

A Clustering based Routing in Wireless Ad Hoc Network to Enhance the Energy Efficiency

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Abstract

One of the effective mechanisms for reducing the cost of data communication in wireless ad hoc networks is energy efficient routing. Mainly the total energy is computed for end to end traversal and then the routes are identified. This paper considers two algorithms Reliable Minimum Energy Cost Routing (RMECR) and Reliable Minimum Energy Routing (RMER) and compares the performance of both. RMECR addresses reliability, energy efficiency and prolonging network lifetime by considering the remaining battery energy of nodes as well as the link quality. RMER find routes that consume minimum energy for traversal. Both of these can be used for end to end traversal and hop to hop traversal. Comparison results show that RMECR performs better than RMER and when will further develop a new algorithm EERCRCR uses clustering technique ,it will enhance the performance.

Keywords: Energy Efficient Routing, Reliability, Battery-Aware Routing, End To End Transmission

I. INTRODUCTION

Wireless ad hoc networks are deployed largely since it is infrastructure less, so that cost of deployment is less. It is also useful as it can be combined with satellite data networks to provide global information to users in remote areas where traditional wired networks can't be used. The main requirements of ad hoc networks are energy efficiency and resilience to packet loss. Routes that consider energy efficiency, not necessarily considers reliability and network lifetime, which may result in finding neither complete nor efficient routes.

Existing works on energy efficient routing of wireless ad hoc network can be classified into three groups. Firstly the algorithms that considers reliability of links to find the most reliable routes, these algorithms consumes less energy since it requires less number of retransmission, but it results in the overusing of some nodes frequently which in turn reduces its network lifetime.

Secondly the algorithms that result in finding energy efficient routes, but these won't consider the remaining battery power of nodes, energy consumption of the nodes as well as the energy consumed by processing elements of transmitters and receivers which may result in the overusing of some nodes which may in turn affects the energy efficiency, reliability and network lifetime.

Thirdly, the algorithm that considers the operational lifetime, which finds routes that is having nodes with higher battery power but won't consider the other two factors.

This paper compares two algorithms for energy efficiency that is Reliable Minimum Energy Routing (RMER) and Reliable Minimum Energy Cost Routing (RMECR) on the basis of the mean packet delivery ratio, delay and throughput.

RMECR is an energy aware routing algorithm that considers the remaining battery power of nodes to find routes that are more reliable, energy efficient and which increases the operational lifetime of the network. RMER just considers only the energy consumption for end to end traversal and both can be used for end to end and hop by hop traversal. Studies showed that RMECR out performs RMER and other energy efficient protocols that already exist.

EERCRCR is an energy efficient routing protocol which takes all the positives of the algorithm RMECR and uses clustering technique to enhance the performance.

II. RELATED WORKS

Mainly algorithms can be classified into three, the one which considers the reliability of links but which overuses some nodes. In [2] De Couto et al introduced the technique of the ETX (Expected transmission matrix) that finds paths with high throughput on multihop wireless networks. ETX reduces the number of transmissions and retransmissions that are needed for delivering a packet successfully to the destination. It also includes the effect of link loss ratio and the asymmetry included in the link loss while it considers both directions of the link and the interference among adjacent links. It also describes the design and implementation of ETX as a metric for both the Destination-Sequenced Distance-Vector Routing (DSDV) and Dynamic Source Routing (DSR) routing protocols, and for the modifications to DSDV and DSR which allow these to use ETX. Measurements have been taken from a 29- node 802.11b test-bed which demonstrated the poor performance of the minimum hop count, and it

also illustrates the causes of that poor performance, and confirms the improved performance of ETX. For long paths it offers the throughput improvement is about a factor of two or more, suggesting that ETX will be more useful as networks grows and when paths become longer.

The second group includes an algorithm that finds energy efficient routes but does not consider the remaining battery power. [3] -[5] Addresses this issue, in [3] it checks the energy efficient, reliable wireless communication in the presence of unreliable or lossy wireless link layers in multi-hop wireless networks. It presents two centralized algorithms, Basic Algorithm for Minimum Energy Routing (BAMER) and General Algorithm for Minimum Energy Routing (GAMER), which optimally solve the problem of minimum energy reliable communication in presence of unreliable link and presents a distributed algorithm, Distributed Algorithm for Minimum Energy Routing (DAMER), which approximates the performance of the centralized algorithms and also leads to significant improvement in performance over existing single path or multi-path based techniques. In [4], it suggests that formulation of minimum energy path based on the fact that energy spent in a single transmission is misleading as the proper metric should include the total energy spent in reliably delivering the packet to its final destination and should consider the expended retransmission. And it suggests that studies should include how link error rates affect the retransmission-aware metric, and how it leads to make an efficient choice between a path that contains a large number of short-distance hops and another path that includes a smaller number of large-distance hops. And it also suggested that the definition of a link cost as a function of both the energy needed for a single transmission attempt across the link and the link error rate. And the cost function, thus describes include the cumulative energy expended in reliable data transfer, and that too for both reliable and unreliable link layers. And it leads to up to 30-70% energy savings over best known schemes that exist during its study, under realistic environments.

This group of algorithms won't consider the energy consumed by the processing elements of transmitter and receivers. Therefore the energy computed by these algorithms is only a fraction of the actual power.

The third category includes algorithms that try to prolong the network lifetime by finding routes consisting of nodes with a higher level of battery energy. [5] is included in this category. In [5] it uses new power-aware metrics for determining routes in wireless ad hoc networks and presents five different metrics based on consumption of battery power at nodes. It proved that using these metrics in a shortest-cost routing algorithm reduces the cost/packet of routing packets by 5-30% over shortest-hop and, using these new metrics ensures that the mean time to node failure is increased significantly. And as it uses shortest-cost routing, it reduces packet delays. The new metrics can be used for traditional routing protocols for ad hoc networks.

III. PRELIMINARIES

A. Network Model

A wireless network topology is designed as a graph $G(V, E)$ where V represents vertices and E represents edges and assumes that all nodes are battery powered. If the battery power of a node comes down the threshold value, the node is assumed to be dead. And generally PDR is the packet delivery ratio that is the number of packets correctly delivered to the destination.

B. Energy Saving Technique

It includes the power used for transmission and receiving. Energy consumption of the transmitter includes energy for the circuit as well as the power for the amplifier and receiver includes a low noise amplifier to save the energy.

C. Hop by Hop and End to End Transmission

Wireless link always faces the attack of transmission errors. So it is important to ensure reliability and this is provided by retransmission schemes. In hop by hop retransmission, a packet which is lost in each hop is retransmitted by the sender to ensure reliability at the link level. This is done until it gets an ACK or until the maximum retransmission limit is reached. In an end to end retransmission the destination node only generates the ACKs. If each hop reliability is achieved, then end to end reliability can be achieved.

D. MECP

MECP is the minimum Energy Cost Routing between two nodes, that is the source and destination, is the path which requires minimum energy cost for the E2E traversal of a packet between two nodes in a network with multiple hops.

E. Clustering

Clustering is grouping of nodes to form clusters and these clusters will have a cluster head and any information can be send to cluster head and will distribute among clusters.

IV. EXISTING ALGORITHMS

A. RMECR

It finds reliable routes that increase the network lifetime and it can be used for both E2E and hop by hop transmission. It not only considers the energy consumed for the packet traversal, but also considers the remaining battery power of the nodes along the route and thus increases the lifetime and reduces overusing of nodes.

It uses Open Link State Routing (OLSR) algorithm for routing and uses the Dijkstra algorithm to find the shortest path, but Dijkstra's algorithm is not an optimal solution, it is just a heuristic solution since dependency is a problem. For finding energy efficient routes, it analyzes the energy cost of a path which includes analyzing the expected count of data transmitted and ACK packets, analyzing the energy cost of a link considering the energy cost of retransmissions, the E2E reliability of a path, and then formulating the energy cost of a path considering the energy cost of links and E2E reliability of the path.

Battery cost of a link is defined as "the fraction of battery energy of two nodes of a link that has been consumed to forward the data"

Many algorithms directly depend on the packet size and an important factor is that the metric used by a routing algorithm for routing should be independent of the packet size, because packets that has different sizes need to be routed through the same path and this problem is solved using RMECR.

B. RMER

It is also used to find the minimum energy cost path. It considers the energy consumed in delivering a packet from source to destination and it does not consider the battery power of the nodes. It actually acts as a benchmark to determine the efficiency of RMECR algorithm. The routes discovered by the RMER are also reliable and energy efficient like RMECR but does not consider the operational lifetime. It outperforms all the existing algorithms and can be used for both end to end transmission and four hops by hop traversal. The analyzing steps are similar to that of RMECR. Here the Expected energy is computed as the energy consumed by all nodes for forwarding a packet from source to destinations. It considers the energy consumed for end to end transmission not the energy consumed for hop by hop.

C. EERCRC

It is an algorithm to enhance the energy Efficiency of Routing in wireless Ad Hoc Networks. It uses clustering technique which groups nodes into clusters that increases the energy efficiency, reduces delay and includes all the positives of RMECR algorithm.

V. PERFORMANCE EVALUATION

The performance of the RMECR and RMER is compared with the existing techniques. Both of them perform better than existing techniques. And among them RMECR offers the best. Performance graph in terms of average number of packets delivered to the destination before the first network failure occurs, average ETX of the selected routes, average E2E reliability, average energy consumed to route a packet from source to destination is shown below. Even though it performs well, it has some difficulties too. Both RMECR and RMER uses OLSR protocol for routing, which is a proactive routing. So network can be flooded with topology information and it uses the Dijkstra algorithm for finding shortest path which is a centralized algorithm, when the dependencies exists, it can be only a heuristic solution not an optimal one, so can use a bellman ford algorithm instead. And can use SNR-based techniques which use SNR-to-PDR profile mapping of the received signal strength to find out the PDR of links. EERCRC takes all the good factors of the RMECR algorithm and additionally add clustering technique which further enhance the performance.

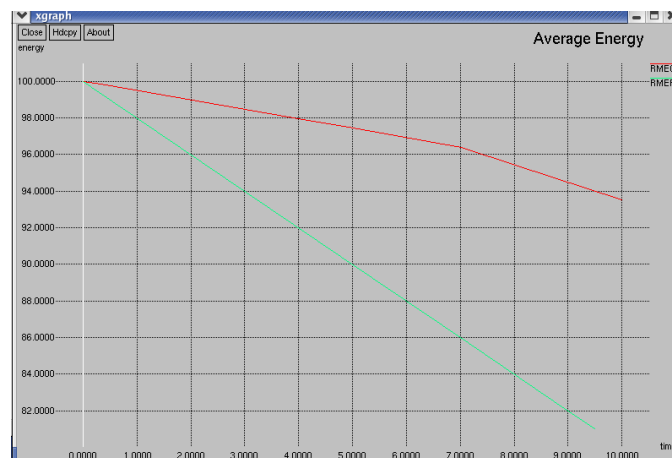


Fig. (a)

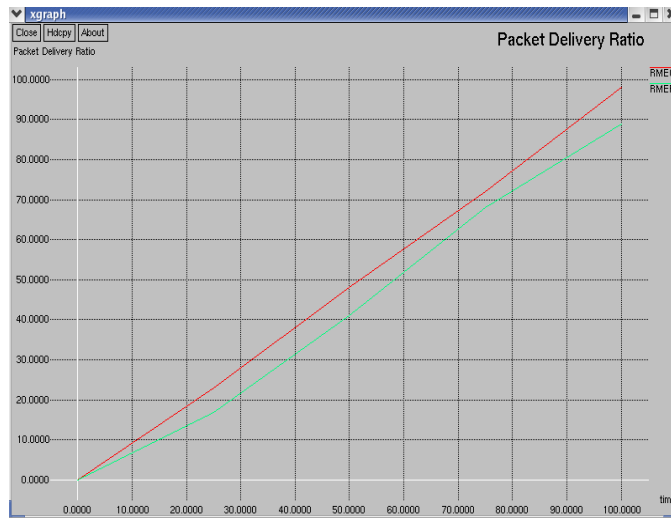


Fig. (b)

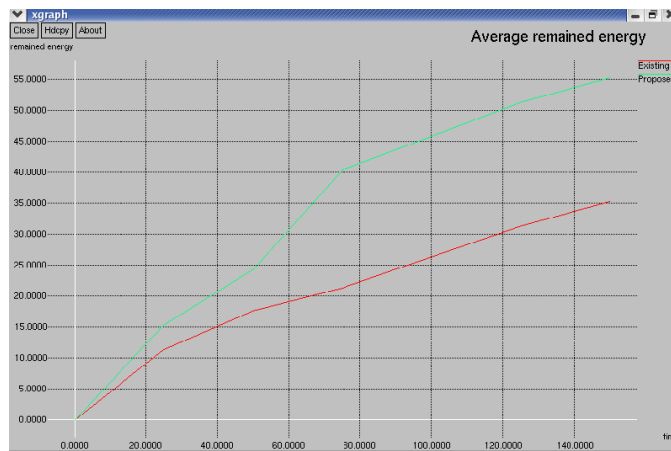


Fig. (c)

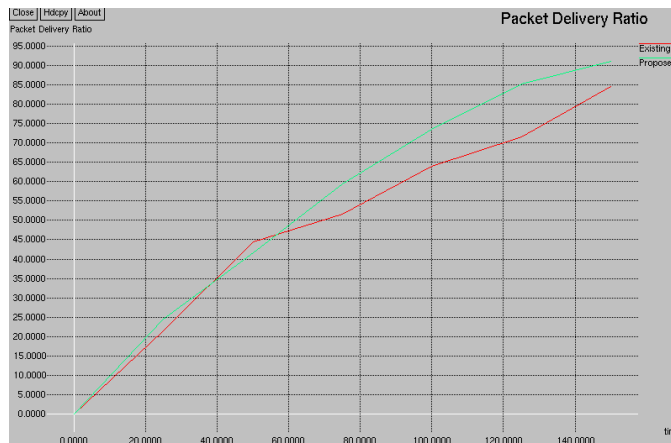


Fig. (d)

Fig. 1: A performance evaluation graph of (a) average energy consumption for delivering a packet to the destination for RMER and RMECR, (b) average packet delivery ratio for RMECR and RMER, (c) average energy for EERCRCR, (d) average PDR for EERCRCR.

VI. RESULT

After analyzing the performance of the algorithms. RMECR proved to be the best algorithm for energy efficient routing as it not only considers the total energy for transmission, but also considers the remaining battery power of the nodes which increase the operational lifetime of the network. If we use, reactive routing instead of proactive routing performance can be further increased. When we compare EERCRCR with RMECR, it offers greater efficiency in terms of delay, packet delivery ratio, reduces delay and proved to be the best among all the existing techniques.

VII. CONCLUSION

Energy efficient routing is an effective way to reduce the cost of communication in wireless ad hoc networks. This paper compares two algorithms RMECR and RMER and finds that RMECR performs well. But there exist some issues like OLSR routing, which affects the performance. Solving these issues, an algorithm EERCRCR is developed which takes all positives of RMECR and uses clustering to improve the performance further in terms of energy and packet delivery ratio.

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