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Abstract-Routing Optimization in mobile ad hoc networks is an ever-demanding task. Mobile ad hoc networks are highly dynamic topology natured and hence several routing protocols meet the challenge of link quality, delay and energy conscious routing. This paper proposes a link quality, delay and energy conscious routing approach based on ant colony optimization. Based on the estimated link quality, delay and residual energy of the nearby nodes, Adaptive node stability (ANS) mechanism is mathematically modeled to make the routing strategy. LQDEARP selects the efficient node based on the ANS mechanism and sends the data packets through that node. Simulation results proved that LQDEARP reduces delay and energy consumption and increases packet delivery ratio than that of the AODV and DECRP protocol.

Keywords-*Mobile AdHoc Networks, Link quality, Delay, Energy, Routing, Ant Colony Optimization.*

1. INTRODUCTION

Ad hoc wireless network is a special case of wireless network devoid of predetermined backbone infrastructure. This feature of the wireless ad hoc networks makes it flexible and quickly deployable. Nevertheless, significant technological challenges are also posed by this property. There are several challenges incorporating issues of efficient routing, medium access, power management, security and quality of service (QoS). As the nodes correspond over wireless links, all the nodes must combat against the extremely erratic character of wireless channels and intrusion from the additional transmitting nodes. These factors make it a challenging problem to exploit on data throughput even if the user-required QoS in wireless ad hoc networks is achieved. A source node that needs to communicate with a destination node uses either a direct link or a multihop route to reach the latter. This requires that all nodes must have some basic routing capability to ensure that packets are delivered to their respective destinations. Repeated route changes cause huge complications in implementing ad hoc networks owing to the mobility of the nodes and intrusion between nodes. The high packet loss rates and recurrent topological changes lead to unbalanced transport layer and constrained amount of traffic being carried out by the network. The three eminent problems in ad hoc networks are the lack of constant packet delivery due to the intrusion and movement of nodes, incomplete bandwidth owing to the channel limitations, and constrained node life span caused as an outcome of small battery size. A major challenge in mobile ad hoc networking is how to maximize data packet delivery in the face of rapidly changing network topology without incurring energy. This is an extension of the previous research work as in [18].

2. RELATED WORKS

Over the last few years, several routing protocols are proposed for mobile ad hoc networks [1]-[7], [12], [13]. A number of performance comparison studies [8]-[11] have revealed that the on-demand routing protocols perform better in terms of packet delivery and routing overhead than proactive routing schemes especially in the presence of node mobility. R.Asokan et.al. [14] have extended the scope to QoS routing procedure. RamaChandran and Shanmugavel [15] have proposed and studied three cross-layer designs among physical, medium access control and routing (network) layers. A.N.AL-Khwildi et.al, [16] have proposed Adaptive Link-Weight (ALW) routing protocol which chooses an optimum route based on the available bandwidth, low delay and long route lifetime. Marjan Kuchaki Rafsanjani et al [17] have proposed a monitoring nodes selection method with high battery power.

Proactive and hybrid schemes do not perform well in dynamic topologies because of the following two major factors: Slow detection of broken links and periodic exchange of route updates even when routes are not needed.

3. LQDEARP

LQDEARP is an on-demand unipath routing protocol. The proposed LQDEARP takes advantage of various features of AODV routing protocol and estimates link quality and also selects the delay and energy aware path towards the destination node. In LQDEARP at first the node based on the received signal strength estimates link quality. Then the delay and energy cost is also estimated. The node which is having more link quality is taken into account. If more than one node is having the same link quality, then the node which is having least delay and energy is chosen. The link quality metric which is proposed in this research work does not negotiate with the noise. The noise is driven out from the wavelength carrier. As in [15] the authors did not considered noise and fading effects in estimating received signal strength.

3.1 Estimating Link Quality

The communication in mobile ad hoc network is based on electronic signals. In mobile ad hoc networks it is possible that a communication path (route) will break. This will happen primarily because of the nodes present in the network are moving around the region.

The Fig1 depicts the scenario when the link is active. In this Fig 1, three nodes are present namely a, b and c. The node-b is within the range of the node-a and node-c. But, the node-a is not within the range of node-c and node-c is not within the range of node-a. Hence for transmission of data from node-a to node-c, the node-b acts as an intermediate node. After some time (as shown in Fig 2), due to the mobility of nodes, the link gets break and the data communication between the nodes becomes unreliable.

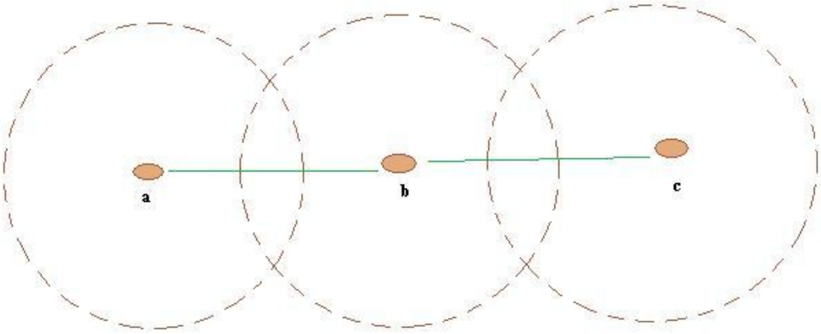

Figure 1: Before the link breaks

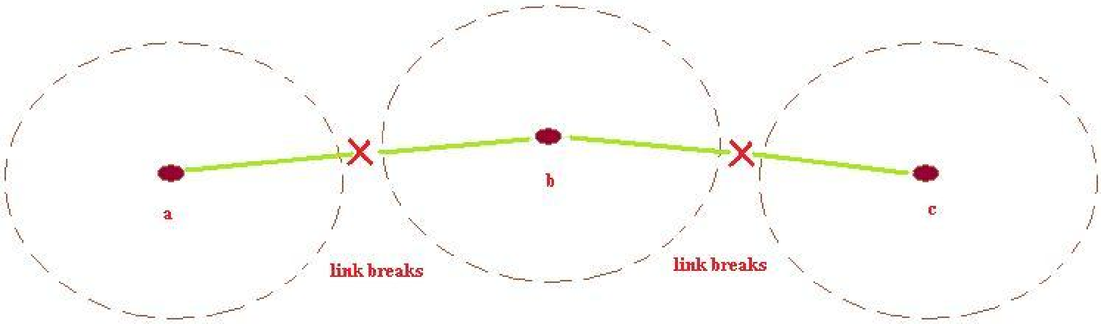

Figure 2: After the link breaks

Due to the mobility of nodes present in mobile ad hoc network it becomes mandatory to consider the quality of the link. As in the previous paper by estimating the energy and delay is not sufficient to make the non-congested data transmission from a source node to the destination node. Suppose in a situation where the delay is less so that congestion will be less in a node but its signal strength is weaker, and then the transmission of data on the particular link is not reliable. Hence this part discusses on the estimation of link quality.

To be able to see that when a node in the mobile ad hoc network is moving and hence a route is about to break. So that factor, it is probable to measure the quality of the signal and based upon that presumption, when the link is going to break. This information which is identified by the physical layer is send to the upper layer when packets are received from a node, and then indicate that node is in less link eminent zone. Less link-eminent zone is the region where the signal strength is weaker which leads to the link failure. Thus, using the received signal strength from physical layer, the quality of the link is predicted and then the links which are having low signal strength will be discarded from the route selection.

Estimation:

When a sending node broadcasts RTS packet, it piggybacks its transmission power ($Pwr_{Transmitter}$). While receiving the RTS packet, the projected node quantifies the strength of the signal received.

$$Pwr_{Rvr} = Pwr_{Ttr} (\lambda / 4 \prod d)^{2} * (AUG_{T}) * (AUG_{R})$$
$$L_q = Pwr_{Rvr} \quad \text{---- (1)}$$

Where,

Pwr_{Rvr} refers Power of the Receiving node,

Pwr_{Ttr} stands for Power of the Transmitting node, λ stands for wavelength carrier (with noise removed), d is the distance between the sending and the receiving node, AUG_R stands for average unity gain of receiving omni-directional antenna, AUG_T

stands for average unity gain of transmitting omni-directional antenna.

3.2 Estimating delay

It is important to estimate delay in mobile ad hoc networks for path optimization. Hence this research focuses to evaluate delay in an exact way. Each mobile node in the ad hoc network is considered as buffer. The data packets or RREQ packets arrive the buffer with poisson distribution and it is referred by λ. Hence the delay of the node can be computed by the following equation.

$$Delay = \frac{\lambda T_2}{2(1-\sigma)} + T_1 \quad \text{---- (2)}$$

- λ is the arriving rate of data packets to the buffer.
- T_1 is the mean service time required to transfer a data packet with success (which also includes retransmission delays).
- σ is the rate occupation which is equal to λT_1.
- T_2 is the second moment of service time distribution.

3.3 Estimating residual energy

The information about the residual energy of the neighbor nodes is stored by every node throughout requesting the other nodes about their residual energies. The residual energies at a node can be calculated as

Residual energy = initial energy – consumed energy ---- (3)

3.4 Adaptive Node Stability (ANS) mechanism

The adaptive node stability uses three parameters. They are link quality, delay and residual energy. By estimating the three parameters the adaptive node stability will be carried out using the below equation

$$ANS = \max\left(LQ\left[energy * \left(\frac{1}{delay} \right) \right] \right) \quad \text{---- (4)}$$

The node with the ANS is selected and the link is established.

4. SIMULATION MODEL AND PARAMETERS

We use NS2 to simulate our proposed protocol in our simulation; the channel capacity of mobile hosts is set to the same value: 2 Mbps. We use the distributed coordination function (DCF) of IEEE 802.11 for wireless LANs as the MAC layer protocol. It has the functionality to notify the network layer about link breakage. In our simulation, 50 to 200 mobile nodes move in a 1500 meter x 1500 meter rectangular region for 100 seconds simulation time. We assume each node moves independently with the same average speed. All nodes have the same transmission range of 250 meters. In our simulation, the speed is set as 5m/s. The simulated traffic is Constant Bit Rate (CBR).

The simulation settings and parameters are described in table 1.

Table1. Simulation settings and parameters

No. of Nodes	50, 75, 100, 125, 150 and 200
Area Size	1500 X 1500 meters
MAC	802.11b
Radio Range	250 meters
Simulation Time	100 seconds
Traffic Source	CBR
Packet Size	512 KB
Mobility Model	Random Waypoint Model
Speed	5 m/s
Initial Energy	0.5 Joules

Performance metrics

Routing overhead, delivery ratio, delay and total energy consumption of nodes.

5. RESULT GRAPHS

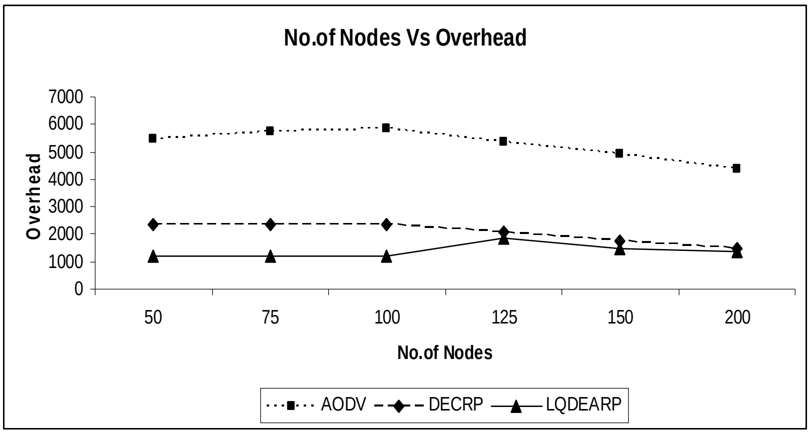

Figure 3: Number of Nodes Vs Overhead Packets

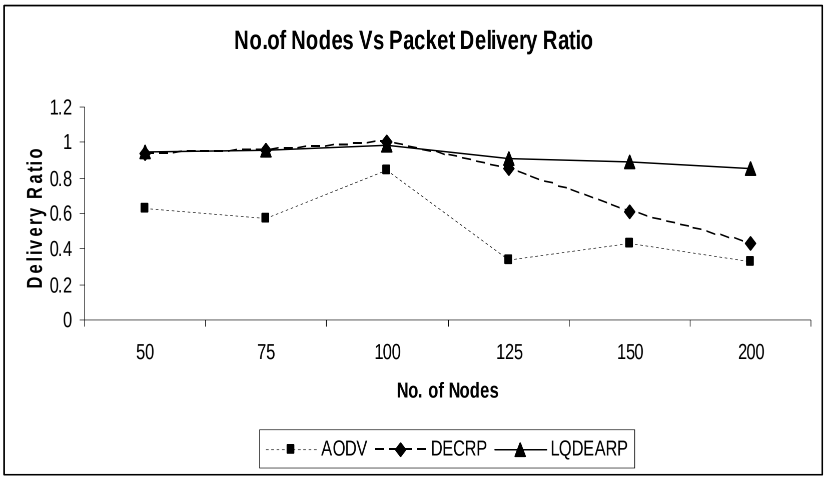

Figure 4: Number of Nodes Vs Packet Delivery Ratio

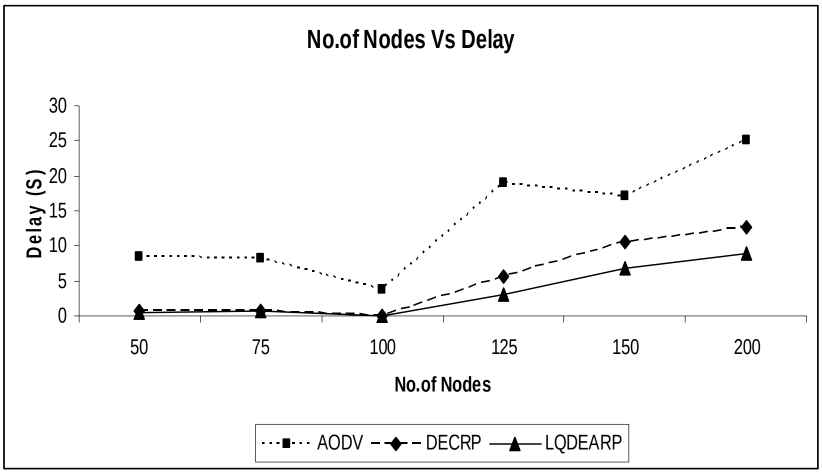

Figure 5: Number of Nodes Vs Delay (sec)

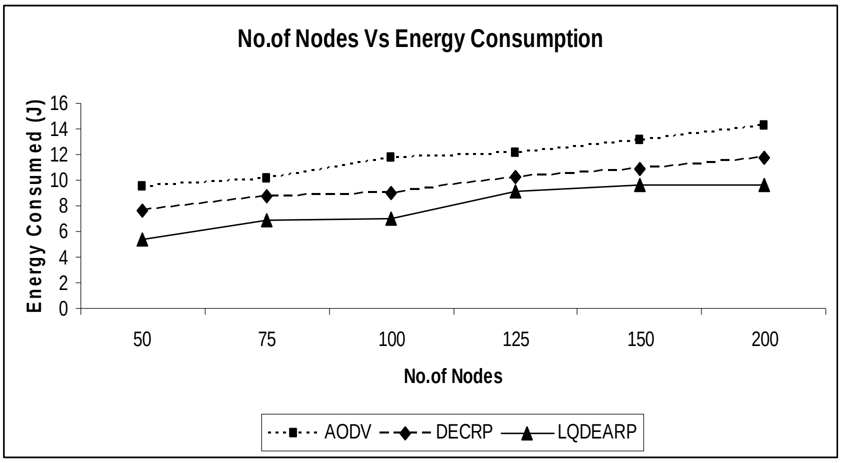

Figure 6: Number of Nodes Vs Total Energy Consumption of Nodes (J)

In fig.3 the number overhead packets in plotted in x-axis and y-axis shows the no. of nodes ranging from 50-200. I can be clearly seen that overhead packets get reduced in LQDEARP than DECRP & AODV.

In fig.4 the delivering ratio of the simulated protocols is shown. From fig.4 delivery ratio of packets increased in LQDEARP than DECRP & ADOV.

In fig.5, it is proved that the delay is reduced in LQDEARP than DECRP & AODV.

In fig.6 it can be observed that total energy consumption of nodes reduced in the proposed protocol LQDEARP than DECRP & AODV.

6. RESULT TABLES

No.of Nodes Vs Overhead

No.of Nodes	AODV (Packets)	DECRP (Packets)	LQDEARP (Packets)
50	5478	2345	1197
75	5743	2345	1190
100	5861	2345	1181
125	5357	2086	1847
150	4924	1766	1500
200	4392	1503	1345

No.of Nodes Vs Packet Delivery Ratio

No.of Nodes	AODV	DECRP	LQDEARP
50	0.628903	0.933902	0.95
75	0.570892	0.956077	0.96
100	0.845248	1	0.98
125	0.340727	0.856716	0.91
150	0.435932	0.607249	0.89
200	0.328503	0.426785	0.85

No.of Nodes Vs Delay

No.of Nodes	AODV (Seconds)	DECRP (Seconds)	LQDEARP (Seconds)
50	8.493277	0.653378	0.543957
75	8.185072	0.80231	0.6539056
100	3.756587	0.014944	0.03756
125	19.07075	5.689394	2.956673
150	17.18173	10.50514	6.873264
200	25	12.75396	8.906532

No.of Nodes Vs Total Energy Consumption

No.of Nodes	AODV (Joules)	DECRP (Joules)	LQDEARP (Joules)
50	9.493277	7.653378	5.385663
75	10.18507	8.80231	6.934562
100	11.75659	9.014944	6.983672
125	12.07075	10.18939	9.073456
150	13.18173	10.90514	9.673416
200	14.26924	11.75396	9.623474

7. CONCLUSION

This paper presented a link quality, delay and energy aware routing approach based on adaptive node stability. An adaptive node stability mathematical modeling is proposed. Based on the estimated link quality, delay and residual energy of the nearby nodes LQDEARP finds the efficient node and sends the data packets through that node.

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