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FORWARDING GROUP NODE SELECTION IN MOBILE AD HOC NETWORKS USING INTELLIGENT DATA ANALYSIS

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ABSTRACT

Mobile Ad hoc Networks (MANET) is identified as an emerging field for the researchers to work on, as there is a huge increase of mobile users nowadays. Applications such as emergency searches, recues, military battlefields, etc., uses the MANET, as it is not possible to establish a fixed network for communication. Especially multicast routing has been preferred to satisfy such needs since same information can be transmitted to a group of users. Even though, many multicast routing protocols had been proposed, still the performance of the multicast routing protocol is lacking to achieve reliability and scalability in MANET while transmitting a packet to multiple users. In this paper, we have proposed a multicast routing protocol to improve the Packet Delivery Ratio (PDR) with minimum control overhead and delay based on intelligent data analysis techniques such as Radial Basis Function (RBF). The main aim of the analysis is used to identify the probability of optimum forwarding group node based on the information augmented with the JOIN_QUERY packet. The performance evolution shows that the proposed approach ensures the PDR and reduction in control overhead significantly.

Keywords: multicast routing, intelligent analysis, basis function, forwarding group, packet information.

INTRODUCTION

Multicasting is a fundamental service for supporting information exchanges and collaborative task execution among a group of users and enabling cluster-based computer system design in a distributed environment. The applications such as emergency searches, rescues, and military battlefields require mandatory information sharing, rapid deployment of nodes, mobility and dynamic reconfiguration (Singh *et al.* 2012). MANETs are applied to critical environments where robustness and reliability are essential, such as military battlefield, emergency rescue, vehicular communication, and mining operations and so on. In the presence of these applications, multicast is very important and useful that holds down network bandwidth and resources, since a single message from one source can be delivered to the multiple receivers simultaneously. One of the main challenges for multicast routing in MANETs is the need to achieve robustness under the conditions of frequent, especially high-speed mobility and node outages. There is a big challenge to design a reliable and scalable multicast routing protocol in the presence of frequent topology change and channel dynamics. (Xiang *et al.* 2010)

ON-DEMAND MULTICAST ROUTING PROTOCOL (ODMRP)

ODMRP is a source initiated multicast routing protocol in which the source node initiates the JOIN_QUERY packet for route discovery. ODMRP sends the data from a source node to the group of receiver nodes. Source node generate the JOIN_QUERY packet and it floods to all the nodes in the network as shown in Figure-1. The receiver node generates a routing table after it receives JOIN_QUERY packet as shown in Figure-2. S1 and S2 are the source node which transmits the data to the group of receivers R1, R2, R3, and R4. S1 generates the JOIN_QUERY packet and it floods the packet to other nodes in the network. If any intermediate node receives multiple JOIN_QUERY packets from the other nodes then the recent packet is only accepted and other packets are rejected by the respective intermediate nodes based on the sequence number.

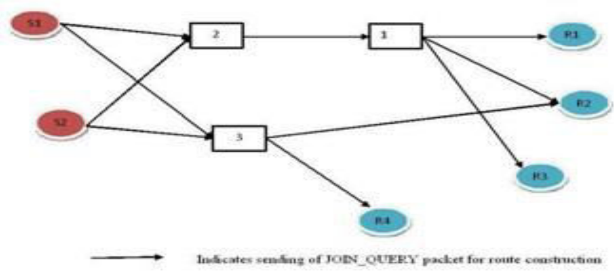

Figure-1. Flooding of JOIN_QUERY packet – Route initialization.

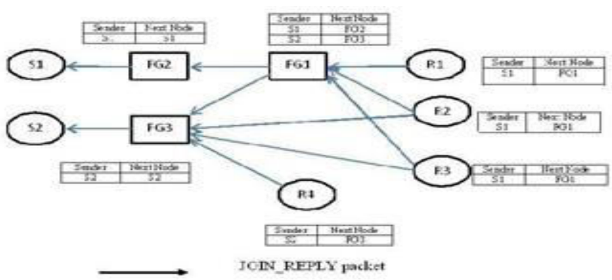

Figure-2. JOIN_REPLY packet – routing table generation.

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JOIN_REPLY packet is forwarded back to the source (reverse path mechanism) based on the path travelled by the JOIN_QUERY packet. If the JOIN_REPLY packet is received by the intermediate nodes then, it checks for the availability of its own identity. If the own identity is available then update its information to the join table and enables the forwarding group (FG) flag. Enabling the FG flag denotes that the respective node is available on the path between the source node and the receiver. Thus the JOIN_REPLY is propagated by each FG member until it reaches the multicast source via the shortest path. ODMRP has many advantages but it suffers from high overhead due to the mesh structure and flooding of JOIN_QUERY packets. For large networks the ODMRP suffers with increase in control overhead. ODMRP is modified by several researchers to address these issues.

RELATED WORKS

Many efforts have been made to develop multicast protocols for MANETs (Gerla *et al.* 2005, Jacquet *et al.* 2002). These include conventional tree based protocols and mesh-based protocols. The tree-based protocols (e.g., LAM, MAODV, AMRIS, and MZRP (Zhang *et al.* 2003) construct a tree structure for more efficient multicast packet delivery, and the tree structure is known for its efficiency in utilizing network resources. However, it is very difficult to maintain the tree structure in mobile ad hoc networks, and the tree connection is easy to break and the transmission is not reliable. The mesh-based protocols (e.g., FGMP, Core-Assisted Mesh protocol, and ODMRP are proposed to enhance the robustness with the use of redundant paths between source and the set of multicast group members, which incurs a higher forwarding overhead. There is a big challenge to support reliable and scalable multicast in a MANET with these topology-based schemes, as it is difficult to manage group membership, find and maintain multicast paths with constant network topology changes. The other multicast routing protocols have been proposed by (Gerla *et al.* 2000, Basagni *et al.* 2001, Chen *et al.* 2002) are more robust than the conventional topology-based multicast schemes, the header overhead increases significantly as the group size increases; this prevents the scaling of these protocols and constrains these protocols to be used only for small multicast groups. Additionally, there is a need to efficiently manage the membership of a potentially large group, obtain the positions of the members, and transmit packets to member nodes that may be located in a large network domain and in the presence of node movements. The existing small-group based geographic multicast protocols normally address only part of these problems.

B. So et al proposed a PEODMRP that limits the transmission area of control messages and establishes sparse mesh (So *et al.* 2004). It reduces the control overhead and redundant data transmission. Soon et al proposed a method to reduce the packet overhead by up to 50% but maintaining similar packet delivery ratio as the original ODMRP. The approach, the refresh rate adjustment scheme used as a feedback system and apply techniques of Control Theory to use motion adaptive refresh techniques for route local recovery to achieve minimum overhead (Soon *et al.* 2005). Baburaj *et al* proposed the approach which uses nature principle that exists in the form of fitness function. It is observed that the performance in the low mobility speed (Baburaj *et al.* 2008). Naderan-Tahan *et al* proposed the problems in detecting link breakages and local recovery procedure in ODMRP is addressed. The author introduced a new join message for nodes intending to join the multicast group and nodes detecting link breakage. In this approach the packet delivery ratio increases while end-to-end delay remains the same as ODMRP (Naderan-Tahan *et al.* 2009). Mohammad Reza EffatParvar *et al* proposed an approach where a cluster based on demand multicast routing protocol with the lack of extension of flat multicast routing protocols in large scale ad hoc networks. SC-ODMRP improves the network performance in terms of end-to-end delay and control packets (EffatParvar *et al.* 2009). Xue-Mei Sun et al proposed a CODMRP that refers to the advantages of fitness for high-speed movement of mesh-based ODMRP, and adopts an enhanced weighted clustering algorithm (EWCA) which produces low delay, high delivery ratio and good extension compared with the ODMRP (Sun *et al.* 2006).

Ghafouri *et al* proposed a reduced Data Transmission ODMRP (RDTODMRP) routing algorithm that considers the network conditions such as mobility speed and traffic load to determine the multiple routes. This reduces the unnecessary redundant routes and their data transmissions. It is observed that the RDTODMRP and LF-RDTODMRP reduce the number of data transmission, control overhead, end to end delay and improves the data packet delivery ratio (Ghafouri *et al.,* 2009). Rajashekar et al proposed a mesh based multicast routing scheme that finds stable multicast path from source to receivers is proposed. The stable paths are found based on selection of stable forwarding nodes that have high stability of link connectivity. The link stability is computed by using the parameters such as received power, distance between neighboring nodes and the link quality that is assessed using bit errors in a packet. The authors observed that the proposed scheme produces better packet delivery ratio, reduced packet delay and reduced overheads (such as control, memory, computation, and message overheads).while compared with ODMRP and EODMRP (Rajashekar *et al.,* 2010). DENG Xis *et al* proposed a NC-ODMRP in which classified the nodes are classified into three categories as ordinary node. The categories are distinguished with different weights by a weight table in the nodes. NC-ODMRP chooses the node with the highest weight as FG nodes between different sender and receiver pairs. It is shown that NC-ODMRP can reduce more than 20% FG number of ODMRP, thus enhances nearly 14% data forwarding efficiency and 12% energy consumption efficiency when the number of multicast senders is more than 5 (DENG Xis *et al.* 2006).

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Shafigh *et al* proposed a method to find out the high-quality forwarding group node. This is achieved by augmenting the join query packets with additional information such as speed, power level of nodes and link bandwidths. The proposed scheme increases the delivery rate up to 40%, while reducing average end-to-end. As a summary, the major problem of the existing approaches would be found in their high data and control overhead which might also leads to low packet delivery ratio due to collision. In this paper a novel approach is proposed to reduce the overhead significantly by augmenting JOIN_QUERY packet with the information such as mobility speed, energy, link duration, and route refresh time. To ensure the packet delivery ratio, fuzzy based control on the selection of forwarding group of node is used (Shafigh *et al.* 2012). Rajashekhar et al proposed a scheme for information priority based multiple paths multicast routing in MANETs that used reliable neighbor node selection mechanism. Neighbor nodes are selected that satisfy certain threshold of reliability pair factor to find non-pruned neighbors. Non-pruned neighbors are used to establish reliable multipath multicast routes with assigned priority levels using request and reply control packets along with node database comprising of neighbor and routing information. Prioritized multipaths carry various priority data to multicast destinations. Neighbor node selection is realized with the help of node power model and mobility model. Robust route maintenance mechanism is provided to handle link and node failure situations. The results of simulation for packet delivery ratio, different overheads and packet delays illustrate the effectiveness of the developed scheme over well-established mesh based multicast routing protocols such as ODMRP and EODMRP (Rajashekhar *et al.* 2011).

Begdillo *et al* proposed a stable route selection in ODMRP for forwarding data. In basic ODMRP route selection function uses minimum delay. But in proposed approach considered nodes energy in route selection from source to destination (Begdillo *et al.* 2010). Jamali et al proposed a stable on demand multicast routing scheme in MANET. This scheme finds stable multicast routes to receivers by considering node's residue energy. It uses a route weighted function in ODMRP route discovery process, to consider both movement and energy information in its operation. Simulation result shows that this approach leads to better performance in terms of packet delivery ratio, throughput and route life time (Jamali *et al.* 2012). Singh et al proposed a simulation based experiments are performed to analyze the performance of On Demand Multicast Routing Protocol by evaluating Packet Delivery Ratio, End to End delay and average throughput. These results are compared with AODV and FSR routing protocols by varying number of nodes and mobility. The comparison shows that ODMRP for ad hoc networks performs better as compared to AODV and FSR (Singh *et al.* 2010). Anwar et al proposed an integrated multiple metrics which could be used to improve the performance of MAODV Routing Protocol for Wireless Mesh Networks. Simulation results show that performance of MAODV-IM is better than MAODV in terms of Packet Delivery Ratio (PDR), Throughput and Average end-to-end delay (Anwar *et al.* 2012). Rajendran et al proposed link stability based on demand multicast routing protocol in MANET. The protocol finds multicast paths to receivers by using route request and route reply packets with the help of routing message and link stability parameters maintained in LST on every node in a MANET. Multicast mesh of alternate routes between every source-destination pair is established in mesh creation segment. Link stability within a mesh network is established by choosing link quality among its neighbors. This shows better quality of link stability and decreases the possibility of link failures and the overhead needed to construct the routes. Link failure conditions are notified to the source with bit error ratio so as to enable the source to start route detection for new path establishments. In addition, simulation is performed to assess the network with control overhead and throughput. The performance metrics are compared with RODMRP and basic ODMRP. The proposed algorithm showed significant improvements in terms of throughput and control overhead compared with to ODMRP and RODMRP (Rajendran *et al.* 2012).

Prasad et al proposed a mesh based multicast routing scheme that finds stable multicast path from source to receivers. The multicast mesh is constructed by using route request and route reply packets with the help of multicast routing information cache and link stability database maintained at every node. The stable paths are found based on selection of stable forwarding nodes that have high stability of link connectivity. The link stability is computed by using the parameters such as received power, distance between neighboring nodes and the link quality assessed using bit errors in a packet. The proposed scheme is simulated over a large number of MANET nodes with wide range of mobility and the performance is evaluated. It is observed that proposed scheme produces better packet delivery ratio, less control overheads and reduced packet delay compared to on-demand multicast routing protocol (ODMRP) (Prasad *et al.* 2011). Rajashekhar *et al* proposed a mesh based multicast routing scheme that finds stable multicast path from source to receivers. The multicast mesh is constructed by using route request and route reply packets with the help of multicast routing information cache and link stability database maintained at every node. The stable paths are found based on selection of stable forwarding nodes that have high stability of link connectivity. The link stability is computed by using the parameters such as received power, distance between neighboring nodes and the link quality assessed using bit errors in a packet. The proposed scheme is simulated over a large number of MANET nodes with wide range of mobility and the performance is evaluated. It is observed that proposed scheme produces better packet delivery ratio, less control overheads and reduced packet delay compared to on-demand multicast routing protocol (ODMRP) (Rajashekhar *et al.* 2010).

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Pandi Selvam et al proposed a qualitative comparison for delivery ratio, control overhead, forwarding efficiency and End-to-End delay of ad-hoc on-demand multicast routing protocols such as MAODV and ODMRP. Both, routing protocols works as on-demand route discovery but different routing mechanisms. Both routing protocols results are shown in the previous section which proves the ODMRP achieves better packet delivery ratio but which has higher overhead while increasing the multicast receiver. Moreover, the ODMRP has better forwarding efficiency and minimum latency on maximum sources and receivers in the multicast group (Pandi Selvam *et al.* 2011). Deepak et al proposed model offers better cost effective performance than conventional AODV protocol which uses simple flooding for route discovery process. In blind flooding technique (used in AODV), each node in the network, retransmits the RREQ packet exactly once, resulting in the maximum no. of retransmissions. In our new approach of selective flooding based on neighbor node density and probability of rebroadcasting, RREQ retransmissions are reduced a lot, hence improving the performance of the algorithm. The main objective of any flooding optimization algorithm is achieve higher reachability with less or minimum no. of RREQ and broadcast packets retransmissions. The proposed model is flexible and can be configured for pure flooding, fixed probability and auto adjusted node density algorithms. The selection of maximum probability value, minimum probability value, average no. of neighbor nodes and node density needs careful calculation and selection for best results. The results confirm that I-AODV, which is based on intelligent route discovery method, performs better than conventional AODV. The performance is evaluated in terms of end-to-end delay, routing overheads, control overheads and IAODV is found better than AODV (Deepak *et al.* 2011).

PROPOSED APPROACH

The proposed approach is designed to identify the optimal forwarding group nodes based on the information available in the JOIN_QUERY packet using intelligent data analysis. The route refresh time and link duration are mandatory information of the JOIN_QUERY packet. Mobility speed and energy are the additional information used in this approach to identify the optimum forwarding group nodes. Therefore, the JOIN_QUERY packets should have mobility speed, energy, link duration and route refresh time along with the other parameters during the route establishment. Figure-3 shows the network design which is used to identify the probability of optimum forwarding group node. To analysis the probability of forwarding group node a radial basis function is used.

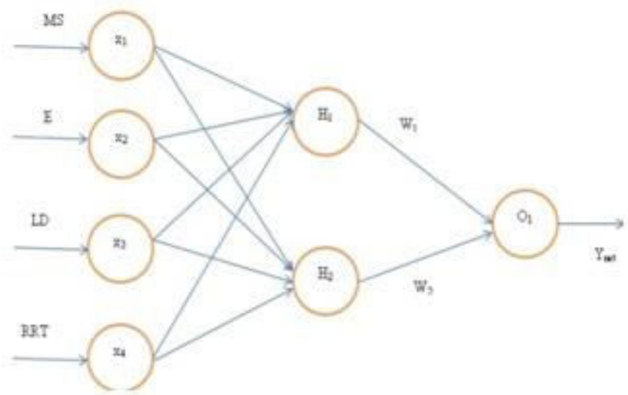

Figure-3. Network design.

The nodes energy, link duration and route refresh time is calculated as follows.

Calculation of energy

The Energy of the nodes is calculated using equation (1)

$$BC_i(t) = l_i - m_i - n_i - o_i \quad (1)$$

Where

BC_i (t) is the residual battery capacity of node i

l_i is initial energy of node i

m_i is the energy required for number of packets transmitted by node i

n_i is the energy required to number of packets received by node i

o_i is the energy required for number of packets transmitted by node i as an intermediate node

From equation (1), the values of l, m, n, o for a node i can be calculated as follows.

$$l = BC_i(0)$$

$$m_i(t) = \sum_{\lambda=0}^{T_i(t)} (P_c(\lambda) + T_c(\lambda))$$

$$n_i(t) = \sum_{\lambda=0}^{R_i(t)} (P_c(\lambda) + R_c(\lambda))$$

$$o_i(t) = \sum_{\lambda=0}^{I_i(t)} (P_c(\lambda) + R_c(\lambda) + T_c(\lambda))$$

where

T_i (t) is the number of packets transmitted by the node i as a source node

R_i (t) is the number of packets received by the node i as an intermediate node

$I_i(t)$ is the number of packets passed through node i as an intermediate node

P_c (λ) is the processing cost of a packet

λ is the arrival rate of the Packet

T_c(λ) is the transmitting cost of the packet

R_c (λ) is the receiving cost of the packet

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Link duration

The duration of the link between two nodes will stay connected LD is given by:

$$LD = \frac{-(A+B)+\sqrt{(C-D)^2}}{H} \tag{2}$$

Where

$$A = p*q$$
$$B = c*d$$
$$C = (p^2+r^2)*R^2$$
$$\mathrm{D} = (p*s-q*r)$$
$$H = p^2+c^2$$
$$p = m_i*\cos(\theta_i)-m_j*\cos(\theta_j)$$
$$q = Z_{X_i}-Z_{X_j}$$
$$r = m_i*\sin(\theta_i)-m_j*\sin(\theta_j)$$
$$s = Z_{Yi}-Z_{Y_j}$$

m_i, m_j is the mobility speed of node I and j respectively

Θ_i and Θ_j is the moving direction of the node i and j respectively

R is the transmission range

The proposed system follows the ODMRP protocol as such in the stages of route initiation and route construction except additional information is augmented in the JOIN_QUERY packet. The main aim of the proposed system is to identify an optimum forwarding group node using an intelligent data analysis. To perform the data analysis the radial basis function network is used. During the process of learning, the input layers, hidden layers and output layers are designed to identify an optimum forwarding group node. The learning process is done with the help of 4-3-1 network. The input layer receives input form the JOIN_REPLY packet and it extracts the parameters such as Energy (E), Mobility Speed (MS), Link Duration (LD), and Route Refresh Time (RRT). The main aim of the learning process is to identify the set of optimum forwarding group nodes to improve the reliability of the ODMRP protocol. The main core of the RBF is its activation function which is based on Gaussian approximation function. A RBF is a real-valued function whose value depends only on the distance from the set of inputs. The RBFN are powerful intelligent analysis technique. In this paper a Radial Basis Function (RBF) activation function is used to perform the training of the network based on the input pattern and the expected output. During the process the weights are initilaized to the hideen layer to perform the analysis. The ouput of the hidden layer in shown in equ (3)

$$v_i(x_i) = e^{-\sum[X_{ji}-X'_{ji}]/\sigma_i^2} \tag{3}$$

Where

vi(xi) is the output of the hidden layer

X'_{ji} is the distance of the RBF unit for input variables

$\boldsymbol{\sigma}_i^2$ is the width of the i^{th} RBF function

X_{ji} is the j^{th} variable of input pattern

The learning process is continued a number of times. Once the trained nodes output is matched to the target value then the process is stopped. This process can be iterated to 1000 times based on the regular intervals.

Algorithm

Step-1: Get the input parameters mobility speed (MS), Energy (E), Link duration (LD), Route Refresh Time (RRT).
Step-2: Initialize the weight matrix with small random values for hidden layer
Step-3: Calculate the radial basis function.
Step-4: Choose the optimum value for FG nodes
Step-5: Calculate the output of the hidden layer
Step-6: Initialize the weight matrix at output layer (W_i)
Step-7: Calculate the output (Y_{net}) of the neural network.

$$Y_{net} = \sum_{i=1}^{H} W_{im} V_i(x_i) + W_0$$

Where

H = number of hidden layer nodes in REF function

Y_{net} = output value of the m^{th} node in output layer for the n^{th} incoming pattern

W_{im} = weight between i^{th} RBF unit and m^{th} output node

W_0 = biasing term at n^{th} output node

The optimum forwarding group node is determined by the average values of the energy, mobility speed, link duration and route refresh time. These average values would be more accurate when receiving large number of JOIN_QUERY packets.When a node receives a JOIN_QUERY packet, it extracts the value of previous nodes information and uses these information for learning the network. The proposed approach introduced a zero overhead to exchange the required information about energy, mobility speed, link duration and route refresh time. This approach reuses the control packet to carry the values of energy, mobility speed, link duration and route refresh time to its neighbors. The impact of the choice of information on the performance of the proposed method is evaluated in the next section.

RESULTS AND DISCUSSIONS

Our proposed approach is simulated in Network Simulators. The learning algorithm is implemented in C Language. The overall aim of the simulation study is to analyze the performance of the proposed approach under the range of various parameters shown in Table 1. A pause time of 0 sec represents a network with very high mobility where all nodes are moving continuously.

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Table-1. Simulation environment.

Area	1000 m * 1000 m
MAC protocol	IEEE 802.11 DCF
Wireless channel	Free Space Propagation Model
Number of nodes	10, 20, 30, 40, 50
Traffic type	Constant Bit Rate
Mobility model	Random way point
Mobility speed	20 ms
Radio range	250 m
Simulation time	400 ms
Pause Time	0 s
Initial energy of the node	1500 joules
Packet size	Default size (512 Bytes)
Channel capacity	2 Mbps
Route refresh time	5 seconds

The Figure-4 & 5 compares the proposed approach with ODMRP, R-ODMRP, and Fuzzy based ODMRP. The ODMRP has high delay compared to all other approaches. ODMRP periodically sends the JOIN_QUERY messages to refresh the FG. But R-ODMRP, Fuzzy based and proposed system restricts the flooding. Therefore numbers of JOIN_QUERY packets discarding are high, that results in low end-to-end delay. It is observed from the simulation results that, the proposed method produced a low end-to-end delay since the proposed approach is used to identify the probability of optimal FG node. It could be observed form Figure-4. In the proposed approach the mobility speed increases the end-to-end delay decreases considerably compared with others particularly this scenario is observed after 4 m/s.

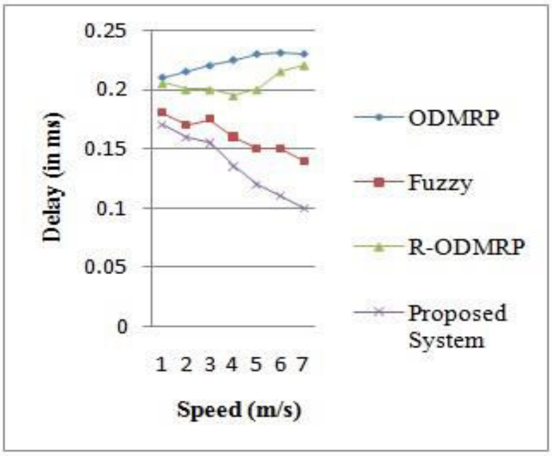

Figure-4. Mobility speed vs delay.

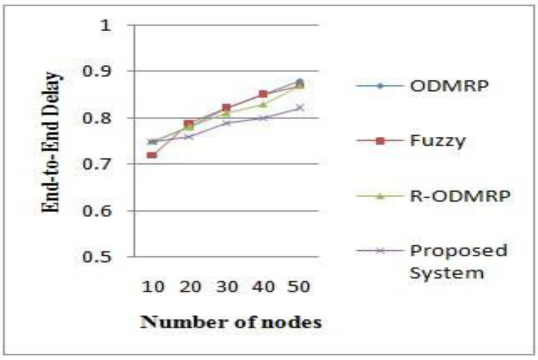

Figure-5. Number of nodes vs End-to-End delay

The ODMRP maintains the largest amount of control overhead compared with other three protocols including proposed approach. The FG and routes are refreshed periodically in ODMRP. There is no observation made on the route refresh time in other modified ODMRP protocols.

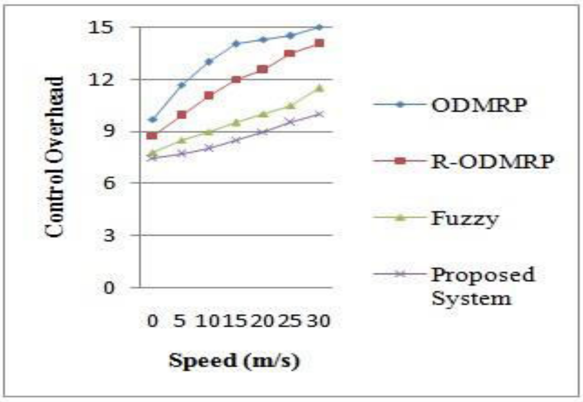

Figure-6. Mobility speed vs control overhead.

In our approach we considered route refresh time as one of the information to the FLS. The proposed approach is identifying the FG based on route refresh time. Therefore, the FGs and routes are refreshed optimal number of times in such a way that to have a less control overhead. It could be from Figure (6) & (7).

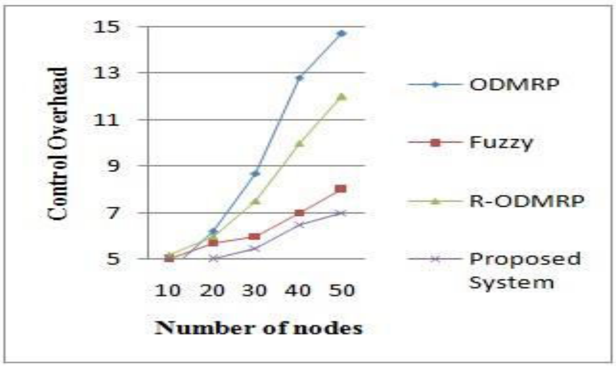

Figure-7. Number of nodes vs control overhead.

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As a consequence of reduced end-to-end delay and control overhead, network life time and packet delivery ratio are significantly increased in the proposed approach compared to the existing systems. It could be observed from the Figure-8 and (9).

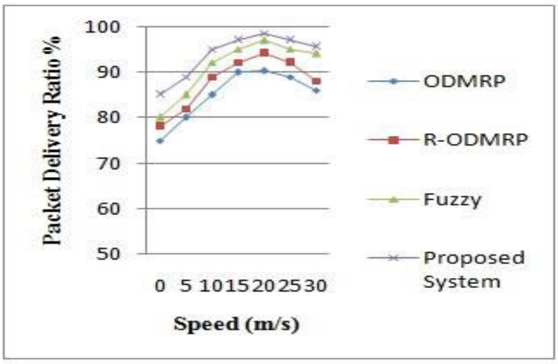

Figure-8. Mobility speed vs packet delivery ratio.

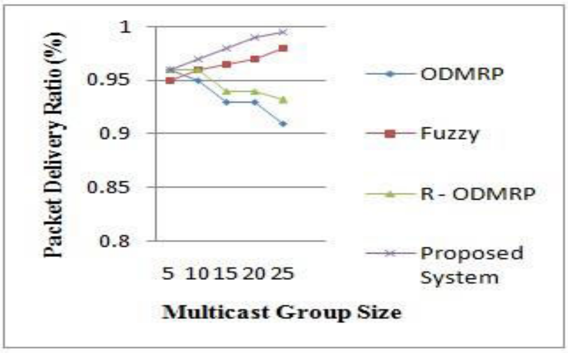

Figure-9. Multicast group size vs packet delivery ratio.

CONCLUSIONS

In this paper, a novel method is proposed to improve the performance of ODMRP in MANET. The proposed method uses the radial basis function to identify the optimum forwarding group node. It uses the information such as mobility speed, energy, link duration and route refresh time augmented in JOIN_QUERY packet to assist the training of the RBFN to identify the optimum forwarding group node. Simulation results show that the proposed approach has many advantages compared with ODMRP, R-ODMRP, and Fuzzy based ODMRP such as less control overhead, end-to-end delay, high packet delivery ratio and low energy consumption.

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