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Analysis of Path selection policy of the Routing Protocols using Energy Efficient Metrics for Mobile Ad-Hoc Networks

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***Abstract*-As routing protocols in MANET are very essential, reducing power consumption is an important in ad hoc wireless networks. Our aim is to improve energy performance of DSR (Dynamic Source Routing) protocol in mobile ad hoc networks. This routing protocol looks for shortest paths which jointly improve packet latency and network life time. Our proposal for a new routing module based on energy metrics. We have tried to minimize the total power needed to transmit packets, maximize the life time of every single node. In this paper, we have performed the comparison analysis of an energy-efficient DSR and AODV protocols by testing energy aware metrics such as Minimum Total Transmission Power Routing, Minimum Battery Cost Routing and Minimum Drain Rate.**

Keywords-Mobile ad-hoc networks, Energy-aware routing, Minimum Total Transmission Power Routing, Minimum Drain Rate

I. INTRODUCTION

The nodes in an ad hoc network are constrained by battery power for their operation. To route a packet from a source to a destination involves a sufficient number of intermediate nodes. Hence, battery power of a node is a precious resource that must be used efficiently in order to avoid early termination of a node or a network. Thus, energy management is an important issue in such networks. Efficient battery management, transmission power management [1] and system power management are the major means of increasing the life of a node. These management schemes deals in the management of energy resources. by controlling the early depletion of the battery, adjust the transmission power to decide the proper power level of a node and incorporate the low power strategies into the protocols used in various layers of protocol stack. There are so many issues and solutions which witnesses the need of energy management [2] in ad hoc wireless networks. Mobile ad hoc network (MANET) is composed of a collection of mobile nodes which can move freely. Therefore, dynamic topology, unstable links, limited energy capacity and absence of fixed infrastructure are special features for MANET when compared to wired networks.

MANET does not have centralized controllers, which makes it different from traditional wireless networks cellular networks and wireless LAN). Due to these special features, the design of routing protocols for MANET becomes a challenge. Classical ad hoc routing protocols, such as AODV [3] and DSR [4], aim to find the shortest path route during the route discovery phase. Shortest-path based routing has good performance for wired networks. However, this is not true for MANET, since shortest path routing causes power depletion by overusing nodes along the shortest path. Sometimes, power depletion at specified nodes can cause network partitioning. In order to solve this problem, energy efficient routing protocols [5]–[6] have been heavily studied in recent years. Most of them consider energy related cost metrics instead of the hop count or distance metrics. We classify the power efficient routing protocols into four categories based on their path selection scheme. The first set of protocols use the energy cost for transmission as the cost metric and aim to save energy consumption per packet. However, such protocols do not take the nodes’ energy capacity into account. Thus, the energy consumption is not fair among nodes in the network.

II. ENERGY-AWARE ROUTING PROTOCOLS

Power consumption in MANETs is an important issue because all or most of the nodes are battery supplied, and the communication infrastructure is composed of the same nodes which are using it. In such context, optimizing energy consumption also means maximizing the overall usability of the network. Power is required for both processing (e.g. protocols operations and applications execution) and communication (e.g. control and data

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messages transmission). To reduce the amount of required power, we can adopt techniques at the several layers of the protocols stack, paying attention to the fact that protocol layers are closely coupled from the power consumption perspective [7]. Research works about these techniques involve, in particular, physical, data link and network layers. At the physical layer, a mechanism for the auto-adjustment of transmission power is an example [8]. At the network level, since a significant amount of energy is spent by a node to transmit packets, the routing algorithm's path selection criteria can affect a MANET's lifetime.

Mehdi Barati et. al. [9] Proposing energy efficient routing protocols for Mobile Ad hoc Network (MANET) and Wireless Sensor Network is an challenging task. Many different routing protocols based on different features have been proposed to the performances of many of these routing protocols have been evaluated focusing on metrics such as delay, routing overhead, and packet delivery. However, no studies have been done to investigate energy aspect of these routing protocols. Thus, this paper will discuss about the power consumption aspect of the MANET routing protocols. A performance comparison of Dynamic Source Routing (DSR) and Ad hoc On-Demand Distance Vector (AODV) routing protocols with respect to average energy consumption and routing energy consumption are explained thoroughly. Finally, an evaluation of these routing protocols based on energy consumption is presented.

The most relevant energy-aware routing protocols proposed in the literature can be distinguished by the number of paths used for the transmissions: there are multi-path and single-path energy-aware protocols. The solutions are further classified based on the objective to achieve. They can try to: (i) minimize the total power needed to transmit packets; (ii) maximize the lifetime of every single node; (iii) minimize the total power needed to transmit packets at the same time maximizing the lifetime of every single node. Some interesting energy efficient route selection schemes, falling in one of the previous categories, are presented in [7] and briefly described in the following.

III. PROPOSED WORK

Minimum Total Transmission Power Routing (MTPR) is a routing protocol aimed at minimizing overall power consumption in MANETs. Given a source s and a destination d, we denote with Pr the total transmission power for a generic route r from s to d. Pr is the sum of the power consumed for the transmission between each pair of adjacent nodes belonging to r. MTPR selects the route r∗ such that r∗=min r ∈ R Pr, where R is the set containing all possible routes from s to d. A simple shortest path algorithm can be used to find this route. A drawback of this schema is that a route with a great number of hops can be selected, with a consequent increase in both delay and path instability (the latter, due to the dynamic nature of the MANETs). A more significant drawback is that, while the total transmission power is reduced, residual energy of every node is not considered and the nodes can fail quickly.

Minimum Battery Cost Routing (MBCR) associates each node ni in the network with a weight fi $(c_i\ (t)) = 1 / c_i\ (t)$, where $c_i(t)$ is the battery capacity level of ni at time t. Given a source s and a destination d, if we say Er the sum of the nodes weights of a generic router from s to d, MBCR selects the route r∗ such that r∗=min $_{r\,\in\,R}$ Er, where R is the set containing all possible routes from s to d. Such a scheme will always choose routes with maximum total residual energy. Nevertheless, this metric does not consider the residual energy of a single node. For instance, if a route includes a node characterized by a very low energy together with others with high energy, such route might be chosen. Indeed, in this case it would be better to choose a path in which all the nodes have comparable energy levels, even though not so high.

With Min-Max Battery Cost Routing (MMBCR), starting from the above definition of $fi(c_i(t))$, for each route r from a source s to a destination d, a cost is defined as $C_r(t)=\max_{i\,\in r} fi(c_i(t))$. The chosen route r∗ verifies the relation $C_{r}*(t)=\min_{r\,\in\,R} C_r(t)$. MMBCR safeguards nodes with low energy level because it selects the route in which the node with minimum energy has more energy, compared to the nodes with minimum energies of the other routes. Nevertheless, it does not take into account explicitly the transmission power consumption, hence resulting in a possible reduction of the overall network lifetime.

Conditional Max-Min Battery Capacity Routing (CMMBCR) proposes an approach based on both MTPR and MMBCR. Let us consider the node of a generic route r from a source s to a destination d, with lowest energy. Let also mr(t) be its energy, and R the set of all the routes from s to d. If some paths with $m_r(t)$ over a specific threshold exist in R, one of these will be chosen using the MTPR scheme. Otherwise, the route r∗ satisfying the relation $m_r*(t)$=maxr∈R $m_r(t)$ will be selected. This scheme suffers from an unfair increment of the forwarding traffic towards nodes with more energy [9].

A. The Basic Minimum Drain Rate Mechanism

Power saving mechanisms based only on metrics related to the remaining power cannot be used to establish the best route between source and destination nodes. If a node is willing to accept all route requests only because it currently has enough residual battery capacity, much traffic load will be injected through that node. In this sense, the actual drain rate of power consumption of the node will tend to be high, resulting in a sharp reduction of battery power. As a consequence, it could exhaust the nodes power supply very quickly, causing the node to halt soon. To mitigate this problem, other metrics, based on the traffic load characteristics, could be employed. To this end, techniques to accurately measure traffic load at nodes should be devised. Even though the number of packets buffered in the node s queue can be used to measure the traffic load, it is not trivial to devise an efficient cost function that combines the buffer information with the remaining battery power.

We propose the drain rate as the metric that measures the energy dissipation rate in a given node. Each node ni monitors its energy consumption caused by the transmission, reception, and overhearing activities and computes the energy drain rate, denoted by DR_i, for every T seconds sampling interval by averaging the amount of energy consumption and estimating the energy dissipation per second during the past T seconds. In this work, T is set to 6 seconds. The actual value of DR_i is calculated by utilizing the well-known exponential weighted moving average method applied to the drain rate values DR_{old} and DR_{sam}, which represent the previous and the newly calculated values. To better reflect the current condition of energy expenditure of nodes, we give higher priority to the current sample drain rate by setting α=0.3, the ratio RBP_i/DR_i where RBP_i denotes the residual battery power at node ni, indicates when the remaining battery of node ni is exhausted, i.e., how long node n_i can keep up with routing operations with current traffic conditions based on the residual energy . The corresponding cost function can be defined as: $C_i=RBP_i /DR_i$ The maximum lifetime of a given path r_p is determined by the minimum value of c_i over the path, that is:

$$l_p= \min C_i \quad (1)$$

The Minimum Drain Rate (MDR)[10] mechanism is based on selecting the route r_m, contained in the set of all possible routes r* between the source and the destination nodes, that presents the highest maximum lifetime value, that is:

$$t_m= r_p =\max l_i \quad (2)$$

Because the status of the selected path can change over time due to variations in the power drain rate at nodes, the activation of a new path selection depends only on the underlying routing protocol. In order to apply those power-aware mechanisms to MANET routing protocols, all source nodes should periodically obtain new routes that take into account the continuously changing power states of network nodes in proactive or reactive manner. When applied to proactive routing protocols, all the nodes are required to maintain the route and update power information of nodes regardless of their demand for routes. In contrast, when applying to on-demand reactive routing protocols, they require all source nodes to perform periodic route recovery in order to find a new power-aware route even when there is no route breakage [11] and 12].

IV. IMPLEMENTATION

The different protocols studied in the earlier chapters have been simulated using NS2 for different set of parameters.

A. *Fixed transmission and receiving power*

Energy consumption only counts receiving and transmission. Thus, idle nodes do not consume energy. The power for transmission and receiving are fixed values, 0.5 Watt and 0.3 Watt, respectively. Assume a packet p with time length t(p); when a node transmits p, its energy capacity will be decreased by Etx(p), where Etx(p)=0.5×t(p); when a node receives p, its energy capacity will be decreased by Erx(p), where Erx(p)=0.3× t(p). Thus, under this model, MTPR is the same as the minimum hop routing. It is possible to modify this model to adjustable transmission power based on the transmission distance. We did simulations with adjustable transmission power, but cannot include the results in this paper due to the space limit. Following Table I represent the parameters.

TABLE I. SIMULATION PARAMETERS ENERGY MODEL

PARAMETERS	VALUE
Initial Energy	3.0J
Transmission Power	0.5watts
Receiving Power	0.3watts
Idle power	0.1watts
Sleeping power	0.05

B. *Network Setting*

We simulate a network with mobile nodes randomly distributed in a region. The mobility model uses the random waypoint model, and node speed is randomly distributed between (0−20) meters per second. We did two sets of simulations for mobile and static scenarios respectively. For the traffic models, we use CBR sources, but the source-destination pairs are randomly chosen over the network. Table II defines network settings.

C. Performance

We evaluate the performance of six routing protocols via simulations under various scenarios. In each table, the columns are the name of the protocol, the average delivery ratio (DR), the average end-to-end delay (Delay), the average energy consumption (E-Con) and among all the nodes. We use bold font to identify the best result in each column.

TABLE II. SIMULATION PARAMETERS NETWORK SETTING

PARAMETERS	**VALUE**
Area	300 x 300
Nodes	10
Node Speed	20 m/s
Simulation Time	300 s
Traffic Type	CBR
Packet Size	1500 bytes

Packet delivery fraction = (Received packets/Sent packets)*100 (3)

Packet delivery ratio of AODV is 90.25% and DSR is 97.89%. Compare to AODV [13], DSR [14] produce best packet delivery ratio.

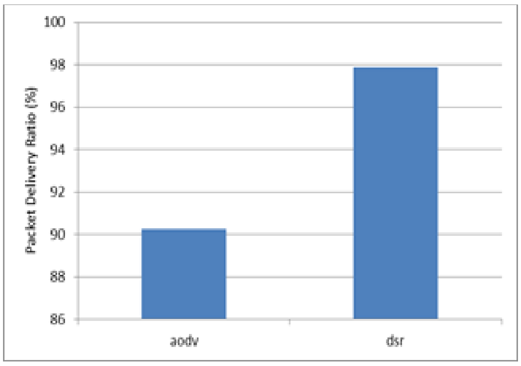

Figure 1. Packer delivery ratio of AODV and DSR

The throughput values of AODV, DSR protocols for 10 nodes are plotted on the different scales to show the effects of varying throughput of the above routing protocols. It is observed from Fig. 1,2,3,4 and 5. The computational results are tabulated in tables I, II and III.

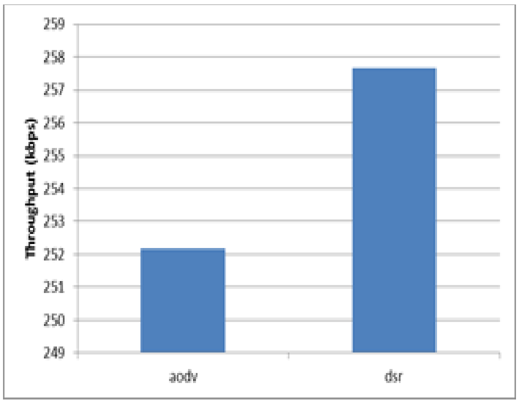

Figure 2. Throughput of AODV and DSR

TABLE III. AVERAGE THROUGHPUT OF AODV AND DSR

Protocol	**Average throughput (kbps)**	**Starting time**	**Stop time**
AODV	252.17	1.12	2.58
DSR	257.66	1.04	2.47

Hence, DSR shows better performance with respect to throughput AODV. The average throughput is tabulated in Table III. The average time from the beginning of a packet transmission at a source node until packet delivery to a destination.

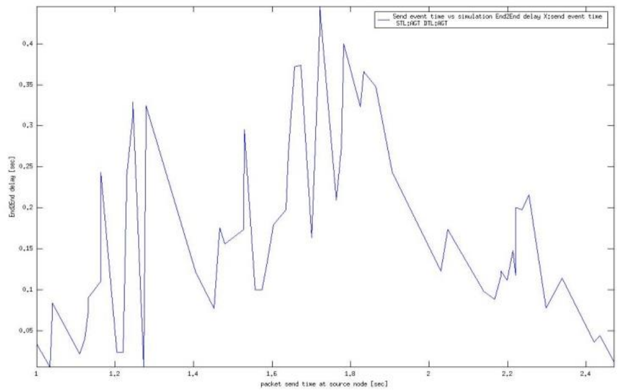

Figure 3. End to End Delay of DSR

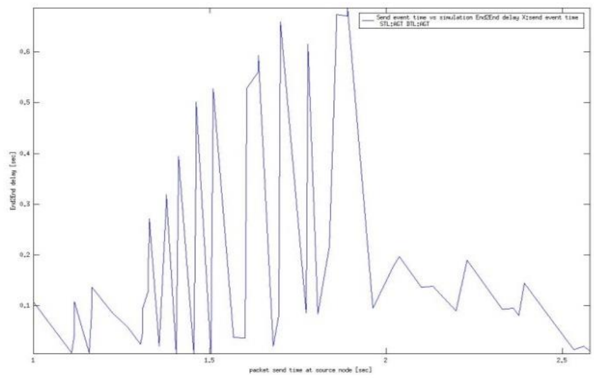

Figure 4. End to End Delay of AODV

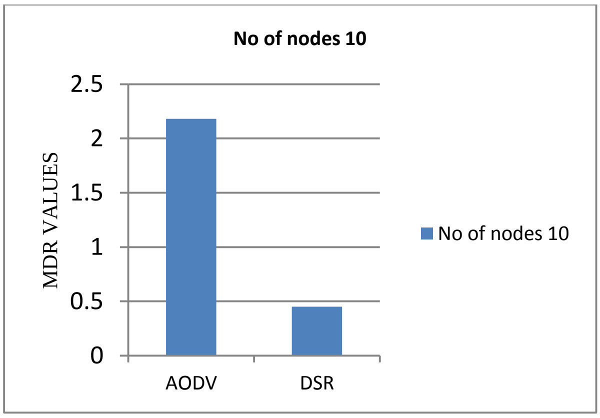

Figure 5. MDR values for AODV and DSR

V. CONCLUSION

This work has analyzed ways to optimize energy metrics in Mobile Ad-hoc Networks. We have proposed and evaluate of the DSR, AODV protocol aimed at considering the mentioned metrics. Experimental results have demonstrated to the above metrics. In fact, our tests have shown that the DSR, AODV routing module has a positive impact both on network lifetime and end-to end delay. In particular, energy-aware routing allows for a prolonged duration of the network nodes, when compared to the native DSR implementation based on shortest path routing. We guarantee a uniform utilization of the nodes involved in the data forwarding phase, which results in extended lifetime of the nodes themselves, as well as improved network availability.

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