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Performance Analysis of Energy Routing Protocols in MANET

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***Abstract*—Mobile Ad-Hoc Networks (MANETs) are a collection of energy constraint mobile nodes which forms a frame free network that does not need any centralized governance. The mobile nodes in MANETs are powered by some power sources usually a battery that cannot be recharged in many real life scenarios. The nodes in MANETs are responsible for routing the data in the network. Untied nodes in moveable particularly appointed systems indisputably depend on the dexterous utilization of their power source. This makes the power consumption in terms of power saving one of the most important aspects of MANET that must be taken into account. Several power-aware routing protocols have been proposed in this area to accomplish efficient utilization of energy in MANET. One of which is Efficient Power Aware Routing (EPAR) that prolongs lifespan of nodes in the network. The route that has nodes with highest power is selected by this protocol and the data packets are transmitted with minimum power usage. In this paper, we compare the performances of some of the energy aware routing protocols such as EPAR, MTPR and DSR based on parameters like throughput, delay, network life time and power consumption by varying multicast group size using extensive simulation.**

Keyword-DSR, EPAR, MTPR, MANET, Power Utilization

I. INTRODUCTION

MANET (Mobile Ad-Hoc Network) is a kind of network that makes use of radio waves for communication between nodes and allows them to have either direct or indirect wireless interaction. The infrastructure less property of MANETs gives the autonomous nodes the license to reorganize themselves in a kind of way. The nodes in these networks function as a host when it transmits data to other nodes in the network. On the other hand, a node behave as a router when it is an intermediary between two different communicating nodes that are out of one another's radio range which causes them to be incapable to communicate directly. Scenarios that have no static structures like emergency services, disaster management and rescue operations embed the application of mobile ad-hoc networks.

In MANET, the route generation is dynamically required for the nodes which are currently active in the transmission of data. Hence, for every transmission in the network, there should be dynamic route generation by the routing protocols. For such networks, the power constraint nature makes it mandatory for the routing protocols to distribute the routes in order to make efficient utilization of power of the nodes [1]. Therefore, designing an appropriate routing protocol in order to reduce the energy consumption of individual nodes in the network is a well-known research problem in MANET. Many applications are there which requires the energy consumption of the nodes to be uniform and the routing protocols to be efficient.

In this paper, we plan to study and analyse the performance of some energy aware routing protocols on the basis of certain performance criteria which includes throughput, delay, network lifetime and power consumption using NS2 simulator. To perform the evaluation, a simulation scenario is designed to carry out the experiment, and the performances of these protocols are compared.

The remaining paper is organized as follows: A detailed description of the research work previously carried out in this field is listed in section II. Brief discussions on considered energy aware routing protocols are presented in section III. Section IV is all about the description of performance metrics considered for evaluating the protocols. The simulation scenario is described in section V along with the result and discussions followed by the conclusion in the last section.

II. LITERATURE REVIEW

Optimizing power utilization in mobile communication systems has drawn significant concern in the literature. With the goal to optimize the consumption of power along with other resources, significant number of energy routing protocols have been proposed by researchers. Two categories of energy consumption have been proposed by authors in [2]. First one constitutes the energy consumed by the nodes in transmitting or receiving data in the network and is termed as active communication energy and the other one is inactive energy consumption which is the energy consumed by the nodes in listening the wireless medium while staying idle.

Considering nodes' energy awareness, another protocol which is an improved version of AODV routing protocol has been proposed in order to maximize the lifespan of network with an application of energy mean value algorithm [3]. While in [4], the authors argue that the best path may not be the shortest path between source-destination pair. It leads them to propose an extension of AODV protocol that considers the remaining power as a function for status of nodes in the network. The next hop in the process of communication is chosen based on the condition of node status.

Authors have proposed another quality of service based routing protocol termed as Q-PAR [5]. The proposed protocol has the capability to extend the lifespan of network by selecting the route with small network overhead. The authors suggest that for small networks, the protocol provides better PDR and less transmission delay with some mechanism for route repair.

Authors in [6] suggest that in a particular circumstance, the nodes' lifetime is predicted by the sink rate of channels. The low channel sink rate causes efficient utilization of battery power and enhances the network lifespan. For minimizing the consumption of energy in the mobile wireless networks, some optimization techniques based on distributed position is discussed in [7] and [8], while in [9], another method called as Blocked-ERS has been proposed which demonstrates the substantial energy-efficient ERS mechanism.

Authors have proposed techniques in [10] and [11] for improving the performances of routing strategies by considering the nodes' energy consumption for route reversal and gateway interconnection. Authors have designed energy efficient routing techniques in order to improve the network performances in terms of routing overhead, PDR, end to end delay and energy consumption. In [12], a different mechanism to conserve energy has been proposed with overall goal to achieve reduction in energy expenditure. This mechanism uses a probability based selection technique incorporated with AODV protocol to select overhearing nodes in order to reduce energy consumption.

It can be observed from the above findings of literature that the overall performance and network lifetime get affected by the energy constraints of nodes in the network as the limited energy puts a bound on nodes' lifespan as well as transmission capabilities of nodes. The nodes may behave selfish because of insufficient power which may cause a link failure during the communication.

This work present a novel comparison of performance of some energy aware routing protocols like EPAR, MTPR and DSR on the basis of certain performance criteria which includes throughput, delay, network lifetime and power consumption using NS2 simulator by varying the group size and analysing its impact on above parameters.

III. OVERVIEW OF ENERGY AWARE ROUTING PROTOCOLS

This section presents a brief introduction of the energy aware routing protocols that we have considered for performance analysis.

A. Efficient Power Aware Routing (EPAR)

EPAR falls under the category of routing protocols which make use of reactive routing mechanisms [13]. Considerable number of nodes gets their residual energy fluctuation minimized by EPAR, thereby dragging out the network lifespan [14]. The protocol identifies the node limit by making use of left over battery power and required amount of energy for a particular route establishment. The selection of routes in EPAR is done on the basis of energy in comparison to DSR in which least count of hops is the criteria for route selection. EPAR makes use of the max-min formulation in the way that every route is investigated for its residual battery power and also for lowest hop energy. Finally, the route with minimal hop energy is chosen. As for example, suppose there are two routes available for data transmission and the first path comprises of three hops with residual energy of values 30, 50 and 95 while the second path is having four hops with energy values 60, 40, 90 and 100 respectively. The second route will be the route selected for transmission as its minimum battery power of value 40 is more prominent than that of the first path.

The aggregate power using max-min formulation can be computed as:

$$Max_K T_K(t) = Min_{i \in k} T_i(t) \tag{1}$$

Where, $T_K(t)$ is the route lifetime and $T_i(t)$ is the predicted lifetime of i^{th} node over route *k*.

The energy utilization can be calculated as:

$$E_c = \sum_{i=1}^{k} T(n_i, n_{i+1}) \tag{2}$$

Where, E_c is the amount of utilized energy, T is the energy utilized in the transmission of packets over one hop and n_i to n_k are the total nodes in the route.

For relatively larger networks where the number of nodes is very large, the application of EPAR is somewhat complicated and it leads to a rise in network overhead.

B. Minimum Total Transmission Power Routing (MTPR)

The MTPR also falls under the same category as EPAR i.e. the reactive routing protocol. The energy that is required to transmit a packet over a route is stored in a simple energy metric [15]. The main advantage of MTPR is that the energy required to transmit per packet is decreased significantly. However, it doesn't have any significant impact on the lifetime of nodes in the network. The path constituted by comparatively larger number of hops but with relatively short transmission range is used by MTPR in order to reduce the aggregate power transmission spent per packet. Besides the advantages, MTPR is also not free from drawbacks and one of which is that the energy source will be depleting very quickly if the routes are constantly accessed through a particular node in the network.

C. Dynamic Source Routing (DSR)

The protocol DSR is a kind of on-demand, reactive routing. In on-demand routing strategy, the routes are discovered only when there is a requirement from a source to transmit data packets. In this type of mechanism, there is no need to maintain a route table explicitly all the time. Route discovery and route maintenance are the two phases that has to be carried out [16]. The first phase is all about broadcasting of the route request packet by the sender to all the nodes in the network. The receivers in the network, when receives the route request packet, reply to the sender with route reply packets, thereby setting up a route between himself and the sender. Route cache is kept at each node as an internal data structure as a part of route maintenance phase. Every node gets the update about the routing path after some interval of time.

Like other protocols, DSR is also not far from drawbacks. The most important of which is that it does not support multicast packet transmission. All intermediate route addresses are added up with the DSR packets which results a decrement in the throughput. Also, DSR fails to identify the invalid entry when it has to make a choice of selection from various routes, and also there is no mechanism for route priority.

IV. PERFORMANCE METRICS

This evaluation study is carried out with an overall goal of analysing the performances of energy aware routing protocols by performing simulation. For this purpose, following metrics has been considered.

A. Throughput

The throughput defines the total aggregate of information that can be delivered successfully to the intended destination from a source over a specific time period [17]. Bits/second is the unit that is usually used to measure the throughput of network. Larger value indicates healthier performance. It is measured as:

$$Throughput = \frac{\sum R_p}{(T_i - T_e)} \quad (3)$$

Where, R_p , T_i and T_e are the amount of received packets by the receiver, transmission initiation time and end time respectively.

B. Delay

It is a measure of time taken by data packets to reach the destination from the instant when it is transmitted by the source node [18]. Lower is the value of delay better is the performance of the network. It is measured in seconds and is given by:

$$Delay = \frac{\sum_{T=1}^{N}(T_r - T_s)}{N} \quad (4)$$

Where, N, T_r and T_s are the total number of data packets that is received, the time instant when t^{th} packet was received and the time instant when t^{th} packet was sent.

C. Network Lifetime

The network lifetime and its effectiveness are greatly affected by the energy level of nodes in the network [19]. The demise of one or more nodes in MANETs will decrease the performance of the network. The network lifetime may be defined as the instant of time at which the first node in the network runs out of energy and is not capable to send a data packet, as losing a node may cause a loss in some of the functionalities of the network.

D. Power Consumption

In a network, power is being used mainly in the process of transmitting data packets from one node to other over the network. Energy is also consumed by the nodes which sits idle in the network while not transmitting any data as they hear the wireless network and waits for any data packets to arrive. Power Consumption can be measured in terms of the number of data packets sent over a period of time versus total energy consumed in doing so.

V. Simulation Scenario and Result Discussion

A. Simulation Scenario

We performed the simulation work using the simulator NS-2.33 for evaluating the performances of the energy aware routing protocols that we have considered for our experiment. We have considered the scattering area for nodes as 1000 x 1000m dimension and a total of 40 nodes at maximum is scattered throughout the area starting from 10 nodes initially. The simulation parameters are listed in the table I.

TABLE I Simulation Parameters

Number of Nodes	10 – 40
Terrain Dimension	1000 x 1000 m
Traffic Type	CBR
Capacity of Channel	2 Mbps
Routing Protocols	EPAR, MTPR, DSR
Communication System	MAC/IEEE 802.11 G

The .tcl file is generated for the parameters considered in the above table.

The procedure followed to carry out the simulation and result calculation is discussed as:

Step 1: The first step of the experiment is all about deciding the source node and the required destination node in the network.

Step 2: In the second step, the selection of route between the source and destination is done among all the available routes that has the maximum energy level.

Step 3: This step applies the mix-man formulation for route selection for data transmission. Two things are calculated in this process. First one is the distance between every nodes and the other is their energy level.

Step 4: In this step, the source neighbours' coordinated are sorted and the node with minimum distance is selected followed by the identifying the next hop in the route. Thus, a route set up is completed.

Step 5: The hop count for each path is calculated and the energy level is also computed simultaneously for each route. Among all the routes, one is selected for communication by applying the max-min formulation

B. Result and Discussion

The NS-2.33 simulator is used for simulation purpose. This section briefly discusses the results as an impact of varying the number of nodes in the network, and compares the performances of routing protocols EPAR, MTPR and DSR based on the simulation. The impact on various metrics is discussed as:

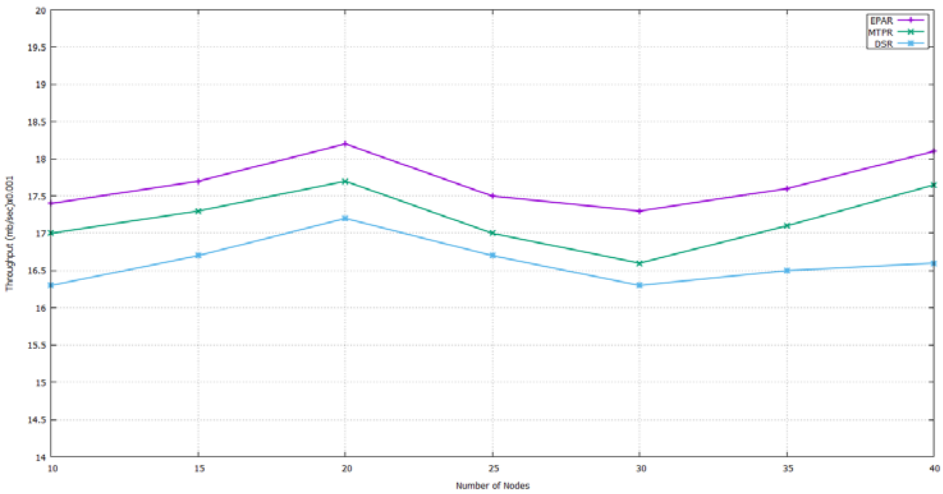

Fig. 1. Throughput versus number of nodes

1) *Throughput:* Throughput as a function of number of nodes for the protocols is shown in figure 1. The result shows that the protocol EPAR has an edge over the rest of the protocols as it gives better throughput as it selects that route for transmission of packets which has the nodes with higher residual energy.

2) Delay: Delay as a function of number of nodes for the protocols is shown in figure 2. The result shows that the protocol EPAR has the lowest delay among all as it selects the route with lowest load while MTPR selects the route with minimum required energy for transmission and DSR does not bother about the traffic of the route. So, EPAR outperforms both.

3) Network Lifetime: Figure 4 explain the behaviour of the protocols in terms of network lifetime. Although the lifetime of the network gradually decreases for all protocols with an increase in number of nodes, but EPAR provides better lifetime in comparison to other protocols.

4) Power Consumption: Figure 5 shows the result for power consumed by the protocols in transmitting the data packets from source to destination. It is obvious that the protocols would consume more power in transmitting more number of data packets over the network. But EPAR consumes lesser power in transmitting same number of data packets than DSR and MTPR as it selects routes based on the residual energy of the nodes.

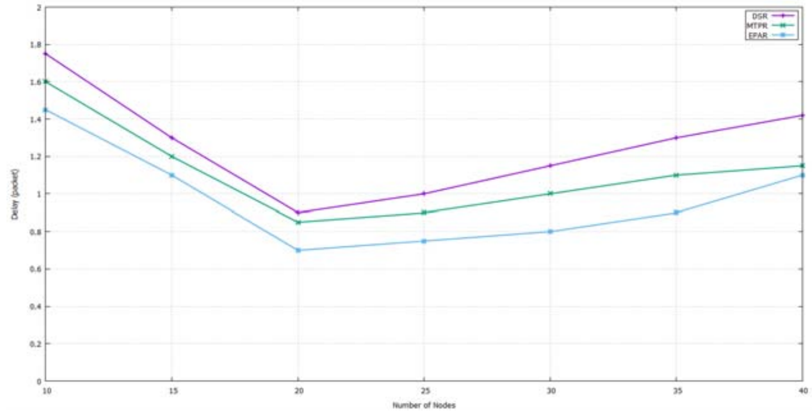

Fig. 2 Delay versus number of nodes

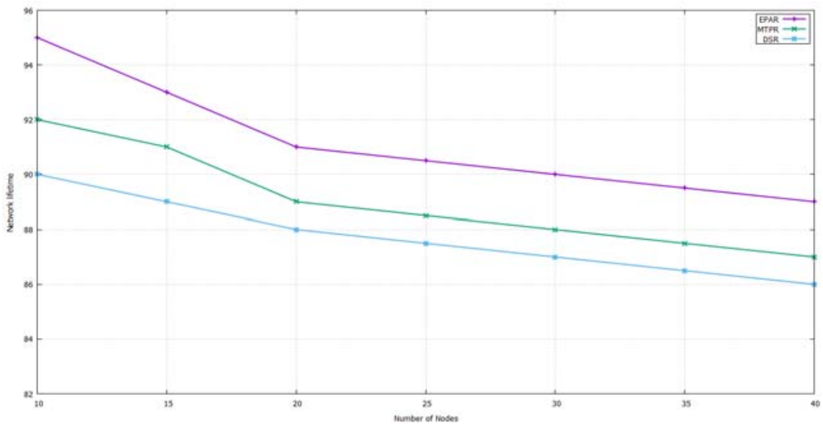

Fig. 3 Network lifetime versus number of nodes

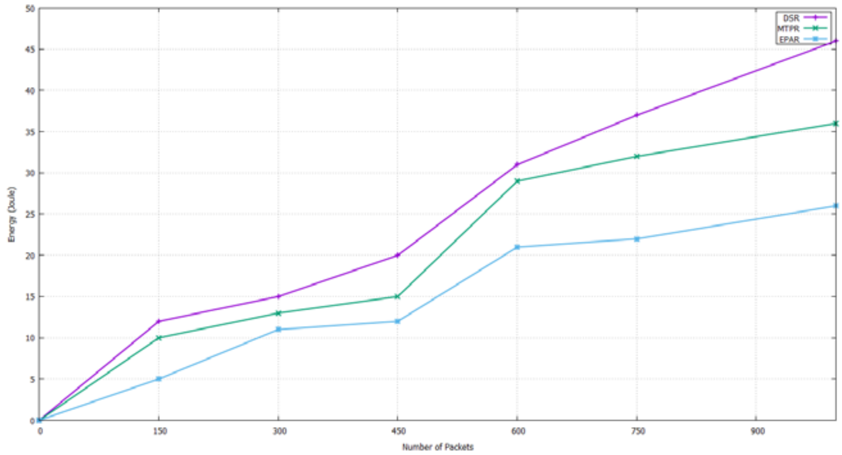

Fig. 4. Power consumption versus number of packets

VI. CONCLUSION

In this paper, we have evaluated the behavior of some power-aware routing protocols. The contributions made in this paper are as follows:

- We analyze the performances of EPAR, MTPR and DSR routing protocols.
- The parameters we focused for the evaluation of the performances are: throughput, delay, network lifetime and power consumption.
- We observe that the protocol EPAR provides better throughput than the other protocols and also it has longer network lifetime in comparison to MTPR and DSR protocols.
- We also observe that the Protocol EPAR has minimum delay in transmitting the data packets from source to destination and also consumes lesser power than MTPR and DSR in doing so.

Thus, by analyzing the results, we conclude that the overall performance of EPAR is far better than the other protocols.

REFERENCES

[1] B. Malarkodi, P. Gopal, and B. Venkataramani, "Performance evaluation of ad-hoc networks with different multicast routing protocols and mobility models," in Proc. ICARTCC, 2009, p. 81.
[2] C. Yu, C. Lee, and H. Y. Youn, "Energy efficient routing protocols for mobile ad-hoc networks," Wireless Communication and Mobile Computing, vol. 3, pp. 959-973, 2003.
[3] J. M. Kim, and J. W. Jang, "AODV based energy efficient routing protocol for maximum lifetime in MANET," AICT-ICIW, pp. 77, 2006.
[4] D. Feng, and Y. Zhu, "An improved AODV routing protocol based on remaining power and fame," Electronic Computer Technology, pp. 117-121, 2009.
[5] V. Rishiwal, S. Verma, and S. K. Bajpai, "QoS based Power Aware Routing in MANETs," Computer Theory and Engineering, vol. 1, no. 1, 2009.
[6] D. Kim, J. J. G. L. Aceves, K. Obraczka, J. C. Cano, and P. Manzoni, "Routing mechanisms for mobile ad hoc networks based on the energy drain rate," IEEE Transactions on Mobile Computing, vol. 2, no. 2, pp. 161-173, 2003.
[7] V. Rodoplu, and T. H. Meng, "Minimum Energy Mobile Wireless Networks," IEEE Journal on Selected Areas in Communications, vol. 17, No. 8, pp. 1333-1343, 1999.
[8] P. J. Wan, G. Calinescu, X. Y. Li, and O. Frieder, " Minimum-energy broadcasting in static ad hoc networks," Wirel. Netw., vol. 8, No. 6, pp. 607-617, 2002.
[9] I. Park, T. H. Meng, and I. Pu, "Blocking Expanding Ring Search Algorithm for Efficient Energy Consumption in Mobile Ad Hoc Networks," IFIP WONS, pp. 191-195, 2006.
[10] A. Syarif, and R. F. Sari, "Performance Analysis of AODV-UI Routing Protocol with Energy Consumption Improvement under Mobility Models in Hybrid Ad hoc Network," Int. J. on Computer Science and Engineering (IJCSE), vol. 3, pp. 2904-2918, 2011.
[11] J. Zhu, and X. Wang, "Model and Protocol for Energy-Efficient Routing over Mobile Ad Hoc Network," IEEE Transactions on Mobile Computing, vol. 10, pp. 1546-1557, 2011.
[12] N. Sumathi, and A. S. Thanamani, "Evaluation of Energy Efficient Reactive Routing Protocols in QoS Enabled Routing for MANETS," Int. Journal of Computer Applications, vol. 14, pp. 10-14, 2011.
[13] Shivashankar, H. N. Suresh, G. Varaprasad, and G. Jayanthi, "Designing Energy Routing Protocol with Power Consumption Optimization in MANET," IEEE Transactions on Emerging Topics in Computing, vol. 2, no. 2, pp. 192-197, June 2014.
[14] P. Chinnaswamy, and A. M. Natarajan, "Optimized replication strategy for intermittently connected mobile networks," Int. Journal of Business Data Communications and Networking (IJBDCN), vol. 8, no.1, pp. 1-18, 2012.
[15] M. Divya, S. Subasree, and N. K. Sakthivel, "Performance Analysis of Efficient Energy Routing Protocols in MANET," Procedia Computer Science, vol. 57, pp. 890-897, 2015.
[16] Shivashankar, G. Varaprasad, and S. H. Narayanagowda, "Implementing a new power aware routing algorithm based on existing dynamic source routing protocol for mobile ad hoc networks," IET Networks, vol. 3, no. 2, pp. 137-142, 2014.
[17] M. A. Qadeer, R. Ahmad, M. S. Khan, and T. Ahmad, "Real time video streaming over heterogeneous networks," International Conference on Advanced Communication Technology, Phoenix Park, pp. 1117-1122, 2009.

[18] M. Haque, T. Ahmad, and M. Imran, “Performance Evaluation of MOSPF, ODMRP, DVMRP and MAODV Ad-Hoc Routing Protocols,” International Journal of Control Theory and Applications (IJCTA), vol. 10, no.13, pp. 189-199, 2017, ISSN: 0974-5572.
[19] M. S. Khan, R. Ahmad, T. Ahmad, and M. A. Qadeer, "Real time streaming video over Bluetooth network," International Multimedia, Signal Processing and Communication Technologies, Aligarh, pp. 181-184, 2009.

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