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Performance comparison of Energy Efficient Routing algorithm prolonging network lifetime in wireless Ad Hoc network

Priyanka R. More[1], Prof. Dr. S.V.Sankpal [2]

[1]D. Y. Patil college of Engineering and Technology, Department of Electronics and Telecommunication
Kolhapur, India
guddu.more45@gmail.com

[2]D. Y. Patil college of Engineering and Technology, Department of Electronics
Kolhapur, India
sankpal16@yahoo.com

Abstract: ***As the nodes in Ad Hoc network are battery limited the most important issue that must be considered in designing a data transmission algorithm for wireless Ad Hoc network is how to save energy while meeting needs of users. While satisfying energy requirement it is also necessary to achieve quality of service. Reliable Minimum Energy Routing (RMER) and Reliable Minimum Energy Cost Routing (RMECR) are two proposed routing algorithms which meets the requirements. RMER and RMECR ensure Energy efficiency and Reliability. RMECR considers residual energy of nodes while finding energy efficient path for data transmission thus RMECR along with Energy efficiency and Reliability also prolongs network lifetime. Simulation results mentioned in this paper show the performance comparison of RMER and RMECR based on the performance metrics Average Residual Energy, Reliability, Throughput***

Keywords: about four key words separated by commas**.**

1. Introduction

Energy-efficient routing is an effective mechanism for reducing energy cost of data communication in wireless ad hoc networks. Energy consumption is one of the most important performance metrics for wireless ad hoc networks, it directly relates to the operational lifetime of the networks. In the Wireless Ad-hoc Networks, battery replacement may not be possible. So as far as energy consumption concerned, should try to preserve energy while maintaining high connectivity. Each node depends on small low-capacity batteries as energy sources, and cannot expect replacement when operating in hostile and remote regions. Overall performance becomes highly dependent on the energy efficiency of the algorithm.

Generally, routes are discovered considering the energy consumed for end-to-end (E2E) packet traversal. Nevertheless, this should not result in finding less reliable routes or overusing a specific set of nodes in the network. Energy-efficient routing in ad hoc networks is neither complete nor efficient without the consideration of reliability of links and residual energy of nodes. Finding reliable routes can enhance quality of the service. Whereas, considering the residual energy of nodes in routing can avoid nodes from being overused and can eventually lead to an increase in the operational lifetime of the network.

Effective mechanism for reducing the energy cost of forwarding the packet in wireless ad hoc network is done by energy efficient routing algorithms. Finding reliable routes can enhance quality of the service. Whereas, considering the residual energy of nodes in routing can avoid nodes from being overused and can eventually lead to an increase in the operational lifetime of the network.

In this paper, we are going through two energy-aware routing algorithm for wireless ad hoc networks called Reliable Minimum Energy Cost Routing (RMECR) and Reliable Minimum Energy Routing (RMER). The proposed algorithm is able to increase the network lifetime and find reliable and energy-efficient routes simultaneously. RMECR finds minimum energy cost routes, where the energy cost of packet forwarding from a node is a function of the remaining battery energy of the node, reliability of the physical link, and required energy for packet transmission. RMECR can reduce the overall energy consumption in the network by finding minimum energy cost routes. It can also find reliable routes in which constituent links require less number of packet retransmissions due to packet loss. Furthermore, RMECR can balance the traffic load in the network and increase the network lifetime by finding routes in which nodes are likely to have more residual battery energy.

Energy efficiency which is directly related to network lifetime , Reliability of successful transmission and Throughput are the important Quality of service (Qos) parameters on which this work is focused. The rest of the paper is organized as follows: In section 2,we present some previous work. In section 3 Details of proposed algorithm is been mentioned. In section 4 we go through simulation scenario and some practical issues that are to be considered. In section 5 simulation results are been shown according to our work. Finally we conclude in section 6.

2. Previous Work

Up to now many routing algorithms have been proposed. They can be grouped as follows: A group of algorithms that consider reliability of links to find reliable routes . D. Aguayo mentioned notion of expected transmission count(ETX) to find reliable routes. It consist of links that require less number of retransmissions for lost packet recovery. Although such routes may consume less energy since they require less number of retransmissions, they do not necessarily minimize the energy consumption for E2E packet traversal. If there are some links more reliable than others, these links will frequently be used to forward packets. Nodes along these links will fail .

The next group includes algorithms that aim at finding energy-efficient routes. Jinhua Zhu developed minimum energy routing scheme. It do not consider actual energy consumption of nodes to discover energy-efficient routes. They only consider the transmission power of nodes neglecting the energy consumed bu processing elements of transmitters and receivers.

The other group includes algorithms that try to prolong the network lifetime. Archan Mishra and Suman Banerjee proposed MRPC, a new power-aware routing algorithm for energy-efficient routing that increases the operational lifetime of multi-hop wireless networks. This algorithm do not consider reliability and energy efficiency.

The algorithm mentioned in this paper that is RMER considers energy efficiency for reliable routes and RMECR algorithm which extends the network lifetime by considering remaining battery energy of nodes.

3. Proposed Algorithm Details

3.1 General Block Diagram

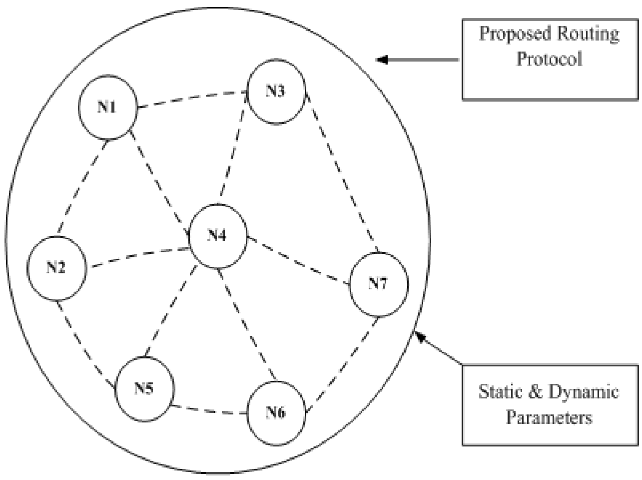

Figure 1: General block diagram of proposed work

Figure 1 shows only seven nodes like that we can use N number of nodes. We assume that all the nodes are identical in their physical characteristics and all communicate via a shared wireless channel. The two proposed algorithms RMER and RMECR describe the procedure that each node should undertake to find Minimum energy cost path , for which they require each node to have a complete image of the network topology. In ad hoc networks, this could be achieved using a link state proactive routing protocol such as optimized link state routing (OLSR). In OLSR, each node periodically shares its view of the network topology with other nodes.

3.2 End To End transmission System

In the E2E system, the ACKs are generated only at the destination and retransmissions happen only between the end nodes. The destination node sends an E2E ACK to the source node when it receives the packet correctly. If the source node does not receive an ACK for the sent packet, it retransmits the packet. This may happen either because the packet or the ACK is lost. In either case, the source retransmits the packet until it receives an ACK for the packet. Retransmission occurs after the expiration of a timer. We assume that the duration of this timer is long enough to prevent unnecessary retransmissions. Here in this work we have focused on End to End systems.

3.3 Minimum Energy Cost Path

The minimum energy cost path (MECP) between a source and a destination node is a path which minimizes the expected energy cost for E2E traversal of a packet between the two nodes in a multihop network. Since energy cost is an additive metric, it may seem that the Dijkstra's shortest path routing algorithm could be used to find MECP. However, the Dijkstra's shortest path routing algorithm is only a heuristic solution for finding MECP, but under some circumstances it could be the optimal solution.

The energy cost of a path is analysed in four steps:

1. Analysing the expected transmission count of data and ACK packets.
2. Analysing the expected energy cost of a link taking into account the energy cost of retransmissions.
3. Analysing the E2E reliability of a path.
4. Formulating the energy cost of a path taking into account the energy cost of links and E2E reliability of the path.

3.4 Energy aware Reliable routing

The objective is to find reliable routes which minimize the energy cost for E2E packet traversal. To this end, reliability and energy cost of routes must be considered in route selection. The key point is that energy cost of a route is related to its reliability. If routes are less reliable, the probability of packet retransmission increases. Thus, a larger amount of energy will be consumed per packet due to retransmissions of the packet.

In this work energy-aware reliable routing algorithms for E2E systems is designed. They are called reliable minimum energy cost routing and reliable minimum energy routing (RMER). In RMER, energy cost of a path for E2E packet traversal is the expected amount of energy consumed by all nodes to transfer the packet to the destination. The energy cost of a link in RMECR is defined as the fraction of the remaining battery energy of the two end nodes consumed to forward a packet across a link.

In case of RMER from Figure 2 first the nodes are created and energy is assigned to those nodes. During this process, HELLO packet are send to the neighbouring nodes and this process continues until all the nodes in the network receives the HELLO packet. In the second step, find the source and destinations nodes. As the next step, find all the shortest path between the source and destination and select the path that consumes minimum energy for transferring the data without considering the remaining battery energy that is the

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residual energy of nodes . This path is considered as the reliable path.

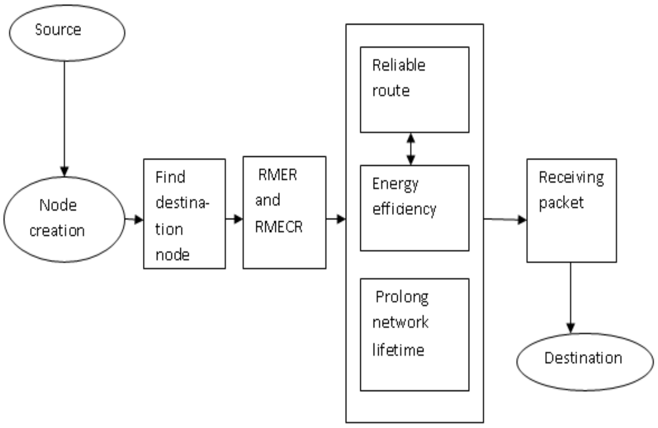

Figure 2 : System diagram

RMER algorithm finds path which minimizes the total energy required for end-to-end packet traversal. RMER does not take into account the remaining battery energy of nodes, and which is used as a point of reference to study the energy-efficiency of the RMECR algorithm. RMER saves more energy compared to existing energy efficient routing algorithms and also increases the reliability of wireless ad hoc networks.

For RMECR algorithm from Fig. 3.2 first the nodes are created and energy is assigned to those nodes. During this process, HELLO packet are send to the neighbouring nodes and this process continues until all the nodes in the network receives the HELLO packet. In the second step, find the source and destinations nodes .As the next step, find all the shortest path between the source and destination and select the path that consumes minimum energy for transferring the data considering the remaining battery energy that is the residual energy of nodes . This path is considered as the reliable path.

RMECR addressed three important requirements of ad hoc networks that are reliability, energy-efficiency, and prolonging network lifetime. This scheme considered the following ideas while pioneering studies neglected those ideas It Considers the impact of limited number of retransmission allowed per packet and packet size .It Considers the impact of acknowledgment packets. It Considers energy utilization of processing elements of transmitter and receiver. RMECR scheme considered the energy utilization, the remaining battery energy of nodes and quality of links to find energy-efficient and reliable paths that increase the operational span of the ad hoc network.

First analyze the energy cost of a path for transferring a packet to its destination considering the impact of E2E ACK then secondly we concentrate on algorithm for finding MECP in end-to-end system thus lastly RMER and RMECR algorithms can be derived there in.

In the E2E system, the energy cost of a path depends on the number of times that the packet and its E2E ACK are transmitted. This, in turn, depends on the E2E reliability of the path. Considering the impact of end-to-end ACK on energy cost and end-to-end reliability of path equal to 1 ,MECP can be found. According to the Dijkstra's algorithm as,

$$C(P(s,v)) = \frac{1}{P_{u,v}(L_d)\ P_{v,u}(L_e)} \times C\big(P(s,u)\big) + W(u,v)]$$

Where, $W(u,v)$ is link weight , L_d is data packet size , L_e is E2E ACK packet size.

Now when the equation for MECP is designed we concentrate on link weight . In RMECR the impact of remaining battery energy is considered while finding link weight and RMECR considers reliability of links in computing total energy cost. The general approach for RMER algorithm energy cost of link is defined as actual amount of energy consumed by two end nodes of links to exchange packet . In RMER the impact of remaining battery energy is not considered.

4. Simulation Scenario and some Practical issues

The following is the description of the simulation setup. To evaluate the performance of RMER and RMECR algorithms, we have considered a network in which nodes are uniformly distributed in a square area. The packet format in our simulation model is based on IEEE 802.11 standard. Each transmitted packet on the physical link consists of three parts: a preamble, a physical layer header, and the payload which includes user data and headers from higher layers.

RMER and RMECR these two algorithms describe the procedure that each node should undertake to find Minimum energy cost path , for which they require each node to have a complete image of the network topology. In ad hoc networks, this could be achieved using a link state proactive routing protocol such as optimized link state routing (OLSR) . In OLSR, each node periodically shares its view of the network topology with other nodes. This is done by the use of so-called topology control messages, which are flooded in the network. Nodes also use periodic beacons to detect their neighbouring nodes.

UDP packet size is 512 bytes unless otherwise indicated. 350m x 350m simulation area is used. Each node starts moving at 10 m/s speed from its initial position to a random target position selected from within the simulation area. When a node reaches the target position, it waits for a pause time period which is 10 ms and then selects another random target location and moves again. Therefore, we can simulate the node mobility by varying the maximum speed and pause time. A UDP connection for a random sender and receiver is selected, and CBR application is run over this connection.

The experiment is carried out by considering different scenarios for experimentation. First scenario consists of 50 nodes, out of fifty, one node is considered as source, another node as destination node . The second scenario contains 75 moving nodes. These nodes starts moving at 10 m/s speed from its initial position to a random target position selected from within the simulation area. UDP connections are created over the random pair of nodes randomly. CBR application is run over these connections. Like this three more scenarios as number of node 100,125 and 150 are considered. This simulation ran for 200 seconds. Simulation time 200s. and repeated for various number of nodes. Simulation parameters used and performance metrics are presented in next chapter.

5. Simulation Results

Several simulations are performed using NS2 network simulator and using following parameters. NS2 generates a big trace files. The performance study includes below parameters obtained by varying the number of nodes as 50,75,100,125,150 respectively. The performance comparison metrics are Average Residual Energy, Reliability and Throughput

5.1 Simulation Parameters

Table 1: Simulation parameters

Parameter	Value
Initial battery energy of each node (B)	100 [J]
Network area	350*350 [m_2]
Path-loss exponent (ŋ)	3
Data rate (r)	100 [Kbps]
Power consumption of transmitter circuit (P_t)	100 [mW]
Power consumption of receiver circuit (P_r)	100 [mW]
Maximum transmission power (P_{max})	150 [mW]
Minimum transmission power (P_{min})	15 [mW]
Maximum# of transmissions in HBH system(Q_u)	7
Transmission range (d_{max})	70 [m]
Data packet size (L_d) 512 [byte]	512 [byte]
MAC ACK packet size (L_h)	240 [bit]
E2E ACK packet size (L_e)	96 [byte]
Hello packet size (L_{hello})	96 [byte]
Battery death threshold (B_{th})	0
Maximum collision probability (P_{Cmax})	0.3
channel sensing time (T_{sense})	50 [µs]
K_{idle}	0.2
K_{sense}	0.4
T_{hello}	10 [s]
T_{tc}	20[s]

5.2 Results:

Average Residual Energy.

It is Average energy remaining after transmission of packets. It is also called as Residual Energy.

Table 2: Average Residual Energy

No of Nodes	RMER	RMECR
50	80.0024	80.4888
75	80.5295	81.5896
100	80.5607	81.8815
125	80.5436	81.7534
150	80.2365	81.5893

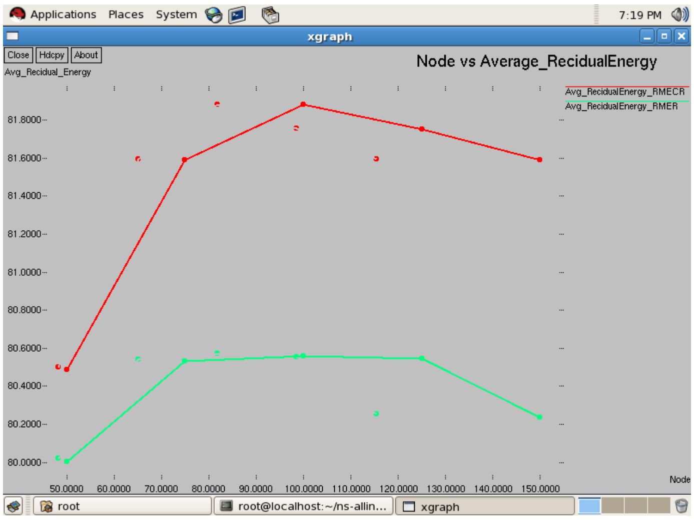

Figure 3: Average Residual Energy

From Table 2 and Fig. 3 we observe that the average residual energy for RMECR is more as compared to RMECR for all the scenario that we have considered. This is because in case of RMECR the remaining battery energy is considered while finding the route from source to destination while in case of RMER the remaining battery emergy is not considered.

Reliability:

Probability that the packet is received by destination node.

Table 3: Reliability

No of Nodes	RMER	RMECR
50	0.997753	0.998698
75	0.99913	0.998707
100	0.997853	0.9995
125	0.999184	0.999274
150	0.998919	0.99937

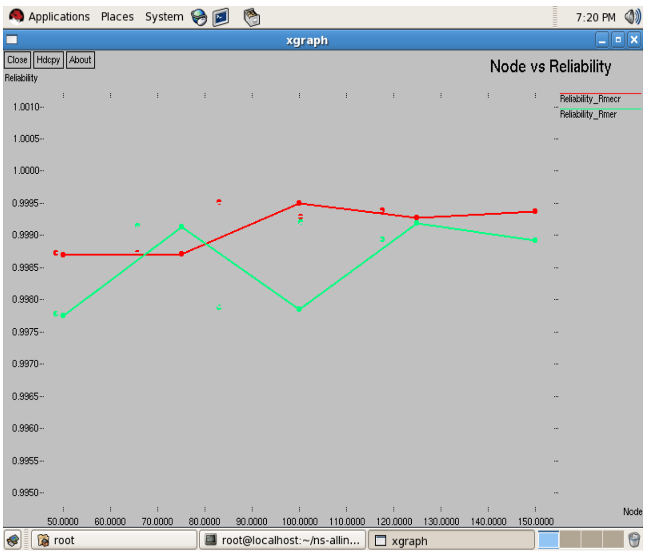

Figure4: Reliability

From Table 3 and Fig.4 we observe that end to end reliability for RMECR is more as compared to that using RMER algorithm .The path in case of RMECR is chosen having nodes whose battery is not drained away so nodes are not being overused and thus the path chosen ensures a reliable path where the probability of successful transmission of data is more.

Throughput:

It is the average rate of successful message delivery over a communication channel.

Table 4: Throughput

No of Nodes	RMER	RMECR
50	36483.7	36589.1
75	36483.7	36589.1
100	36483.7	36589.1
125	36483.7	36589.1
150	36483.7	36378.2

Figure 5: Throughput

From Table 4 and Fig.5 we can see that the throughput for RMECR is more for the scenario 50,75,100,125 nodes and for 150 node scenario the throughput for RMER is more as compared to RMCER. this is because the delivery ratio for packets is more for RMECR as compared to RMER but as the traffic load increases the OLSR generates more control packets and thus the delivery of packets drops slightly.

6. Conclusion

The paper describes the performance comparison of RMER and RMECR algorithms. RMER does not consider remaining battery power of nodes. RMECR on the other hand considers the remaining battery energy of nodes while route selection. Simulation results for performance metrics Average Residual Energy, Reliability, and Throughput is obtained. From Table2,Table.3,Table 4 and Fig.3,Fig.4,and Fig.5 we conclude that Average Residual Energy, Reliability ,Throughput results are better for RMER as compared to RMECR. The details of the results are mentioned in the results section. Suppose we consider for 150 nodes scenario the reliability of RMER IS 99.8% while for RMECR is 99.9% comparatively. The network lifetime is directly related to the remaining battery energy of nodes and in case of RMECR from Fig. 3 and Table 2 the Average Residual energy is more as compared to RMER thus we finally conclude that along with Energy efficiency and Reliability , RMECR also prolongs the network lifetime.

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