# Energy Efficient Dynamic Route Discovery Protocol for Mobile Ad Hoc Networks

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## ABSTRACT
A mobile ad hoc network is a collection of wireless nodes that have a dynamic topology and rely on batteries for their operation. Routing in these ad hoc networks is highly complex as there is no central coordinator in contrast to cellular networks. Many routing protocols have been developed for mobile ad hoc networks. Since nodes in an ad hoc network are powered by battery which is limited, there is a need for energy efficient routing protocols to optimize the performance of the network. In this paper we have proposed a new energy efficient dynamic route discovery (EEDRD) protocol which increases the lifespan of the network by efficiently minimizing the routing overhead and managing the power consumed by the nodes in the network. The performance of the proposed protocol is compared with dynamic route discovery (DRD) protocol-a variant of existing energy efficient min-max battery cost routing (MMBCR) protocol. From the simulation results it is observed that the proposed protocol gives increased network lifetime, better throughput performance and packet delivery ratio, less delay and routing overhead as compared to MMBCR and DRD protocols.

## General Terms
MANETs, Routing Protocols, Battery Power Consumption.

## Keywords
Battery power management, MMBCR protocol, DRD protocol, Network lifetime, QoS parameters, Routing Overhead.

## 1. INTRODUCTION
A mobile ad hoc network [MANET] [4], [5], [9], [12] is a wireless infrastructureless network that has gained a lot of importance in wireless communications since past few years. Nodes within an ad hoc network generally rely on batteries for their operation. Since the lifetime of these energy sources is limited, battery power [1], [2], [3] is one of the most important constraints for the operation of the ad hoc network. Thus, it is very difficult and challenging task to design an energy efficient routing protocol for MANETS that increases the lifetime of the network by managing the battery power of individual nodes in the network. In this paper, we have proposed a new energy efficient dynamic routing protocol that manages the battery power of nodes by initiating the route discovery process only after sending certain number of data packets and adapts a new route based on energy levels of nodes in that route.

The rest of the paper is organized as follows. Section II discusses about the dynamic route discovery (DRD) protocol. Section III describes the proposed energy efficient dynamic route discovery protocol (EEDRD) in detail. Section IV and section V gives the simulation setup and simulation results followed by conclusions in section VI.

## 2. DYNAMIC ROUTE DISCOVERY (DRD) PROTOCOL
Dynamic route discovery (DRD) protocol is actually a variant of min-max battery cost (MMBCR) protocol [8]. In the existing energy efficient protocols such as MBCR and MMBCR, once a route is selected by the route discovery process, same route is used until the data transmission is completed or until the selected route fails due to exhaustion of battery of a node in that route. If a node in the selected route has less battery power, then certainly that node will die out causing route failure and thus results in total network failure. Thus to avoid the problem of overburdening the intermediate nodes in the selected route, in DRD protocol a mechanism of dynamic route discovery is introduced in which the route discovery process is initialized periodically i.e., at regular intervals and a new route is adapted taking into consideration the battery power of intermediate nodes. Though DRD protocol overcomes the problems encountered in MMBCR protocol and increases the lifetime of the network, due to periodic route discovery the amount of routing overhead is increased resulting in increased delay and less average residual energy. The problem of routing overhead encountered in DRD protocol is overcome in the proposed EEDRD protocol.

## 3. PROPOSED ROUTING PROTOCOL: ENERGY EFFICIENT DYNAMIC ROUTE DISCOVERY (EEDRD) PROTOCOL
Dynamic route discovery protocol improves the lifetime of the network to some extent as compared to the existing energy efficient protocols like MBCR and MMBCR. Reinitializing the route discovery process periodically at regular intervals to know the energy levels of nodes and change route accordingly results in increasing the routing overhead. Routing overhead though consumes very less amount of energy as compared to data packets, may contribute for delay and energy consumption. Thus, there is a need to overcome the routing overhead problem encountered in DRD protocol.

To avoid unnecessary routing overhead, a new mechanism of route discovery is introduced in Energy Efficient Dynamic Route Discovery (EEDRD) protocol. In this EEDRD protocol instead of reinitializing route discovery process periodically; route discovery is initialized only after transmission of an optimum number of data packets. If this number is less, i.e., if route discovery is initialized after transmitting say 10 data packets then the nodes are involved in this discovery process wherein their energy level is reduced. As a result node failure time is reduced that is nodes involved in this discovery mechanism die out quickly. If the number is more, i.e., if route discovery is initialized after transmitting say 100 packets then less frequently nodes are used up in the discovery process resulting in saving the energy of nodes. An optimum value of this number must be chosen carefully depending on the size of the network and the energy level of nodes to avoid routing overhead and maximize the lifetime of network.

## 4. SIMULATION SETUP

The Network Simulator (NS-2) [10], [11] environment is used to conduct the simulation that uses the ad-hoc networking extensions provided by the University of California at Berkeley. UDP with CBR as the traffic source is used in the simulation process. A terrain size of area 1000m*1000m with varying number of nodes from 0 to 50 are used for various network scenarios. The size of the data packet used is 1000 bytes. The number of source-destination pairs is varied to change the offered load in the network. The parameters used for simulation are described in the table given below.

**Table 1. Simulation Parameters**

| Parameter | Value |
|---|---|
| Terrain Size | 1000*1000 |
| MAC layer | 802.11 |
| Routing Protocols | DRD, EEDRD |
| Number of nodes | 10,20,30,40,50 |
| Radio Propagation Model | Two Ray Ground |
| Simulation Time | 100sec |
| Traffic Source | CBR |
| Packet Size | 1000B |
| Initial Energy | 1000Joules |
| Tx, Rx & Idle Power Consumption | 0.1W |
| Bandwidth | 11MB |
| Data rate | 11Mbps |

## 5. SIMULATION RESULTS

A network scenario is created as an example network and is developed in Network Animator as shown in fig.1 using the script with Tool Command Language to compare the performance of both the proposed and existing routing protocol in terms of route failure time and network lifetime. The network scenario shown in fig.1 below consists of 10 nodes.

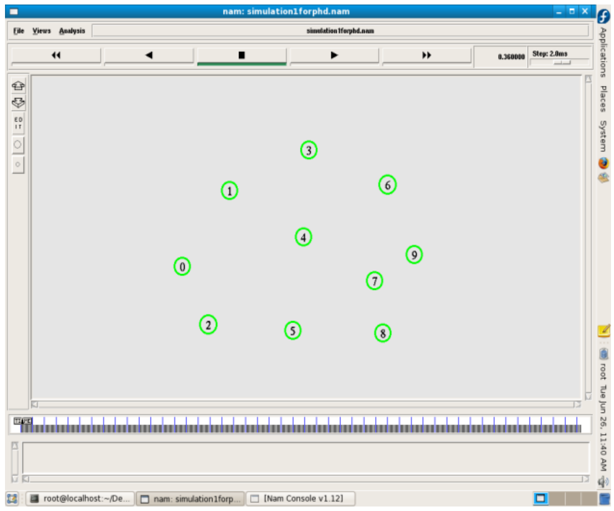


**Fig.1. A snapshot of example network to show the route selected by DRD and EEDRD protocols**

### 5.1 Route selection by DRD protocol

In DRD routing protocol, route selection process is initialized at regular intervals to know the battery capacity of each node. If a node battery capacity becomes very low compared to other nodes in a route, the route discovery process selects an alternate route to avoid the exhaustion of that node in the network. In the example network of figure1, the route discovery process is initialized after certain period and a new route is selected if the energy level of any node in that route is found to be low. Data packets are transmitted from node 4 to node 1, node 4 to node 6 and node 4 to node 7 till 30 seconds. Due to periodic route discoveries and new routes selection, the energy level of each node varies. To transmit data from node 0 to node 9, the route discovery is initiated and route 0-5-8-9 is selected as it has the minimum cost function among the routes available between 0 and 9.

To ensure that the nodes do not exhaust their battery power, route discovery process is initialized periodically. A new route is used each time for transmission of the remaining data packets.

### 5.2 Route selection by the proposed Energy Efficient Dynamic Route Discovery (EEDRD) protocol

In DRD protocol, route discovery process is initialized periodically to know the energy levels of nodes and change route accordingly. Due to continuous route discovery process, there is a chance of increasing the routing overhead. Hence the routing overhead, though consumes very less amount of energy as compared to data packets, may contribute for delay and energy consumption to some extent. To avoid unnecessary routing overhead a new mechanism is introduced such that the DRD protocol initiates the route discovery only after sending certain number of data packets. This new algorithm is called Energy Efficient DRD (EEDRD) protocol. In the example network of fig.1 route discovery is initialized only after source node sends 110 data packets. Simulations were carried out for increasing number of data packets starting from 10 to 150 and the network failure time was calculated for each simulation. The optimum value of the number of data packets was found to be 110. It is observed that the network failure time increases if the route discovery is initialized only after sending large number of packets i.e., if route discovery is delayed little. But at a value of 110, the network failure time is found to be maximum and for values beyond 110 the network failure time decreases. This is due to the problem of overburdening the same route for a longer period resulting in early exhaustion of node in that route. From the simulation results it is observed that, for 110 number of packets sent, the network failure time is maximum and the routing overhead decreases.

Simulations are also carried out by evaluating the QoS parameters like throughput, packet delivery ratio, end-to-end delay, routing overhead and residual energy to compare the performance of DRD and EEDRD protocol. Number of sources is increased from 1 to 5 in steps of one in a 50 nodes network and the corresponding performance metrics are measured. Figures 2 to 6 below gives the performance comparison of EEDRD and DRD protocols in terms of application oriented metrics such as throughput, packet delivery ratio, delay, residual energy and normalized routing load with varying number of sources. Due to less routing overhead, throughput and packet delivery ratio increases and is more for EEDRD protocol compared to DRD protocol. Average delay increases with number of sources but is less for EEDRD compared to DRD protocol. Residual energy decreases with increasing number of sources and with time but is comparatively more for EEDRD as compared to DRD protocol. Normalized routing load is comparatively less for EEDRD protocol resulting in increasing the network lifetime.

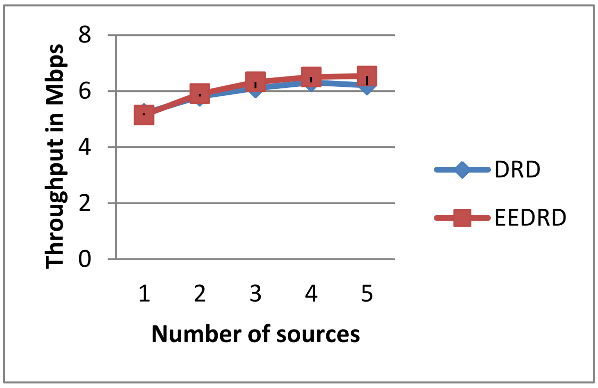


**Fig.2 Throughput Vs Number of Sources**

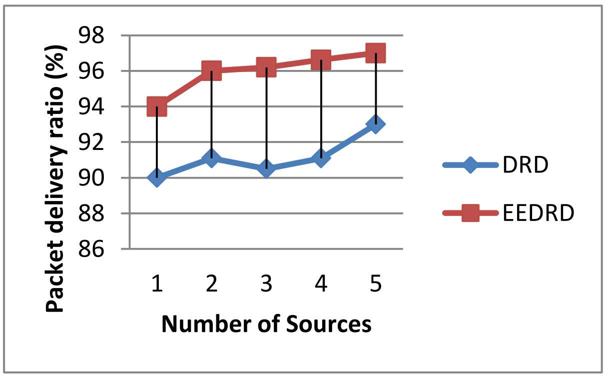


**Fig.3 Packet Delivery Ratio Vs Number of Sources**

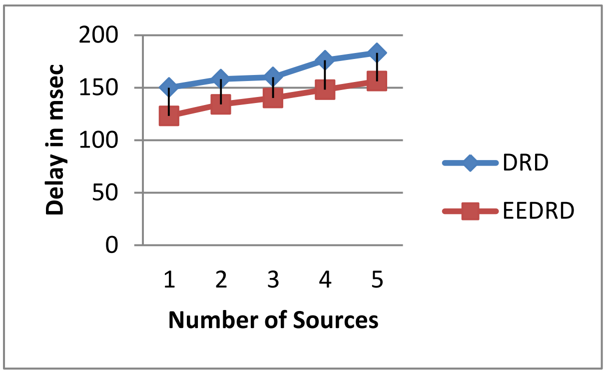


**Fig4. Delay Vs Number of Sources**

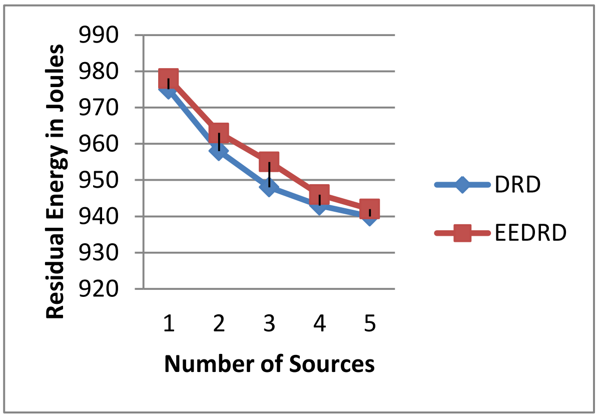


**Fig.5 Residual Energy Vs Number of Sources**

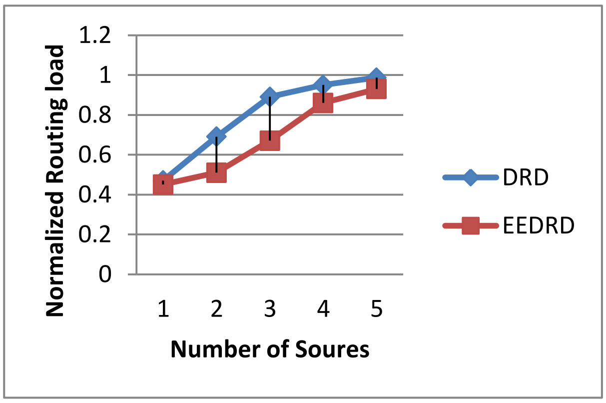


**Fig.6 Normalized Routing Load Vs Number of Sources**

# 6. CONCLUSIONS

In this paper, a new energy efficient dynamic route discovery algorithm is proposed based on DRD and MMBCR in which route discovery process is initialized only after sending some fixed number of packets, updating the cost function and adapting a new route based on the energy levels of nodes in that route. In MMBCR, the chances of link failure are more as the route selected is not changed unless a node in that rote is terminated due to battery exhaust, DRD protocol avoids the early termination of nodes by selecting different route through route discovery process if it finds any node in that route with less battery energy. But due to periodic route discovery, DRD protocol suffers with increased routing overhead problem which in turn decreases energy levels of nodes in the network resulting in reducing its lifespan. In the proposed EEDRD protocol, routing overhead problem is reduced by initializing route discovery process only after transmitting certain number of data packets. Thus, unnecessary routing overhead is reduced resulting in minimizing the energy consumption of nodes and increasing network lifetime. Thus, from simulation results we conclude that the new routing mechanism provides an efficient way of utilizing the energy of nodes. The performance of the protocols is evaluated using throughput, packet delivery ratio, end-to-end delay, average residual energy and normalized routing load. These metrics are evaluated and compared with existing protocol by varying the number of sources. EEDRD protocol achieves high throughput and packet delivery ratio and less routing overhead as compared with DRD protocol.

# 7. REFERENCES

[1] C.F.Chiasserini, R.Ramesh Rao, "Improving Battery Performance by Using Traffic Shaping Techniques", IEEE Journal on Selected Areas in Communications, July 2001.

[2] C.F.Chiasserini, R.Ramesh Rao, "Energy Efficient Battery Management", IEEE Journal, Vol.19,No.7,2001.

[3] L.M.Freeney, "An energy Consumption Model for Performance Analysis of Routing Protocols for Mobile Ad Hoc Networks", Mobile Networks and Applications, Vol.6 p.239-249,2001.

[4] Marwan Krunz, Alaa Muqattash and Lee, "Transmission Power Control in Wireless Ad Hoc Networks:Challenges, Solutions and Open Issues", IEEE INFOCOM 2003.

[5] Suresh Singh, Mike Woo and C.S.Raghavendra, "Power Aware Routing in Mobile Ad Hoc Networks", ACM/IEEE MOBICOM 1998.

[6] M.Adamou, S.Sarkar, "A Framework for Optimal Battery Management for Wireless Nodes", IEEE 2002.

[7] S.Narayanaswamy, V.Kawadia, R.S.Sreenivas and P.R.Kumar, "Power Control in Ad Hoc Networks: Theory, Architecture, Algorithm and Implementation of the COMPOW Protocol", Proceedings of the European Wireless Conference, Feb 2002.

[8] C.K.Toh, "Maximum Battery life Routing to Support Ubiquitous Mobile Computing in Wireless Ad Hoc networks", IEEE Communications Magazine, June 2001.

[9] Eun-Sun Jung and Nitin H.Vaidya, "Power Aware Routing Using Power Control in Ad Hoc Networks", ACM SIGMOBILE Mobile Computing and Communications Review, July 2005.

[10] UCB/LBNL/VINT Network Simulator http://www.mash.cs.berkeley.edu/ns/referred on March 2010.

[11] "The Network Simulator–ns-2", available at http://www.isi.edu/nsnam/ns/referred on march 2010.

[12] Siva Ram Murthy C. and Manoj B.S, "Ad Hoc Wireless Networks Architectures and Protocols," Pearson Education Inc. p.no.642-643.