Distributed Multicast routing protocol for Mobile Ad Hoc Networks

TZAY-FARN SHIH[1†] ,CHAO-CHENG SHIH[2] and CHIN-LING CHEN[1]

[1]Department of Computer Science and Information Engineering,
Chaoyang University of Technology,
Taichung, Taiwan 41349, R.O.C

[2]Department of Information Management
Shih Hsin University
Taipei, Taiwan 116, R. O. C

Abstract: - Multicasting will be concerned as an essential part of mobile Ad Hoc networks. Many proposed routing algorithms require maintaining a global network state at each node, the imprecision of global state and the large amount of storage and communication overhead induce poor scalability. In this paper, we propose a distributed cluster-based QoS multicast routing algorithm which only requires maintaining a local state at each node. Our protocol partitions the network into square clusters. In each cluster, a cluster head and gateways are selected. Then, a distributed computation collectively utilizes the local state information to construct multicast tree in a hop-by-hop basis. Simulations are conducted to evaluate the performance of our algorithm. As it turns out, our protocol has better performance and lower routing overhead than the non-cluster based algorithm.

Key-Words: - mobile ad hoc network, multicasting, loop-free, proactive, reactive

1 Introduction

Without any typical wiring requirements, wireless networking offers freedom moving around the effective area. There are currently two variations of mobile wireless networks. They are known as infrastructure and infrastructureless mobile network, or mobile ad hoc network (MANET). Nodes of these networks function as routers. According to how route information is collected, ad hoc network routing protocols can be classified as proactive and reactive [1].

Many applications of computer network will involve multiple users. Thus, multicasting will likely be an essential part of networks. In multicast communication, messages are concurrently send to multiple destinations. One of the core issues that providing such mechanisms is multicast routing [2-7]. In addition, QoS in ad hoc networks has recently also received more attention. QoS routing is the process of choosing the routes to be used by the flow of packets of a logical connection in attaining the associated QoS constraints. There are two QoS multicast routing strategies [8], source routing and distributed routing. In the source routing, a feasible path is locally computed at the source node that induce the scalability problem in large networks. In the distributed routing, the path computation is distributed among the intermediate nodes so it is more scalable. The availability of small, inexpensive low-power GPS receiver and techniques for calculating relative coordinates based on signal strengths make it possible to apply position-based routing algorithm in ad hoc mobile network [9].

The rest of the paper is organized as follows. Our protocol is described in Section 2. Section 3 presents the simulation model and the simulation results. Finally, we give a conclusion in Section 4.

2 Distributed Location-Aware Cluster Multicast QoS routing protocol

In this section, we describe the operation of our distributed location-aware cluster multicast QoS routing protocol (DLACMQR).

If the effective transmission radius of each mobile node is R, then we let the value of L equal to $R/\sqrt{2}$. Thus, the entire network can be divided into a number of $L \times L$ square regions, called zones or clusters. It guarantees each pair of nodes in the same cluster always within the effective transmission range. By the assistance of position information of each node that obtained from positioning device such as global positioning system (GPS), each node can do self-clustering.

[†] Corresponding author.

After the clusters have been constructed, a cluster head selection algorithm is used to determinate a cluster head of each cluster. It always chooses a node nearest to the center of cluster as the cluster head by contention. A node of this kind has longer distance away from the side of cluster; it will take more time to roam out of this region so that it will keep a longer route life. If the distance of two adjacent cluster heads is longer than the effective transmission radius, the gateway selection algorithm is running to choose an intermediate node that is nearest to those two cluster heads as a gateway node to be responsible for packet relay. Otherwise, the gateway selection algorithm will not be triggered.

The procedure of route discovery is based on a best predecessor replacement policy [10]. When a node receives a probe packet, it checks the QoS constraints and compares the accumulated metric (e.g. delay and cost) of the current probe packet with the previous probe packets'. If the QoS constraints are satisfied and the accumulated metric of the new probe is better than the previous probes' accumulated metric, the node changes its predecessor to the node that the new probe packet comes from and forwards this probe packet immediately. Owing to every node select the best predecessor, the path constructed by this algorithm is optimal.

When a source node needs to transmit packets and a valid route is not available, it initiates a route discovery procedure to setup a path. It sends a route probe packet, called PROBE, to its cluster head. If the destination is in the same cluster, the cluster head will forward this probe packet to the destination node directly. On the contrary, the cluster head forwards the PROBE packet to its gateway nodes. After receiving the PROBE, the gateway nodes forward the PROBE to the proper neighboring cluster head immediately, the process is repeated until either the destination or an intermediate node with a valid route to the destination is reached. Then, the destination or intermediate node will select an optimal route based on the best predecessor replacement policy and reply an acknowledgement packet, denoted ACK, to its predecessor. The ACK packet will be continually forwarded along the reverse direction of PROBE until the source node is reached. Once the source node received the ACK packet, the route is established and the source node starting to transmit data packets. While a node received a PROBE packet with better accumulated metric and there is a route between the source node and this node, the node must to send a TEARDOWN packet to the source node to delete the old path between them.

When a packet encounters a broken link in the data transmission procedure at a node, the node will inform the source node immediately by sending an ERR packet backward to it. While the source node received an ERR packet, it deletes the related entry of routing table and initiates route discovery to reconstruct new path immediately.

In our proposed protocol, the route discovery process is responsible by the source node, destination nodes, cluster heads and gateway nodes not by all network nodes. Thus, DLACMQR is scalable. The larger number of network nodes, the more efficiency our protocol will be.

3 Simulation Model and Results

We have developed a simulator for our distributed cluster based routing protocol DLACMQR. The simulator was implemented within Global Mobile Simulation (GloMoSim) library by C++ language. We tried to evaluate the performance of DLACMQR and ODMRP. The implementation of ODMRP followed the specification in the Internet Draft draft-ietf-manet-odmrp-02.txt. The real execution time, average collision, average probe overhead, data loss rate and throughput are studied by simulation. The network nodes were generated according to a uniform distribution. All nodes were placed in a 1000 M × 1000 M range to simulate actual network. In DLACMQR, we let the side length of the square region L to be 200 meters. In every run, there are two multicast groups. One of them has two source nodes and the other has one source node. The traffic generators used by the three source nodes in the simulator are CBR. The CBR simulates a constant bit rate traffic generator. The generators initiated the first packet in different time and send a 512 bytes packet every 500ms time interval. The join time and leave time of all group members were set to 0 and 400 seconds respectively. The QoS constraint we concerned in the simulation is end-to-end delay. The bandwidth is 2Mbps.

Fig. 1 shows the total times of collision happened in ODMRP and DLACMQR for different network size. The number of collision occurred in DLACMQR is much less than ODMRP and collision is increased in proportion to the network size. This result meets our expectation. The probability of collision is proportioned to the number of packets want to be transmitted. The lager amount of nodes needs to transmit packet and transmitting packet by broadcasting will produce a mass scale of traffic and induce more collision. In ODMRP, a lot of nodes take part in the route probing and data relay process and it transfer data and control packet by broadcasting, which causes the times of collision to increase

ISBN: 978-960-6766-79-4

ISSN 1790-5117

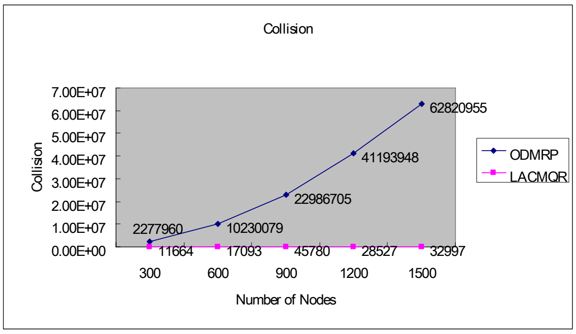

Fig. 1 Collision occurred.

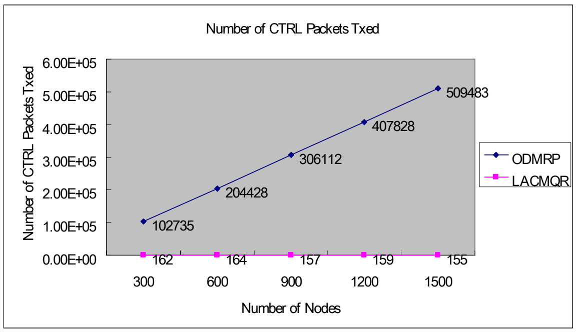

Fig. 2 Control packets transmitted.

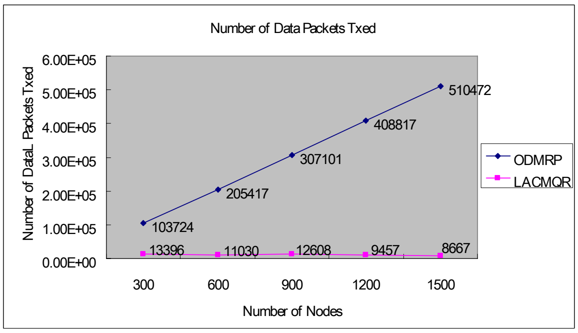

Fig. 3 Data packets transmitted.

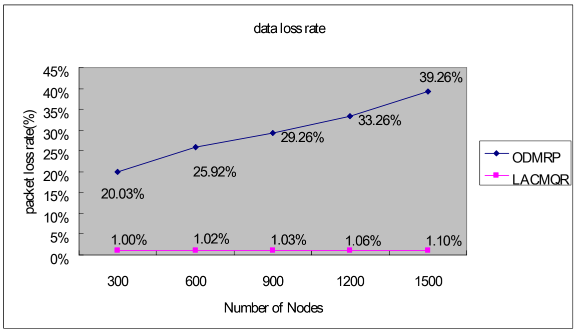

Fig. 4 Data loss rate.

near exponential. On the contrary, in DLACMQR only cluster head, gateway, source and destination nodes are responsible for routing and data transmission. DLACMQR send packet to target node by unicasting. These two characteristics result in the lower occurrence of collision in our protocol.

The control packets of ODMRP include join query packets, join reply packets and acknowledgement packets. In DLACMQR, the control packets consist of join query packets, join reply packets and tear down packets. Fig. 2 depicts the curve of the total number of control packets transmitted in ODMRP and DLACMQR. The figure shows that the mesh-based protocol ODMRP produced higher control packets than the tree based methodology DLACMQR. The considerable quantities of control packet that generated by ODMRP is resulted from the large amount of routing nodes and their flooding behavior. In DLACMQR, the routing nodes are proportion to the number of clusters and limited within an upper bound that we described in theorem 1. When an intermediate node receives a PROBE packet, it relays the packet to the accurate neighbor nodes by unicasting. Because the numbers of partitions are identical, the amounts of PROBE packets are similar for different network size.

The total number of DATA packets transmitted in ODMRP and DLACMQR for different network size is illustrated in Fig. 3. In ODMRP, DATA packets are transmitted by broadcast. While the member of forwarding group receives a non-duplicated DATA packet, it rebroadcasts this packet to its neighbor nodes until all neighbor nodes have received this packet the flooding stop. DATA packet may be duplicated and forwarded along different paths. DATA packet flooding in forwarding group will generate large quantities of duplicated packets propagate in the network. It causes a high probability of collision and reduces the performance of packet transmission. In DLACMQR, the DATA packets are transmitted along the constructed multicast tree by unicast. While the intermediate node receives a DATA packet, it replicates and relays the received DATA packet to the right next hop to the destinations. Each node will receive a same DATA packet only once. Hence, ODMRP produces a huge amount of duplicated DATA and exhausts a lot of resources.

Fig. 4 presents the data loss rate of ODMRP and DLACMQR. In this figure, we find that the data loss rate of ODMRP is much higher than DLACMQR. The high data loss rate is also resulted from the poor characteristics of ODMRP that we mentioned above. The flooding policy used in ODMRP produces a lot of duplicated packets to propagate around the network. The limited resources (e.g., bandwidth and power etc.) are mostly exhausted by those unnecessary packets.

4 Conclusion

In this paper, we proposed a distributed cluster-based multicast routing algorithm, called DLACMQR. Our algorithm requires maintaining every node's local state that saves the storage and communication overhead significantly. We divided the entire network into a number of square regions called zones or clusters by the assistance of physical location information of every mobile node that get from global positioning device. The route discovery is running in source node, destination nodes, cluster heads and gateway nodes, which reduces the probing traffic significantly. The comparison of DLACMQR and ODMRP was studied through extensive simulation. The simulation results reveal that DLACMQR has much better performance than ODMRP. The cluster head selection algorithm and gateway node selection algorithm have a great effect on the performance and the route lifetime of DLACMQR. We are now trying to develop a new cluster head and gateway selection algorithm based on genetic algorithm.

References:

[1] E. M. Royer, C. K. Toh, "A Review of Current Routing Protocols for Ad Hoc Mobile Wireless Networks," IEEE Personal Communications, pp. 46-55, Apr. 1999.

[2] S.-J. Lee, W. Su, and M. Gerla, "On-Demand Multicast Routing Protocol (ODMRP) for Ad Hoc Networks," Internet Draft, draft-ietf-manet -odmrp-02.txt, January 2000.

[3] L. Ji and M.S. Corson, "A Lightweight Adaptive Multicast Algorithm," In Proceedings of IEEE GLOBECOM'98, Sydney, Australia, pp. 1036-1042, Nov. 1998.

[4] J.J. Garcia-Luna-Aceves and E.L. Madruga, "A Multicast Routing Protocol for Ad-Hoc Networks," In Proceedings of IEEE INFOCOM'99, New York, NY, pp. 784-792, Mar. 1999.

[5] E.M. Royer and C.E. Perkins, "Multicast Ad-hoc On-Demand Distance Vector (MAODV) Routing," IETF Internet Draft, draft-ietf-manet-maodv-00.txt, July 2000.

[6] C.-C. Chiang, M. Gerla, and L. Zhang, "Forwarding Group Multicast Protocol (FGMP) for Multihop, Mobile Wireless Networks," Baltzer Cluster Computing, vol. 1, no. 2, pp. 187-196, 1998.

[7] Y.-B. Ko and N.H. Vaidya, "Geocasting in Mobile Ad Hoc Networks: Location-Based Multicast Algorithms," In Proceedings of IEEE WMCSA'99, New Orleans, LA, pp. 101-110, Feb. 1999.

[8] Satyabrata Chakrabarti and Amitabh Mishra, "QoS Issues in Ad Hoc Wireless Networks," IEEE Network Magazine, pp. 142-148, Feb. 2001.

[9] R. Jain, A. Puri and R. Sengupta, "Geographical Routing Using Partial Information for Wireless Ad Hoc Networks," IEEE Personal Communications, pp. 48-57, Feb. 2001.

[10] T. F. Shih and C. C. Shih, "Efficient Approaches for Finding QoS Constrained Paths with Applications for Multicast Routing," Proc. of 8th Joint Conference on Information Sciences, Jul. 2005, pp. 312-315.