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# Energy Efficient Routing In Mobile Adhoc Networks:A Survey

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## Abstract

*Mobile ad hoc Network (MANET) is a special type of wireless network in which collection of mobile network interfaces may form a temporary network without the aid of any established infrastructure or centralized administration. Due to host mobility, network topology often changes and so finding and maintaining routes is very important problem. So energy conservation is a critical issue in ad hoc wireless networks for node and network life. Mobile devices in a MANET must operate under energy constraints since they typically rely on a battery, which has a finite capacity. For these mobile nodes, the most important system design criteria for optimization may be energy conservation.A recent trend in ad hoc network routing is the reactive on-demand philosophy where routes are established only when required. In this paper, we have survey various techniques to make AODV (Ad Hoc on Demand Distance Vector Routing) protocol energy efficient.*

## 1. Introduction

A mobile ad hoc network (MANET) is comprised of mobile hosts that can communicate with each other using wireless links. Some scenarios where an ad hoc network can be used are business associates sharing information during a meeting, emergency disaster relief personnel coordinating efforts after a natural disaster such as a hurricane, earthquake, or flooding, and military personnel relaying tactical and other types of information in a battlefield. It is featured by dynamic topology(infrastructureless), multi hop communication, limited resources (bandwidth, CPU, battery, etc.) and limited security.These characteristics put special challenges in routing protocol design. The one of the most important objectives of MANET routing protocol is to maximize energy efficiency, since nodes in

MANET depend on limited energy resources. The primary objectives of MANET routing protocols are to maximize network throughput, to maximize energy efficiency, maximize network lifetime, and to minimize delay. The goal of energy-aware routing protocol is to maximize the *network lifetime*. Several routing algorithms for MANETs have been proposed in the literature, and they differ in the way new routes are found and existing ones are modified.

### 1.1. Motivation

Battery power of the nodes is primarily consumed while transmitting packets (in addition to performing the processing in the nodes). As, MANETs are multi hop, there are chances of a node's involvement in data transfer irrespective of not being a target or a source. The routing algorithm decides which of the nodes needs to be selected in a particular communication. Thus, routing algorithms play an important role in saving the energy of a communication system and the life of the nodes and thus of the whole network. Conventionally used algorithms such as DSR and AODV do not take care of energy in nodes in determining a route that leads to an imbalance of energy level in the network. Some nodes die out soon as they are used in most of the packet transmission paths and on the contrary, there are nodes that are not used even a single time. This energy imbalance affects the reliability of the system.

## 2. Design Challenges

The design of algorithms for MANETs poses new and interesting research challenges. Data communication in a MANET differs from that of wired networks in different aspects. The wireless communication medium does not have a foreseeable behavior as in a wired channel. On the contrary, the wireless communication medium has variable and unpredictable characteristics. The signal strength and propagation delay may vary with respect to time and environment where the mobile nodes are. Unlike a wired network, the wireless medium is a broadcast medium; that is, all nodes in the transmission range of a transmitting device can receive a message. The bandwidth availability and computing resources (e.g., hardware and battery power) are restricted in mobile ad hoc networks. Algorithms and protocols need to save both bandwidth and energy and must take into account the low capacity and limited processing power of wireless devices. This calls for lightweight solutions in terms of computational, communication, and storage resources.

An important challenge in the design of algorithms for a mobile ad hoc network is the fact that its topology is dynamic. Since the nodes are mobile, the network topology may change rapidly and unexpectedly, thereby affecting the availability of routing paths.

## 3. Routing Protocol Classification

A routing protocol is needed whenever a packet needs to be handed over via several nodes to arrive at its destination. A routing protocol has to find a route for packet delivery and make the packet delivered to the correct destination. Routing protocols can be classified into three categories depending on their properties. The classifications are:

1.Centralized versus Distributed
2.Static versus Adaptive
3.Reactive versus Proactive

In centralized algorithms, all route choices are made by a central node, while in distributed algorithms, the computation of routes is shared among the network nodes. In static algorithms, the route used by source destination pairs is fixed regardless of traffic condition. It can only change in response to a node or link failure. This type of algorithm cannot achieve high throughput under a broad variety of traffic input patterns. In adaptive routing, the routes used to route between source-destination pairs may change in response to congestion. A third classification that is more related to ad-hoc networks is to classify the routing algorithms as either proactive or reactive.

In Proactive (Table-Driven) Routing Protocols, nodes maintain one or more routing tables about nodes in the network. These routing protocols update the routing table information either periodically or in response to change in the network topology. The advantage of these protocols is that a source node does not need route-discovery procedures to find a route to a destination node. On the other hand the drawback of these protocols is that maintaining a consistent and up-to-date routing table requires substantial messaging overhead, which consumes bandwidth and power, and decreases throughput, especially in the case of a large number of high node mobility. There are various types of Table Driven Protocols: Destination Sequenced Distance Vector routing (DSDV), Wireless routing protocol (WRP), Fish eye State Routing protocol (FSR), Optimized Link State Routing protocol (OLSR), Cluster Gateway Switch Routing protocol (CGSR), Topology Dissemination Based on Reverse Path Forwarding (TBRPF).

In the Reactive (On Demand) routing protocols, there is an initialization of a route discovery mechanism by the source node to find the route to the destination node when the source node has data packets to send. When a route is found, the route maintenance is initiated to maintain this route until it is no longer required or the destination is not reachable. The advantage of these protocols is that overhead messaging is reduced. One of the drawbacks of these protocols is the delay in discovering a new route. The different types of reactive routing protocols are: Dynamic Source Routing (DSR), Ad-hoc On-Demand Distance Vector routing (AODV) and Temporally Ordered Routing Algorithm (TORA).

## 4. Related Work

Due to the frequent changes in network topology and the lack of the network resources both in the wireless medium and in the mobile nodes, mobile ad hoc networking becomes a challenging task. Routing is very important issue in mobile ad hoc network. Some of the existing routing protocols we have studied are as follows:

### 4.1. Ad hoc On Demand Routing Protocol

AODV routing protocol is a reactive [1] routing algorithm. It maintains the established routes as long as they are needed by the sources. AODV uses sequence numbers to ensure the freshness of routes. Route discovery and route maintenance for AODV are described below:

(1) Route Discovery

The route discovery process is initiated whenever a traffic source needs a route to a destination. Route discovery typically involves a network-wide flood of route request (RREQ) packets targeting the destination and waiting for a route reply (RREP). An intermediate node receiving a RREQ packet first sets up a reverse path to the source using the previous hop of the RREQ as the next hop on the reverse path. If a valid route to the destination is available, then the intermediate node generates a RREP, else the RREQ is re-broadcast. Duplicate copies of the RREQ packet received at any node are discarded. When the destination receives a RREQ, it also generates a RREP. The RREP is routed back to the source via the reverse path. As the RREP proceeds towards the source, a forward path to the destination is established.

(2) Route Maintenance

Route maintenance is done using route error (RERR) packets. When a link failure is detected, a RERR is sent back via separately maintained predecessor links to all sources using that failed link. Routes are erased by the RERR along its way. When a traffic source receives a RERR, it initiates a new route discovery if the route is still needed. Unused routes in the routing table are expired using a timer-based technique.

### 4.2. Stable routing with power factor (SBNRP)

In [2], the author has proposed a new method that takes care of on demand routing along with a new concept of backbone nodes with power factor. Selection of backbone nodes is made upon availability of nodes and battery status. Each route table has an entry for number of backbone nodes attached to it and their battery status. The protocol is divided into three phases: Route Request, Route Repair and Error Phase.

**Route Construction Phase**

The scheme does not require any modification to the AODV's RREQ (route request) propagation process. In this scheme when a source needs to initiate a data session to a destination but does not have any route information, it searches a route by flooding a ROUTE REQUEST (REQ) packet. Each

REQ packet has a unique identifier so that nodes can detect and drop duplicate packets. An Intermediate node with an *active* receiving a no duplicate REQ, records the previous hop and the source node information in its route table i.e. backward learning. It then broadcasts the packet or sends back a REP (route reply) packet to the source if it has an *active route* to the destination. The destination node sends a REP via the selected route when it receives the first REQ or subsequent REQs that traversed a better *active route*. When a link break in an active route is detected, an ERR message is used to notify that the loss of link has occurred to its one hop neighbor. Here ERR message indicates those destinations which are no longer reachable. When a node that is not part of the route overhears a REP packet not directed to itself transmit by a neighbor (on the primary route), it records that neighbor as the next hop to the destination in its alternate route table. From these packets, a node obtains alternate path information and makes entries of these backbone nodes (BN) in its route table. If route breaks occurs it just starts route construction phase from that node. The protocol updates list of BNs and their power status periodically in the route table.

**Route Error & Maintenance**

In this scheme data transmits continuously through the primary route unless there is a route disconnection. When a node detects a link break, it performs a one hop data broadcast to its immediate neighbors. The node specifies in the data header that the link is disconnected and thus the packet is candidate for alternate routing. Upon receiving this packet route maintenance phase starts by selecting alternate path and checking power status.

**Local Repair**

When a link break in an active route occurs, the node upstream of that break may choose to repair the link locally if the destination was no farther and there exists BNs that are active.

The scheme has been applied to AODV and it was observed that the performance improved. It was found that overhead in this protocol was slightly higher than others, which is due to the reason that it requires more calculation initially for checking backbone nodes. This also caused a bit more end to end delay.

### 4.3. Local Energy Aware Routing

The author has proposed modification in AODV that is LEAR-AODV in [3]. In AODV, each mobile node has no choice and must forward packets for other nodes. In LEAR-AODV, each node determines whether or not to accept and forward the RREQ message depending on its remaining battery power. When it is lower than a threshold value, the RREQ is dropped; otherwise, the message is forwarded. The destination will receive a route request message only when all intermediate nodes along the route have enough battery levels.

### 4.4. Improved AODV Using Mean Energy Value

In an existing AODV, if a source node is going to communicate with a destination node, the source node broadcasts RREQ messages first and a path is established by the RREP reply to RREQ arrive first. However, in improved AODV proposed in [4], energy remaining in the nodes participating in the path between the source and the destination is accumulated and delivered to RREQ message using a new field added to the RREQ message (using 11 bits of the reserved filed). By dividing the whole energy calculated into the number of nodes participating in the network, which is obtained using the hop counter, one can obtain the mean energy of network on the participation path. After obtaining the mean energy, the destination node unicasts RREP message who has highest mean energy.

### 4.5. Energy Constraint Node Cache AODV (ECNC_AODV)

The main aim of the proposed algorithm [5] is to reduce the number of routing packets generated due to flooding method so that there should be reduction in energy consumption; routing overhead and increase in network lifetime could be achieved, without affecting the throughput of the network.

The steps involved in the proposed algorithm are:

(1) The source node generates RREQ packet and broadcast it to its neighbors.

(2) At intermediate node, if $En > Eth$ and $T- \tau \leq T(N)$, then nth node will forward RREQ packet, if $En > Eth$ and nth node is having one neighbor then it will forward RREQ packet so that destination is not missed else if $En < Eth$, then drop RREQ packet.

(3) The destination node after receiving RREQ packet will send RREP packet back to the source node. The destination routine is not changed.

Here En is the current node energy, Eth is the set energy threshold (normal zone is considered), T is the current time, T(N) is the time when last data packet transmitted through node N and $\tau$ is another small set time threshold which decides the memory of the node.

## 5. Conclusion

The majority of the work reported in the literature focuses on the protocol design and performance evaluation in terms of traditional metrics such as throughput, delay and routing overhead. However, much less attention has been paid in making the routing protocol energy efficient. In critical

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environments such as military or rescue operations, where ad hoc networks will be typically used, conserving of battery power will be vital in order to make the network operational for long durations. Recharging or replacing batteries will often not be possible. This makes the study in energy-aware routing critical. In this paper, we have surveyed several routing techniques to make AODV energy efficient.

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