A NEW ENERGY LEVEL EFFICIENCY ISSUES IN **MANET**

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ABSTRACT

Energy is the scarcest resource for the operation of the mobile ad hoc networks. Idle energy consumption is responsible for a large portion of the overall energy consumption in the wireless interfaces of the mobile nodes. Therefore, it is crucial to energy conservation efforts that this source of energy is eliminated or reduced. Our goal in this research is to create a new energy conservation scheme that works on reducing idle energy consumption. This scheme works with existing routing algorithms of all categories. It aims at achieving energy conservation in a manner fair to all network nodes. It is distributed in nature, and its functionality is independent of the strategy and architecture of the routing protocol

Keywords: *MANET, CBR, TCP, DSR, AODV*

1. INTRODUCTION

Nodes within an ad hoc network generally rely on batteries (or exhaustive energy sources) for power. Since these energy sources have a limited lifetime, power availability is one of the most important constraints for the operation of the ad hoc network. There are different sources of power consumption in a mobile node. Communication is one of the main sources of energy consumption .Since the rate of battery performance improvement is rather slow currently, and in the absence of breakthroughs in this field, other measures have to be taken to achieve the goal of getting more performance out of the currently available battery resources. Within this study, we focus our efforts on methods to reduce the power consumed in communications between ad hoc network nodes.

2. RELATED WORK

Several studies have dealt with measuring energy consumption in the wireless interfaces of mobile nodes, e.g. [1] [2] to determine the exact sources of energy consumption in the wireless interfaces. These studies examined the different modes of operation of the wireless interfaces. It was found that a mobile node's wireless interface consumes energy not only while communicating with other nodes, but also while in idle mode, i.e. when the node is listening to the medium but not handling packets. Communications in ad hoc networks are done via using the RF transceiver at the source, intermediate and destination nodes to exchange information. The source node sends control and data messages which are received by one or more receiving nodes, depending on the message type. The receiving node could be the intended receiver of a packet, or it could be on the path to the end destination (when the destination is not within range from the source) and in this case it acts as a forwarder of the traffic. In order to address the energy efficiency issues in the communications within ad hoc networks, it is important to understand the energy model which represents the power consumption behavior in the ad hoc network node wireless interfaces [3].

3. ENERGY MODELS

Following are the types of energy consumption that have been identified:

- Energy consumed while sending a packet
- Energy consumed while receiving a packet
- Energy consumed while in idle mode
- Energy consumed while in sleep mode which occurs when the wireless interface of the Mobile node is turned off

It should be noted that the energy consumed during sending a packet is the largest source of energy consumption of all modes. This is followed by the energy consumption during receiving a packet. Despite the fact that while in idle mode the node does not actually handle data communication operations, it was found that the wireless interface consumes a considerable amount of energy nevertheless. This amount approaches the amount that is consumed in the receive operation. Idle energy is a wasted energy that should be eliminated or reduced through energy-efficient schemes. Through energy consumption measurements studies, experiments have also been conducted to determine the power consumption patterns in the different active modes. In some experiments, the instantaneous power consumption per communication mode, e.g. send, receive, idle and sleep modes, has been measured. Some experiments went even further to include more details about the energy consumption pattern per subtype of the operation [1], [2]. For example, the cases of unicast and broadcast are considered to have different costs. This has been explained based on the fact that unicast operations in IEEE 802.11 involve the exchange of control packets between the sending and receiving nodes while broadcast operations do not involve such an exchange. However, these studies did not directly address cases of repeated resending of control packets that may happen due to glitches in the transmission operations over the wireless communication channels. It has been shown [4] that energy consumed in the retransmit operations is responsible for a considerable amount of energy consumption. Since this case cannot be avoided with the use of energy-efficient algorithms, especially in the transition between node wakeup and sleep times, using the model described by [1], [2] may introduce some inaccuracies. Throughout this study, we have benefited from [1] and other measurements studies in the usage of the values that they measured for the energy consumption of the wireless interfaces during the different modes.

3.1 Energy Efficiency Metrics

Energy efficiency metrics are needed to both devise and evaluate energy conservation schemes. The “Minimize energy consumed/packet” metric basically addresses the average energy consumed per packet, over the number of hops that are traversed by this packet. Hence, if $e_{i,j}$ is the energy consumed in transmitting one packet between nodes i and j, then the energy consumed for packet x, e_x, transmitted from source to destination over n hops, is:

$$e_x = \sum_{i=1}^{n} e_{i,i+1}$$

As for the “Minimize cost/packet” metric, a cost function has to be defined. The total cost (or energy) of sending a packet along some path is the sum of node costs along that path. This metric is generally used if we are trying to derive an algorithm that maximizes the life of all nodes in the network. There is an important difference between this metric and the first one (Minimize energy consumed/packet). The former makes sure that the nodes that are low in energy do not lie on many paths while the latter does not consider the energy level of the nodes as long as the path a packet takes will result in minimum energy consumption for that packet.

If ensuring fair energy distribution amongst network nodes is of concern, then the “Minimize variance in node energy levels” metric must be used. This metric ensures that all nodes in the network remain up and running together for as long as possible. A way to achieve this could be via selecting the routing path (if several are available) based on the energy levels of the different nodes on the path. That is, one would determine the smallest value of node energies on a certain path, and compare it with the corresponding value on the other paths. The path with largest bottleneck energy value is selected. We will show later that, as one of the aspects of our energy conserving strategy, we have opted to using this method as one of our measures to ensure fairness amongst network nodes. we compare the algorithms with regard to average overall amount of energy used to route packets together with packet delivery performance. We also use the standard deviation of remaining node energies as a measure for energy distribution between network nodes, when comparing the algorithms [8].

3.2 Energy Consumption Issues

To get an idea about the nature of some of the energy consumption issues that are encountered in ad hoc networks, we performed a comparison study of some popular ad hoc routing algorithms [5]. These two algorithms use the shortest-path routing strategy and do not have an energy conservation technique. We demonstrate the difference between the algorithms in terms of their energy consumption. We used the ns2 simulator [6] to conduct our investigation. We also used the [7] wireless and mobility enhancements to ns2. We use a relatively high value for the maximum node speed and run simulations for different pause time values for this speed. Our goal is to examine and compare the energy consumption patterns at a mobility condition that would cause the topology to change relatively fast. Note that the only reasonable energy consumption comparison that can be performed is at the system level, i.e. average energy comparison. It does not make sense from the point of view of examining different routing strategies to perform the comparison at the individual node level, since the different algorithms may select different nodes to route packets. We did not perform detailed performance comparisons of the algorithms in terms of their ability to deliver packets under different conditions since this was the subject of other studies e.g. [6], [9]. We only compared their energy consumption patterns under different conditions and the corresponding packet delivery ratios.

4. RESULT

This was to ensure that lower energy consumption did not come at the expense of the algorithm's packet delivery performance. Tables 4-1 and 4-2 show the values that we used for the different simulations. Table 4-1 shows the common simulation parameters. The results of our simulations represent the average of 5 runs each with different mobility scenario. We used the same traffic pattern for all simulation experiments. Our movement scenarios are characterized by a pause time. Each node starts the simulation by remaining stationary for "pause time" seconds. It then moves to a selected random destination at a speed that is uniformly distributed between zero and the maximum speed that we selected for the simulation. This pattern then repeats itself over and over until the end of the simulation. We ran the simulations for different pause times for each of the mobility scenarios. The power consumption values for the different modes of operation are listed in Table 4-2.

We selected CBR for traffic instead of TCP to be able to perform the comparison between the algorithms under equal conditions since TCP changes the load (the number of packets it sends) based on the network conditions, which would prevent a direct comparison between the algorithms. With these simulation conditions, we obtained results that are plotted in Figure 4-1.

Table 4-1: Simulation parameters for the case study

Number of nodes	50
Dimensions of simulation area (m×m)	1500×300
Initial node energy (Joules)	1000
Simulation time (seconds)	600
Traffic type	CBR, 3 packets/
Packet size (bytes)	512
Number of traffic connections	20
Maximum speed (m/s)	20

Table 4-2: Energy model parameters for the case study

Rx Power Consumption	1.0 W
Tx Power Consumption	1.4 W
Idle Power Consumption	0.83 W

The results indicate that the energy consumption patterns of DSR and AODV are quite close, with DSR performing slightly better than AODV especially with high mobility conditions. As part of the energy performance, we also measured the standard deviation of remaining node energies in order to see how the nodes are utilized in both AODV and DSR. It is worth mentioning that the lower the standard deviation, the more balanced node utilization is. Figure 4-2 shows these results. The figure also shows that DSR and AODV perform quite closely with AODV

showing slightly better results than DSR especially at higher mobility. This is due to the fact that all nodes have to send AODV HELLO messages periodically. This implies more equal utilization of network nodes. However, if we only consider these energy consumption measures, the picture is incomplete.Therefore, packet delivery ratios are important for a complete understanding of the results.
Figure 4-3 shows the corresponding performance of the algorithms in terms of the packet delivery ratios. From this chart, we see that the data delivery performance is almost identical for DSR and AODV, for the conditions of our simulation. From this we see that for the simulation cases that we have studied, the DSR algorithm offers the best combination of energy consumption performance and the data delivery performance. It is followed quite closely by the AODV algorithm to the extent that they both seem to be almost identical for most of our cases.
We also measured the two algorithms with respect to idle energy consumption, see Figure 4- 4. In general, idle energy consumption is an obvious candidate for energy conservation efforts. We found that AODV and DSR are similar in this regard. The idle energy consumption constitutes well above half of the energy consumption for both algorithms. It is worth mentioning that the results concerning idle energy are somewhat different from those obtained through other studies e.g. [10]. The reason is the difference in the used energy model in these particular simulations. In any case, it is clear from most studies that idle energy accounts for at least 50% of total energy consumption in ad hoc network operation.

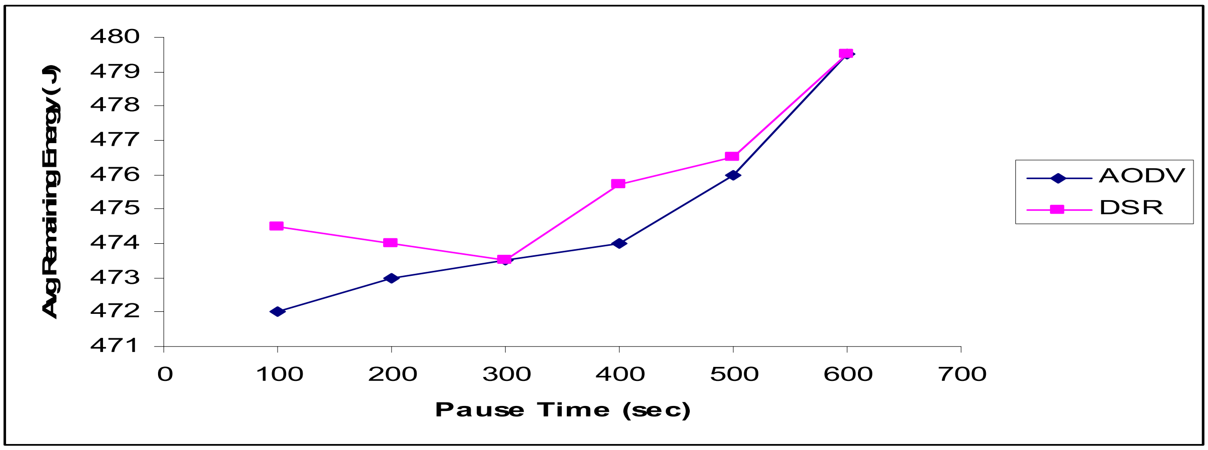

Figure 4-1: Energy consumption patterns for DSR and AODV

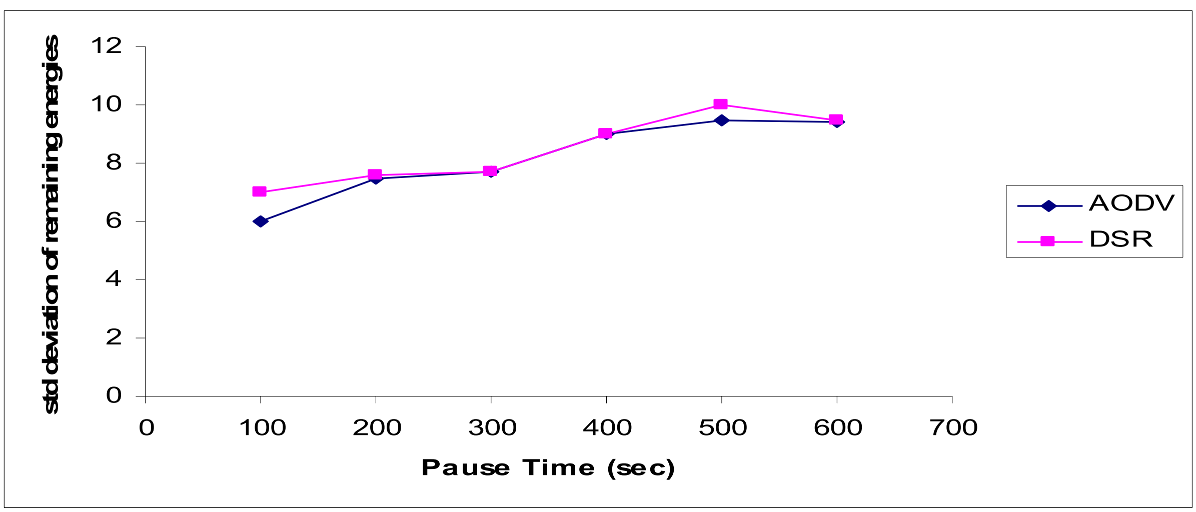

Figure 4-2: Node utilization under the AODV and DSR routing protocols

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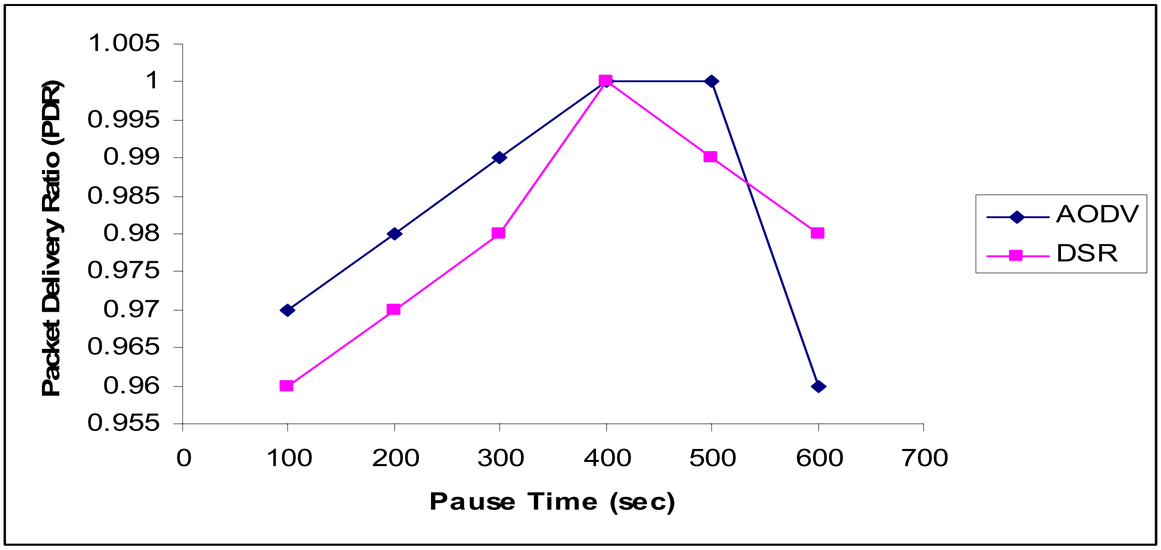

Figure 4-3: Packet delivery ratio for AODV and DSR

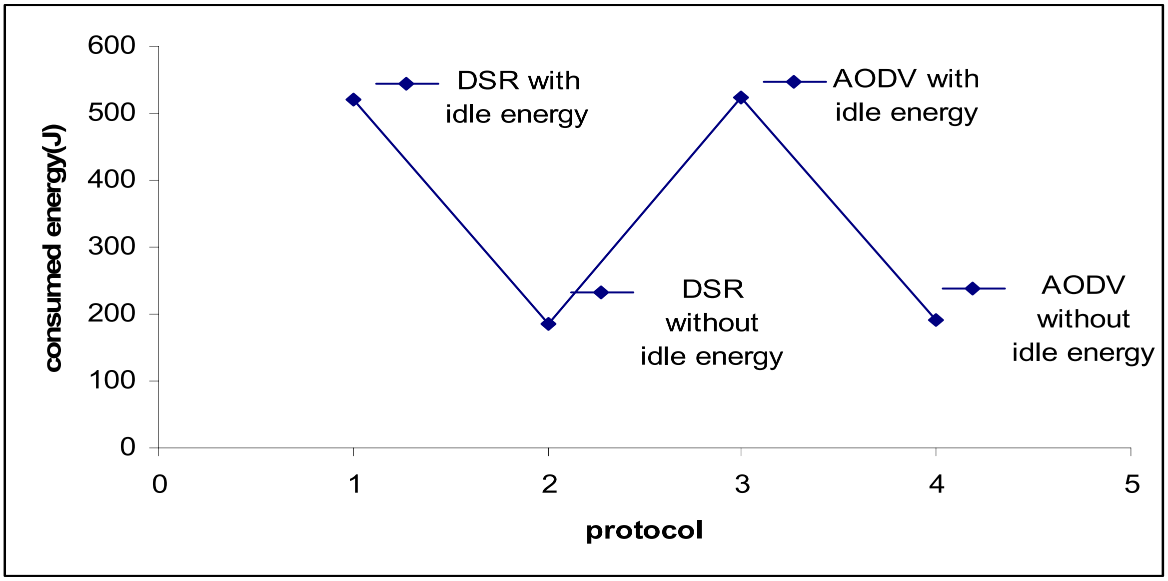

Figure 4-4: Energy consumption with and without idle energy in DSR and AODV

(pause 400 sec)

So identifying when nodes can go from a relatively high-energy idle state to a low-energy sleep state is one important avenue for energy conservation. Also, despite the fact that idle energy provides an inherent source of energy balance between different nodes to some extent, we can still see some energy imbalance between network nodes. Energy fairness, therefore, is another area that needs to be focused on. This becomes of special importance as idle energy gets reduced due to some energy conservation strategy, as this undesired source of balance that exists with algorithms with no energy conservation strategies would be reduced or eliminated.

5. CONCLUSION

In this paper, an overview of energy efficiency issues in ad hoc networks was given. Energy models widely used in analyzing and devising ad hoc protocols were discussed. The sources of energy consumption that pertain to

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communications in ad hoc network were shown to exist in four main modes of operation: transmitting, receiving, idle and sleep modes. The sources of energy consumption overhead such as idle condition, collisions and protocol control messages have been discussed. The metrics used for energy-efficiency strategies have also been explored briefly. We presented a case study which sheds light on some of the energy inefficiency issues encountered in ad hoc networks.

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