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Reliable and Stable Route Construction in Mobile Ad Hoc Networks Using R- Learning Techniques

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***ABSTRACT** :Mobile Ad Hoc Networks (MANETs) are types of wireless network consist of mobile nodes which are communicating each other via wireless radio links without any underlying physical infrastructure. Due to infrastructure less, node mobility, and unreliable radio links, the reliable routing is the most challenging issue in the MANET. In this paper, we proposed novel heuristic approach called Reinforcement Learning (RL) based Reliable Hybrid Multicast Routing (RL-RHMRP) which possesses ability to learn the network context and makes routing decisions in selection of neighbor nodes and route establishment process. RL-RHMRP works based on reliable intermediate node forwarding mechanism and follows Q-Learning (QL) method (one of the RL technique) with On-policy and Model-based features. Reliable Decisive Factor (RDF) is computed based on measured power level, received signal strength, mobility, and link stability of a node. Our scheme chooses the best path from mesh of paths for data transmission by considering computed sum of RDF value for both proactive and reactive MANETs region. Simulation evaluation has been done in NS-2 for various performance parameters like Packet Delivery Ratio, Jitter, End-to-end delay, and Overheads in comparison to the zone based routing protocols such as ZRP (Zone Routing Protocol) and MZRP (Multcast Zone Routing Protocol). It is observed from result and discussions section that RL-RHMRP out performs than ZRP and MZRP.*

***KEYWORDS -** MANETs, Hybrid routing, Reliability decisive factor, Link stability, Zone radius, Q-learning.*

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I. INTRODUCTION

Radio links between the nodes in MANETs are more susceptible and receptive to variations in the channel characteristics compared to links in wired networks [1]. To perform reliable routing among the group members, the routing mechanism for wireless MANETs must ensure that, the route establishment process should have links with higher reliability factor.

There are three classes of routing protocols in the MANETs. (1) A proactive protocol where every node has stored the full path to every possible destination. (2) A reactive routing protocol invokes route establishment procedure when it has data to send. (3) Hybrid routing protocols, which attempt to combine both proactive and reactive approach to overcome the drawbacks of each protocols [2].

Several researchers from last few decades working on conventional way of solving the routing problem at MANETs. In this paper, we emphasize on solving the long last routing problem in more Heuristic manner using reinforcement technique. Our work is more focused on how to apply reinforcement technique (sub class of Machine Learning (ML)) approach to solve the problem in selecting a reliable path in multicast routing for MANETs. Nodes in MANET adopts R-learning approach to learn about their neighbor nodes and make a decision based on the available action policies and Q-values (i.e reliability, energy).

II. RELATED WORKS

The work given in [4] is an extended version of the Q-Routing algorithm, developed using RL (Reinforcement Learning) techniques. Authors introduce new two matrices to estimate link availability and node mobility called GPS-based link availability metric and mobility metric. It employes RL technique of the Q-Routing for critical MANET applications, taking into account mobility, node energy consumption, and link stability. It introduces flooding overhead while selecting neighbor nodes while route establishment process. Authors in [5]uses RL approach of Q-Learning to design an algorithm for performing both call admission control and routing in integrated service networks. however, authors in this paper do not consider battery constraints into account. In \cite{Tao-Tagashira-Fujit:AL}, route problem is considered in terms of route lifetime using a proactive approach, but it does not consider energy dissemination of the nodes and exclude the loop formation problem handling in route maintenance process.

kinematics and selective sweeping (QKS) described in[6] designed to establish and utilize a mobile ad hoc underwater distributed networks. QKS focuses more on RL based routing algorithms, which have the ability to

explore the network environment and adapt routing decisions to the constantly changing topology in underwater networks due to node mobility and energy usage. Authors present a routing algorithm based on Q-learning (one of the RL approaches) with additional Kinematic and Sweeping features. Authors address the potential slow convergence associated with pure RL algorithms.
The work given in [7] is based on the principle of a mamdani fuzzy logic. In DFES-AODV each node uses FLS (Fuzzy Logic System) to decide its Route REQuests (RREQs) forwarding probability. A node implementing an RL-based routing protocol learns either how to adjust some routing parameters or how to make routing decisions (i.e. choosing next-hop or path for routing). In [8], each node learns how to choose its next-hop for routing using stochastic gradient descent RL algorithm. A node decision depends on its neighbors' selfishness and residual energy.

Authors in [10] introduces collaborative reinforcement learning (CRL) as a technique that enables groups of reinforcement learning agents to solve system optimization problems via online in dynamic and decentralized networks. The work given in [11] discusses reward shaping reinforcement learning technique exploration based on prior knowledge of Context sensitive reward shaping for sparse interaction multi agent systems. Future Coordinating Q-learning (FCQ-learning) is used to automatically detect the agents when should take each other into consideration.

III. Preliminaries

R-Learning algorithm
1: Begin:
2: Let S=Xi be the finite state space
3: A(Xi) =Ak finite and non-empty set of actions available before state space ;
4: r:XxA!R, A real-values one step reward function, where r_ r(Xi), Ak is the reward function acquire
by the system as it is in state Xi 2 S and action Ak 2 A(Xi) is chosen
5: The probability P(Xi, Xj, Ak) that in the next time step, the system will be in state Xj 2 S when action
Ak 2 A(Xi) in state Xi 2 S is chosen.
6: END
Algorithm 1 defines a finite set of states (nodes), available actions (pruning/non-pruning), and rewards (stable path) in given time step t. Application of this algorithm for pruning the neighbor nodes having less reliability factor and selecting the stable path with nodes having more reliability factor .

Figure 1: Illustration of R-learning co-relation with routing in MANETs

Figure 1 show the co-relation of RL algorithms to the routing in mobile ad hoc networks. RL algorithms consider transition occurrences tests and gained rewards. In RL, the agent (node) and the environment (neighbor nodes) interact each other at discrete time steps, at time t, the agent observes state X(t) and produces an action A(t); then, it receives the reward (stable path) R(t + 1) and observes the environment to summaries the new state X(t + 1). The agents objective is to learn an optimal policy p and optimize the selective return.

IV. Reliable Neighbor Node Selection

Our scheme employs reliable neighbor node selection mechanism to establish stable multicast routes in MANET based on node reliability factor. The reliable routing in MANETs must ensure that the nodes participating in route establishment process should have stable links. In this section, we present our designed models with inputs, outcomes, and necessary assumptions.

V. MULTICAST ROUTE DISCOVERY

REQUEST PACKET FORMAT

Following section discusses details about route request and reply packet. Request packet details:

SNAddress: It is address of the source from where the path need to be established to the multicast destinations.

MGAddress: It is multicast group address where destinations are present as group members.

Hopcount: It is the maximum integer value set by source node and its value decrease by one after visiting each node. It is used to discard the packet when HC reaches zero and inform the same to its source node.

ZID: It is the id of an zone from where packet is originated.

rZoneList: It is contains IDs of zones that this packet has passed through.

FlagID: Is the packet identifier, flag value is set to 1 to recognize RQ packet.

SeqNo: Is the integer number set at source node to receive packet in a sequence manner to avoid duplication of request packet at intermediate nodes.

RFmin: It is minimum link quality between two neighbor nodes and it should be higher than threshold value and this field get update when reliability factor less then threshold value. It defines the minimum value of RDF for a path.

VisitedInfo: It stores address of all previously visited nodes by RQ packet from source to destinations.

Timestamp: The waiting time of nodes set at source; if next hop was not found then node will wait for given time stamp value.

REPLY PACKET DETAILS

SNAddress: It is the address of the source from where the path need to be established to the multicast destinations.

DestAddress: is identifies the destination node address where RP packet originated.

MGAddresses: is the multicast group address where destinations are present as group members.

Hopcount: is the maximum integer value set by source node and its value decrease by one after visiting each node. It is used to discard the packet when HC reaches zero and inform the same to its source node.

ZID: It is the id of an zone from where packet is originated.

rZoneList: It contains IDs of zones that this packet has passed through. FlagID is the packet identifier flag value is set to 0 to recognize reply packet.

Seqno: Is the packet identification number set at source node to receive packet in a sequence manner to avoid duplication of request packet at intermediate nodes.

RFmin: It is the final value of a path brought by RQ packet at destination. For RP packet, this value is unchanged until it is delivered to the source.

ViitedNodeInfo: Is same as in RQ, the sequence of addresses stored in this field are utilized by RP packet to route it to the source from destination node. The route traced is through the sequence of addresses starting from tail end address to front address.

TimeStamp:It is the waiting time of nodes set at source; if next hop was not found then node will wait for given time stamp value.

VI. Simulation

We used NS-2 to evaluate our proposed RL-RHMRP scheme. A discrete event simulation is done to test operation effectiveness of the scheme. In this section we describe the simulation model and simulation The MANETs consisting of n nodes is planned and implemented using network simulator with other parameters based on which the network is framed. Each simulation is run for 300s, and during this time, the mobile nodes are moved in accordance with the random way-point model. When the node reaches its destination, it is immediately moved to another destination. The average velocities of the nodes are 5, 10, 15, 20 and 25 m/s, as specified in accordance with a normal distribution. IEEE 802.11 is the wireless network specification used as the MAC and physical layer protocol. The simulator is applied for proposed RL-RHMRP and results are obtained for assessment and draw the graph using obtained data in separate tool.

In simulation, the time interval of beacon transmissions is chosen to be 1s. We simulate 30 CBR traffic flows, originated by randomly selected sending nodes. Each CBR flow sends data at 1Kbps using 64 byte packets. We used two-ray-ground propagation model. Each nodes transmission range can vary from 0 to Rmax. Network area i.e length and breadth (l and b) set to 1000m x 1000m. The power consumed by each transmission is 3mW for omnidirectional transmission of the maximum 250m range and lower for shorter transmit ranges and 2mW for reception of the packets within the transmission range.

SIMULATION PROCEDURE

To illustrate results of the simulation, we have taken n=125, l=1000m, b=1000m, Ei=1000J, Tx Power=3mW, Rx Power=2mW. Simulation procedure for the proposed scheme is as follows.

(1) Generate ad hoc network in the given area by random nodes placement method. Each node maintains a database to store the information as specified in the scheme.

(2) Based on the value of zone radius find internal nodes and peripheral nodes of each nodes zone.

(3) Generate application connection requests by randomly selecting source destination pairs.

(4) Compute power level and reliability factor for pair of neighbor nodes (one hop).

(5) Compute Reliability Decisive Factor (RDF) based on power, mobility, and signal strength model.

(6) Generate the multicast group members among the placed nodes. Use RQ and RP packet to establish multicast route.

(7) Generate the packets for transmission from group members using MAC and channel model.

(8) Determine performance parameters for the scheme.

The following performance metrics are used for evaluating the proposed RL-RHMRP scheme.

(i) Packet delivery ratio: It is defined as the ratio of a number of packets received by a group member to the number of packets transmitted by a group member (point-to-point).

(ii) End-to-end delay: It is time taken by the source node to communicate among its neighbors by sending packet from the source to multicast destination across the network.

(iii) Jitter: Time variation between packets arriving caused by network congestion, route changes, or timing drift is called Jitter.

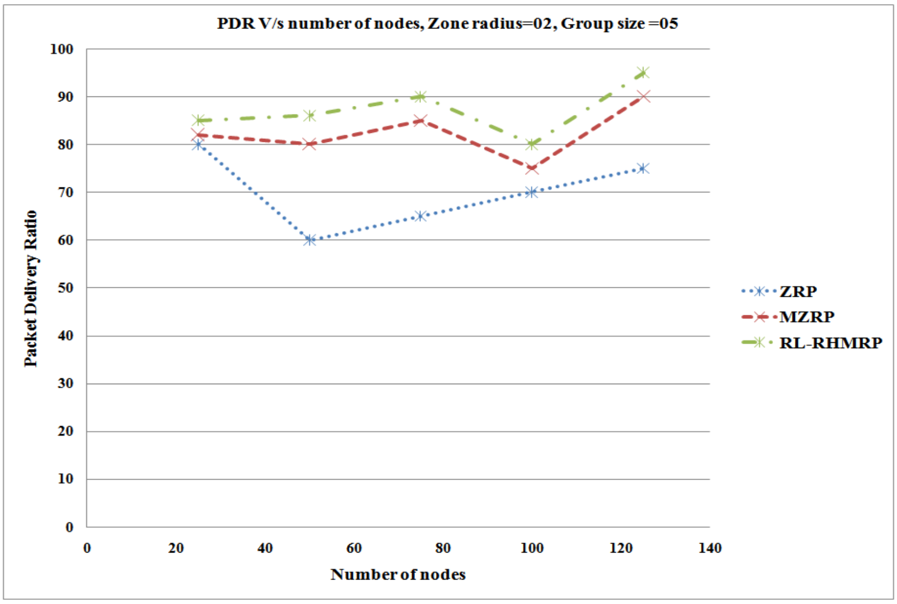

Figure 6.1: Packet delivery ratio Vs number of nodes at zone radius 2hop, Group size=05

From figure 6.1 it shows that, when network density is less i.e for 25 nodes number of packets received are more as compared at high network density. This is because of number of nodes increase, number of overlapping zones increases, thus query messages also increases some extent it is less in case of RL-RHMRP as it reduces the route acquisition delay. For reactive region PDR gradually increases because of reduced overheads due to on demand routing establishment process. The RL-RHMRP have higher throughput when compared to ZRP and MZRP. At RL-RHMRP number of nodes have low transmission rates but more than ZRP and MZRP.

In our simulation, time constraint is 100 sec, the power drained for transmission is 3mWatt, and reception is 2mWatt. Total number of packets and total numbers of bytes at the destination received within this simulation time are reduced for ZRP and MZRP due to increased delay but this is overcome in case of RL-RHMRP. For higher zone radius higher in the number of nodes and which leads larger flooding and hence packet delivery ration is reduced for both ZRP and MZRP. As RL-RHMRP follows selective border casting method, packet delivery ration of RL-RHMRP is high when zone radius is high compared to ZRP and MZRP.

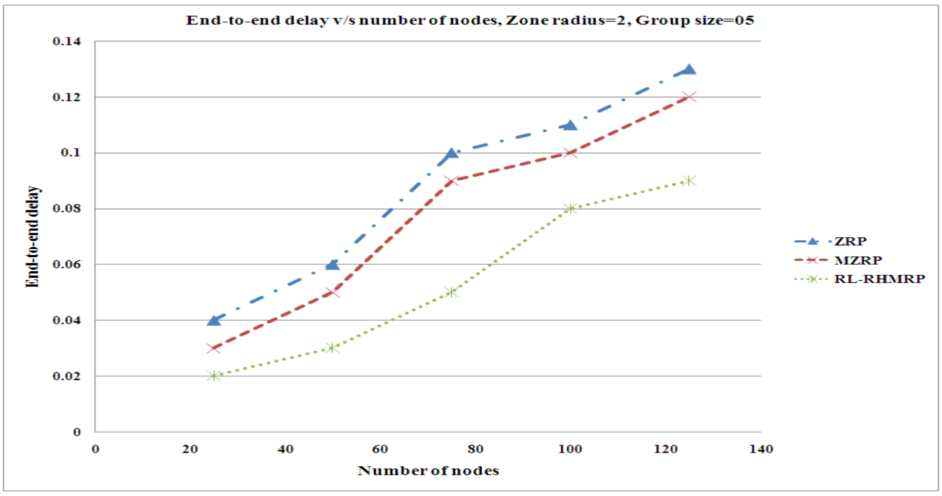

Figure 6.2: Average end-to-delay (in ms) Vs number of nodes at zone radius 2hop, Group size=05

Figure 6.2 shows the end-to-end delay for RL-RHMRP in comparison with ZRP and MZRP against the total number of nodes for a given transmitted power. The increasing of total number of nodes in network means that both the node density and rate of route discovery in each zone increase. The end-to- end delay for ZRP, MZRP and RL-RHMRP for with zone radius 2 shown in figure 8. As density of network increases (i.e number of nodes increases or for higher zone radius) route discovery becomes more complex, because centralized node routing zones will highly overlap with each other, hence the route request queries will be flooded in to the network, and the intermediate nodes will send same route request queries multiple times, hence the route acquisition delay will have higher percentage. But our scheme is not face any problem with higher node density as it follows selective border casting method i.e transmitting packet only for the peripheral nodes whose RDF is above the predefined threshold value. And hence reduces the route acquisition delay.

Jitter is the variation in the time between packets arriving, caused by network congestion, timing drift, or route changes. From figure 8, we can observe that at 25 nodes both the protocols have small jitter value, but at 50, 75, 100, and 125 nodes have higher value as query packets will be flooded throughout the network and hence control overhead increases. It consumes more time to reconfigure the route if link failure occurs. RL-RHMRP has lower jitter as compared to ZRP and MZRP because of its self context learning about their neighbors and selective flooding of route request packets to its bordercast nodes whose RDF is higher then pre-defined threshold value.

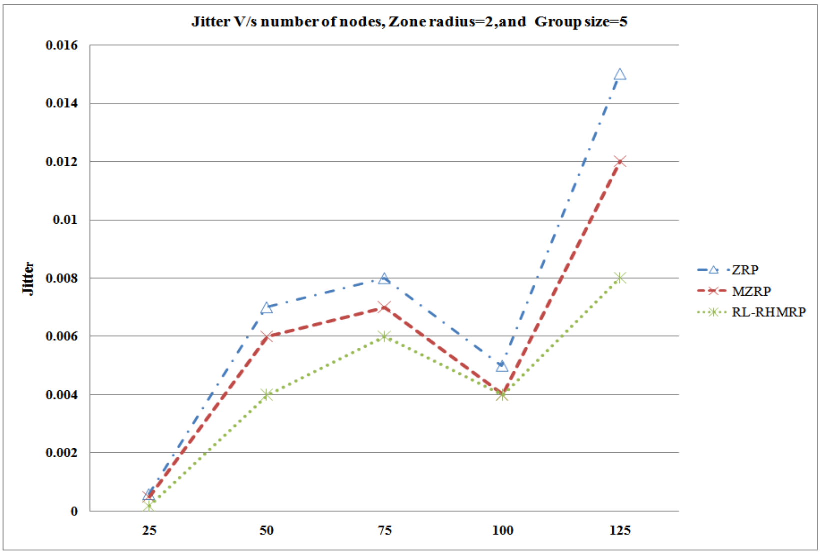

Figure 6.3: Jitter Vs number of nodes at zone radius 2hop zone radius 2hop, Group size=05

VII. CONCLUSION

In this paper, we proposed novel approach called Reinforcement Learning (RL) based Reliable Hybrid Multicast Routing (RL-RHMRP). The scheme RL-RHMRP is works based on packet forwarding mechanism through reliable intermediate nodes. RL-RHMRP significantly routes a packets to multicast group member without packet loss because of its reliable and robust route construction mechanism. RL-RHMRP provide reliable routing since the nodes present in the network are checked against its reliability factor before deciding route to multicast group members. Proposed scheme has shown a good development over metrics like PDR, delay, and throughput. However, there are certain overheads associated with proposed scheme such as maintaining neighbor node information, maintaining multicast route information, creation of an RQ and Reply packet. Nevertheless, proposed scheme facilitates the robust route selection mechanism to increase the MANETs life time.

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