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Forwarding Node Reduction with Link Break Time Prediction

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Abstract

Multicast routing protocols in mobile ad hoc networks suffer in flooding of control messages for route maintenance and redundant data packet delivery because of multiple paths in the mesh. These lead to data and control overhead in the routing process which affects the utilization of the bandwidth and efficiency of the routing protocol. In this paper, we suggested a Forwarding Node Reduction with Link break time Prediction (FNRLP) algorithm to reduce the redundant paths without affecting the reliability by minimizing the number of forwarding nodes in the mesh. It also predicts the active route break time to reduce the unnecessary control packets using receiving signal power strength. This algorithm is implemented in On Demand Multicast Routing Protocol (ODMRP) and compared with other protocols such as ODMRP, ODMRP-LM, and ODMRP-GM. The comparison shows that the proposed protocol outpaces other protocols.

Keywords: Multicast routing, data overhead, and control overhead.

INTRODUCTION

Many receivers may involve in the message exchanges through multicasting for group communications. Nowadays, audio/video streaming, online conferences are very popular group communication applications [3]. The mesh-based multicast routing protocols are reliable and highly robust against mobility than the tree-based multicast routing because of their multiple paths to the destinations [7]. This leads to deliver excessive data packets. They also flood periodic control messages for route maintenance. These make more overheads in routing than the overheads in tree-based routing protocols [5]. The control overhead is the important metric in measuring the efficiency of a multicast routing protocol. The data traffic utilizes more bandwidth than the control traffic [9].The mesh-based multicast routing protocols maintain the paths to the receivers by flooding the periodic control packets in a certain interval. These unnecessary control packets make control overhead. To avoid these overhead, we need less amount of data forwarding with backup paths, adaptive interval time for route refreshment and forwarding group maintenance [4]. In this paper, Forwarding Node Reduction with Link break time Prediction (FNRLP) algorithm is proposed to minimize the number of forwarding nodes and to predict the link breakage time. The remaining sections of this paper are arranged as follows: Section II illustrates the related works for reducing the overheads from the literature. Section III explains the methods to minimize the number of forwarding nodes and prediction for topology changes and active route's breakage time. Section IV discusses the simulation results through graphs. The final section concludes this work with future enhancement.

REVIEW OF LITERATURE

The routing is very important metric in mobile ad hoc network. It needs efficient and minimum overhead algorithms or methods. If the proposed method has high control overhead, then the method does not work well [1]. The routing overhead determines the scalability of the routing protocols [2]. So many authors tried to reduce the overhead in their works. The routing is very important metric in mobile ad hoc network. It needs efficient and minimum overhead algorithms or methods. If the proposed method has high control overhead, then the method does not work well [1]. The routing overhead determines the scalability of the routing protocols [2]. So many authors tried to reduce the overhead in their works. In this proposed work, we aggregated both data and control overhead reduction methods in one algorithm at mesh construction phase and route maintenance phase respectively.

Fayez Khazalah, Ismail Ababneh and Zaki Malik. [4] proposed Global Maintenance (GM) and Local Maintenance (LM) algorithm for flooding join queries only when topology changes and for routes updated only by prediction of breakage time of active route respectively in the ODMRP protocol. These methods reduced control overhead caused by periodic control messages for route maintenance. Gowrishankar.S, T.G.Basavaraju, Manjaiah.D.H, M.Singh and Subir Kumar Sarkar. [6] presented the theoretical analysis of various approaches such as cluster-based approach, header compression, connecting with the Internet to reduce overheads. Nabil Nissar, Najib Naja and Abdellah Jamali [8] gave RREQ forwarding probability algorithm to improve the performance of AODV and reduce route overhead. The AODV protocol has less overhead than the mesh based routing protocol. Komlan Egoh, Roberto Rojas-Cessa, and Nirwan Ansari [10] proposed distributed diffusion-based mesh (DDM) algorithm for distributed mesh construction. Kumaran Sambandan, Gergely V. Záruba, and David Levine. [11] delivered data reliably to downstream forwarding group members & multicast receivers with a help of round robin window to increase the reliability and control overhead in the ODRMP. Pedro M. Ruiz and Antonio F. Gomez-Skarmeta [12] suggested distributed heuristics algorithm based on the epidemic propagation of forwarding nodes to reduce the data overhead in the ODMRP. Xiang.X, Wang.X and Yang.Y. [13] offered the virtual-zone-based structure to manage membership and position information for lower control overhead, data transmission overhead, and multicast group joining delay. This is suitable for the geographically based routing protocol. Yali Wang and J.J. Garcia-Luna-Aceves. [14] recommended best two-hop nodes through Euclidean distance to minimize the broadcast route request. From the above works, we concluded that reducing duplicate and excessive data and control messages will be the efficient way of overhead reduction in mesh-based multicast routing in mobile ad hoc network.

PROPOSED WORK

The mesh-based multicast routing protocols form a set of nodes to forward or redirect a packet from the sender to receivers. The paths formed by the collection of all these nodes may construct different structures like shortest path tree, shared tree, minimal Steiner tree, acyclic meshes, etc [12]. In general, this underlying structure is protocol specific because the path creation process of a particular protocol is determined by the corresponding routing protocol. There are two kinds of approaches to creating multicast trees: Shortest path tree and shared tree. The shortest path method provides the best route and the shared tree consider a link which is used by a lot of receivers. In both cases, there is no chance for minimal data overhead. Some multicast routing protocols such as ODMRP and CAMP have redundant links for their robustness. They deal the mobility of nodes, but they do not reduce the forwarding cost. The cost of the tree,i.e C(T), is considered as a number of data forwarding paths. The minimal data overhead with shortest path tree and Steiner tree is given in figure 1.

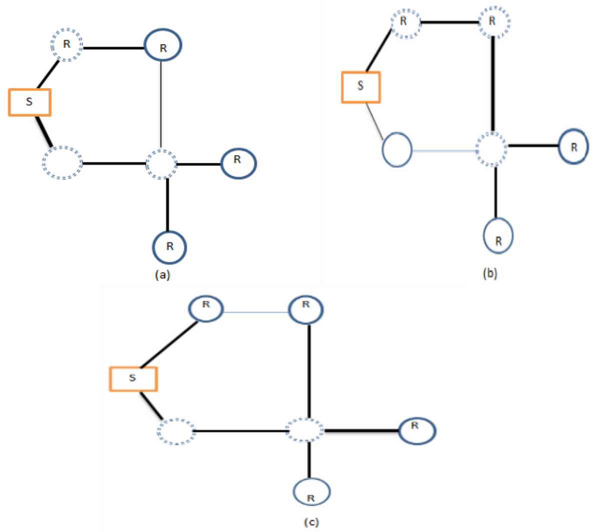


Figure 1: A different form of Multicast trees for the similar ad hoc network

(a) Shortest path tree,C(T)=4 (b) Steiner tree, C(T)=4 (c) Minimal data overhead tree, C(T) = 3.

In this, double-dashed circles are forwarding nodes and bold lines are the links. When we compared to other structures, the minimal data overhead tree has less cost. This structure is considered for creating a mesh in ODMRP. So a mesh structure is created with less forwarding nodes to provide low data overhead. To find minimal data overhead tree, the distributed counting process is included for counting the number of forwarding nodes with less cost of the tree. For the single tree T_1 in a mesh, there is no redundancy. When considering the T2 in a mesh, there is T1 ⊕ T2 with C(T1) +C(T2)-C(T1∩T2) i.e C(T2) - C(T1∩T2) forwarding nodes. In general, for the T1...Tn trees in mesh, the number of forwarding nodes added by the tree is computed by

$$RN_i = C(T_i) - C(T_i \cap (T_1 \oplus \ldots \oplus T_{i-1})) \qquad (1)$$

In (1), RN is a Redirecting node or forwarding node, i denotes ith node. Ti represents the ith tree and C(Ti) means the cost of Ti .The C(Tn ∩ (T1 ⊕ · · · ⊕ Tn−1)) denotes that cost of tree Tn excluding the tree T1 to Tn-1 without any repeated paths. The number of forwarding nodes has been added by the tree Ti is computed according to (1). The term C (Tn ∩ (T1 ⊕ · · · ⊕ Tn−1)) will be increased when the number of trees included into the mesh.

In traditional ODMRP, after the refreshment, the old path will still remain active for two additional intervals. So the forwarding nodes increased. In this approach, least cost path does not change frequently. So number of nodes is not increased.

The ODMRP protocol creates and updates routes & forwarding groups by flooding the join queries periodically. The frequent mesh refresh is needed to overcome connectivity disruptions. The high flexibility and short refresh interval lead to high overhead, which is a drawback in ODMRP. So the right value for refresh interval decreases the high control overhead and also the active multicast routes and forwarding groups refreshed on time avoid the data packets loss. The forwarding group of nodes for each multicast group has formed considering shortest paths between group members. The source nodes are responsible for establishing multicast forwarding groups. It periodically sends a join query packet to entire network. The receiver creates a joins reply and set the membership flag then broadcasts its own join reply. In the proposed work, the forwarding group timeout, and route refresh interval timeout predicted based on the receiving signal power strength. Some assumptions for this prediction are: the sender's power is constant and during the prediction time, the two neighbor nodes keep their moving speed and directions. The relative movements of a node A and a node B is shown in figure 2. If node A receives a signal from node B, then the link break time of link A-B is calculated from (2). The receiver or forwarding node creates a route error packet to the upstream nodes if the prediction time is less than the current time + critical period (the time period to find alternative path).

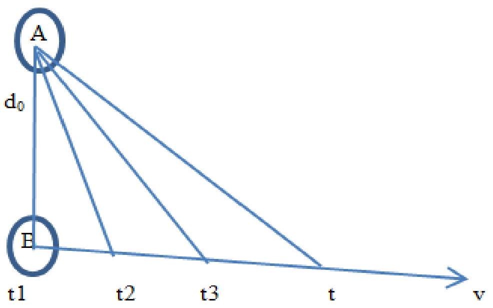


Figure 2: Virtual movements of two mobile nodes A and B

$$t = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} \qquad (2)$$

In (2), t is the prediction time. The variables a, b and c is the constants calculated as follows:

$$a = t_2\sqrt{P_2 P_s}\beta$$

$$b = \sqrt{P_s}\left(\left(\sqrt{P_1} - \sqrt{P_2}\right) - t_2^{\,2}\sqrt{P_2}\beta\right)$$

$$c = t_2\sqrt{P_2 P_s} - t_2\sqrt{P_1 P_2}$$

$$\beta = \frac{\sqrt{P_1 P_2}\, t_2 + \sqrt{P_2 P_3}\, t_3 - \sqrt{P_1 P_3}\, t_3 - \sqrt{P_2 P_3}\, t_2}{\left(t_2 t_3^2 - t_3 t_2^2\right)\sqrt{P_2 P_3}}$$

Ps is the received signal power threshold in the wireless network interface. *P*1, *P*2, and *P*3 are three consecutive signal powers received by a node from another node at times *t*1, *t*2, and *t*3, respectively.

Minimal data overhead mesh creation method

The figure.3 illustrates the mesh construction phase of FNRLP algorithm. The minimum FNCount route is chosen for creating multicast tree for mesh construction.

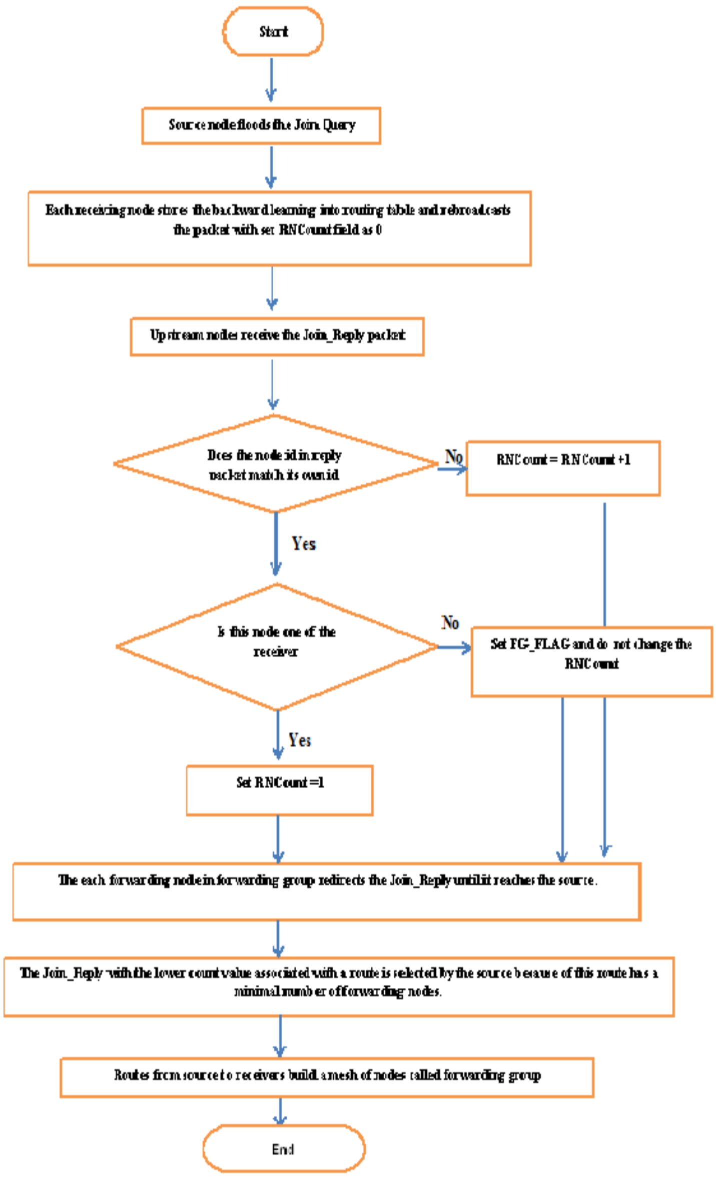


Figure 3: Mesh Construction Phase

Link Break Time Prediction Method

The Algorithm 1 shows the link break time prediction method between node A and B in FNRLP algorithm. This algorithm is implemented only on the multicast receiver and forwarding group member. Here, node A may be a multicast receiver or forwarding group member.

Algorithm 1 Link break time prediction

1: Node A receives three consecutive data packets from node B.
2: It calculates the break time of the link A-B.
3: **If** the break time <= current time + critical period, **then** the link is in critical position.
4: Node A creates predicted route error packet. It checks the source and neighbour node pair in its link table.
5: **If** the pair is found, the break time information already sent to the source.
6: **Else** node A inserts the source node and neighbour node pair with the current time into the link table.
7: The predicted route error packet is sent to the source node via upstream node B.
8: The source node receives the packet and compares the Min_Refresh_Interval parameter with the RT (RT=current time – last join query sent time).
9: **If** the RT < Min_Refresh_Interval value, it discards the predicted route error packet.
10: **Else** it floods the new join query.

So that the periodic control message sending for route maintenance is avoided by this method. The source sends the join query only when current active route break immediately. The route maintenance phase is simplified with minimal control messages.

SIMULATION AND RESULT ANALYSIS

Simulation environment

The simulator used for this work is NS2.32 (Network Simulator). The area of the simulation is 1000 x 1000 m. The time taken for simulation is 200s. The CBR traffic type and 802.11 Mac protocol have been used. The Random Waypoint mobility model and Two Ray Ground Radio propagation model are adapted for this work. The queue length is 50 MB and the packet size is 2000 bytes. The number of nodes varies from 60 to 100. The pause time and node speed are considered from 5 to 25 ms and 1-5 m/s respectively. The proposed ODMRP-FNRLP is compared with the ODMRP, ODMRP-LM and ODRMP-GM protocols. The performance metrics such as forwarding efficiency packet delivery ratio and normalized overhead are considered for the performance analysis of the varying number of nodes, pause time, interval time, mobility speed and simulation time.

Observed Results

The forwarding efficiency of ODMRP-FNRLP is increased when the size of multicast group increased as in the figure 4. This algorithm handles more receivers with the minimum forwarding nodes. So, without any congestion, the packet forwarding is done efficiently.

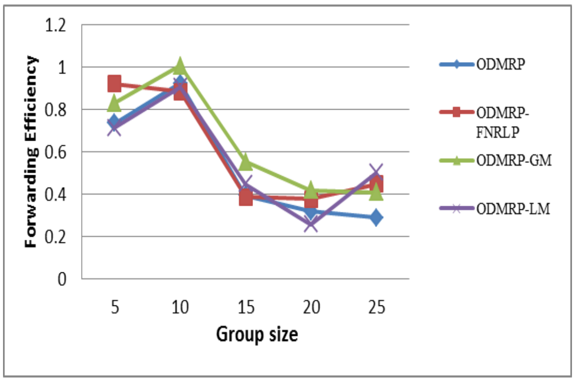
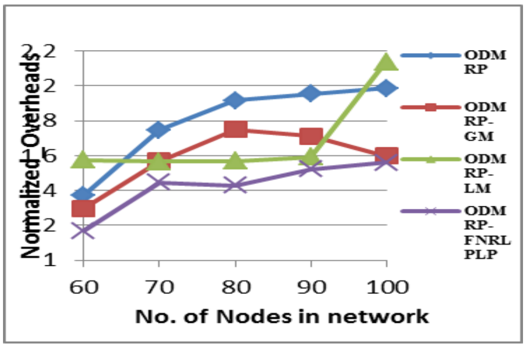


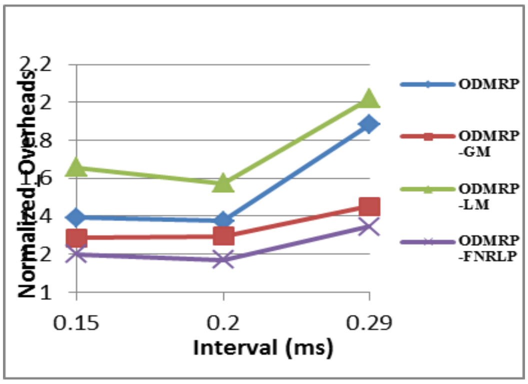
Figure 4: Forwarding efficiency as the function of multicast group size

The refresh interval time is the key performance parameter for evaluating a routing protocol. The FNRLP algorithm finds alternative route to source node to receive multicast data. In ODMRP-FNRLP, frequently sending route request packets are reduced and redundant data packets are minimized. Since the less number of control packets generated at the interval time, the ODMRP-FNRLP produces the low normalized overhead as depicted in the figure.5. The pause time and speed are considered for mobility nature for the nodes. Their high values for pause time and speed show their high mobility. The lower values are for low mobility environment. As of the figure 5, ODMRP-FNRLP protocol gives low overhead than others when the pause time is increased and also for the simulation time. In figure 5, the overhead of ODMRP-FNRLP is low at varying mobility speed than the other protocols. The frequent topology changes and link breaks due to mobility speed are handled in setting the route refresh-time and forwarding group time-out by the ODMRP-FNRLP. So that the low normalized overhead is in high mobility scenario.

The figure 6 shows that the packet delivery ratio of ODMRP-FNRLP is higher than other protocols with irrespective nodes in the network. This protocol has high packet delivery ratio for the large route interval time due to the quick update in the up-to-date route information and membership information. The ODMRP-FNRLP has high packet delivery ratios while the pause time is varied and simulation time. The more number of nodes in the network also gives the high packet delivery ratio.



(a)



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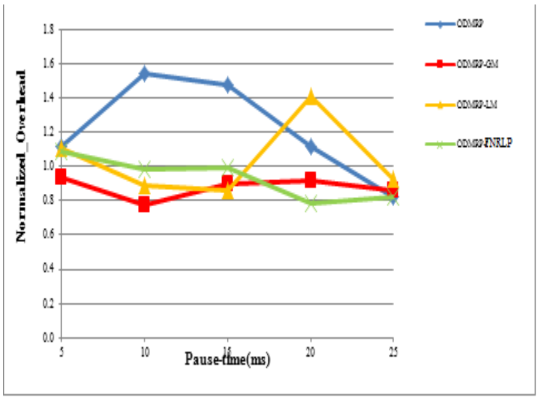
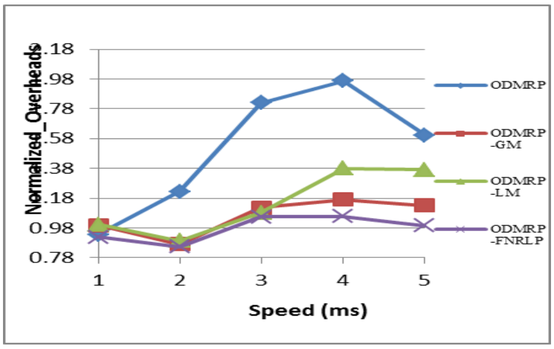


(c)



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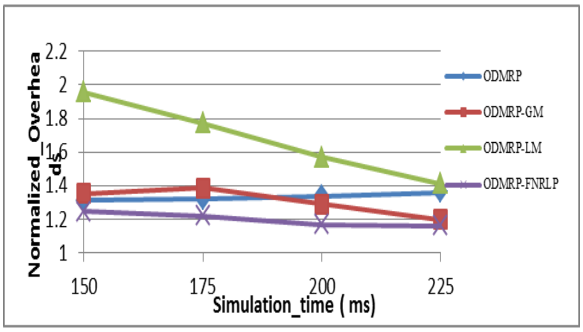
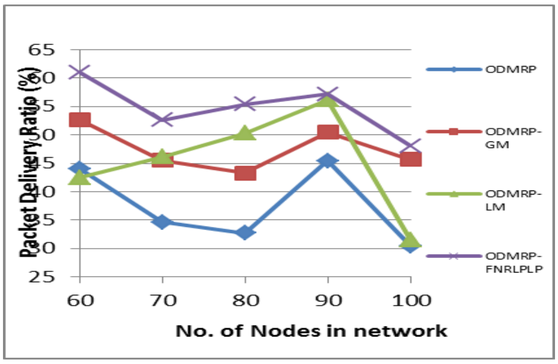
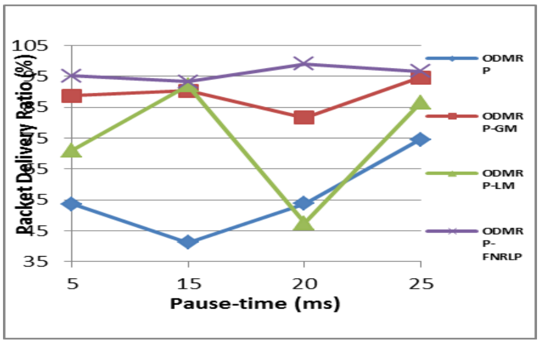


(e)

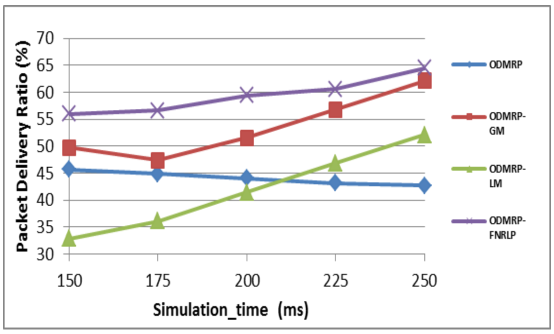
Figure 5: Normalized overhead is the function of (a) number of nodes, (b) refresh interval time, (c) pause time, (d) speed and (e) simulation time



(a)



(b)



(c)

Figure 6: Packet delivery ratio as the function of (a) number of nodes, (b) pause-time and (c) simulation time

CONCLUSION

The overhead in routing protocols determines its efficiency. Normally, mesh-based multicast routing protocols have more overhead than tree-based routing protocols. The proposed ODMRP-FNRLP reduces overheads with minimal routes to the receivers and minimal control messages for route maintenance. It reduces latency time between source and receivers. It prevents the collisions among forwarding nodes. It also provides the high packet delivery ratio and low normalized overhead in the routing process. From the observed result, this protocol is well suited for high-speed mobility environment. This protocol has more forwarding efficiency than the other protocols when the size of multicast group in the network is increased. For the further work, we will consider energy level of forwarding nodes while constructing the mesh structure.

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