ISSN: 2278 – 1323
International Journal of Advanced Research in Computer Engineering & Technology
Volume 1, Issue 5, July 2012

Energy Efficient Geographical Routing Protocol with Location Aware Routing in MANET

Shwaita Kodesia

M.Tech Research Scholar
Department of Computer Application
Samrat Ashok Technological Institute
Vidisha (M.P.), India
shwaitakodesia20@india.com

Asst. Prof. PremNarayan Arya

Department of Computer Application
Samrat Ashok Technological Institute
Vidisha (M.P.), India
premnarayan.arya@rediffmail.com

Abstract-

A Mobile Ad hoc Network (MANET) is a kind of wireless ad-hoc network, and is a self configuring network of mobile routers (and associated hosts) connected by wireless links the union of which forms an arbitrary topology. The routers are free to move randomly and organize themselves arbitrarily, thus the network's wireless topology may change rapidly and unpredictably. Energy is a vital resource for MANET. The amount of work one can perform while mobile node is fundamentally constrained by the limited energy supplied by one's battery. Dynamic Source Routing (DSR) protocol is one of the most well known routing algorithms for ad hoc wireless networks. DSR uses source routing, which allows packet routing to be loop free. DSR increases its efficiency by allowing nodes that are either forwarding route discovery requests or overhearing packets through having frequent listening mode to cache the routing information. This paper suggests an approach to utilize location information using Geographical Routing Protocol (GRP) to improve performance of Dynamic Source routing protocols for mobile ad hoc networks. By using location information, the proposed GRP with Location Aware Routing (LAR) protocols limit the search for a new route to a smaller request zone of the mobile ad hoc network. Our experimental results show the effectiveness of performance on power consumption than existing works.

Keywords- MANET, DSR, GRP, LARP, Energy Consumption

Introduction

Mobile ad hoc networks consist of wireless mobile hosts that communicate with each other, in the absence of a fixed infrastructure.1 Routes between two hosts in a Mobile Ad hoc Network (MANET) may consist of hops through other hosts in the network. Host mobility can cause frequent unpredictable topology changes. Therefore, the task of finding and maintaining routes in MANET is nontrivial. Many protocols have been proposed for mobile ad hoc networks, with the goal of achieving efficient routing. Geographic routing (also called geo-routing or position-based routing) is a routing principle that relies on geographic position information. It is mainly proposed for wireless networks and based on the idea that the source sends a message to the geographic location of the destination instead of using the network address. The idea of using position information for routing was first proposed in the 1980s in the area of packet radio networks and interconnection networks. Geographic routing requires that each node can determine its own location and that the source is aware of the location of the destination. With this information a message can be routed to the destination without knowledge of the network topology or a prior route discovery [1-2].

There are various approaches, such as single-path, multi-path and flooding-based strategies. Most single-path strategies rely on two techniques: greedy forwarding and face routing. Greedy forwarding tries to bring the message closer to the destination in each step using only local information. Thus, each node forwards the message to the neighbor that is most suitable from a local point of view. The most suitable neighbor can be the one who minimizes the distance to the destination in each step (Greedy). Alternatively, one can consider another notion of progress, namely the projected distance on the source-destination-line (MFR, NFP), or the minimum angle between neighbor and destination (Compass Routing). Not all of these strategies are loop-free, i.e. a message can circulate among nodes in a certain constellation. It is known that the basic greedy strategy and MFR are loop free, while NFP and Compass Routing are not. Greedy forwarding can lead into a dead end, where there is no neighbor closer to the destination. Then, face routing helps to recover from that situation and find a path to another node, where greedy forwarding can be resumed. A recovery strategy such as face routing is necessary to assure that a message can be delivered to the destination. The combination of greedy forwarding and face routing was first proposed in 1999 under the name GFG (Greedy-Face-Greedy). It guarantees delivery in the so-called unit disk graph network model. Various variants, which were proposed later, also for non-unit disk graphs, are based on the principles of GFG [4-6]. This paper proposed an approach to utilize location information using Geographical Routing Protocol (GRP) to improve performance of Dynamic Source routing protocols for mobile ad hoc networks. By using location information, the proposed GRP with Location Aware Routing (LAR) protocols limit the search for a new route to a smaller request zone of the mobile ad hoc network.

Background Techniques

Power Management in MANET

The mobile nodes in an ad hoc network are limited battery powered; power management is an important issue in such networks. Battery power is a precious resource that should be used effectively in order to avoid the early termination of nodes. Power management deals with the process of managing resources by means of controlling the battery discharge, adjusting the transmission power, and scheduling of power sources so as to increase the life time of nodes in the ad hoc networks. Battery management, transmission power management and system power management are three major methods to increase the life time of nodes.

Mechanisms for Energy Consumption

There are two mechanisms affect energy consumption, these are power control and power management. If these mechanisms are not used wisely, the overall effect could be an increase in energy consumption or reduced communication in the network.

- **Power Control**

The aim of communication-time power conservation is to reduce the amount of power used by individual nodes and by the aggregation of all nodes to transmit data through the ad hoc network. Two components determine the cost of communication in the network. First one is direct node to node communication or transmission. The transmission rate can be adapted by the sender. Second is forwarding of data through the networks. In the first case it can use the power control techniques to conserve the power. Whereas in the second case we can use the energy efficient routing schemes.

Current technology supports power control by enabling the adaptation of power levels at individual nodes in an ad hoc network. Since the power required transmitting between two nodes increases with the distance between the sender and the receiver, the power level directly affects the cost of communication. The power level defines the communication range of the node and the topology of the network. Due to the impact on network topology, artificially limiting the power level to a maximum transmit power level at individual nodes is called topology control.

MAC layer protocols coordinate all nodes within transmission range of both the sender and the receiver. In the MAC protocols, the channel is reserved through the transmission of RTS and CTS messages. Node other than the destination node that hears these messages backs off, allowing the reserving nodes to communicate undisturbed. The power level at which these control messages are sent defines the area in which other nodes are silenced, and so defines the spatial reuse in the network. Topology control determines the maximum power level for each node in the network. So topology control protocols minimize power levels increase spatial reuse, reducing contention in the network and reducing energy consumption due to interference and contention. The use of different power levels increases the potential capacity of the network.

Once the communication range of a node has been defined by the specific topology control protocol, the power level for data communication can be determined on a per-link or even per-packet basis. If the receiver is inside the communication range defined by the specific topology control protocol, energy can be saved by transmitting data at a lower power level determined by the distance between the sender and the receiver and the characteristics of the wireless communication channel.

Power aware routing reduces the power consumption by finding the power efficient routes. At the network layer, routing algorithms must select routes that minimize the total power needed to forward packets through the network, so-called minimum energy routing. Minimum energy routing is not optimal because it leads to energy depletion of nodes along frequently used routes and causing network partitions.

- **Power Management**

Idle-time power conservation spans across all layers of the communication protocol stack. Each layer has different mechanisms to support power conservation. MAC layer protocols can save the power by keeping the nodes in short term idle periods. Power management protocols integrate global information based on topology or traffic characteristics to determine transitions between active mode and power save mode. In ad hoc networks, the listening cost is only slightly lower than the receiving cost. Listening costs can be reduced by shutting off the device or placing the device in a low-power state when there is no active communication. The low-power state turns off the receiver inside the device, essentially placing the device in a suspended state from which it can be resumed relatively quickly. But the time taken to resume a node from completely off state is much more and may consume more energy.

The aim of any device suspension protocol is to remain awake the node when there is active communication and otherwise suspend. Since both the sender and receiver must be awake to transmit and receive, it is necessary to ensure an overlap between awake times for nodes with pending communication.

Different methods such as periodic resume and triggered resume can be used when to resume a node to listen the channel. In periodic resume, the node is suspend the nodes most of the time and periodically resumes checking if any packet destined to it. If a node has some packets destined for it, it remains awake until there are no more packets or until the end of the cycle [3-5].

The main reasons for power management in MANETs are the following:

➔**Limited Energy Reserve:** The main reason for the development of ad hoc networks is to provide a communication infrastructure in environments where the setting up of fixed infrastructure is impossible. Ad hoc networks have very limited power resources. The increasing gap between the power consumption requirements and power availability adds to the importance of energy management.

➔**Difficulties in Replacing Batteries:** In some situations, it is very difficult to replace or recharge batteries. Power conservation is essential in such situations.

➔**Lack of Central Coordination:** The lack of central coordination necessitates some of the intermediate node to act as relay nodes. If the proportion of relay traffic is more, it may lead to a faster depletion of power source.

➔**Constraints on the Battery Source:** Batteries will increase the size of the mobile nodes. If we reduce the size of the battery, it will results in less capacity. So in addition to reducing the size of the battery, energy management techniques are necessary.

➔**Selection of Optimal Transmission Power:** The transmission power determines the reach ability of the nodes. With an increase in transmission power, the battery charge also will increase. So it is necessary to select an optimum transmission power for effectively utilize the battery power.

➔**Channel Utilization:** The frequency reuse will increase with the reduction in transmission power. Power control is required to maintain the required SIR at receiver and to increase the channel reusability [5] and [6].

Related Works

- ***Minimum Energy Routing (MER) Protocol***

Minimum Energy Routing (MER) can be described as the routing of a data-packet on a route that consumes the minimum amount of energy to get the packet to the destination which requires the knowledge of the cost of a link in terms of the energy expanded to successfully transfer and receive data packet over the link, the energy to discover routes and the energy lost to maintain routes. MER incurs higher routing overhead, but lower total energy and can bring down the energy consumed of the simulated network within range of the theoretical minimum the case of static and low mobility networks. However as the mobility increases, the minimum energy routing protocol's performance degrades although it still yields impressive reductions in energy as compared performance of minimum hop routing protocol [6] and [8].

- ***Lifetime-aware Tree (LMT) Protocol***

The Lifetime-aware tree routing algorithm maximizes the ad hoc network lifetime by finding routes that minimize the variance of the remaining energies of the nodes in the network. LMT maximizes the lifetime of a source based tree, assuming that the energy required to transmit a packet is directly proportional to the forwarding distance. Hence, LMT is said to be biased towards the bottleneck node. Extensive simulation results were provided to evaluate the performance of LMT with respect to a number of different metrics (i.e., two definitions of the network lifetime, the root mean square value of remaining energy, the packet delivery ratio, and the energy consumption per transmitted packet) in comparison to a variety of existing routing algorithms and Least-cost Path Tree (LPT). These results clearly demonstrate the effectiveness of LMT over a wide range of simulated scenarios [3] and [8].

- ***Lifetime-aware Refining Energy Efficiency of Trees (L-REMIT)***

Lifetime of a tree in terms of energy is the duration of the existence of the service until a node dies due its lack of energy. L-REMIT is a distributed protocol and is part of a group of protocols called REMIT (Refining Energy efficiency of Trees). It uses a minimum-weight spanning tree (MST) as the initial tree and improves its lifetime by switching children of a bottleneck node to another node in the tree. A tree is obtained from the "refined" MST (after all possible refinements have been done) by pruning the tree to reach only group nodes. L-REMiT is a distributed algorithm in the sense that each node gets only a local view of the tree and each node can independently switch its parent as long as the tree remains connected that utilizes an energy consumption model for wireless communication. L-REMiT takes into account the energy losses due to radio transmission as well as transceiver electronics. L-REMiT adapts a given tree to a wide range of wireless networks irrespective of whether they use long-range radios or short-range radios [1] and [4].

- ***Localized Energy-aware Routing (LEAR) Protocol***

Local Energy-Aware Routing (LEAR) simultaneously optimizes trade-off between balanced energy consumption and minimum routing delay and also avoids the blocking and route cache problems. LEAR accomplishes balanced energy consumption based only on local information, thus removes the blocking property. Based on the simplicity of LEAR, it can be easily be integrated into existing ad hoc routing algorithms without affecting other layers of communication protocols. Simulation results show that energy usage is better distributed with the LEAR algorithm as much as 35% better compared to the DSR algorithm. LEAR is the first protocol to explore balanced energy consumption in a pragmatic environment where routing algorithms, mobility and radio propagation models are all considered [3] and [4] and [8].

- ***Conditional Max-Min Battery Capacity Routing (CMMBCR) Protocol***

The Conditional Max-Min battery capacity routing (CMMBCR) protocol utilizes the idea of a threshold to maximize the lifetime of each node and to fairly use the battery fairly. If all nodes in some possible routes between a source-destination pair have larger remaining battery energy than the threshold, the min-power route among those routes is chosen [3]. If all possible routes have nodes with lower battery capacity than the threshold, the max-min route is chosen. CMMBCR protocol selects the shortest path if all nodes in all possible routes have adequate battery capacity (i.e. the greater threshold). When the battery capacity for some nodes goes below a predefined threshold, routes going through these nodes will be avoided, and therefore the time until the first node failure, due to the exhaustion of battery capacity is extended. By adjusting the value of the threshold, we can maximize either the time when the first node powers down or the lifetime of most nodes in the network [10] and [11].

Proposed Mechanism

One possibility direction to assist routing in Mobile Ad Hoc Network (MANET) is to use geographical location information provided by positioning devices such as global positioning systems (GPS). Instead of searching the route in the entire network blindly, position-based routing protocol uses the location information of mobile nodes to confine the route searching space into a smaller estimated range. The smaller route searching space to be searched, the less routing overhead and broadcast storm problem will occur. In this paper, we proposed GRP based Location Aware Routing (LAR) protocols limit the search for a new route to a smaller request zone of the mobile ad hoc network.

Proposed GRP based Location Aware Routing (LAR) protocol

We now describe the GRP based Location Aware Routing (LAR) algorithm. As mentioned in the introduction, we are interested in routing queries to regions in proposed sensor-net applications. The process of forwarding a packet to all the nodes in the target region consists of two phases:

1. Forwarding the packets towards the target region:

GRP based Location Aware Routing uses a geographical and energy aware neighbor selection heuristic to route the packet towards the target region. There are two cases to consider:

(a) When a closer neighbor to the destination exists: GRP based Location Aware Routing picks a next-hop node among all neighbors that are closer to the destination.

(b) When all neighbors are further away: In this case, there is a hole. GRP based Location Aware Routing picks a next-hop node that minimizes some cost value of this neighbor.

2. Disseminating the packet within the region:

Under most conditions, we use a Recursive Geographic Forwarding algorithm to disseminate the packet within the region. However, under some low density conditions, recursive geographic forwarding sometimes does not terminate, routing uselessly around an empty target region before the packet's hop-count exceeds some bound.

Assumptions:

1. Each query packet has a target region specified in some way (for the description of the algorithm, we assume a rectangular region specification).
2. Each node knows its own location and remaining energy level, and its neighbors' locations and remaining energy levels through a simple neighbor hello protocol.

Note that a node can obtain its location information at low cost from GPS or some localization system which presumably is already available due to the needs of sensor net applications.

3. The link is bi-directional, i.e., if a node hears from a neighbor Ni, then its transmission range can reach Ni. This is not an unreasonable choice as most MAC layer protocols, such as IEEE 802.11, assume symmetric links.

Neighbor Computation

We assume that the node N is forwarding Packet P, whose target region is R. The centroid of the target region is D. Upon receiving a packet P, the node N routes P progressively towards the target region, and at the same time tries to balance the energy consumption across all its neighbors. Node N achieves this trade-off by minimizing the learned cost h (Ni, R)) value of its neighbor Ni. Each node N maintains state h (N, R)) which we call its learned cost to region R. A node infrequently updates its h (N, R) h (N, R) value to its neighbors. We discuss this infrequent update later. We implicitly define h (N, R) in the next. If a node does not have h (Ni, R)) state for a neighbor Ni, it computes the estimated cost c (Ni, R) as a default value for h (Ni, R) The estimated cost c (Ni, R)) of Ni is defined as follows:

$$c\ (Ni, R) = \alpha d\ (Ni, R) + (1-\alpha)\ e\ (Ni) \ldots\ldots\ldots\ldots\ldots (1)$$

Where α is a tunable weight, d (Ni, R)) is the distance from Ni i to the centroid D of region R normalized by the largest such distance among all neighbors of N, and e (Ni) is the consumed energy at node Ni normalized by the largest consumed energy among neighbors of N.

After a node picks a next-hop neighbor Nmin, it sets its own h (N, R)) to h (Nmin, R) + C (N, Nmin) where the latter term is the cost of transmitting a packet from N to Nmin. C (N, Nmin) can also be a combination function of both the remaining energy levels of N, Nmin and the distance between these two neighbors.

The intuition for minimizing the estimated cost function C (N, R) is as follows:

→When all nodes have equal energy, these degenerates to the classical greedy geographic forwarding: forwarding the packet to the nearest neighbor to destination.

→When all neighbors are equidistant, this degenerates to load splitting among neighbors. Note that minimizing the energy cost among neighbors is a local approximation to the lowest energy cost path, if it is more expensive to use a node that has less remaining energy. Since GRP based Location Aware Routing makes forwarding decision only based on local knowledge, an approximation to the global lowest cost path is the best that a local algorithm can achieve.

Now that a node has a learned cost state h (N, R)) or a default estimated cost function c (N, R)) for each neighbor, we now describe the forwarding actions at node N. As with other geographical routing schemes, there are two cases to consider:

1. If at least one neighbor of N is closer to D than n;
2. All neighbors are further away from D than N.

- **Closer Neighbor**

As mentioned before, under GRP based Location Aware routing, the packet contains a target region field. Therefore, a forwarding node can make locally greedy choice in selecting next-hop node. Whenever a node N receives a packet, it will pick the next hop among the neighbors that are closer to the destination, at the same time, minimizing the learned cost value h (Ni, R). Since it picks a next-hop node from closer neighbors, it will route progressively towards the target region when there are no holes. Without holes, the learned cost is a combination of consumed energy and distance, minimizing the learned cost value is a trade-off between routing towards the next-hop closest to the destination and balancing energy usage.

- **Neighbors are Farther Away**

In this case, N knows it is in a hole. A node's learned Cost h (N, R)) and its update rule are combined to circumvent holes. Intuitively, when there is no hole in the path towards R, the nodes learned cost h (Ni, R) is equivalent to the estimated cost c (Ni, R). However, when there is a hole in the path towards R, the node's learned cost represents "resistance" to following the path towards that hole; "resistance" that the estimated cost cannot provide.

Suppose the distance between the nearest two neighbors is 1, and each node can reach its 8 neighbors. The nodes in black, i.e., G, H, I are energy depleted nodes, thereby cannot relay packets. Suppose node S wants to send a packet to region R with centroid at T. For illustration purposes, we use T to denote this region. Again, for simplicity, we illustrate the algorithm using pure geographic routing, i.e., we set in Equation 1 to be 1, and we use direct distance instead of normalized distance mentioned.

After the first packet reaches the destination, the correct learned cost value will be propagated one-hop back. Every time a packet is delivered, the correct learned cost value will be propagated one hop away. Therefore, suppose the path length from S to T is n, the learned cost will converge after the node delivers n packets to the same target T. Note that the convergence of learned cost does not affect successfully routing a packet out of holes, it only affects how efficient is the hole routing path. Propagating the learned cost values further upstream through the update rule will enable the packet to have an earlier chance to avoid holes (i.e., more effectively circumnavigate holes), and at the same time avoid depleting the nodes surrounding the holes.

The learned costs together with its update rule help to learn the route around holes. Intuitively, the learned cost is set to the current best choice available. The estimated cost c (N, R) is a combination of the normalized distance from a neighbor to the destination and its normalized remaining energy level. In equation 1, it can be adjusted to emphasize minimizing path length to the destination or balancing energy consumption. We tried several variants of this estimated cost function. For example, we tried different energy cost functions and different normalization denominators. The simulation results show that the algorithm performance is not very sensitive to the particular estimated cost function. Our explanation is that it is the comparison (relative value among all the neighbors), not the absolute estimated cost value that matters, since it is used to make a local selection among all the neighbors. For computing c (N, R), each node needs to know neighbors' energy levels and locations. A node also needs neighbors' learned cost to make forwarding decisions. Various techniques are possible: e.g., piggybacking these on data traffic, requesting this information on demand, advertising the information only when its value changes significantly, or a combination of the above.

Recursive Forwarding

Before a packet reaches the target region R, we use the forwarding rules described in the previous section. Once the packet is inside the target region, a simple flooding with duplicate suppression scheme can be used to flood the packet inside region R. However, flooding is expensive in terms of energy consumption, due to the fact that in this simple flooding scheme, every node has to broadcast once, and all its neighbors receive this broadcast message. This is especially expensive in high-density networks, which is the case for some proposed sensor net applications where nodes are densely and redundantly deployed for robustness. This demonstrates the necessity to use an energy efficient routing algorithm in place of flooding in disseminating the packet inside the target region, or any kind of flooding in sensor networks.

Therefore, we use a Recursive Geographic Forwarding approach to disseminate the packet inside target region R. Suppose the target region R is the big rectangle, and now node Ni receives a packet P for region R, and finds itself inside R. In this case, Ni creates four new copies of p bound to 4 sub-regions of region R. Repeat this recursive splitting and forwarding procedure until the stop condition for recursive splitting and forwarding are satisfied.

The recursive splitting terminates if the current node is the only one inside this sub-region. The criteria to determine this is when the farthest point of the region is within a node's transmission range.

Results Analysis

Simulation Environment

In this paper we proposed location information using Geographical Routing Protocol (GRP) to improve performance of Dynamic Source routing protocols was successfully implemented using OPNET modeler 14.0, in which I have implemented the algorithm in existing techniques by making necessary changes in the existing system. The following choices are made for simulation considering accuracy of result and available resources. Then, we carry out quantitative and comprehensive evaluation of performance in terms of time, overall performance ratio, and traffic sensitivity. The simulation parameters of our paper work as follows:

Length of WMN	1000 (M)
No. of mobile nodes	20-3000
Packet rate of normal connection	1
Movement Model	Random Waypoint
Traffic type	CBR, FTP
Max. mode speed	5 m/s – 60 m/s
No. of connections between nodes	5 – 60
Pause time	10 s
Rate (packet per sec)	2 packets/s
Data payload (packet size)	28 – 1024 bytes

Table 1 Simulation parameters

The random waypoint model is chosen for movement patterns. In the random waypoint model of mobility, nodes choose a destination and move in a straight line toward the destination at a speed uniformly distributed between 0 meters/second (m/s) and some maximum speed. When a node reaches its destination, it stays during a specified period of time called pause time, chooses a new destination and begins moving towards it immediately in the same speed. Depending on number of connections and maximum node speeds, we have designed different simulation scenarios on average throughput, and end to end delay.

Performance Metrics

The performance metrics used for the comparison are the same as those used for evaluating the proposed GRP with Location Aware Routing (LAR) protocols.

➔**The efficiency of data packet delivery** is defined as the measured ratio of the number of data packets delivered to their destinations to the number of all packets generated in the network. Note that each time a packet is forwarded this is counted as one packet transmission.

➔**Average end-to-end delay** of transferred data packets includes all possible delays caused by buffering during route discovery, queuing at the interface-queue and retransmission delays at the medium access control layer.

The efficiency of data packet delivery ratio

The delivery ratio is plotted against the node mobility we observe that GRP with Location Aware Routing (LAR) protocol schemes performs better in low node mobility rate while as the mobility rate increases the delivery ratio slightly drops. The performance of the network is also significantly reduced when GRP with Location Aware Routing (LAR) protocol schemes are under congestion and the node mobility increases with respect to GRP without Location Aware Routing (LAR) protocol. However, this behavior is normal because as the node mobility increases the network topology changes making nodes send RREQ packets more frequently. The proposed GRP with Location Aware Routing (LAR) Protocol schemes increases the delivery ratio compare with GRP without Location Aware Routing (LAR).

Average end-to-end delay

End-to-end delay in proposed GRP with Location Aware Routing (LAR) Protocol schemes under congestion is high because the adversary node waits before sending route reply packet. This waiting time is random with a maximum equal to the time taken by a packet to travel through network diameter as the adversary gives an impression that the packet traveled to the actual node. This affects the end-to-end delay, especially for packets whose destinations are quite close to source nodes. Thus, end-to-end delay shows more random pattern for proposed GRP with Location Aware Routing (LAR) than proposed GRP without Location Aware Routing (LAR). The proposed GRP with Location Aware Routing (LAR) Protocol schemes under traffic restores back the end-to-end delay and the performance better than proposed GRP without Location Aware Routing (LAR) Protocol schemes.

Conclusion

In this paper we compared the two protocols DSR (dynamic source routing) and LARP (Local Awareness Routing Protocol) for proposing third routing protocol GRP with LARP. DSR is continuously sending packet to every different node without any request by any node and wait for their acknowledgement and then send the packet to it. LARP send the packet only when the node has any request or any requirement. Hence we know that in mobile ad-hoc network node move from different place to place. And in our proposed work GRP (Geographic routing protocol) with LARP. GRP help us to calculate distance. GRP is used to calculate the distance between requesting node from the master node and when there is minimum distance from master node to requesting/receiver node. The proposed protocols limit the search for a route to the so-called request zone, determined based on the expected location of the destination node at the time of route discovery.

References

[1] Kirti Aniruddha Adoni and Radhika D. Joshi, "Optimization of Energy Consumption for OLSR Routing Protocol in MANET", International Journal of Wireless & Mobile Networks (IJWMN) Vol. 4, No. 1, February 2012, pp. 251-262.

[2] Ashish Kumar, M. Q. Rafiq and Kamal Bansal, " Performance Evaluation of Energy Consumption in MANET", International Journal of Computer Applications (0975 – 8887) Volume 42– No.2, March 2012, pp. 7-12.

[3] M. Mohammed, "Energy Efficient Location Aided Routing Protocol for Wireless MANETs", International Journal of Computer Science and Information Security, vol. 4, no. 1 & 2, 2009.

[4] O. Tariq, F. Greg & W. Murray, " On the Effect of Traffic Model to the Performance Evaluation of Multicast Protocols in MANET", Proceedings of the Canadian Conference on Electrical and Computer Engineering, pp. 404–407, 2005.

[5] B. Wang and S. K. S. Gupta, "On Maximizing Lifetime of Multicast Trees in Wireless Ad hoc Networks", Proceedings of the IEEE International Conference on Parallel Processing, 2003.

[6] R. Vaishampayan, J.J. Garcia-Luna-Aceves, "Energy Efficient and Robust Multicast Routing in Mobile Ad Hoc Networks", Proceedings of the IEEE International Conference on Mobile Ad-hoc and Sensor Systems, 2004.

[7] Y. Lia, X. Chengb and W. Wuc, "Optimal Topology Control for Balanced Energy Consumption in Wireless Networks". J. Parallel and Distributed Computing, vol. 65, no. 2, pp. 124 – 131, February 2005.

[8] M. Maleki and M. Pedram, "Lifetime-Aware Multicast Routing in Wireless Ad hoc Networks", Proceedings of IEEE Wireless Communications and Networking Conference, 2004.

[9] M. Gerla, S.J. Lee, W. Su, On-Demand Multicast Routing Protocol (ODMRP) for Ad-hoc Networks, Internet draft, draft-ietf-manet-odmrp-02.txt, 2000.

[10] J. Kao, R. Marculescu, "Predictive Energy-efficient Multicast for Large Scale Mobile Ad Hoc Networks", Communications and Networking Conference, pp. 709-713, January 2008.

[11] V. Rishiwal, M. Yadav, S. Verma, S. K. Bajapai, "Power Aware Routing in Ad Hoc Wireless Networks, Journal of Computer Science and Technology, vol. 9, no. 2, pp. 101-109, October 2009".