Improving Packet Delivery Ratio in ODMRP with Route Diversity

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Summary
A MANET[1] is a set of mobile nodes that are free to move dynamically and unpredictable in environment, but this dynamic nature of the network topology cause for many challenges in MANET. Multicasting is one of methods that because of group-oriented computing are mostly used in MANET routing. Protocols have designed for multicasting in MANETs that ODMRP is one of them. ODMRP is on-demand and mesh based protocol that delivers packets from source to destination by building a mesh.

PDR is most important metric that we should consider in packet forwarding. It may affects by different criteria such as packet size, group size, action range and mobility of nodes. ODMRP uses single path to forwarding packets and this cause to PDR2 reduction in destination. The proposed method in this article uses multi coded paths technique. Thus due to route diversity and overcoming single route breakage, our approach can improve PDR from source to destination.

Key words:
Routing, Multicast, MANET, PDR, ODMRP.

1. Introduction

With increasing new technology and different applications, use of wireless networks will be increased. Wireless networks may be classified in two parts: Infrastructure or Ad hoc networks. In infrastructure networks, the router will be constant and nodes will be mobile, but MANETs do not need any infrastructure support. Mobile ad hoc network composed of mobile nodes connected by wireless links, and each node can acts or operates as router to forward packets. The networks topology of MANETs may change frequently due to mobility of nodes. The term “Ad hoc” implies that this network is setup for a limited period of time, the applications that use this network may be mobile and the environment may change dynamically.

The ad hoc applications include on line gaming, classroom communication, battlefield communications, scientific explorations and etc. In the application level, MANET users communicate with together as teams. Thus applications need for group communication (multicasting) to data forwarding and real time traffics. Routing in mobile ad hoc networks because of frequent topology changes and dynamic group membership has special problems and require robust and flexible mechanisms for discover and maintenance the routes. Because of group-oriented computing multicasting is one of the methods that mostly used in MANET routing. Thus by combining the applications of ad hoc networks with multicasting we can provide large number of group applications. Multicasting reduces the communication cost for application that sending the same data to many destinations instead of sending via multiple unicast. The main advantage of multicasting is, it can utilize the wireless links efficiently by exploring the inherent nature of the broadcast. But in MANETs and its routing, mobile multicasting faces several challenges, such as multicast group members move and transient loops may forms during tree reconfiguration.

Therefore, constructing and maintaining multicast tree should be simple to keep channel overhead low. Many multicast routing protocols have been proposed and designed for ad hoc networks. Most of them, such as DVMRP and FGMP require periodical transmission of control packets in order to maintain multicast group membership and multicast tree root, thereby wasting a lot of bandwidth. But MOODV and ODMRP try to minimize the communicating overhead by on demand route discovery process. In this paper we discuss ODMRP protocol. Previously we say that ODMRP is a mesh based protocol and applies on-demand procedures to build routes. This protocol uses soft state to maintain multicast group memberships.

For improving QOS3 , PDR is one of the important metrics. Different factors such as, packet size, group size mobility and action rang, May affect and cause to PDR reduction with single route failure. In ODMRP, after constructing multicast table, neighbour table and routing table, we can define a route between source and destination, and multicast source can transmit packets to receivers via selected routes. ODMRP uses only one path to forward the packets. If this path fails due to dynamic nature of network nodes, the packet is lost and routing process must be start again to find a new routes. The proposed approach in this article, uses multiple paths with diversity coding to end-to-

[1] Mobile Ad hoc Network
[2] Packet Delivery Ratio

[3] Quality Of Service

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end forwarding packets, and illustrate that use of multiple paths could maintain the source to destination connection longer time. In other words, if a node keeps multiple paths to destination frequency searching for new routes is much lower.

The rest of this article is organized as follows: section 2 explains overview about ODMRP. Proposed approach is presented in section 3 and simulation results with OPNET simulator are illustrated in section 4.

2. ODMRP Protocol

On-demand multicast routing protocol (ODMRP) is mesh based protocol and uses a forwarding group (FG) concept. In other words only a subset of nodes forwards the multicast packets. In this protocol group membership and multicast routes are established and updated by the source on demand. Consider figure 1, the source S, desiring to send packets to a multicast group but having no route to it. In this way, it will broadcast JOIN-QUERY control packets to the entire network. These JOIN-QUERY packets periodically broadcast to refresh the membership information and update routes. When an intermediate node receives the JOIN-QUERY packet, it stores the source ID and sequence number in its message cache to detect any duplicates. The routing table is updated with the upstream node ID (i.e, backward learning) from the message which was received for the reverse path back to the source node. If the message is not a duplicate and the Time-To-Live (TTL) is greater than zero, it is rebroadcast.

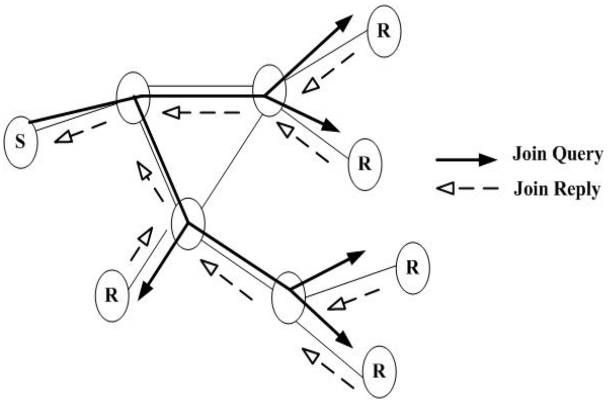

Figure 1: Join Query and Join Reply propagation

When the JOIN-QUERY packets reach a multicast receiver, it creates and broadcast a JOIN-REPLY to its neighbours. When a node receives a JOIN-REPLY, it checks whether the next hop node ID of one the entries matches its own ID or not. If it does, the node realizes that it is on the path to the source and thus is part of forwarding groups. It then sets the FG-flag and broadcasts its JOIN-REPLY build on matched entries. The JOIN-REPLY is thus propagated by each forwarding group member until it reaches the multicast source via the shortest path. This process constructs (or updates) the routes from source to destinations and builds a mesh of nodes, the forwarding group. The forwarding group concept has been illustrated in figure 2. The forwarding group is a set of nodes responsible for forwarding multicast data on shortest paths between any member pairs. All nodes inside the bubble (multicast members and forwarding group nodes) forward multicast data packets.

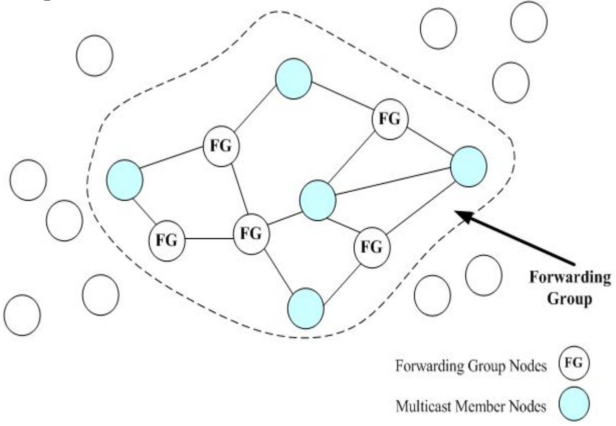

Figure 2: Forwarding group concept

The mesh provides richer connectivity among multicast member compared to trees. Redundancy among forwarding group helps overcome node displacements and channel fading. Thus, frequent reconfigurations are not required.

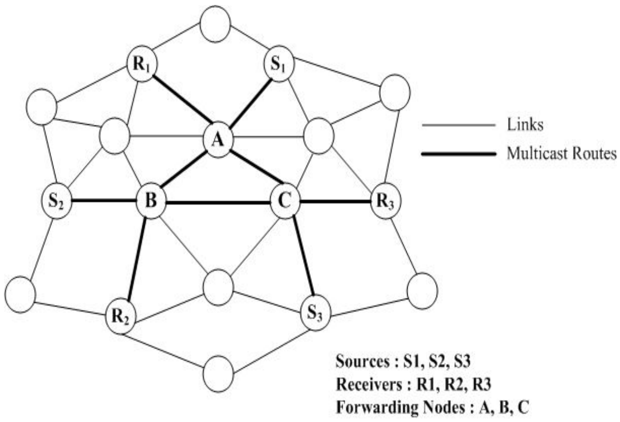

Figure 3: Mesh structure

Figure 3 shows the robustness of a mesh reconfiguration. Three sources S1, S2 and S3 send multicast data packets to three receivers R1, R2 and R3 via three Forwarding group A, B and C. Suppose the route from S1 to R2 is <S1-A-B-R2>. In a tree configuration, if the link between nodes A and B breaks or fails, R2 cannot receive any packets from

S1 until the tree is reconfigured. On the other hand, ODMRP already has a redundant route <S1-A-C-B-R2> to deliver packets without going through the broken link between nodes A and B.

After this group establishment and route setup process, a multicast source can transmit packets to destinations via selected routes, and forwarding groups. While it has data to send, the source periodically sends JOIN-REPLY packets to refresh the forwarding group and routes. When receiving a multicast data packet, a node forwards it only if is not a duplicate and the setting of the FG-flag for the multicast group has not expired. This procedure minimizes traffic overhead and prevents sending packets through stale routes. In ODMRP soft state approach is taken to maintain multicast group members. No explicit packets need to be sent to join or leave the group. In other words, there is not extra signaling. if a multicast member wants to leave the group, it simply stops sending JOIN QUERY packets, since it does not have any multicast data to send to the group. If a destination no longer wants to receive from a particular multicast group, it does not transmit the JOIN REPLY for that group. Nodes in the forwarding group are demoted to non-forwarding nodes if not refreshed (no JOIN REPLIES received). This feature is very suitable for the mobile ad hoc network environment, in which join/leave operations may happen more frequently, and the cost of group maintenance is very high.

Finally, after this route construct process between source and destination, and saving in routing table and MRT4 table, multicast source start to transmit packets. But the route from source to destination may be failed due to dynamic nature of the network. Thus the packet is lost and the routing process should start again to find a new route. This procedure is caused to PDR reduction.

3. Proposed Algorithm

In the previous section we say that in ODMRP and packet forwarding time, the packet delivery ratio reduces due to link breakage. In the proposed approach, the data packets which are forwarded use more than one best neighbour at the source node, and only through the best neighbour at the intermediate nodes. In addition, the packets which are ready to send in source, encoded and using diversity coded routes for data forwarding to overcome single route failure. The codes are also transmitted in the similar way as data. In this approach we have restricted the multipaths to only 3. Using more than 3 paths lead to unreliable routing and increase packet drop.

[4] Multicast Routing Table

Such that has been showed in figure 4 there are three paths for sending packets from source node. First packet is forwarded from first path, second packet is forwarded from second path and coded packet (the XOR of first and second packets) is forwarded from third path. This procedure continues until forwarding all packets from source. In this approach, Sp is total number of packets to be transmitted in source, Dp is total number of packets received in destination, n is data packet id, m is block id and k is path number.

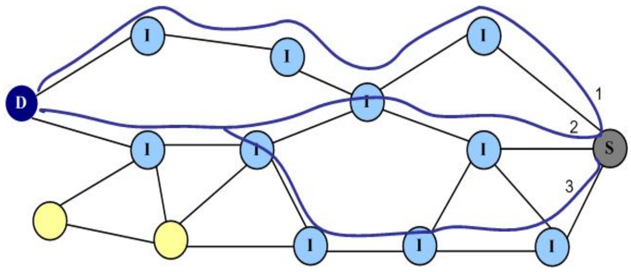

Figure 4: Forwarding packets from diversity route

The packets in source node are forwarded from explained three paths. Intermediate nodes prevents duplicate packets and loop creation, Also in the destination node, depending on conditions, it posses self healing nature. It means that if first packet does not arrive to destination, it can obtain by XORing second packet with coded packet, and if second packet does not arrive, it can obtain by XORing first packet with coded packet. This process caused to improving PDR.

We discuss this algorithm in three phases with detail:

- ***Source node***

Step 0: Initialize m=n=k=1.

Step 1: Check whether n $==S_p+1$,

Yes: Go to step 5.

No: Go to step 2.

Step 2: Check whether m is a multiple of 3,

Yes: Go to step 4.

No: Go to step 3.

Step 3: Assign block id m to packet number n, transmit the packet through k^{th} path. Increment m, n and k by 1. Go to step 1.

Step 4: Compute diversity code using,

$$\text{Coded packet} = (n-2)^{th} \text{ packet } \oplus (n-1)^{th} \text{ packet}$$

Assign block id m to coded packet and transmit it through k^{th} path. Increment m by 1, reset k to 1. Go to step 1.

Step 5: End.

- ***Intermediate node (I):*** this phase has made of from two steps:

Step 1: Reach Packet to node I, it checks for all entries in data table whether m=entry id,

Yes: Drop the packet

Go to step 3.

No: packet is new. //This step drops the duplicate packets.

Step 2: Check whether the best neighbour for node I is already present in the packet.path traversed field,

Yes: check the same with the next best neighbour.

Continue till a neighbour node that is not in the packet.path traversed field is found,

Route the packet through that node. //This step avoids looping.

Step 3: End.

Destination node (D):

Step 0: Initialize the number of packet D_P =0.

Step 1: Check the block id of the received packets if it is a multiple of three,

Yes: Go to step 2.

No: increment D_P and decode.

Step 2: Check if any two previous data packets is not received,

Yes: Go to step 3.

No: Go to step 1.

Step 3: Recover the lost packet as,

$$Re\,cov\,erd\ \ packet \begin{cases} (n\text{-}1)^{th}\ \text{data packet} \oplus \text{Code packet} & ,\ \text{If } (n\text{-}2)^{th} \text{ packet is lost} \\ (n\text{-}2)^{th}\ \text{data packet} \oplus \text{Code packet} & ,\ \text{If } (n\text{-}1)^{th} \text{ packet is lost} \end{cases}$$

Increment the packet DP parameter. Go to step 1 still the simulation time is over.

Step 4: Calculate the Packet delivery ratio for each destination node as, $\mathbf{PDR = D_P / S_P}$.

4. Simulation Results

For simulation proposed approach, the OPNET simulator (Optimum NETwork) has been used. OPNET is general purpose network simulator that operates as discrete event, and it uses C++ codes for simulating. Main purpose of OPNET is optimizing costs, performance and accessibility. It uses a hierarchical model to define each aspect of the system. The top level consists of the network model, where topology is designed. The next level is the node level, where data flow models are defined. A third level is the process editor, which handles control flow models. Finally, a parameter editor is included to support the three higher levels.

Figure 5 and figure 6 are shown node model and process model of ODMRP in OPNET.

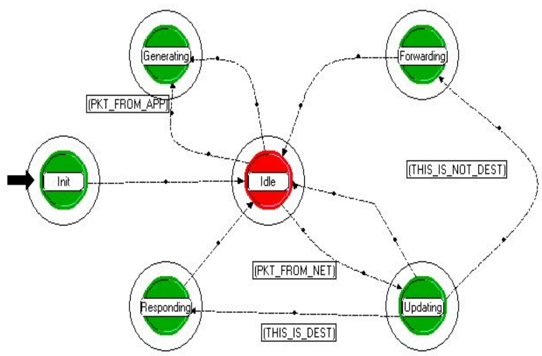

Figure 5: ODMRP node model

Our approach is implemented by modeling a network with 100 mobile nodes in a action range of 1000 x 1000 sq. meter area. Each node is placed uniformly and its mobility is modeled using random wave point. The simulation results have been discussed for 10 minutes simulation time with 2Mbps bandwidth. MAC layer protocol is IEEE 802.11 and number of packet sent is 100.

The performance of the approach and simulation results are illustrated for mobility, packet size, group size and action range metrics by implementing multicasting using single path and diversity paths. The simulation of the approach is carried out for adequate number of times to obtain the optimal results.

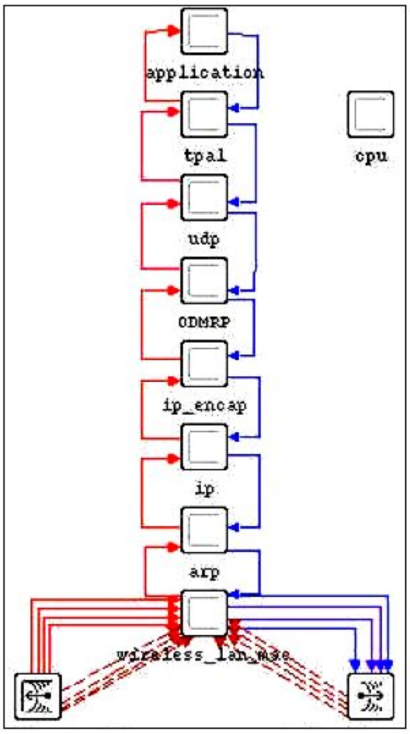

Figure 6: ODMRP process model

The PDR performance with respect to mobility is plotted in figure 7. From the results, it is clear that as mobility increases, the PDR decreases for two cases. The performance of algorithm with path diversity is approximately 7 – 15% better than that without diversity code at a mobile speed in the range of 40–50 km/hr. From the results shown in figure 8, it is observed that as the number of member increases, the PDR decreases, but the decrease is less for the diversity code case. The effect of size of packet is given in figure 9. In this, it is clearly seen that PDR is not affected by the size of the packet for without diversity scheme, but it decreases for single path for the connection is lost before transmission of the entire packet. The figure 10 shows the PDR Vs action range for fixed 100 nodes. In this as the action area increases, the nodes are sparsely placed and hence reliable routes are very less so the PDR decreases. From all the above figures it is clear that the coded route diversity technique results in improved PDR and hence improves the quality of service.

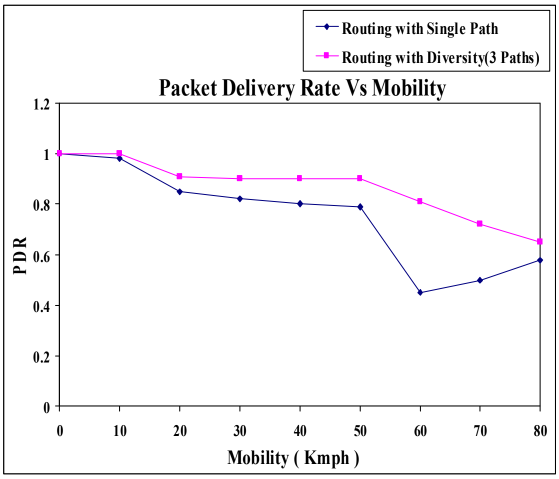

Figure 7: PDR Vs Mobility

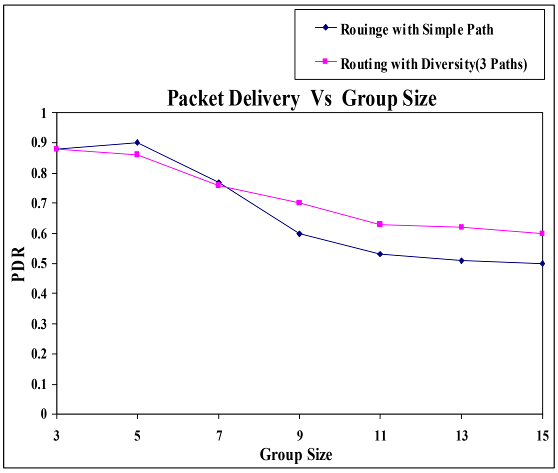

Figure 8: PDR Vs Group Size

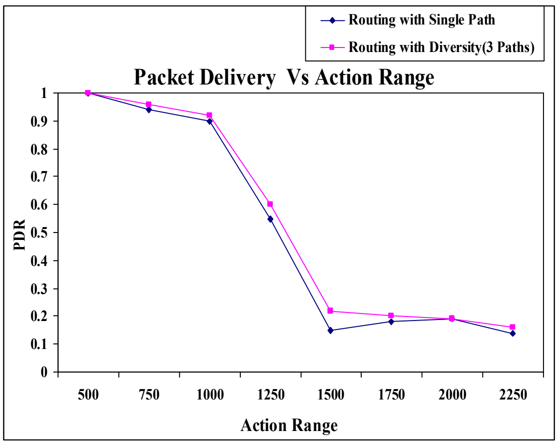

Figure 9: PDR Vs Action range

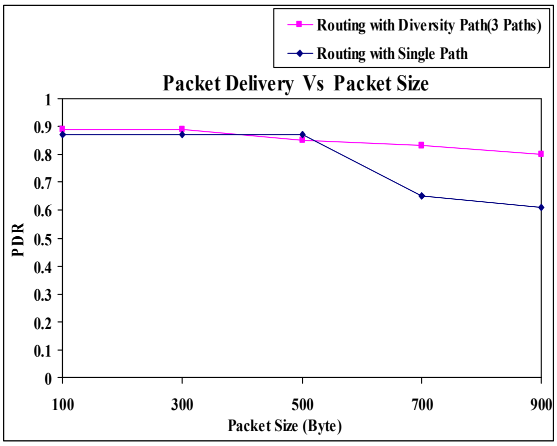

Figure 10: PDR Vs Packet size

5. Conclusion

ODMRP is on-demand and mesh based protocol that forwards data packets from source to destination with creating mesh. One of the important metrics in QOS of forwarding packets is PDR. PDR may affect by mobility, Group Size, Packet Size and action range. Since ODMRP use single route for forwarding packets, if this route fails the packet is lost and cause to PDR reduction in destination. The proposed approach uses multiple routes with diversity coding for packet forwarding in source. Thus PDR improves due to route diversity and overcoming singe route breakage. Simulation results illustrate that using multiple coded paths instead of single path will be better in ODMRP. This approach has overhead but according to results for PDR, we don't consider in here.

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