CROSS-LAYER APPROACH FOR REAL TIME COMMUNICATION IN MANET

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Abstract: We consider a cross-layer design of mobile ad-hoc networks. Traditional networking approaches uses and optimize separately each of the three layers: physical layer, medium access and network layer. This may lead to largely suboptimal network designs. In this work, we propose a jointly optimal design of the three layers, and we show a significant performance improvement over the traditional approach. Limited battery power, other resource constraints and mobility of nodes make QoS provisioning difficult to achieve in MANET. This paper proposes a novel algorithm that uses cross layer parameters to select an optimum route on the basis of received SNR value, low delay and long route lifetime. The key components of our approach include a cross-layer design (CLD) to improve information sharing between different protocol layers. In this work, we modify the Ad hoc On-demand Distance Vector (AODV) routing protocol to avoid routing through bad quality links.

Keywords: - Cross Layer Design (CLD), MANET, QoS, routing protocol, SNR

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1. Introduction

Mobile ad hoc networks (MANETs) are autonomously self-organized networks without infrastructure support. In a mobile ad hoc network, nodes move arbitrarily; therefore the network may experience rapid and unpredictable topology changes. Because nodes in a MANET normally have limited transmission ranges, some nodes cannot communicate directly with each other. Hence, routing paths in mobile ad hoc networks potentially contain multiple hops, and every node in mobile ad hoc networks has the responsibility to act as a router**.**

Most of the existing ad hoc routing protocols optimize hop count when making a route selection. Significant examples are Ad hoc On Demand Distance Vector (AODV) [1], Dynamic Source Routing (DSR) [2], and Destination Sequenced Distance Vector (DSDV). As shown in fig.1, Traditional protocol architecture follows strict layering principles, which ensure interoperability, fast deployment, and efficient implementations. However, lack of coordination between layers limits the performance of such architectures due to the specific challenges posed by wireless nature of the transmission links. To overcome such limitations, cross-layer design has been proposed. Its core idea is to maintain the functionalities associated to the original layers but to allow coordination, interaction and joint optimization of protocols crossing different layers in order to allow non-adjacent layers to communicate directly to improve the overall network performances as shown in fig.2.

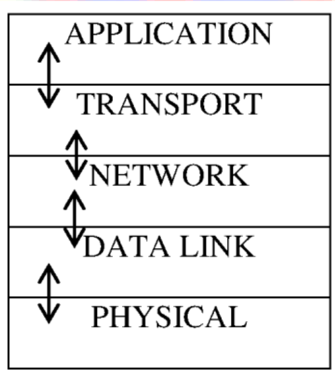

Fig.1: Traditional approach-information exchange

This paper presents a new reliable ad hoc routing protocol, which is essentially a succession of on-demand and link-weight routing protocols. The protocol is able to provide a reliable route with the assurance of SNR, low delay and longer route lifetime. It helps to find a more appropriate path that is able to guarantee the QoS requirements during the whole connection.

The remainder of the paper is organized as follows. Section 2 describes related work. Section 3 focus on the background, section 4 provides the working of the proposed protocol. Finally section 5 concludes the paper.

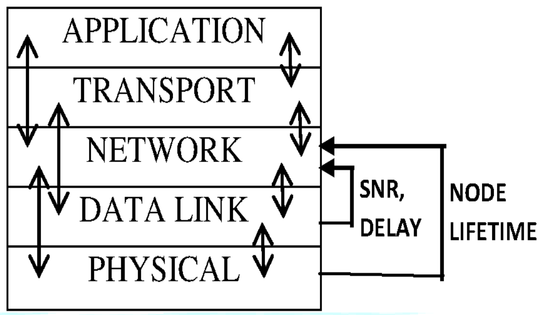

Fig.2: Cross layer approach-information exchange

2. Related Work

There are several approaches for QoS routing protocols based on on-demand principles of route discovery. Many proposals and models addressed Cross-Layer Design (CLD) for communication among mobile nodes of the wireless networks and considered the link quality in their designs and architectures.

Fuad Alnajjar et al., proposed a protocol that was an extension to DSR protocol that uses either SNR (Signal to Noise Ratio) or RP (Received Power) to determine route [2]. Accounting only for SNR can't provide bandwidth and delay guarantees required by multimedia applications. Rekha Patil and A.damodarm [3] proposed a cost based power aware cross layer routing protocol which deals with calculating cost based on battery capacity only. Al-Khwildi et al., proposed Adaptive Link-Weight Routing Protocol using Cross-Layer Communication for MANET which adaptively selects an optimum route on the basis of available bandwidth, low delay and long route lifetime. It provides advantage over AODV only in terms of network load and route discovery time [4]. In [5] author proposed quality of service provisioning in MANET using a cross-layer approach for routing, a novel MANET routing protocol, Type of Service, Power and Bandwidth Aware AODV (TSPBA-AODV), which overcomes resource constraints and simultaneously provides QoS guarantees using a cross-layer approach, is proposed in this paper. In [6], this paper presents a solution to only energy conservation by a cross layered approach. In

[7] the author again proposed a CLD that uses only SNR or RP as parameter over AODV protocol.

3. Background

AODV is Ad-hoc On Demand Distance Vector Routing protocol. It is purely On-Demand routing protocol where each mobile host operates as a specialized router, and routes are obtained as needed (i.e., on-demand) with little or no reliance on periodic advertisements. The route discovery and route maintenance is done by four messages in AODV. These messages are Route Request (RREQ) and Route Reply (RREP), Route Error (RERR) and HELLO messages. Route Request (RREQ) and Route Reply (RREP) messages are used for route discovery. Route Error (RERR) messages and HELLO messages are used for route maintenance.

When a node wishes to send a packet to some destination, it checks its routing table to determine if it has a current route to a destination. If yes, it forwards the packet to the next hop node and if no, then it initiates a route discovery process which begins with the creation of Route Request (RREQ) packet. The packet contains– source node's IP address, source node's current sequence number, destination IP address, destination sequence number. The Packet also contains broadcast Id number which is incremented whenever the source issues a new RREQ. Each neighbor either satisfies the RREQ by sending a route reply (RREP) back to the source (reverse path setup), or rebroadcast the RREQ to its own neighbors after increasing the hop count. Since an intermediate node could have many reverse routes, it always picks the route with the smallest hop count.

Each node periodically sends HELLO messages to its precursors. If a node has received no messages from some outgoing node for some fixed period of time then that node is presumed to be no longer reachable. Whenever a node determines one of its next-hop to be unreachable, it generates a Route Error (RERR) message. The node sends the RERR to each of its precursors. These precursors update their routing tables and in turn forward the RERR to their precursors and so on.

4. Proposed Protocol

The proposed protocol is an extension to AODV protocol which uses a cross layer approach to improve performance of the traditional AODV protocol.

4.1 Packets Format

The proposed routing protocol finds the best route with QoS assurance by using two control packets: Route Request packet (RREQ) and Route Reply packet (RREP) respectively.

The RREQ packet consists of the following Fields: source ID, Intermediate ID, Destination ID, Received SNR, Link Weight which mainly based on three QoS factors (SNR, Delay, Node lifetime) and Request ID. The source node fills the field value in the RREQ packet and broadcast it to the neighboring nodes. When an intermediate node received the RREQ packet, it compares among all other RREQ received from the neighboring nodes, and records the link weight information of the route that meets the best worst SNR, and has low accumulated delay and long route lifetime. In a similar fashion, the RREQ packet are updated at every intermediate node and re-broadcasted to its neighboring nodes till it reaches the destination. Every intermediate node has the best optimum route parameters which is unicasted back in a RREP packet along with the source ID and Destination ID. The RERR packet is same without any change as used in traditional AODV protocol.

3.2 Route Parameters

In order to select an optimum path this protocol uses three parameters:
received SNR value, delay and node lifetime.

Signal to Noise Ratio (SNR):-

The proposed model assumes that, during the route discovery process, each node has the channel side information available in terms of received SNR in that packet transmission. While a node receives the route request, it also has the information of the SNR. If the node takes part in the route reply process, then it stores the SNR value in the buffer. A similar approach was also proposed in [2] for DSR protocol. SNR is defined as the ratio of signal power to the noise power. A ratio higher than 1:1 indicates more signal than noise.

$$SNR = (P_{signal} \div P_{noise})$$

In decibels, the SNR is defined as

$$SNR_{dB} = 10\log_{10}(P_{signal} \div P_{noise}) = P_{signal,dB} - P_{noise,dB}$$

The neighbor nodes of source (and so on) receive route request packet. It also has the information on the received SNR of the packet during reception. If the node itself is the destination, it puts the received SNR value in the route reply packet. If the node is to rebroadcast the route request to its neighbors, it stores the SNR value in its buffer for future use. If the node is neither the destination, nor is to rebroadcast the route request, it discards the received SNR value. With the relay method, the route request reaches the Destination. In the reverse path transmission of route reply, each pair of nodes compares the SNR values ‘stored in the buffer’ and ‘received via route reply’. Only the smaller value of the two is stored in the next route reply reverse path. The process continues till reaching back to source node.

Delay:- The end-to-end packet delay is calculated as the time interval when the packet is sent by the source to the time when it is delivered to the destination node. The link delay is calculated after reception of every RREQ by using the RREQ packet creation time information and reception time.

Node lifetime: - The Node lifetime is an important parameter for route selection and our implementation provides an estimated value of left battery lifetime in each RREQ and is interpreted as shown in Table.

Table: Node lifetime weighting

Left Battery	Up to 100 %	Up to 80%	Up to 60%	Up to 40%	Up to 20%
Node lifetime weight	1	2	3	4	5

3.3 Route discovery

The route discovery begins when a source node wants to have a route to some destination. It then generates the request_id and places its own id, destination id, along with the node’s lifetime, link delay and received SNR in the RREQ packet. The source node then broadcast the RREQ packet. The receiving node on receiving this RREQ packet, update its route table. The table contains node_id, the three parameters and request _id. When processing the received RREQ packet from neighboring nodes, the current node first checks whether its node’s battery is above the threshold value because if the node runs out of battery, the source node would have to find an alternative path to destination again.

Referring to fig.3 and fig.4, node S wants to communicate with node G, node S will broadcast RREQ to look for the destination. The values on the links represent the value of signal to noise ratio of the link and corresponding delay. The intermediate node stores the received

SNR, delay and node lifetime value in its table. At every node nodes' battery should be greater than the threshold value otherwise it sends a RERR message and discards the packet and should find an alternative route to the destination, as in case at node B, where the node's battery is 5 which represents that it is left only with 20% left battery and therefore it should be discarded and should not participate further.

At the destination multiple RREQ messages will arrive and the node G has a list of qualified routes through C and F. When the route request packet arrives at the destination or an intermediate node with a route to the destination, a route reply packet (RREP) will be generated. This RREP packet is then sent back to the source node following the reverse route contained in the route request packet. Each intermediate node will update the SNR value if their link value of SNR is lower than the existing recorded value in the route reply packet. If SNR values of its link are greater than recorded value, the node will not update the value. The process will continue until the route reply packet reach the source node. In this case, the source node receives multiple RREP message and then it selects the route which has best worse SNR value along end to end route and lowest delay.

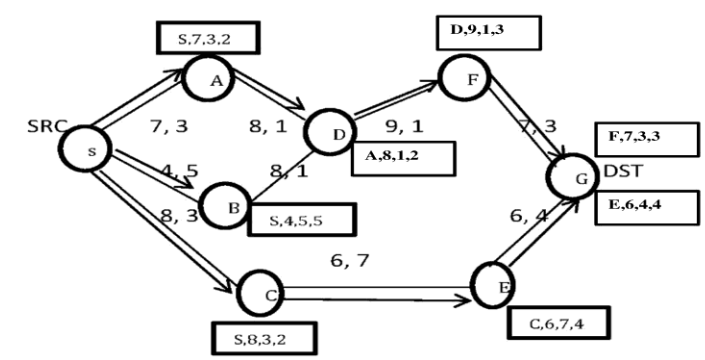

Fig.3: Propagation of RREQ packet

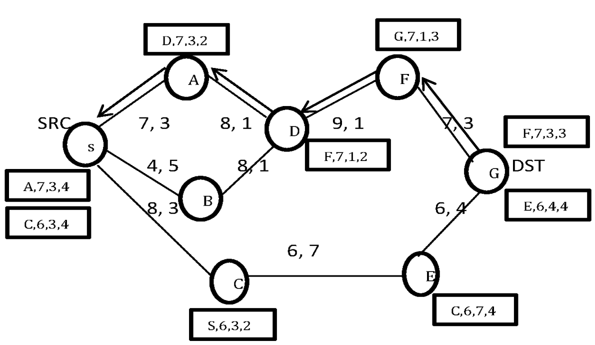

Fig.4: Path taken by RREP packet

Since the proposed algorithm is a succession of AODV protocol and inherently it follows similar mechanism. However in case of proposed algorithm there is support of QoS parameters and an optimum route is selected according to a request.

The route selection is dependent on the selection of link weight parameters and is not fixed as in case of AODV where route is selected based on minimum hop count. In case of failure of primary route, the AODV initiates a rediscovery process which is time consuming while in case of proposed algorithm an alternative route is always available in all nodes from source to destination. The flowchart given in fig.5 explains the proposed algorithm in details.

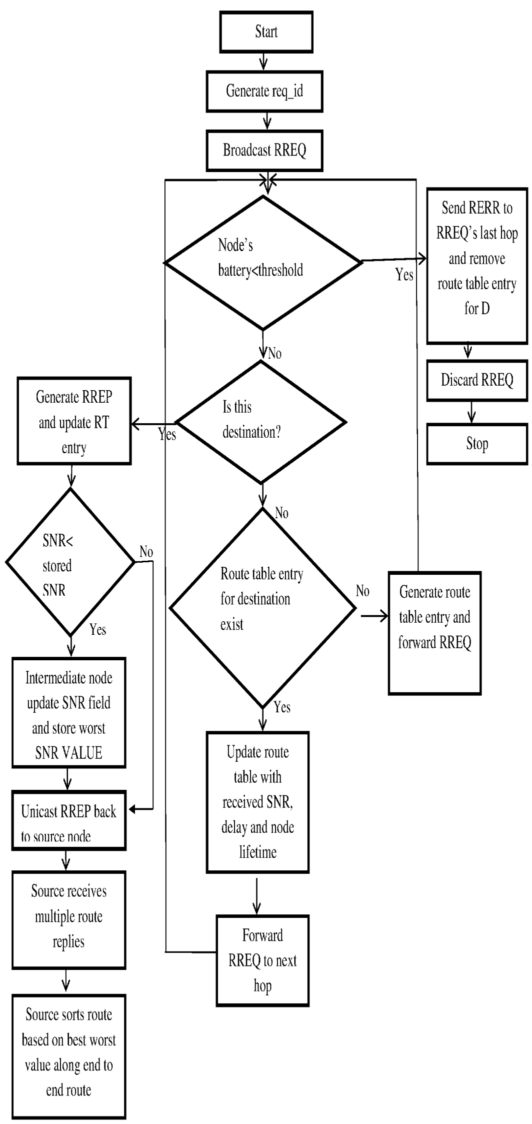

Fig.5: Route discovery and establishment process chart

4. Conclusion

This paper presented an algorithm for routing in MANET which is a succession of AODV protocol. In our future work we will show through simulation that the proposed routing protocol will provides a significant improvement in performance as compared to traditional AODV protocol. It provides flexibility and an optimum path which in turns provides a better improvement in QoS level when compared to the traditional AODV routing protocol. The various QoS parameters include:

1. **Packet delivery ratio:** It is the ratio of the data packets delivered to the destinations to those generated by the sources.
2. **Average end to end delay:** The average end-to-end delay of data packets is the interval between the data packet generation time and the time when the last bit arrives at the destination.
3. **Throughput:** The throughput metric measures how well the network can constantly provide data to the sink. Throughput is the number of packet arriving at the sink in unit time.
4. **Number of Packets dropped:** This is the number of data packets that are not successfully sent to the destination during the transmission. The concept of cross-layer provides a wide field of information exchange between layers. We focused on SNR which is useful information to exchange because a low SNR level impacts throughput on the path. A low SNR level leads to a high bit error rate and consequently to a low link throughput. This protocol uses SNR, delay and node life time information in the calculation of the network metric to choose the link with the best available quality.

5. References

[1] C.E. Perkins, E.M. Royer. (1999), Ad-hoc on-demand distance vector routing, WMCSA 2nd IEEE Workshop, pp. 90-100.

[2] Fuad Alnajjar, Yahao Chen. (2009) ―SNR/RP aware routing algorithm: cross-layer design for Manets, International Journal of Wireless & Mobile Networks (IJWMN), Vol 1, No 2, pp. 127- 136.

[3] Rekha Patil & A.Damodaram. (2008) "Cost Based Power Aware Cross Layer Routing Protocol For Manet", IJCSNS International Journal of Computer Science and Network Security, Vol. 8, No.12, pp. 388-393.

[4] Al-Khwildi, A.N., Khan, S., Loo, K.K., Al-Raweshidy, H.S. (2007) "Adaptive Link-Weight Routing Protocol using Cross-Layer Communication for MANET", WSEAS Transactions on Communications, Vol. 6, Issue. 11, pp. 833-839.

[5] Ruchita Goyal, Divyanshu and Manoj Mishra. (2011), "Quality of service provisioning in Manet using a cross-layer approach for routing", International Journal of Computer Networks & Communications (IJCNC), Vol. 3, No. 3, pp. 81-92.

[6] Vijayan R, Mareeswari V, Samyukta V, (2013), "Enhancing Energy Efficiency of Routing Protocol through Cross Layer Interactions in MANET", International Journal of Engineering and Technology (IJET), Vol. 5, No. 2, pp. 1147-1152.

[7] Muhammed Kamrul Islam, Rong Ke Liu, (2013), "Cross-Layer Optimization of AODV routing protocol for MANET", International Conference on Computer Science and Electronics Engineering (ICCSEE), 2nd Conference ICCSEE, pp. 1834-1837.