumed energy for transmission and reception mode can be calculated as below:

In transmission mode power consumed for transmitting a packet

Consumed energy = transmitting power (Pt) * transmission time (T) (2)

In reception mode power consumed for receiving a packet

Consumed energy = reception power (Pr) * reception time (T) (3)

where

Reception time = Data size/ Data rate (4)

Remaining energy of each node is calculated as from equation 2 and 3.

Left Energy or remaining energy = Current Energy – Consumed Energy (5)

Relationship between reliability energy and reliability value is shown by table 3. On the basis of remaining energy of the node, that node is given chance to participate in routing. Those nodes which are having remaining energy up to 50 % left can participate in routing.

Table 3:Relationship between the reliability energy and reliability value

Remaining energy in %	Reliability (R)	Reliability Value
80-100	✓ High	1.0
79-50	✓ Medium	0.6
49-30	× Low	0.2
29-00	× Very Low	0.0

.

If the reliability is very low, the node rejects the route request. If the reliability is medium the route request is then forwarded to next farthest intermediate node. When the route request reaches the destination, it checks. If it is found that every node has high reliability, this route is selected as the route for sending the data.

E.COST ANALYSIS

Link Cost is based on the cross layer design that rejects the paths with nodes having less battery support than the specified threshold. Link distance is highly dependent on network topology and it is very difficult to control the link distance. For the calculation of the link cost the information that is needed is (i) transmit power (ii) remaining battery capacity of the node at any time t (can be obtained from above equations) (iii) Fully charged battery. Link cost can be calculated as follows [31]

$$C(\pi,t) = \sum_{k\pi} C_i(t) \qquad (6)$$

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$$C_i(t) = \rho_i \left[\frac{F_i}{E_i(t)}\right]^{\alpha} \quad (7)$$

Where
ρi = transmit power of node i.
Fi = full charge battery capacity of node i.
Ei (t) = remaining battery capacity of node i at time t.
α = +ve weighting factor

Table 4: Comparison of FILDRC and AODV

	FILDRC	AODV
On Demand Route Selection	✓ Yes	✓ Yes
Neighbour Maintenance	✓ Yes	✓ Yes
First Feasible Route Failure	✓ Alternative Routing	× Rediscovery of Route
Routing path	✓ Best Feasible	× Fixed
QoS Support	✓ Yes	× No

Both FILDRC and AODV are reactive on demand route selection protocol. Reactive protocols seek to set up routes on-demand. If a node wants to initiate communication with a node to which it has no route, the routing protocol will try to establish such a route. In case of failure of primary route, AODV initiates a rediscovery process while in the case of FILDRC an alternative route is always available in all nodes from source to destination.

F. Route Maintenance

Route maintenance is initiated whenever the best feasible route that is selected to route between source and destination is broken or changed due to reasons like node mobility, battery failure. Once the best feasible route selection is done, destination node starts a timer to keep track of the availability of selected route. If data packets from source do not reach the destination node and the timer expires, it is assumed that the selected route between the source and the destination is lost or broken. In this case destination node selects alternative best route and initiates the process again. FILDRC avoid unnecessary flooding and overloading of the ad-hoc network. In route maintenance phase FILDRC do not use “HELLO” messages, instead it goes for an alternative path that is available.

VI. SIMULATION AND RESULTS

The performance of our algorithm is evaluated using discrete event simulator. The simulation of the ad-hoc network for 100 nodes in a 1000 m area is considered. Initially all the battery is charged fully. When the process starts the initial energy is progressively reduced by data transmission/ reception. When the battery totally discharges the node cannot take part in the communication process. Each node has a radio propagation range of 250 meters and channel capacity was 2 Mb/s. Performance metrics are node energy consumption which is the average energy spent by node to transmit data from source to destination. Data delivery ratio is number of data packets sent by the source and the number of data packets received by destination. Average time is the time between the data packet send by the source and the time the destination receives it. Figure 3 gives the compares speed and the throughput. Figure 4 shows number of hops in route which reduce the energy consumed for transmission. The average packet delay for FILDRC and AODV is shown in figure 5. Figure 6 describes about the speed and the end-to- end throughput. Table 5 shows about the simulation parameters. Figure 2 shows the network with light load of 10 connections, a medium load of 30 connections, a heavy load of 50 connections and a very heavy load of 70 connections. In figure 3 and figure 6 shows end-to-end delays are observed in paths. At low load, end-to-end delay is lower than high load networks. This delay includes all the delay caused in route discovery latency, transmission delay etc. When the load increases, delay increases as there are too many request sender. Figure 4 shows that total numbers of bytes that have been successfully delivered to the destination nodes. Better throughput is observed as it integrates cross layer design with it. Figure 5 is the ratio of the data packets delivered to the destination node.

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Table 5: Simulation parameters

Simulation Parameters	Value
Transmission Range	250 m
Simulation time	>800 s
Topology Size	1000m * 1000 m
Number of nodes	50
Number of destination	1
Traffic type	Constant bit rate
Packet rate	5 packets/s
Packet Size	512 bytes
Radio range	350 m
Transmit power	660mW
Receive power	35mW
Initial energy in batteries	10 Joules
Signal Strength Threshold	-80 dbm
Energy Threshold	0.001 mJ

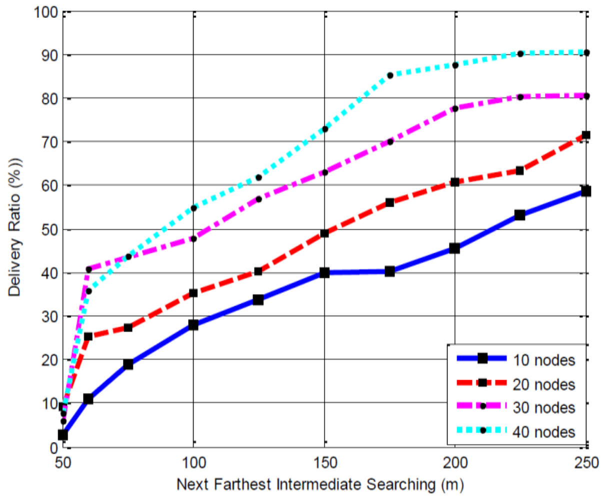

Figure. 2 Delivery ratio at different farthest intermediate nodes.

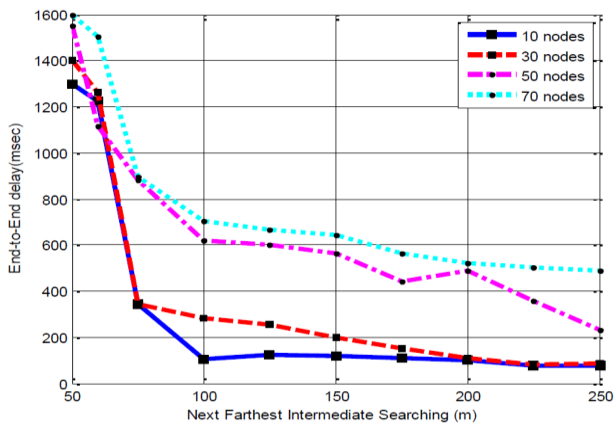

Figure 3. End-to-End delay at different number of connections

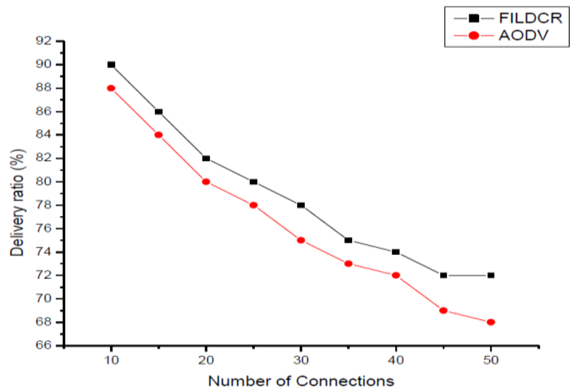

Figure 4. No. of Connection Vs Delivery ratio

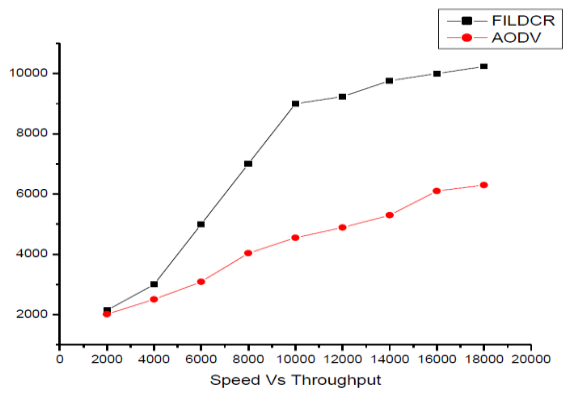

Figure 5. Speed Vs Through put Graph

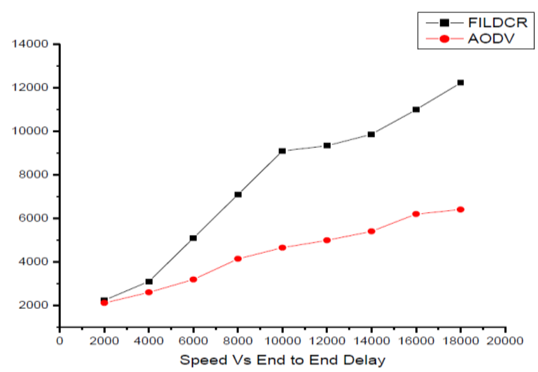

Figure 6. Speed Vs End to End delay graph

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VII. CONCLUSION

This research work FILDRC with cross layer approach improves the end to end delay, throughput and also reduces the overhead to some extend. Simulation results prove that FILDRC is better than AODV. Traditional protocol selects the route with the smallest hop count. This can be implemented in military environment. It is observed that when load density is low, the link distance should be short; otherwise the link distance is large. Link distance is adjusted according to the network load. For better performance end-to-end delay and throughput must be improved. Hence, in this paper, we have discussed about the link distance on networks, end-to-end delay and throughput in multi hop wireless networks. The future research work would be upgrading an efficient cross layer design considering very high mobility issues in MANET.

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