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다중 포스트의 적응형 Zoning으로 MANET을 위한 효율적 라우팅

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Adaptive Zoning with Multiple Posts for Efficient Routing in MANET

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Abstract

Many routing protocols have been proposed for mobile ad-hoc networks, but most protocols do not consider the physical location of the communicating nodes. In this paper we propose adaptive zoning approach with multiple hosts for reducing the number of route request messages. The proposed approach makes the sub-request zone has shorter interval than the existing schemes between the source and destination. This results in significantly lower routing overhead than the existing schemes as verified by computer simulation.
Keywords: Ad hoc networks, wireless networks, routing protocols, simulation, and performance evaluation.

1. Introduction

There exist two variations of mobile wireless networks, infrastructured network and Mobile Ad hoc NETworks (MANET). The infrastructured network of fixed and wired gateways consist of a group of mobile and a much smaller number of base stations or access points. MANET is characterized by changing/unpredictable network topology, high degree of mobility, energy-constrained mobile nodes, bandwidth-constrained, intermittent connection, and memory-constrained. The routing protocols for MANET need to emphasize convergence, bandwidth overhead, forwarding latency, and route and cache correctness.

Since their emergence in the 1970s, most protocols proposed for MANET are categorized as `table-driven' and `source-initiated on-demand driven'[14]. The table-driven approach attempts to maintain up-to-date routing information from each node to every other node in the network. With the second approach, when a source wants to send a packet to a destination, it invokes the route discovery mechanisms to find the path to the destination.

Nowadays, new challenges for MANET are battery constraints, security hazard, packet losses due to transmission errors, and so on. One of the most important considerations is limited wireless transmission range. Several protocols use the location information for controlling the transmission range such as LAR(Location Aided Routing) [9], DREAM(Distance Routing Effect Algorithm for Mobility) [3], RDMAR(Relative Distance Micro-Discovery Routing) [1], GEDIR(Geographic Distance Routing) [15], and GLS(Global Location Service) [10].

LAR is one of the protocols using location information to reduce routing overhead. Location information can also be piggybacked on any message from destination to source. Even though it has some advantages, there are some limitations for reducing overhead such that the nodes need to know their physical locations and do not take into account possible existence of obstructions for radio transmissions. In order to solve these problems, we propose adaptive zoning approach with multiple hosts for reducing the number of route request messages. The proposed approach makes the sub-request zone has shorter interval than the existing schemes between the source and destination. This results in significantly lower routing overhead than the existing schemes.

The rest of the paper is organized as follows: Section 2 presents an introduction of existing routing protocols that utilizing location information. Section 3 presents how the routes are discovered based on flooding technique on route discovery and the LAR protocol. In Section 4, we propose the adaptive zoning approach. Section 5 presents the simulation model and performance of the proposed scheme, and compares it with earlier schemes. Finally, Section 6 is the conclusion of the paper.

2. Related Work

Most routing protocols for MANET do not consider the physical location of the nodes, but some protocols do that. DREAM (Distance Routing Effect Algorithm for Mobility) [3] uses location and speed information, and employs flooding of data packets as the routing mechanism unlike LAR. It is table-driven routing protocol having features found in DSDV [12]. Here the source sends data packet to all neighbors in a cone rooted at source node. The nodes periodically broadcast their physical locations, and nearby nodes update their information frequently while distant ones do that less frequently.

RDMAR (Relative Distance Micro-Discovery Routing) [1] estimates the distance between source and intended destination in the number of hops. The source node sends route request with time-to-live (TTL) value which is equal to the estimated distance. The hop distance estimate is based on the physical distance that the nodes may have to travel since the previous route discovery, and transmission range.

With GEDIR (Geographic Distance Routing) [14], location of the destination node is assumed to be known. Each node knows location of its neighbors and forwards a packet to its neighbors closest to the destination. This algorithm terminates when an edge is traversed twice consecutively.

With GLS (Global Location Service) [10], each node maintains its location information at other nodes in the network. Density of nodes who know location of a node decreases as distance from it increases. Each node updates its location periodically – nearby nodes receive the updates more often than distant nodes. A hierarchical grid structure is used to define near and far.

3. Location-Aided Routing

While most mobile ad-hoc routing protocols do not consider the physical location of destination node, more complementary measures have become to be used for improving the routing efficiency. Here the critical consideration is on flooding control packets, which causes significant overhead for each route request. We first illustrate basic flooding based algorithm, and then the Location-Aided Routing.

3.1 Flooding for Route Discovery

DSR(Dynamic Source Routing) [7,8] and AODV(Ad-hoc On-Demand Vector) [13] protocol use flooding algorithm when they need the route discovery. For example, assume Node-1 (S) wants to determine a route to Node-8 (D) in Figure 1. There are many routes from S to D. The adjacent nodes check whether the request message is redundant, and broadcast the request to theirs neighbors. If some intersections receive overlapping messages, they discard the redundant route request.

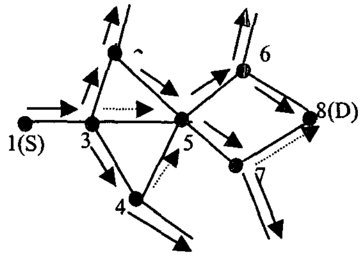

Figure1. Flooding for route discovery.

As the route request is propagated to other nodes, the path the request traversed is included in the route request packet. When D receives the route request finally, it responses it by sending a route reply message to S. The route reply message traverses backward the path obtained from the route request packet. If D does not receive a route request message, then S initiates route discovery. Owing to having timeout with all the nodes, a new route discovery is initiated. Timeout may occur if the destination does not receive a route request, or if the route reply message from the destination is lost.

In addition, a route discovery is initiated when S recognizes that a previously determined route to D is broken, or when S does not know a route to D. If the next hop on the route is broken when S sends a data packet along a particular route, the path returns a route error message along a particular node. When S receives the route error message, it initiates route discovery for D.

3.2 Location-Aided Routing Protocol

LAR [9] is a source-initiated on-demand routing protocol having features found in DSR and AODV. DSR and AODV are based on variations of flooding. Flooding algorithm is used for many redundant transmissions of route requests through the forwarding nodes located far away from destination. So, they need a new approach to reduce the number of nodes to whom route request is propagated.

LAR is one of the protocols using location information to reduce routing overhead. Location information can also be piggybacked on any message from destination to source. Destination may also proactively distribute its location information. Location information at LAR may be provided by Global Positioning System (GPS) [4,5]. A mobile host is possible to know its physical location by using GPS, moves in a two-dimensional plane.

3.2.1 Expected Zone

It utilizes two physical zones, expected zone and request zone. Consider S that needs to find a route to D. Assume that S knows that D was at location L at time t_0, and current time is t_1. Then, from the viewpoint of S at time t_1, the "expected zone" of D is the region that S expects to contain D at time t_1. S can determine the expected zone based on the knowledge that D was at location L at time t_0. If S knows that D travels with average speed v, then S may assume that the expected zone is the circular region of radius $v(t_1 - t_0)$, centered at location L. Thus, expected zone is only an estimate made by S to determine a region that potentially contains D at time t_1.

If S does not know the previous location of D, then S cannot reasonably determine the expected zone. Hence, the entire region that may potentially be occupied by the ad-hoc network is assumed to be the expected zone. In this case, this algorithm reduces to the basic flooding algorithm. If it has more information regarding mobility of a destination node, it can result in a smaller expected zone. Refer to Figure 2.

3.2.2 Request Zone

Assume the same condition as above for S and D. S defines a request zone for the route request. A node forwards a route request only if it belongs to the request zone. To increase the probability that the route request reaches D, the request zone should include the expected zone. The LAR protocol uses rectangular shape request zone.

3.2.3 The LAR Operation

Assume that S knows that D was at location (X_d, Y_d) at time t_0. S initiates a new route discovery for D. In this scheme, S is also assumed to know the average moving speed of D, v.

As aforementioned, S defines the expected zone at time t_1 as the circle of radius $R = v(t_1 - t_0)$ centered at location (X_d, Y_d). Recall that the request zone is the smallest rectangle that encompasses S and the expected zone. For example, assume that S's neighbors are three nodes as shown in Figure 2(b). The two nodes accept the route request message from S because it is located in the expected zone. On the other hand, the remainder discards the route request message from S because it is outside the expected zone. Therefore, the numbers of route request messages can be reduced compared to simple flooding.

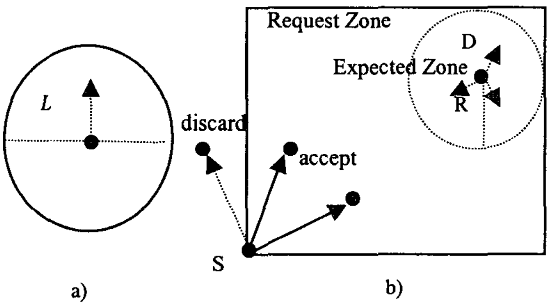

Figure2 a) Expected Zone b) LAR

3.3. LAR scheme Using Fixed Host

This scheme utilizes a fixed host (called post) [6] for further reducing the number of route request messages. Assume that a post coexists in the request zone. At first, S sends a route request message to it. The next time the post forwards the route request message to D. As shown in Figure 3, S sends message only to its neighbors within each request zone. Compared to LAR, LAR-using post can reduce the number of messages.

4. The Proposed Scheme

We introduced two ways of reducing route request messages based on flood routing in Section 3. The existing schemes have some advantages and disadvantages. The advantages are reduction of the scope of route request flood and overhead of route discovery. However, the disadvantages are that the nodes need to know their physical locations and do not take into account possible existence of obstructions for radio transmissions. Note that there exist some limitations in reducing the overhead:

- The number of route request messages varies with the request size. First of all, the request zone varies according to the average moving speed of D, v. If the request zone is large, it is better to use flooding algorithm.
- The request zone varies with the location of S. In other words, according to the location of S, the request zone will be rectangular or square. In addition, the performance is significantly influenced according to the location of post.

The limitation above forces us to use supplementary measure in the routing, and motivates the proposed approach of adaptive zoning with multiple posts. Assume that two or more posts coexist within a large request zone. If S sends the route request message to the nearest post, then the nearest post sends it to other adjacent post toward D, and this process repeats until the message reaches D. Compared with the existing LAR approach, the proposed scheme is expected to significantly reduce the number of message for large request zone. Also, the sub-request zone expects to get shorter interval than the existing schemes between S and D.

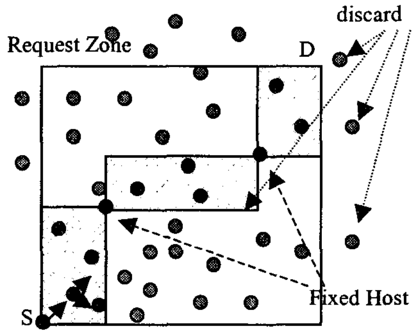

Figure3. LAR using Plural Fixed Hosts

5. Simulation Model and Results

The simulator for evaluating the proposed approach is implemented using the Global Mobile Simulation (GloMoSim) library [16]. The GloMoSim library is a scalable simulation environment for wireless network systems using the parallel discrete-event simulation capability provided by PARSEC [2]. Here we simulate and compare four routing algorithms – flooding, LAR, LAR using a fixed host, and the proposed adaptive zoning approach. The simulation environment is summarized in Table I.

Table I. Simulation model.

Square region	1000 unit x 1000 unit
# of nodes in the network	40, 60, and 80
Simulation time	1000 seconds
Node placement	Uniform distribution
Radio Frequency	800000bits/s
Average Speed	5 and 20 units/s

We assume that each node moves continuously without pausing at any location. For the simulation, one S and D are chosen randomly, respectively.

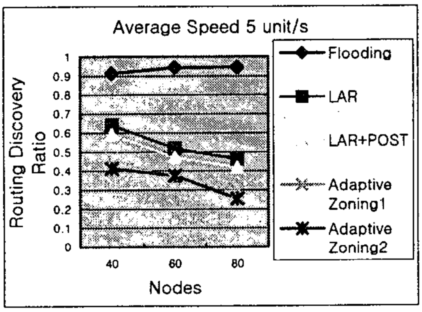

Figure 4. For 40, 60, and 80 nodes, at average speed 5 units/s

The initial locations (x,y coordinates) of the nodes are obtained using uniform distribution. We assume that transmission error or congestion does not occur. In Figure 4 and 5, Adaptive zoning1 and Adaptive zoning2 has 2 and 3 posts, respectively. Also, x-coordinate is the total number of nodes in the network, and y-coordinate is route discovery ratio which is the number of received packets per total packets. Observe that the proposed approach improves the ratio for either case of moving speed.

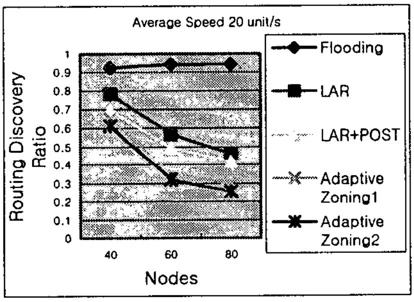

Figure 5. For 40, 60, and 80 nodes, t average speed 20 units/s

6. Conclusions

We have presented adaptive zoning approach for improving the efficiency of existing LAR protocol proposed for MANET routing. Simulation results indicate that it significantly lower the routing overhead compared to three existing schemes. More comprehensive study will be carried out for more dynamic environment such as varying speed and larger network.

References

[1] G. Aggelou and R. Tafazolli, "Relative distance micro-discovery ad hoc routing (RDMAR) protocol," IETF, Internet Draft, draft-ietf-manet-rdmar-00.txt, Sept. 1999.

[2] R. Bagrodia, R. Meyer, M. Takai, Y. Chen, X. Zeng, J. Martin, and H. Y. Song, "PARSEC: A Parallel Simulation Environment for Complex Systems," IEEE Computer, vol. 31, no. 10, October 1998, pp. 77-85

[3] S. Basagni, I. Chlamtac, V. R. Syrotiuk, and B. A. Woodward, "A Distance Routing Effect Algorithm for Mobility (DREAM)," in the fourth annual ACM/IEEE international conference on Mobile computing and networking, pp. 76-84, October 1998

[4] G. Dommety and R. Jain, "Potential networking applications of global positioning system (GPS)," Tech. Rep. TR-24, CS Dept., The Ohio State University, April 1996.

[5] T. Imielinski and J. C. Navas, "GPS-based addressing and routing," Tech. Rep. LCSR-TR-262, CS Dept., Rutgers University, March (Updated August) 1996.

[6] J.-K. Jeong and J.-H. Kim, "Performance Improvement of Location-Aided Routing Using Fixed Post in Mobile Ad Hoc Networks," International Conference on Parallel and Distributed Processing Techniques and Applications, CSREA, IV, pp.2095-2100, Las Vegas, Nevada, June 2000.

[7] D. Johnson and D.A. Maltz, "Dynamic source routing in ad hoc wireless networks," in Mobile Computing (T. Imielinski and H. Korth, eds.), Kluwere Academic Publishers, 1996.

[8] D. Johnson, D.A. Maltz and J. Broach "The dynamic source routing in mobile ad hoc networks (Internet-Draft)," Mar. 1998.

[9] Y.-B. Ko and N. H. Vaidya, "Location-Aided Routing (LAR) in mobile ad hoc networks," Wireless Networks, Volume 6 Issue 4, pp. 307-321, July 2000.

[10] J. Li, J. Jannotti, D. Couto, D. Karger, and R. Morris, "A Scalable Location Service for Geographic Ad Hoc Routing," Proceeding of ACM Mobicom, August 2000.

[11] B. Parkinson and S. Gilbert, "NAVSTAR: global positioning system – ten years later," in Proceeding of IEEE, pp. 1177-1186, 1983.

[12] C. E. Perkins and P. Bhagwat, "Highly Dynamic Destination-Sequenced Distance-Vector Routing (DSDV) for Mobile Computers," Computer Communications Review, pp. 234-244, October 1994.

[13] C. E. Perkins and E. M. Royer, "Ad hoc on demand distance vector (AODV) routing (Internet-Draft)," Aug. 1998.

[14] E. Royer and C.-K. Toh, "A Review of Current Routing Protocols for Ad-Hoc Mobile Wireless Networks," IEEE Personal Communications, pp46-55, April 1999

[15] I. Stojmenovic and X. Lin, "Geographic Distance Routing in Ad Hoc Wireless Networks," Preprint, SITE, Computer Science Technical Report, TR 98-10, University of Ottawa, 1998.

[16] UCLA Parallel Computing Laboratory and Wireless Adaptive Mobility Laboratory, GloMoSim: A Scalable Simulation Environment for Wireless and Wired Network Systems. http://pcl.cs.ucla.edu/projects/glomosim