Reliable Geographic Routing Protocol (RGRP) towards Improving Quality of Service (QoS) in Heterogeneous Mobile Ad Hoc Networks

R.Vadivel
Assistant Professor,
Department of Information Technology,
School of CSE,
Bharathiar University
Coimbatore 641 046.

B.Narasimhan
Assistant Professor,
Department of Computer Technology,
Dr. N.G.P. Arts and Science College,
(Affiliated to Bharathiar University),
Coimbatore 641 048.

ABSTRACT

Developing Quality of Service (QoS) aware routing protocol is an ever demanding task for Mobile Ad hoc Networks (MANETs). This research aims in developing Reliable Geographic Routing Protocol (RGRP) towards improving Quality of Service (QoS) in heterogeneous MANET. RGRP is an adaptive on-demand geographic routing protocol which builds efficient paths based on the need of user applications and adapt to various scenarios to provide efficient and reliable routing. To lessen the impact due to inaccurate local topology knowledge, the topology information is updated at a node in a periodic manner based on network dynamics and traffic demand. On-demand routing mechanism is used in order to reduce control overhead compared to the proactive schemes which are normally adopted in current geographic routing protocols. The QoS metrics such as throughput, packet delivery ratio, delay, overhead, packets drop are taken for comparison with Ad-hoc On-demand Distance Vector (AODV) protocol. NS2 is used for simulation and the results proved that the proposed RGRP outperforms AODV in all aspects such as improved throughput, packet delivery ratio and decreased delay, overhead.

1.INTRODUCTION

Mobile Ad hoc Networks are infrastructure less networks with the ability to deploy anytime anywhere. The characteristics of MANET are dynamic topology, battery constrained and in real time situations it is heterogeneity. In MANET the wireless nodes could self configured and form a network with an arbitrary topology as shown in Fig.1. Various studies have been made to increase the performance of ad hoc networks and support more advanced mobile computing and applications [44], [45], [46]. The existing MANET routing protocols can be categorized as proactive [24], [42], reactive [43], [35], [34], and hybrid [39], [40], [41]. The proactive protocols also known as table-driven protocols will maintain the routing information actively, while the reactive protocols (also called as on-demand protocols) will create and maintain the routes in on-demand basis. The hybrid protocol mingles the reactive and proactive routing approaches. The proactive protocols acquire high control overhead when there is no traffic. On the other hand reactive protocols, the network range or restricted-range flooding for route discovery and maintenance limits their scalability, and the need of search for an end-to-end path prior to the packet transmission also incurs a large transmission delay. The topology-based schemes are usually designed to sustain long-term and continuous traffic. Also they are very inefficient when the data traffic is irregular as said in [32], [31], [30]. In topology based schemes where the nodes are frequently involved in a long period of services with only occasional data exchanges for association or upon events. Nowadays, geographic unicast [29], [28], [33], [36] and multicast [10], [11], [12] routing protocols have drawn a lot of attentions. It is assumed that mobile nodes are aware of their own positions through GPS or other localization schemes [15], [14] and a source can obtain the destination's position through some kind of location service [25], [47]. In geographic unicast protocols, an intermediate node makes packet forwarding decisions based on its knowledge of the neighbors' positions and the destination's position inserted in the packet header by the source.

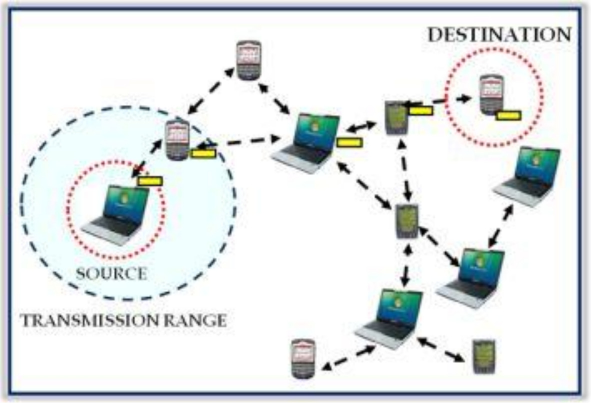

Fig.1 Mobile Ad hoc Networks

The packets are transmitted greedily to the neighbor that allows the packet forwarding to make the greatest geographic progress toward the destination. When no such a neighbor exists, perimeter forwarding [29], [28] is used to recover from the local void, in which packets traverse the face of the glamorized local topology sub-graph by applying the right hand rule until greedy forwarding can be resumed. As the forwarding decisions are only based on the local topology, geographic routing is more scalable and robust in a dynamic environment. Even though geographic routing has many advantages and has shown a great potential, the inaccurate knowledge of local geographic topology and destination position can greatly affect routing performance. This not only leads to a larger packet delivery latency and more collisions, but can also result in a routing failure. Beaconless schemes have been proposed [38], [17], [2], [3] to find the next-hop forwarders in the absence of beacons before each packet transmission. Although this avoids the overhead of sending periodic beacons when there is no traffic, the search of next-hop forwarder before each packet sending introduces a high overhead and end to- end delay during packet transmissions [7].

2.RELATED WORKS

The conventional on-demand routing protocols [43], [35], [34] often involve flooding in route discovery phase, which limits their scalability. LAR [33] and DREAM [36] make use of the nodes' position information to reduce the flooding range. In LAR, the flooding of route searching messages is restricted to a request zone which covers the expected zone of the destination. In DREAM, intermediate nodes forward packets to all the neighbors in the direction of the estimated region within which the destination may be located. Unlike topology-based routing protocols, geographic routing protocols [28] are based on mobile nodes' positions. Some recent geographic routing studies focus on the improvement and design of forwarding schemes (e.g., [37] [5]), designing routing metric [1], better recovering from local void [8] or analyzing the routing performance [27]. The work in [23], [22], [21] consider the combination of location and other cost factors in routing. Our focus is to address the issues due to the inaccuracy of geographic topology information, and adapt the protocol in various scenarios to improve routing performance. These schemes can work with ours to achieve different objectives. The recovery strategy of our first routing protocol also avoids the reliance of planar graph which may not be available in a practical environment [21]. Tschopp et al. [18] have tried to combine geographic routing and topology-based routing in ad hoc networks to overcome the shortcomings of both kinds of routing. The work uses a beacon-based algorithm for the embedding of the connectivity graph. However, the unavoidable distortion of the embedding will result in non-optimal routing and even forwarding failure. The position information has the following three sources which all impact routing performance, with the first two assumed to be known and the third one contained in geographic routing protocols: 1) positioning system (e.g.,GPS): each node can be aware of its own position through a positioning system, which may have measurement inaccuracy. 2) location service: every node reports its position periodically to location servers located on one or a set of nodes. The destination positions obtained through these servers are based on node position reports from the previous cycle and may be outdated. 3) local position distribution mechanism: every node periodically distributes its position to its neighbors so that a node can get knowledge of the local topology. Recently, the impact of the position inaccuracy from the first source has been studied in [13], [20], [9] and the second one is discussed in [19]. Being an important self-contained part of geographic routing protocols, the design of position distribution mechanism will affect local topology knowledge and hence geographic forwarding, but little work has been done to study and avoid its negative impact. Son et al. [19] conducts a simulation-based study on the negative effect of mobility induced location error on routing performance. Instead, we make a quantitative analysis on the negative effect. Most importantly, we propose two on-demand adaptive geographic routing protocols that can meet different application and traffic needs and adapt to different conditions. Our routing schemes are designed to be efficient and robust, with adaptive parameter settings, flexible position distributions, and route optimization. Authors in [38], [17], [2], and [3] attempted to remove the proactive beacons in geographic routing protocols to reduce overhead. CBF [38] and GeRaF [17] proposed different schemes to avoid contention in selecting the next-hop forwarding nodes. The need of changes at both the MAC layer and the network layer increases the complexity of the two protocols and the uncertainty of the performance. In BLR [2], after a forwarding node broadcasts the data packet, its neighbors in a restricted area will contend for packet relaying. Apart from the inherent unreliability of broadcast, as a data packet is generally much longer than a path search message, the competition in data packet forwarding from multiple neighbors will lead to much higher collision probability. Additionally, since the best next hop may not be located in the restricted area, restricting the forwarding only from nodes in the designated area would lead to non-optimal routing. The contention scheme also cannot guarantee only one neighbor wins for the relaying [38], leading to redundant packet forwarding and more collisions. Therefore, the proposed packet relay method cannot work properly when the traffic load is high. In contrast, our preliminary studies [16] indicate that a higher packet delivery ratio can be obtained if the next-hop relay node can be found before packet forwarding. Instead of sending the control messages to select the forwarder first or purely relying on neighboring nodes to compete in forwarding, BOSS [3] broadcasts the data directly and selects the first node that successfully receives the packet as the next-hop forwarder. Although this may better ensure the packet to be received correctly, similar to BLR [2], broadcasting a larger data packet may increase the probability of collisions when multiple neighboring nodes attempt to transmit packets simultaneously, thus consuming more bandwidth for retransmissions. Different from [3], we set a conservative signal to noise threshold for the received control message to ensure more reliable data transmissions upon channel fading. The reliable unicast transmission can be ensured by MAC layer such as 802.11 which reserves the channel through RTS/CTS to avoid collision. More recently, efforts have been made to address local transmission void [4] by forming planar graph without complete neighbor information or consider energy efficiency along with beaconless transmissions [6], [5]. Although existing beaconless schemes reduce the overhead due to active beacons, the search of the next-hop forwarder for each packet makes the end-to-end delay of these beaconless schemes significantly higher than that of GPSR, i.e., almost ten times as shown in [7]. In contrast, our first protocol only needs to search for the next-hop forwarder when the traffic is initiated or when the cached next-hop forwarder cannot be reached.

3.PROPOSED WORK

RGRP based only on a single hop neighbor node positions to make greedy and perimeter forwarding. RGRP contains a reactive beaconing mechanism that is adaptive to the traffic need. The periodic beaconing is generated at a time when a node overhears data traffic from its neighbor nodes during the first time. The beaconing is terminated when no traffic is heard for a pre-defined time duration. A forwarding mobile node will broadcast a request (REQ) message to generate its neighbor node's beaconing while needed and the neighbor mobile nodes will have random back off before broadcasting a beacon to evade collision. Based on the neighbor topology information, RGRP takes the local void recovery method to evade the need of extra searching. Also RGRP have important parameters for optimal performance. Each mobile node keeps three time values $Time_{REQ}$, $Time_{REQ}Heard$, and $Time_{LBC}$, in which $Time_{REQ}$ records the time when the latest REQ or data packet was sent out, $Time_{REQ}Heard$ is the time when the latest

REQ or data transmission was heard, and $Time_{LBC}$ saves the last beaconing time. A REQ message or a data packet also serves as a beacon since it contains the forwarder's position. Whenever a node receives a REQ or overhears a data transmission from its neighbor, it broadcasts a BEACON carrying its position if CT _ $Time_{LBC}$ _ BC, where CT is the current time and BC is the beaconing interval. This is to make sure that the periodic beaconing is only triggered by the first heard REQ or a data packet after a calm period. The interval BC is bounded within ½BC; MIN; BC; MAX. To avoid continuous beaconing from multiple neighbor nodes, the BEACON sending time is jittered by a random time delay smaller than the interval INT_{jitter}. After a beacon is sent at time T, at the next beaconing time BC, the node efficient path will recover the local void by taking advantage of larger range topology information. In a recovery process, Freq increases its searching range to two hops. Since the absence of a REPLY on the first attempt will be caused by the loss of REQ or REPLY message due to collisions. At the time when a REQ reaches a one-hop neighbor that is closer to Distance Dist than Freq, the neighbor sends back a REPLY after a back off period. Else, the one-hop neighbor of Freq continues broadcasting the REQ to its own one-hop neighbors. When a second-hop neighbor of Freq gets this REQ and is closer to Dist, it sends a REPLY following the reverse path of the REQ message, with the back off period. Different from that in greedy forwarding, a random number between 0 and 1 for both one-hop neighbors and two-hop neighbors is used to avoid potential reply collisions from neighbors that have similar distance Dist to the destination node. When a REPLY is sent by a two-hop neighbor, the intermediate nodes record the previous hop of the REPLY as the next-hop toward Dist with the transmission mode set as recovery RECY. On the other hand, when the REPLY is originated from a one-hop neighbor of frequency Freq, Freq set the transmission mode to be greedy. To avoid overhead, an intermediate node drops a REPLY if it already forwarded or overheard REPLY from a node closer to Dist than the current replier. While then it will unicast the data packet to the detected next hop with the corresponding transmission mode.

If the route searching fails, Freq may expand the searching range again by increasing the value of HOP until it reaches MAXhops. As an alternative of searching for an end-to-end path as in the conventional topology-based routing, the location information is used to guide the searching and selection of relay node(s) toward the destination. As the recovery forwarding is only triggered when needed and the relay nodes will usually be found within a small range (i.e., 80% of the transmission range), the path searching overhead and delay are much smaller than that in conventional topology-based routing.

4.SIMULATION SETTINGS AND PERFORMANCE METRICS

Simulation Settings

We use NS2 [16] to simulate our proposed technique. In our simulation, the channel capacity of mobile hosts is set to the same value: 2 Mbps. We use the distributed coordination function (DCF) of IEEE 802.11 for wireless LANs as the MAC layer protocol. It has the functionality to notify the network layer about link breakage. In our simulation, we keep the number of mobile nodes as 200. The mobile nodes move in a 1500 meter x 1500 meter square region for 150 seconds simulation time. We assume each node moves independently with the varying speed between 0.5 to 2 m/s. All nodes have the varying transmission range between 100 to 200 meters. The simulated traffic is Constant Bit Rate (CBR). Our simulation settings and parameters are summarized in table 1.

Table 1. Simulation Settings

No. of Nodes	200
Simulation Time	150 Seconds
Area Size	1500 X 1500
Mac	802.11
Radio Range	250m
Simulation Time	150 sec
Traffic Source	CBR
Packet Size	512 KB
Mobility Model	Random Way Point
Speed	0.5 to 2 m/s
Rate	100 KBs

4.2 Performance Metrics

We evaluate mainly the performance according to the following metrics.

- Average end-to-end delay: The end-to-end-delay is averaged over all surviving data packets from the sources to the destinations.
- Average Packet Delivery Ratio: It is the ratio of the number .of packets received successfully and the total number of packets transmitted.
- Overhead: It is the number of control packets exchanged during the entire transmission of data packets.
- Throughput: The number of packets successfully transmitted from source to destination.

The simulation results are presented in the next section.

5.RESULTS AND DISCUSSIONS

From fig.2 it is shown that the packet delivery ratio is comparatively better in RGRP with AODV. From fig.3 it is visible that the number of overhead packets of RGRP is lesser than that of AODV. From fig.4 it is can be observed that the throughput in terms of packet is better than the proposed RGRP than AODV. Finally from Fig.5, the observation showed that RGRP consumes less delay than AODV.

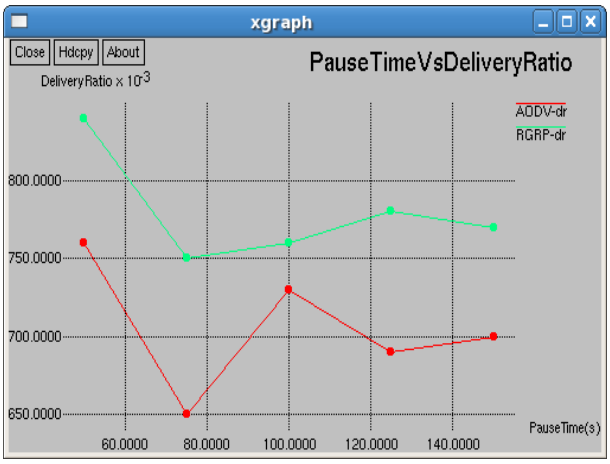

Fig.2 Pausetime Vs Delivery Ratio

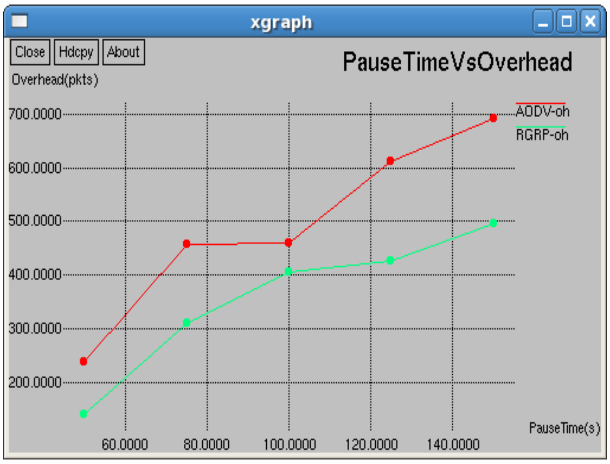

Fig.3 Pausetime Vs Overhead

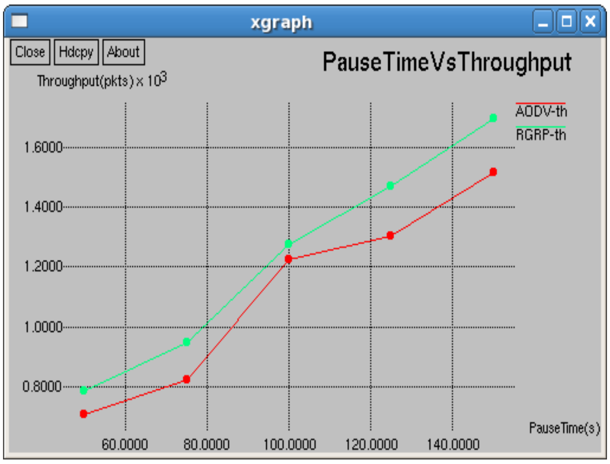

Fig.4 Pausetime Vs Throughput

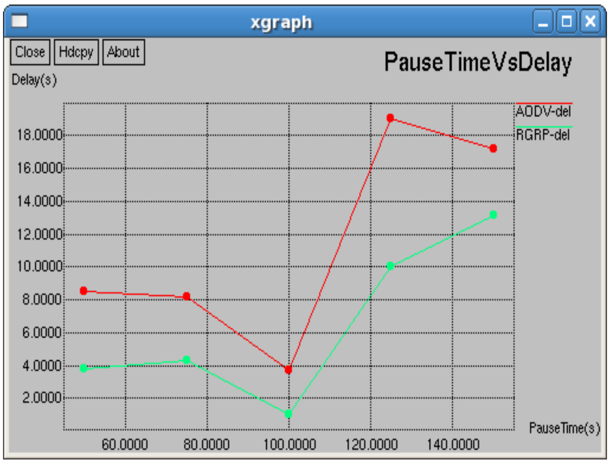

Fig.5 Pausetime Vs Delay

6.CONCLUSION AND FUTURE WORKS

In this paper, we have proposed Reliable Geographic Routing Protocol (RGRP) for improving QoS in MANETs. RGRP is an adaptive on-demand geographic routing protocol. RGRP constructs efficient paths which adapts to various scenarios to provide QoS efficient and reliable routing. To lessen the impact due to inaccurate local topology knowledge, the topology information is updated at a node in a periodic manner based on network dynamics and traffic demand. On-demand routing mechanism is taken in order to reduce control overhead. The QoS metrics throughput, packet delivery ratio, delay, overhead, packets drop are taken for comparison with Ad-hoc On-demand Distance Vector (AODV) protocol. NS2 is used for simulation and the results proved that RGRP outperforms AODV in all aspects such as improved throughput, packet delivery ratio and decreased delay and, overhead.

7. ACKNOWLEDGEMENTS

The first author thanks UGC for allocating Minor Research Project grant during Feb 2011 to Feb 2013 Grant Number 39-947/2010 (SR). The second author thanks the management of Dr.N.G.P. Educational Institutions for providing career opportunity as an Assistant Professor in the Department of Computer Technology at Dr. N.G. P. Arts and Science College, Coimbatore.

8. REFERENCES

[1] Y. Li, Y. Yang, and X. Lu, “Routing Metric Designs for Greedy, Face and Combined-Greedy-Face Routing,” Proc. IEEE INFOCOM, pp. 64-72, Apr. 2009.

[2] M. Heissenb, T. Braun, T. Bernoulli, and M. Wlchli, “BLR: Beacon- Less Routing Algorithm for Mobile Ad-Hoc Networks,” Elsevier’s Computer Comm. J., vol. 27, no. 11, pp. 1076-1086, July 2003.

[3] J.A. Sanchez, R. Marin-Perez, and P.M. Ruiz, “BOSS: Beacon-Less on Demand Strategy for Geographic Routing Inwireless Sensor Networks,” Proc. Fourth Int’l Conf. Mobile Ad-Hoc and Sensor Systems, p. 110, 2007.

[4] S. Ruhrup, H. Kalosha, A. Nayak, and I. Stojmenovic, “Message- Efficient Beaconless Georouting with Guaranteed Delivery in Wireless Sensor, Ad Hoc, and Actuator Networks,” IEEE/ACM Trans. Networking, vol. 18, no. 1, pp. 95-108, Feb. 2010.

[5] H. Zhang and H. Shen, “Energy-Efficient Beaconless Geographic Routing in Wireless Sensor Networks,” IEEE Trans. Parallel and Distributed Systems, vol. 21, no. 6, pp. 881-896, June 2010.

[6] M. Jain, M.K. Mishra, and M.M. Gore, “Energy Aware Beaconless Geographical Routing in Three Dimensional Wireless Sensor Networks,” Proc. First Int’l Conf. Advanced Computing, pp. 122-128, Dec. 2009.

[7] J.A. Sanchez, P.M. Ruiz, and R. Marin-Perez, “Beacon-Less Geographic Routing Made Practical: Challenges, Design Guidelines, and Protocols,” IEEE Comm. Magazine, vol. 47, no. 8, pp. 85-91, Aug. 2009.

[8] F. Zhang, H. Li, A. Jiang, J. Chen, and P. Luo, “Face Tracing Based Geographic Routing in Nonplanar Wireless Networks,” Proc. IEEE INFOCOM, pp. 2243-2251, May 2007.

[9] Y. Kim, R. Govindan, B. Karp, and S. Shenker, “Lazy Cross-Link Removal for Geographic Routing,” Proc. Fourth Int’l Conf. Embedded Networked Sensor Systems (Sensys), 2006.

[10] X. Xiang, X. Wang, and Y. Yang, “Supporting Efficient and Scalable Multicasting over Mobile Ad Hoc Networks,” IEEE Trans. Mobile Computing, vol 10, no. 4, pp. 544-559, Apr. 2011.

[11] X. Xiang, X. Wang, and Y. Yang, “Stateless Multicasting in Mobile Ad Hoc Networks,” IEEE Trans. Computer, vol. 59, no. 8, pp. 1076-1090, Aug. 2010.

[12] X. Xiang, X. Wang, and Z. Zhou, “Robust and Scalable Geographic Multicast Protocol for Mobile Ad Hoc Networks,” Proc. IEEE INFOCOM, May 2007.

[13] Y. Kim, J.-J. Lee, and A. Helmy, “Modeling and Analyzing the Impact of Location Inconsistencies on Geographic Routing in Wireless Networks,” Mobile Computing and Comm. Rev., vol. 8, no. 1, pp. 48-60, 2004.

[14] W. Xi, Y. He, Y. Liu, J. Zhao, L. Mo, Z. Yang, J. Wang, and X.-Y. Li, “Locating Sensors in the Wild: Pursuit of Ranging Quality,” Proc. ACM Conf. Embedded Networked Sensor Systems, 2010.

[15] Z. Yang, Y. Liu, and X.-Y. Li, “Beyond Trilateration: On the Localizability of Wireless Ad-Hoc Networks,” IEEE/ACM Trans. Networking, vol. 18, no. 6, pp. 1806-1814, Dec. 2010.

[16] X. Xiang, Z. Zhou, and X. Wang, “Self-Adaptive On Demand Geographic Routing Protocols for Mobile Ad Hoc Networks,” Proc. IEEE INFOCOM, May 2007.

[17] M. Zorzi and R.R. Rao, “Geographic Random Forwarding (GeRaF) for Ad Hoc and Sensor Networks: Energy and Latency Performance,”IEEE Trans. Mobile Computing, vol. 2, no. 4, pp. 337-348, Oct.-Dec. 2003.

[18] D. Tschopp, S. Diggavi, M. Grossglauser, and J. Widmer, “Robust Geo-Routing on Embeddings of Dynamic Wireless Networks,” Proc. IEEE INFOCOM, May. 2007.

[19] D. Son, A. Helmy, and B. Krishnamachari, “The Effect of Mobility- Induced Location Errors on Geographic Routing in Ad Hoc Networks: Analysis and Improvement Using Mobility Prediction,” Proc. Wireless Comm. and Networking Conf. (WCNC ’04), 2004.

[20] K. Seada, A. Helmy, and R. Govindan, “On The Effect of Localization Errors on Geographic Face Routing on Sensor Networks,” Proc. IEEE Third Int’l Workshop Information Processing in Sensor Networks (IPSN), 2004.

[21] Y. Kim, R. Govindan, B. Karp, S. Shenker, “Geographic Routing Made Practical,” Proc. Second Conf. Symp. Networked Systems Design & Implementation, 2005.

[22] S. Lee, B. Bhattacharjee, and S. Banerjee, “Efficient Geographic Routing in Multihop Wireless Networks,” Proc. ACM MobiHoc, 2005.

[23] K. Seada, M. Zuniga, A. Helmy, and B. Krishnamachari, “Energy Efficient Forwarding Strategies for Geographic Routing in Wireless Sensor Networks,” Proc. ACM Second Int’l Conf. Embedded Networked Sensor Systems (Sensys ’04), Nov. 2004.

[24] C. Perkins and P. Bhagwat, “Highly Dynamic Destination- Sequenced Distance-Vector Routing (DSDV) for Mobile Computers,” Proc. ACM Conf. Comm. Architectures, Protocols and Applications (SIGCOMM ’94), 1994.

[25] J. Li, J. Jannotti, D.S.J.D. Couto, D.R. Karger, and R. Morris, “A Scalable Location Service for Geographic Ad Hoc Routing,” Proc. ACM MobiCom, pp. 120-130, 2000.

[26] F. Kuhn, R. Wattenhofer, Y. Zhang, and A. Zollinger, “Geometric Ad-Hoc Routing: Of Theory and Practice,” Proc. Int’l Symp. the Principles of Distributed Computing (PODC), 2003.

[27] F. Kuhn, R. Wattenhofer, and A. Zollinger, “An Algorithmic Approach to Geographic Routing in Ad Hoc and Sensor Networks,” IEEE/ACM Trans. Networking, vol. 16, no. 1, pp. 51-62, Feb. 2008.

[28] B. Karp and H.T. Kung, “Greedy Perimeter Stateless Routing for Wireless Networks,” Proc. ACM MobiCom, pp. 243-254, Aug. 2000.

[29] P. Bose, P. Morin, I. Stojmenovic, and J. Urrutia, “Routing with Guaranteed Delivery in Ad Hoc Wireless Networks,” Wireless Networks, vol. 7, no. 6, pp. 1572-8196, Nov. 2001.

[30] P. Ghosh, N. Roy, and S.K. Das, “Mobility-Aware Efficient Job Scheduling in Mobile Grids,” Proc. IEEE Int’l Symp. Cluster Computing and the Grid, pp. 701-706, May 2007.

[31] M. Li and Y. Liu, “Underground Coal Mine Monitoring with Wireless Sensor Networks,” ACM Trans. Sensor Networks, vol. 5, no. 2, article 10, Mar. 2009.

[32] X. Xiang and X. Wang, “A Scalable Geographic Service Provision Framework for Mobile Ad Hoc Networks” Proc. IEEE Int’l Conf. Pervasive Computing and Comm., Mar. 2007.

[33] Y. Ko and N. Vaidya, “Location-Aided Routing (LAR) in Mobile Ad Hoc Networks,” Wireless Networks, vol. 6, pp. 307-321, July 2000.

[34] H. Rangarajan and J.J. Garcia-Luna-Aceves, “Using Labeled Paths for Loop-Free On-Demand Routing in Ad Hoc Networks,” Proc. ACM MobiHoc, May 2004.

[35] D.B. Johnson, Y. Hu, and D.A. Maltz, “The Dynamic Source Routing Protocol (DSR) for Mobile Ad Hoc Networks for IPv4,” IETF RFC 4728, Feb. 2007.

[36] S. Basagni, I. Chlamtac, V. Syrotiuk, and B.A. Woodward, “A Distance Routing Effect Algorithm for Mobility (DREAM),” Proc. ACM/IEEE MobiCom, pp. 76-84, 1998.

[37] L. Blazevic, S. Giordano, and J.-Y.L. Boudec, “Self Organized Terminode Routing,” Cluster Computing J., vol. 5, no. 2, pp. 205- 218, 2002.

[38] H. Fussler, J. Widmer, M. Kasemann, M. Mauve, and H. Hartenstein, “Beaconless Position-Based Routing for Mobile Ad- Hoc Networks,” Technical Report TR-03-001, Dept. of Math. and Computer Science, Univ. Mannheim, Germany, 2003.

[39] Z. Haas, M. Pearlman, and P. Samar, “Zone Routing Protocol (ZRP),” IETF Internet draft, July 2002.

[40] V. Ramasubramanian, Z.J Haas, and E.G Sirer, “SHARP: A Hybrid Adaptive Routing Protocol for Mobile Ad Hoc Networks,” Proc. ACM MobiHoc, June 2003.

[41] R. Beraldi and R. Baldoni, “A Caching Scheme for Routing in Mobile Ad Hoc Networks and Its Application to ZRP,” IEEE Trans. Computers, vol. 52, no. 8, pp. 1051-1062, Aug. 2003.

[42] P. Jacquet, P. Muhlethaler, and A. Qayyam, “Optimized Link- State Routing Protocol,” IETF MANET Internet draft, Mar. 2002.

[43] C. Perkins, E.M. Royer, and S. Das, “Ad Hoc On-Demand Distance Vector (AODV) Routing,” IETF RFC 3561, July 2003.

[44] Y.C. Tseng, S.Y. Ni, and E.Y. Shih, “Adaptive Approaches to Relieving Broadcast Storms in a Wireless Multihop Mobile Ad Hoc Network,” IEEE Trans. Computers, vol. 52, no. 5, pp. 545- 557, May 2003.

[45] Y. Cai, W. Lou, M. Li, and X.-Y. Li, “Energy Efficient Target-Oriented Scheduling in Directional Sensor Networks,” IEEE Trans. Computers, vol. 58, no. 9, pp. 1259-1274, Sept. 2009.

[46] W. Wu, J. Cao, J. Yang, and M. Raynal, “Design and Performance Evaluation of Efficient Consensus Protocols for Mobile Ad Hoc Networks,” IEEE Trans. Computers, vol. 56, no. 8, pp. 1055-1070, Aug. 2007.

[47] I. Abraham, D. Dolev, and D. Malkhi, “LLS: A Locality Aware Location Service for Mobile Ad Hoc Networks,” Proc. Workshop Discrete Algorithms and Methods for MOBILE Computing and Comm. (DialM), 2004.