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Energy Aware and Adaptive Cross Layer Routing Protocol (EACLRP) for MANETs

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ABSTRACT: MANET stands for Mobile Ad-hoc networks which are temporary networks formed without a fixed central base station such as an access point. It establishes instantaneous communication infrastructures for civilian and military applications. However due to mobility of the nodes in these types of network, there occurs frequent link breaks and quick exhaustion of battery power. This calls for additional route reconstruction and thus an increase in routing overhead. Also interference from other mobile hosts leads to reduced performance of network. This paper presents a novel scheme, Energy aware and Adaptive Cross Layer Routing Protocol, EACLRP which is aimed at prolonging the network lifetime and to efficiently route the packets across the network. It makes use of cross layering approach to improve network parameters such as throughput, packet delivery ratio and end-to-end delay of the network. The protocol is simulated using Network Simulator-2.

KEYWORDS: MANET, signal strength, residual energy, signal-to-noise ratio, cross layer, interference.

I.INTRODUCTION

Mobile ad hoc networks are decentralized type of networks without any aid of a pre-existing infrastructure. They are becoming popular because of its low cost of implementation and rapid deployment. They are also called as infrastructure-less networks. The nodes in a MANET are the senders as well as routers of data. Such networks are easily deployable without intervention from a main server or access point. In such a scenario, routing protocols are crucial. There are mainly two sections of routing protocols which are Proactive routing protocols [1] and Reactive routing protocols [1]. Proactive routing protocols create a routing table to all possible destinations in the network beforehand. This consumes a lot of bandwidth for periodic advertisements and for sharing link failure statuses. Whereas in reactive or on-demand routing protocols, routes are established only on demand that is whenever a route is actually needed. This saves on bandwidth with the cost of an initial latency. An example of proactive routing protocol is Destination Sequenced Distance Vector (DSDV) [1] and that of reactive routing protocol is Ad hoc On Demand Distance Vector (AODV) routing protocol [1].

Link breaks in a mobile ad hoc network can mainly happen due to the following reasons. One of the reasons is that the nodes are not aware of its own energy level. So the low energy nodes also participate in routing and may die out in between a data transfer leading to link breaks. Another reason is the mobility of the nodes. They are free to move at any time and to any distance which results in disruption of an already established path. Congestion in the network is yet another reason. Link stability is a measure of how stable the link is [3]. Stability based routing protocols [2] tends to select paths that will last longer. Additional overhead is incurred in establishing a new route. Most of the routing protocols establish an alternate path after a link failure. In this work, a novel "make-before-break" mechanism is proposed, to enhance the route maintenance procedure. This adaptive mechanism finds an alternate route for transferring the data, when there appears any chance for link failure due to mobility [3], energy drain and congestion, through cross layer approach.

When traffic increases, there is considerable amount of noise and interference from other mobile hosts. There could be many packets that reach a particular destination at the same time resulting in interference or collision among the desired packet and the noisy ones leading to packet loss. This affects the throughput and packet delivery ratio of the network. Noise gets mixed up with desired signals [4] and can be interpreted falsely as a signal which may lead to several undesired consequences. It is essential that such noise and interferences be separated from actual signal and make the communication system more efficient. Therefore, the paper takes into account the interference issues from other ongoing transmissions in order to further improve performance metrics.

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II.CROSS LAYER DESIGN

With the development in wireless communication and networking, researchers are focussing on improving the performance of the layered architecture. It is repeatedly argued [6] that although layered architectures have served well for wired networks, they are not suitable for wireless networks. Researchers have come up with a proposal which they call as the cross-layer design approach. Thus, there have been a lot of cross-layer design proposals recently. A cross-layer design refers to designing of protocols by utilizing the linkage or inter-relationship between the protocol layers. This aids in achieving performance gains. This is unlike layering [5], where the protocols at the different layers are designed independently.A cross layer design establishes interdependencies among layers thus attaining cooperation between them. In cross layering, protocols use the state information [6] flowing throughout the stack to adapt their behavior accordingly. Data or parameters from a layer can be shared between layers which are nonadjacent in contrast to traditional layered architecture leading to faster performance gains and QoS improvements. For instance, battery power, signal strength, speed are some of the physical layer parameters. Using a cross layer design, this information can be passed on to higher layers for taking an efficient routing decision. Using the cross layer approach, protocols belonging to different layers can cooperate and operate by sharing the network information while still preserving the distinction between the layers in protocol design.

III.LITERATURE SURVEY

Literature survey shows the changes that have been done with routing protocols to achieve performance gains. Prime importance is given to modifications to AODV protocol since it is considered efficient due to its less bandwidth consumption and on-demand behaviour. Researchers have worked on cross layer optimizations for faster network performance and reduced network overhead.

In [7], authors have proposed the protocol EBL (A Routing Protocol for Extend network life time through the Residual Battery and Link Stability in MANET) which could reduce energy consumption in MANET by considering the parameters residual battery capacity, distance between nodes and link stability. A threshold is set up for these parameters and is included in the route request (RREQ) packet for broadcasting to its neighbors. The receiving node would compare its own battery capacity, signal strength and distance to its neighbor with the threshold to determine whether the node can participate in routing. In Signal Stability Adaptive Routing (SSA), links are classified as strong and weak depending up on the received signal strength when packets are forwarded through them [7].

In [8], a cross layer approach is proposed by the authors to select a stable route based on the node's current energy. The protocol called as SQ-AODV also proposes a make-before-break strategy in order to find an alternate route before the link break.

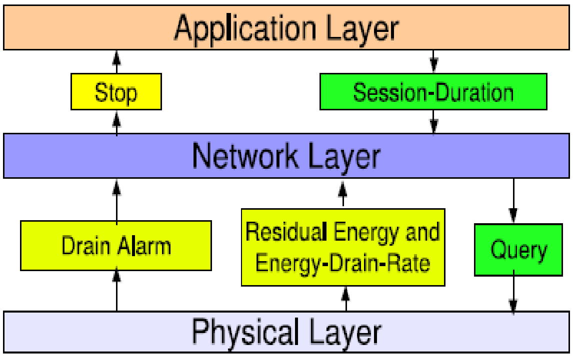

Fig. 1 Cross Layer Architecture in SQ-AODV [8]

In figure 1, the cross-layer architecture used in SQ-AODV is shown. The parameters cross layered are drain alarm which is used to indicate if the node is in a critical battery situation, residual energy and energy-drain rate. Also queries are used to obtain information from application layer such as session duration which are used in network layer for effective routing. It is possible to obtain significant advancement in QoS in terms of packet delivery ratio and packet delay by the selection of energy aware nodes. Also, the adaptive make-before- break mechanism helps to establish alternate routes before actual link failure thus avoiding packet drop. This results in increased packet delivery rate and

major QoS improvement which in turn provides minimum energy consumption without compromising on end-to-end delay performance [8].
Route Discovery by Cross Layer Routing Protocol [9] (RDCLRP) is introduced by the authors taking into account, the following objectives:

- Minimize delay in route searching [9]
- Minimize communication overhead
- Minimize battery consumption
- Local repair
- Maximize packet delivery rate
- Mobility

RDCLRP [9] makes use of adaptive Hello Warning Messages (HWM) to warn the nodes before a link break. This is accomplished by keeping track of position of node as well as the battery power of nodes, thus a cross layer approach is used to share the parameters from physical layer to be used in network layer. Using fuzzy rules, a Hello Interval (HI) [9] is set up during which HWM messages are sent by the critical node, which is the node that is either exhausted of energy or is changing its position. When the traffic or node density increases, performance of RDCLRP is found to fall.

From the reviews it is clear that modifications need to be done to route discovery and route maintenance phases of routing protocols. The use of cross layer design is also crucial for performance gains. The following section describes the EACLRP protocol which is a modification of the Ad hoc On Demand Distance Vector (AODV) routing protocol in order to improve the network connectivity and thus prolong the network lifetime.

IV.PROPOSED SOLUTION

The paper concentrates on two scenarios: low traffic and high traffic case. This is due to the fact that under low traffic conditions, noise and interference are negligible and can be ignored. But they are inherent in the case of high traffic. These undesired signals play a key role and need to be considered seriously failing to which will degrade the system performance such as throughput and packet delivery ratio. The proposed protocol, EACLRP incorporates a cross layer approach through sharing of parameters viz. signal strength/signal-to-interference and noise-ratio (SINR), remaining energy of node or the residual battery capacity and queue length from the physical layer to be used in the network layer for efficient and robust routing decision. Fields to include the threshold values of these parameters need to be present in the Route Request and Route Reply messages which are sent during the route discovery and route maintenance phases of the protocol respectively. EACLRP is obtained by making enhancements to the basic AODV protocol.

Parameters cross layered between physical and network layer for low traffic is:
(i) Received signal strength (SS)
(ii) Residual battery capacity (RES_B) and
(iii) Interface queue length (IFQ).

Parameters cross layered between physical and network layer for high traffic is:
(i) SINR (Signal-to-Interference-and-Noise-Ratio)
(ii) Residual battery capacity and
(iii) Interface queue length.

SINR is calculated using the formula:

$$\text{SINR} = \frac{\text{Received signal power}}{\text{Interference power + Noise power}}$$

Proposed protocol considered refinement to AODV instead of DSR (Dynamic Source Routing) protocol (which is also a reactive protocol) is that DSR usessource routing where the entire route is a part of the header. So when extra fields are inserted, the packet header gets extended which then lead to added overhead. This may diminish the performance of the network even more.

A) ROUTE DISCOVERY

Route discovery process starts when a node is required to forward a packet to a particular destination. It searches for any available path in its route cache or table. Threshold values for signal strength/SINR denoted by SINRT/SST, residual battery capacity RES_BT and Interface Queue Length IFQT are calculated and stored beforehand.

Algorithm
Input: A route request RREQ packet P from a neighbor node.

```
1. Start
2. At physical layer, calculate SINR/SS, RES_B and IFQ.
3. Using cross layer design, pass SINR/SS, RES_B and IFQ parameters to network layer.
4. Include the parameters as fields of RREQ packet P.
5. If SINR/SS <SINRT/SST and RES_B<RES_BT and IFQ <IFQT, then drop RREQ packet P.
6. If SINR/SS>= SINRT/SST and RES_B>=RES_BT and IFQ>=IFQT, then forward/send RREP packet.
7. Stop
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B) ROUTE MAINTENANCE

If an intermediate node is in the critical battery state or receiving weaker signal packets, then it will create an **Alert message** and broadcast it to its neighbours. This is done to determine an alternate route before the link break, otherwise would lead to additional packet drops. Neighbours on receiving the Alert packet, check for a route in its cache for the destination defined in the Alert packet. If route is available, then it returns the route to the downstream node of the node broadcasting the Alert packet. The downstream node on receiving the route, update its routing table. The data packets are routed in the new route, preventing the packet drops due to link break. If the destination node is with a critical battery situation, then it will send the stop traffic intimation to the source node, to avoid future packet drops and wastage of resources.

Algorithm
Input: A packet P from a neighbouring node

```
1. Start
2. Execute periodically
3. If intermediate node and if SS<SST and RES_B<RES_BT, then send Alert message to 1 hop neighbours
4. If destination node, send stop traffic intimation to source node.
5. Establish alternate route
6. Stop
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V. RESULT AND DISCUSSION

In order to examine the performance gains achieved by EACLRP, it is compared with the normal AODV protocol. The protocols are simulated using Network Simulator, NS-2. Results are categorized into low traffic and high traffic scenarios. First, consider the low traffic scenario.

Table 1 Simulation parameters for low traffic scenario

Parameter Name	**Value**
Topology	500mx500m
Number of nodes	25
Transmission range	250m
Simulation time	150sec

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Number of flows	3
Traffic type	CBR
Battery Threshold	40%
Interface Queue Length	50

Table 1 shows the parameters considered for simulating low traffic case using 25 nodes with three data flows or traffic. Traffic type is Constant Bit Rate (CBR) and the threshold battery capacity is set as 40%. Queue length and transmission range set to 50 and 250 metres respectively. Only if an intermediate node has a capacity greater than these threshold capacities, then only it can participate in routing.

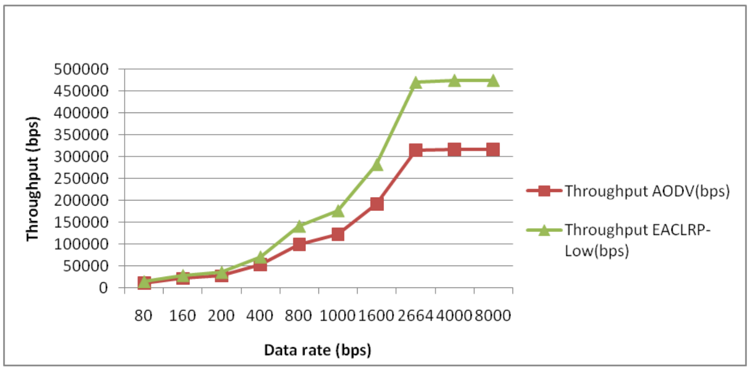

Fig. 2 Data rate Vs Throughput for AODV and EACLRP under low traffic

Figure 2 shows the comparative plot between normal AODV and modified AODV (EACLRP) for throughput versus data rate in low traffic case. EACLRP could increase the throughput by 31.78% with respect to AODV. This rise can be credited due to the efficient utilization of node resources as well as link quality during route discovery which leads to more number of packets reaching the destination.

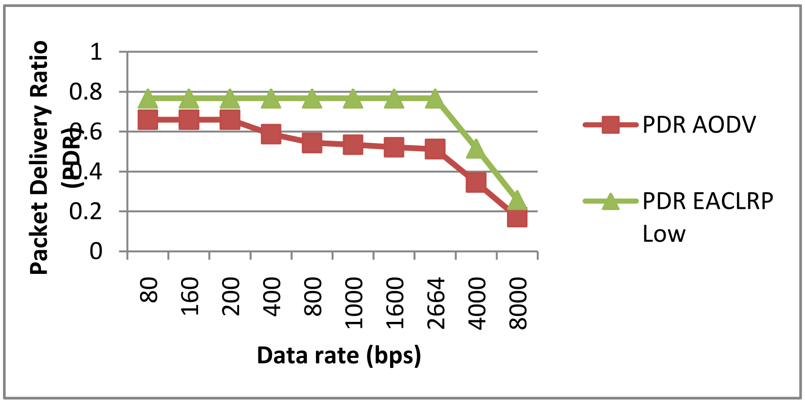

Fig. 3 Data rate Vs PDR for AODV and EACLRP under low traffic

Figure 3 shows the plot of data rate versus Packet Delivery Ratio (PDR) for AODV and EACLRP under low traffic case. PDR of EACLRP is 24.76% greater compared to AODV. After some high data rate, PDR of EACLRP is found to decline. This is because increasing data rate of flows increases traffic in the network. When the data rate reaches the maximum level that could be handled by each node, queues get filled and incoming packets get dropped. This reduces PDR.

Now when the traffic increases, there is interference from other mobile hosts. So SINR parameter is cross-layered for improving the efficiency of EACLRP protocol under highly congested scenario. Consider the high traffic case with 100 nodes with three data flows initially.

Table 2 Parameters for simulating high traffic

Parameter Name	**Value**
Topology	500mx500m
Number of nodes	100
Transmission range	250m
Simulation time	150sec
Number of flows	3
Traffic type	CBR
Packet size	512 bytes
Battery Threshold	40%
Interface Queue Length	50

Table 2 shows the parameters used for simulating high traffic in NS2. Here the number of nodes is set to 100 with 3 data flows. The rest of thresholds set for battery capacity, signal strength and interface queue length are as given in the table.

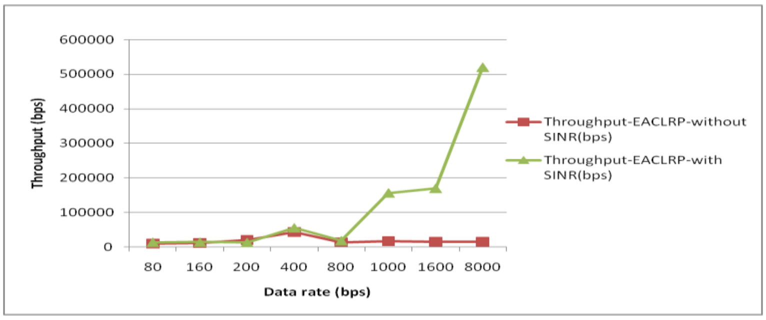

Fig. 4 Throughput Vs Data rate with and without using SINR

Figure 4 shows the plot of throughput in high traffic scenario with and without considering the effects of noise and interference. It is very evident from the graph that throughput is increasing when SINR parameter is used. There is an increase of 84.87% in throughput when SINR is incorporated for routing. But as the data rate increases, number of packets sent to destination also increases which leads to additional collisions resulting in a noisy network. However, through the use of interference metric, we could increase the throughput of the network whereas it does not increase to the requisite amount in the other case, that is, without using interference metric.

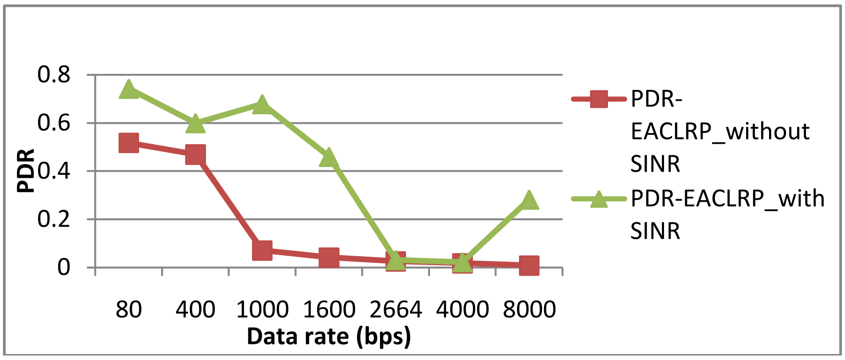

Fig. 5 PDR VS Data Rate with and without using SINR

From figure 5, it can be seen that by introducing SINR parameter, there is an increase of 59.29% in PDR when compared to PDR without using SINR. Then there is a gradual decline in PDR with the data rate in the graph which shows that as number of packets sent to the destination increases, it leads to slight congestion in the network leading to a dip in PDR curve, whereas in the case with no SINR parameter, PDR variation is very sharp. It drops very abruptly due to collision and interference from other mobile transmissions leading to more packet loss and subsequent reduction in PDR.

VI.CONCLUSION

Keeping the energy conservation and network connectivity in mind, Ad-hoc On demand Distance Vector (AODV) routing is modified to obtain Energy Aware and Adaptive Cross Layer Routing Protocol (EACLRP).Cross layer solution is emerging as a new trend which helps in sharing the information and resources between layers and at the same time does not add any control overhead. Under high traffic conditions, performance of EACLRP is maintained by incorporating SINR parameter. The proposed protocol is found to increase throughput and packet delivery ratio of the network.

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BIOGRAPHY

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