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A Survey of Energy Aware Ad Hoc Routing Protocols

V.Seethalakshmi

Associate Professor/ECE,

Sri Shakthi Institute of Engineering and Technology,
L&T Bypass, Chinnampalayam, Coimbatore-641062. Tamilnaddu, INDIA.

Dr. G. Mohan Kumar

Principal, Park College of Engineering and Technology, NH 47, Kaniyur,
Coimbatore-641059, INDIA.

Abstract-Mobile Ad hoc Network (MANET) is infra-structure less ad hoc environment. The nodes in the MANET have limited battery. Also nodes move away without giving any notice to its cooperative nodes, causing changes in network topology and thus, these changes may degrade the performance of a routing protocol. Hence the energy consumption and routing path lifetime are important issue in MANET. Existing energy efficient routing protocols like Minimum Total transmission Power Routing (MTPR), Minimum Battery Cost Routing (MBCR), Min-Max Battery Cost Routing (MMBCR), Conditional Max-Min Battery Capacity Routing (CMMBCR), Energy efficient routing for Ad hoc On-demand Multipath Distance Vector (ENERGY_AOMDV) are analyzed and concluded that ENERGY_AOMDV performs better than other existing protocols discussed above. The simulation is carried out using network simulator NS-2.35 under Linux platform. The performance metrics used for evaluation are packet delivery ratio, latency, throughput, energy consumption, overhead and packet received.

Keywords: MTPR, MBCR, MMBCR, CMMBCR, ENERGY_AOMDV

I. Introduction

MANET is a wireless infrastructure less network having mobile nodes. Communication between these nodes can be achieved using multi hop wireless links. Each node will act as a router and forward data packets to other nodes. Mobile adhoc networks are operating without any centralized base station. It uses multi hop relaying. Since the nodes are independent to move in any direction, there may be frequent link breakage. The advantage of MANET is its instant deployment[7].

Various protocols have been developed for adhoc networks such as Minimum Total transmission Power Routing (MTPR), Minimum Battery Cost Routing (MBCR), Min-Max Battery Cost Routing (MMBCR), Conditional Max-Min Battery Capacity Routing (CMMBCR), Energy efficient routing for Ad hoc On-demand Multipath Distance Vector (ENERGY_AOMDV). These protocols offer varying degrees of efficiency. This paper aims to find out an energy efficient routing protocol. It also aims to limit power consumption of nodes in the highly mobile network in order to increase the life time of the network. The main objective of this paper is to analyze on-demand routing protocol for ways it could be improved. This can be done by measuring energy with respect to network size and taking into consideration the remaining battery power. It also proposes further research into more efficient protocols or variants of existing protocols such as AOMDV. This paper also proposes a new routing algorithm based on link stability and energy efficiency so that the new algorithm provides better performance than MTPR, MBCR, MMBCR, CMMBCR and ENERGY_AOMDV.

II. Overview of Existing Routing Protocols

There are lot of energy efficient routing protocols. Some of them are listed below

A. Minimum Total transmission Power Routing (MTPR)

This protocol is dependent on interference, noise, distance between hosts, and desired BER. This will select route with more hops than other routing algorithms ($\text{power} \propto d^n$). This approach will significantly increases end-to-end delay. On the downside, this approach will in most cases tend to select routes with more hops than others. This is realizable due to the fact that transmission power is inversely proportional to distance. Thus,

more energy may be wasted network-wide since a larger number of nodes are now involved in routing as all nodes that are neighbours to the intermediate nodes will also be affected, unless they were in sleep mode and also if the selected routes are via specific host, the battery of this host will be exhausted quickly[8].

Algorithm

1. Calculate the total transmission power for all routes between source and destination.
2. Select the route with minimum total transmission power among all routes.

B. Minimum Battery Cost Routing (MBCR)

Minimum battery cost routing (MBCR) utilizes the sum of the inverse of the battery capacity for all intermediate nodes as the metric upon which the route is picked.

Algorithm

1. Find the total battery cost for each route from source to destination
2. Select the route for transmission which having minimum total cost among all routes.

If all nodes have similar battery capacity, it will select shorter hop route. It prevents hosts from being overused, increasing lifetime. However, since it is the summation that must be minimal, some hosts may be overused because a route containing nodes with little remaining battery capacity may still be selected [9].

C. Min-max battery cost routing (MMBCR)

Min-max battery cost routing (MMBCR) treats nodes more fairly from the standpoint of their remaining battery capacity. Smaller remaining battery capacity nodes are avoided and ones with larger battery capacity are favoured when choosing a route[3].

Algorithm

1. For each route, select battery cost function which having maximum value among all nodes in the route.
2. Now select the route with minimum battery cost among all routes.
In this algorithm, instead of summing the battery cost function of all nodes of the individual routes, select the battery cost which is maximum among all nodes of route[2].

D. Conditional max-min battery capacity routing (CMMBCR)

The combined protocol is called conditional max-min battery capacity routing (CMMBCR). Both goals (maximize lifetime of each node and use the battery fairly) cannot be achieved simultaneously by any of previous protocols like MTPR, MBCR, MMBCR. In this algorithm battery capacity is used instead of cost function as a route selection metrics and uses a battery capacity "threshold" (Y) for selecting the route[9].

Algorithm

1. For each route 'j' find the minimum capacity (R_j) among all nodes in that route
2. If $R_j \geq Y$ is true for some or all routes between a source and destination. Apply Minimum Total Transmission Power Routing (MTPR) scheme to select path among all routes which satisfying above condition.
3. Else Select the route 'i' with the maximum battery capacity.

E. ENERGY_AOMDV

The concept of ENERGY_AOMDV is to find the node residual energy of each route in the process of selecting path, select the path with minimum node residual energy and sort all the routes based on the descending order of node residual energy[4]. Once a new route with greater nodal residual energy is emerging, it is again selected to forward rest of the data packets. It can improve the individual node's battery power utilization and hence prolong the whole network's lifetime.

Algorithm

1. Find the node residual energy of each route in the route discovery phase.
2. Find the path with minimum node residual energy.
3. Sort out all the routes based on the descending value of node residual energy

4. Select the optimal route with maximal node residual energy to forward the data packets[5].

III. Methodology

The main limitation of MANET is the availability of battery, since nodes are typically battery-limited. Power consumption is governed by link connectivity and overheads required to maintain connectivity in addition to running onboard electronics. Early “death” of MANET nodes due to energy depletion may cause several problems such as link failure, network partition and communication interruption. Therefore it is required to limit the power consumption of mobile nodes, prolong the life time of battery and to maintain the stable energy efficient network.

In the existing system, different energy efficient routing protocols in MANETs are compared by many researchers. Some implemented overhead reduction and efficient energy management as in ENERGY_AOMDV in MANET. Some compared the performance of ENERGY_AOMDV and AOMDV based on the node termination rate as well as the overall throughput of the network. Some researchers compared MTPR, MMBCR, MBCR & CMMBCR in terms time and no. of nodes. These works provide detailed performance analysis on adhoc routing protocols but link stability was not addressed. It does not reflect the topological change and link stability. In the proposed system, various routing protocols such as MTPR, MBCR, MMBCR, CMMBCR and ENERGY_AOMDV are compared with respect to more metrics. Protocol performances are tested in higher mobility situations. Routing protocols are analyzed in terms of energy aware metrics.

IV. Results and Discussion

The Simulation is carried out in NS2 under LINUX platform. The aim of these simulations is to analyze the performance of protocols like MTPR, MBCR, MMBCR, CMMBCR and ENERGY_AOMDV for its efficiency in terms of energy consumption, latency, packet delivery ratio, packet lost and throughput.

A. Simulation Environment

The table1 shows the simulation environment in NS2.

Table 1 Simulation Environment

Simulation Time	100S
Topology size	1000m x 1500m
Number of nodes	25
Mac Type	MAC 802.11
Radio Propagation Model	Two ray model
Radio Propagation Range	250m
Pause time	0s
Max Speed	4m/sec – 24m/sec
Initial energy	100J
Transmit power	0.4W
Receive Power	0.3W
Traffic type	CBR
CBR rate	512 bytes x 6 per sec

B. Simulation Parameters

- 1. Packet delivery ratio** It is the ratio of the data packets delivered to the destinations to those generated by the sources.
- 2. Energy consumption** This is the ratio of the average energy consumed in each node to total energy.
- 3. End to end delay** This is the ratio of the interval between the first and second packet to total packet delivery.
- 4. Throughput** The throughput metric measures how well the network can constantly provide data to the sink. Throughput is the number of packet arriving at the sink per ms.

5. Number of Packets dropped This is the number of data packets that are not successfully sent to the destination during the transmission. In this study the time versus number of packets dropped have been calculated.

C. Simulation Results

Figure 1 shows that the packet delivery ratio of networks using ENERGY_AOMDV is maximum compared to MTPR, MBCR, MMBCR and CMMBCR.

Figure2 shows the comparison of overhead versus time for MTPR, MBCR, MMBCR, CMMBCR and ENERGY_AOMDV protocols using 25 nodes. It shows that the overhead of network using ENERGY_AOMDV is minimum compared to MTPR, MBCR, MMBCR and CMMBCR

Fig 1 Comparison of packet delivery ratio versus time

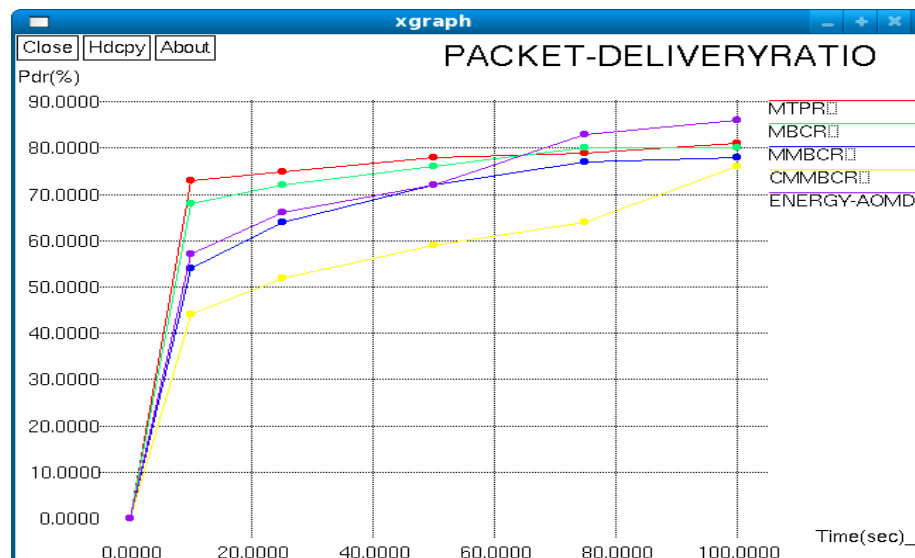


Fig 2 Comparison of overhead versus time

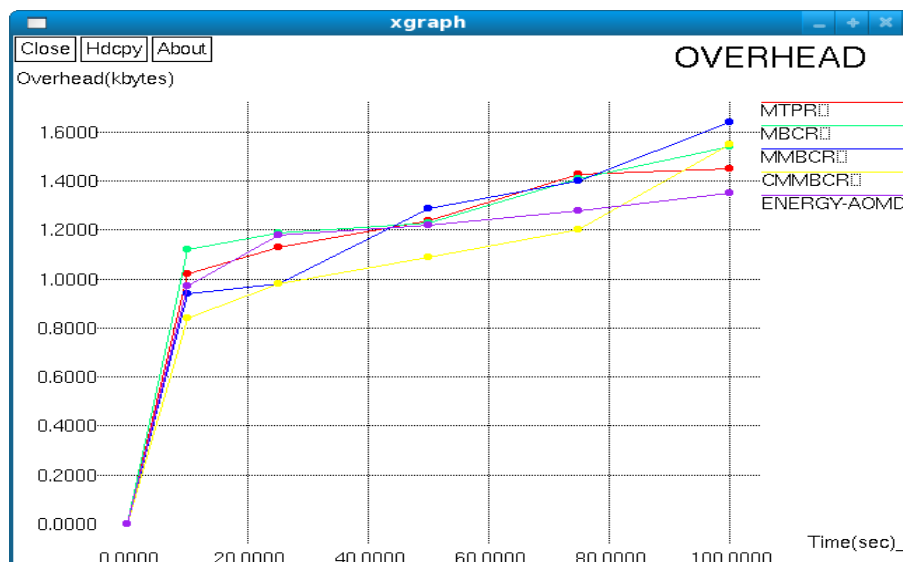


Figure3 shows the comparison of energy consumption versus time for MTPR, MBCR, MMBCR, CMMBCR and ENERGY_AOMDV protocols using 25 nodes. It shows that the energy consumption of network using ENERGY_AOMDV is minimum compared to MTPR, MBCR, MMBCR and CMMBCR.

Fig 3 Comparison of energy consumption versus time using 25 nodes.

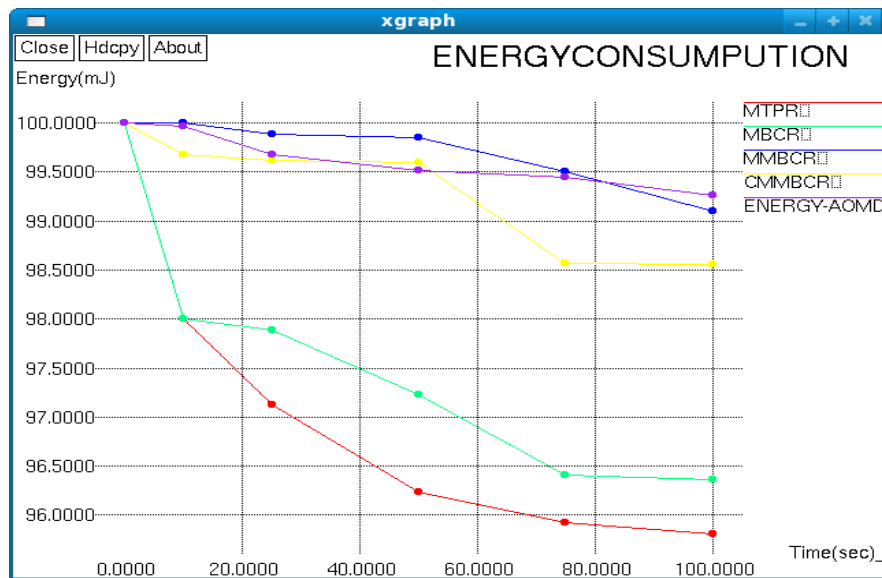


Fig 4 Comparison of end-to-end latency versus time using 25 nodes

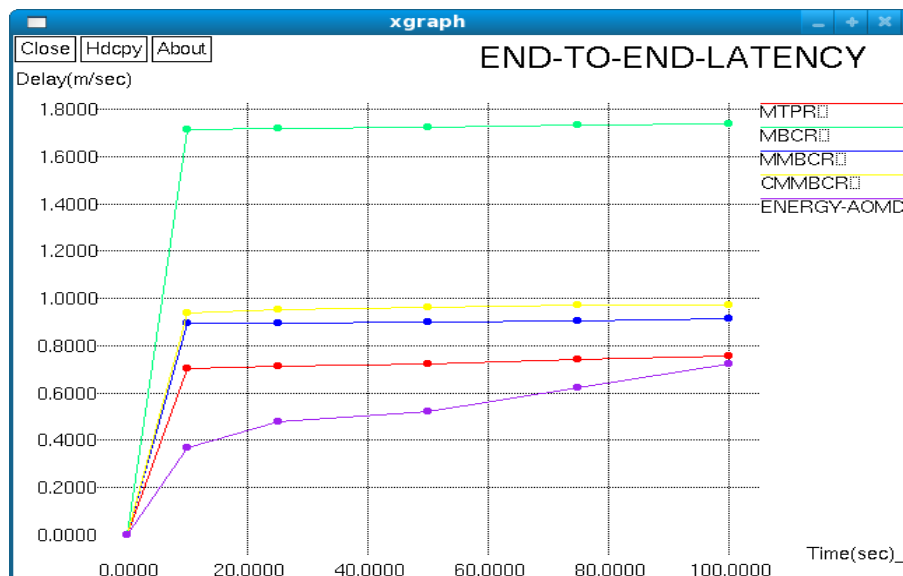
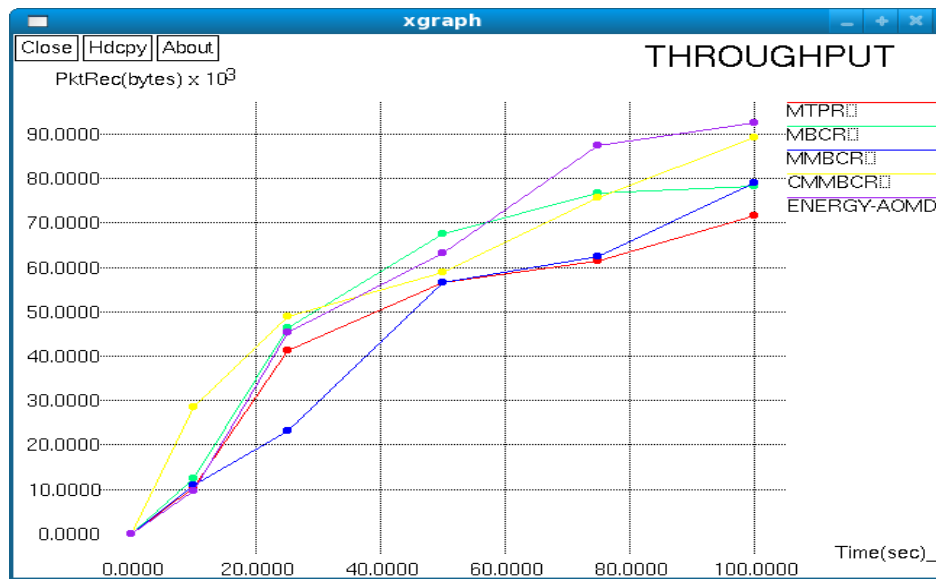


Figure4 shows the comparison of end-to-end latency versus time for MTPR, MBCR, MMBCR, CMMBCR and ENERGY_AOMDV protocols using 25 nodes. It shows that the end-to-end latency of network using ENERGY_AOMDV is minimum compared to MTPR, MBCR, MMBCR and CMMBCR.

Figure5 shows the comparison of throughput versus time for MTPR, MBCR, MMBCR, CMMBCR and ENERGY_AOMDV protocols using 25 nodes. It shows that the throughput of network using ENERGY_AOMDV is maximum compared to MTPR, MBCR, MMBCR and CMMBCR.

Fig 5 Comparison of throughput versus time using 25 nodes.



V. Conclusion

In this paper, performances of different routing protocols in MANET such as MTPR, MBCR, MMBCR, CMMBCR and ENERGY_AOMDV in different network environments were evaluated. ENERGY_AOMDV is analyzed as the best protocol compared to MTPR, MBCR, MMBCR and CMMBCR.

VI. Future work

This paper proposes further research into more energy efficient & stable protocols or variants of existing protocols and network topologies that can improve the performance of MANETs. Emphasis is on protocols that could be suitable for the implementation of scalable system in high mobility environments such as in manufacturing or product distribution industries. Also the protocols are planned to test in terms of four mobility models such as Random Way point Mobility (RWM), Reference Point Group Mobility (RPGM), Manhattan Grid Mobility (MGM), Random Direction, City Section, Manhattan mobility models and Gauss-Markov Mobility (GMM) in two different traffic patterns such as CBR and TCP.

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