Resourceful Power Aware Routing Protocol in MANET

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Abstract: Power saving is an important factor in Mobile Ad hoc Networks, because most of the equipment in MANETs are battery powered. So we have to reduce the power consumption of each and every node. There are several methods to reduce the power consumption of nodes. An effective method is sending the packets with optimum power. In this paper, we propose an energy efficient power aware routing (EPAR) protocol, a new power aware routing protocol. The objective of the proposed protocol is to increase the service lifetime of MANET with dynamic topology. Basically, EPAR is an improvement of DSR (Dynamic Source Routing) protocol. In EPAR path is chosen based on hop count and mobility in addition to energy unlike DSR where path is chosen based only on minimum number of hops. The proposed approach is a dynamic distributed, load balancing approach that avoids power-congested nodes and chooses paths that are lightly loaded. This helps the protocol to achieve minimum variance in energy levels of different nodes in the network and maximizes the network lifetime. This improves the throughput of our network and the main motivation is to reduce the power consumption of each and every network.

Keywords: MANET, EPAR, DSR, RREQ, RREP, Packet delivery ratio

1. Introduction

In the past few decades with the advent in technology the wireless networks are become popular. Wireless networks can be classified in two types: Infrastructure networks and Infrastructure less networks. The former type contains a centralized system that controls and maintains the communication between the nodes of the network. Examples are Cellular networks and Wireless mobile networks. The later type referred as wireless Ad hoc networks because nodes of the network are organized in ad hoc manner where the nodes themselves organized the connection between one another in a multi-hop manner without any fixed infrastructure. Ad hoc networks because of being infrastructure less can deploy in a given environment and also provides robust transmissions or applications. They are most prominently used for emergency services like disaster recovery and military operations.

In today's world, communication is a very important concern of the people. It is very important for exchanging information between people to, or from anywhere and at any time irrespective of the mobility of the nodes. A MANET consists of a set of mobile hosts that carry out basic networking functions like packet forwarding, routing, and service discovery without the help of an established infrastructure. Nodes of an ad hoc network rely on one another in forwarding a packet to its destination, due to the limited range of each mobile host's wireless transmissions. An ad hoc network uses no centralized administration. This ensures that the network will not cease functioning just because one of the mobile nodes moves out of the range of the others. Nodes should be able to enter and leave the network as they wish. Because of the limited transmittion

range of the nodes, hops are generally needed to reach other nodes. The topology of ad hoc networks varies with time as nodes move, join or leave the network. This topological instability requires a routing protocol to run on each node to create and maintain routes among the nodes.
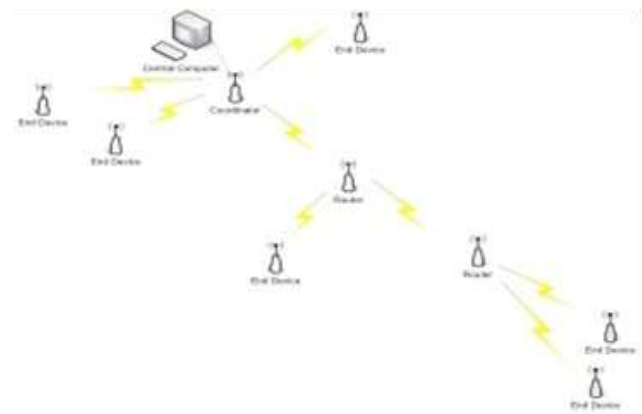

Figure 1 Message transmission hop by hop in MANET

Mobile nodes in MANETs are battery driven and hence they have limited energy level to transmit the data packets. Also the topology of the network is dynamic i.e. nodes in the network are moving. If a node moves out of the radio range of the other node, then the link between them is broken. There are two major causes for a link breakage in MANET:

- When nodes die because of energy exhaustion
- When node(s) move out of the radio range of its neighboring node(s).

1.1 Limitations of MANET

- **Limited bandwidth:** Wireless link continue to have significantly lower capacity than infrastructure networks. In addition, the realized throughput of wireless communication after accounting for the effect of multiple access, fading, noise, and interference conditions, etc. is often much less than a radio's maximum transmission rate.
- **Dynamic topology:** Dynamic topology membership may disturb the trust relationship among nodes. The trust may also be disturbed if some nodes are detected as compromised.
- **Routing overhead:** In wireless ad hoc networks, nodes often change their location within network. So, some stale routes are generated in the routing table which leads to unnecessary routing overhead.
- **Battery constraints:** Devices used in these networks have restrictions on the power source in order to maintain portability, size and weight of the device.
- **Security threats:** The wireless mobile ad hoc nature of MANET's brings new security challenges to the network design. As the wireless medium is vulnerable to eavesdropping and ad hoc network functionality is established through node cooperation, mobile ad hoc networks are intrinsically exposed to numerous security attacks.
- **Hidden terminal problem:** The hidden terminal problem refers to the collision of packets at a receiving node due to the simultaneous transmission of those nodes that are not within the direct transmission range of the sender, but are within the transmission range of receiver.
- **Packet losses due to transmission errors:** Ad hoc wireless networks experience a much higher packet loss due to factors such as increased collisions due to the presence of hidden terminals, presence of interference, unidirectional links; frequent path breaks due to the mobility of nodes.

1.2 Applications of MANET

With the increase of portable devices as well as progress in wireless communication, ad-hoc networking is gaining importance with the increasing number of widespread applications.

- **Military Scenarios**: MANET supports tactical network for military communications and automated battle fields.
- **Rescue Operations**: It provides Disaster recovery, means replacement of fixed infrastructure network in case of environment disaster.
- **Data Networks**: MANET provides support to the network for the exchange of data between mobile devices.
- **Device Networks**: Device networks support the wireless connections between various mobile devices so that they can communicate.
- **Free Internet Connection Sharing:** It also allows us to share the internet with other mobile devices.
- **Sensor Network**: It consists of devices that have capability of sensing, computation and wireless networking. Wireless sensor network combines the power of all three of them, like smoke detectors, electricity, and gas and water meters.

2. Related Research Work

Most of the previous work and studies on routing in wireless ad-hoc networks deals with the problem of discovering and maintaining optimum paths to the destination during mobility and changing positions of the nodes in the network [17],[18]. In [7], the authors presented a simple algorithm that can be implemented and guarantees strong connectivity and assumes limited node range. Shortest path algorithm is used in this strongly connected backbone network. However, the path may not be the minimum energy solution due to the possible omission of the optimal links at the time of the backbone connection network calculation. In [4], the authors developed a dynamic routing algorithm for establishing and maintaining connection-oriented sessions which uses the idea of proactive to cope with the unpredictable topology changes.

2.1 Proactive Routing Protocol

In Proactive Routing Protocol [14], each node maintains the network topology information in the form of routing tables by periodically exchanging routing information. Whenever a node requires a path to destination, it runs an appropriate path finding algorithm on the topology information it maintains. 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 the maintaining a consistent and up-to-date routing table that 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 (DSDV), Fish eye State Routing (FSR) etc.

2.2 Reactive Routing Protocol

In ref [20], Reactive routing protocol is also known as on-demand routing protocol. These protocols have no routing information at the network nodes if there is no communication. They do not maintain or constantly update their route tables with the latest route topology. They obtain the necessary information for the route and establish a connection in order to transmit or receive the packet. There are various types of on-demand routing protocols: Dynamic Source Routing (DSR), Ad-hoc On-demand Distance Vector routing (AODV).

2.3 Dynamic Source Routing Protocol

DSR is a type of reactive routing protocol. DSR is composed of two main mechanisms route discovery and route maintenance as shown in figure 4. Route Discovery: It is the method in which the source node receives the end node source destination path. In DSR to further reduce the cost of route discovery, the RREQs are initially broadcasted to neighbors only by zero-ring search, and then to the entire network if no reply are received. When an intermediate node forwarding a packet detects through Route Maintenance that the next hop along the route for that packet is broken, if the node has another route to the packet destination it uses it to send the packet rather than discard it. Route maintenance: In route maintenance a routing entry contains all the intermediate nodes information not only the next node information. The source node has entire routing path, and the packet is sent through that routing path. If the source node does not have entire routing

path, then it execute route discovery mechanism by sending the route request (RREQ) packets in the network. Then in reply the route reply (RREP) packet is send by the node which has path to destination node.
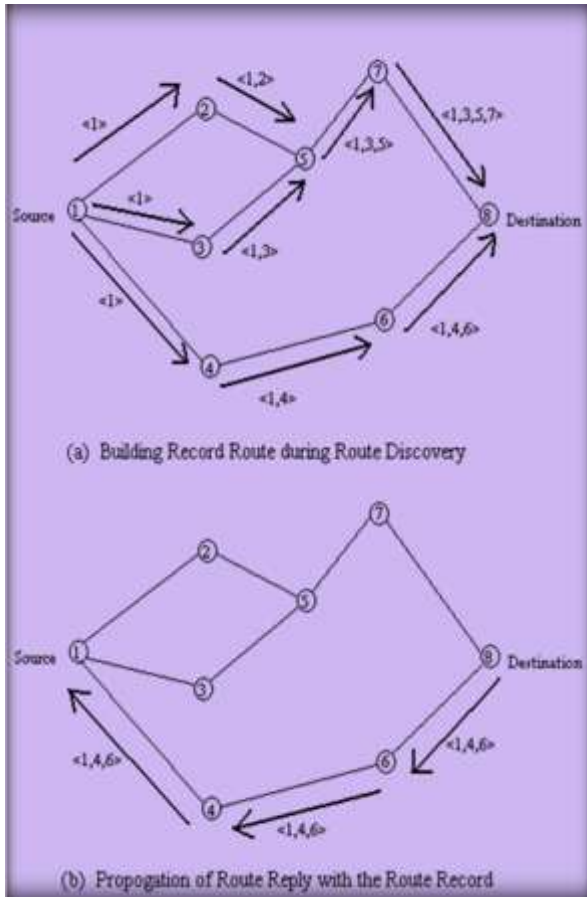

Figure 3 Architecture for Data Transmission

EPAR algorithm is an on demand source routing protocol that uses battery lifetime prediction. The objective of this routing protocol is to extend the service lifetime of MANET with dynamic topology. This protocol favors the path having maximum lifetime.

First of all the lowest hop energy for each path is calculated, which is referred as the battery power for each path. Then the maximum lowest hop energy is selected. The selected path should have maximum life time. It increases the network lifetime of the MANET shown in equation:

$$\underset{k}{Max}\, T_k\, t = \underset{i\in K}{Min}\, T_i\, t$$

$T_k(t)$ – lifetime of the path k
$T_i(t)$ –Predicated lifetime of node i in path k
K- Set of available shortest path
The objective of this routing protocol is to extend the service lifetime of MANET with dynamic topology.

Figure 2 Dynamic Source Routing

4. Design and Implementation

4.1. Topology of Network

Figure 3 shows how the path is selected for the transmission of data as EPAR algorithm is an on demand source routing protocol that uses battery lifetime prediction. In figure 4.1, DSR selects the shortest path S-3-4-D or S-3-2-D. But proposed EPAR selects S-1-2-D only, because that selected path has the maximum lifetime of the network (1000s). It increases the network lifetime of the MANET. The objective of this routing protocol is to extend the service lifetime of MANET with dynamic topology. This protocol favors the path whose lifetime is maximum .
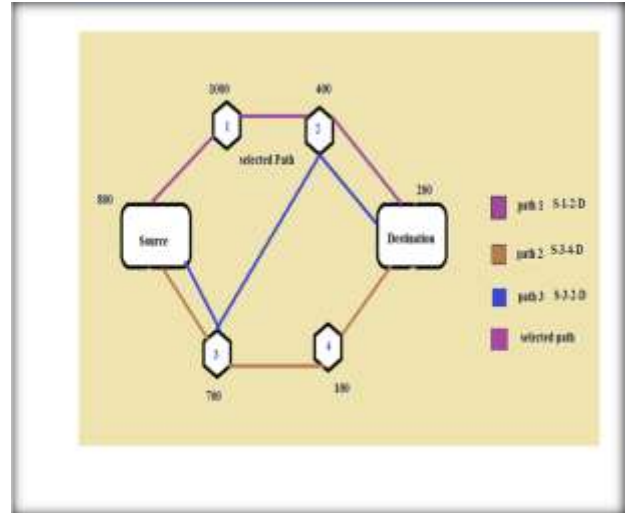
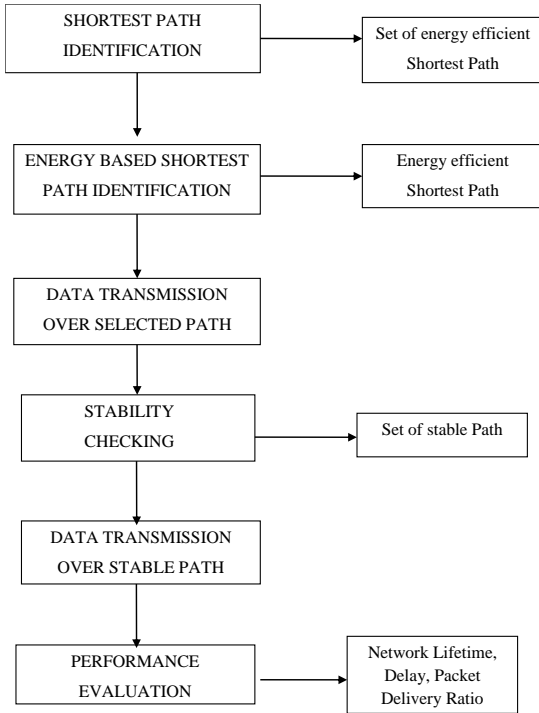### 4.2 Data Packet Format in EPAR

Table 1 shows the data packet format for EPAR. The packet includes the DSR fields besides the special fields of EPAR.

Table 1 Data packet format in EPAR

IP Header	DSR fixed header	DSR source header	DSR source route address	EPAR source route MTP	Link flag	DATA

4.2. Block Diagram

```
┌──────────────────┐      ┌──────────────────┐
│  SHORTEST PATH   │─────▶│ Set of energy    │
│  IDENTIFICATION  │      │ efficient        │
│                  │      │ Shortest Path    │
└──────────────────┘      └──────────────────┘
         │
         ▼
┌──────────────────┐      ┌──────────────────┐
│ ENERGY BASED     │─────▶│ Energy efficient │
│ SHORTEST PATH    │      │ Shortest Path    │
│ IDENTIFICATION   │      │                  │
└──────────────────┘      └──────────────────┘
         │
         ▼
┌──────────────────┐
│ DATA TRANSMISSION│
│ OVER SELECTED    │
│ PATH             │
└──────────────────┘
         │
         ▼
┌──────────────────┐      ┌──────────────────┐
│ STABILITY        │─────▶│ Set of stable    │
│ CHECKING         │      │ Path             │
└──────────────────┘      └──────────────────┘
         │
         ▼
┌──────────────────┐
│ DATA TRANSMISSION│
│ OVER STABLE PATH │
└──────────────────┘
         │
         ▼
┌──────────────────┐      ┌──────────────────┐
│ PERFORMANCE      │─────▶│ Network Lifetime,│
│ EVALUATION       │      │ Delay, Packet    │
│                  │      │ Delivery Ratio   │
└──────────────────┘      └──────────────────┘
```

5. Performance Metrics for Proposed Protocol

Following performance metrics are used to evaluate and analyze the performance of Dynamic Source Routing (DSR) protocol and are evaluated based on the three performance metrics that are given below:

- **Packet Delivery Ratio**: The packet delivery ratio is the total number of data packets received by the destination over the total number of data packets transmitted or generated by the CBR source. The PDR shows how successful a protocol performs delivering packets from source to destination. The higher for the value give the better results. This metric characterizes both the completeness and correctness of the energy efficient routing protocol.

- **Delay**: The average time taken by a data packet to arrive at the destination is referred as delay. It also includes the delay caused by route discovery process and the queue in the data packet transmission. Only the data packets that successfully delivered to destination are counted. Once the time difference between every CBR packet sent and received was recorded, dividing the total time difference over the total number of CBR packets received gave delay for the received packets.

- **Network Life Time**: Network lifetime is the time at which the first network node runs out of energy to send a packet, because to lose a node could mean that the network could lose some functionality or it is the time span from the deployment to the instant when the network is considered nonfunctional. When a network should be considered nonfunctional is, however, application-specific. It can be, for example, the instant

when the first mobile node dies, a percentage of mobile nodes die, the network partitions, or the loss of coverage occurs. It effects on the whole network performance. If the battery power is high in all the mobile nodes in the MANET, network lifetime is increased.

5. Simulation Setup and Result Discussion

Extensive simulation operations were performed using NS version 2.3X. In the beginning of the simulation we have created a simulation environment that has 20 nodes in the area of 600*600 m. Then we increased the number of nodes to 30, then 40 and lastly to 50nodes. So we can say that our simulated environment is supportive of minimum 20 nodes and maximum 50 nodes. Table 2 shows the simulation parameter setting for the protocol evaluation.

Table 2 Simulation Parameters

PARAMETERS	*VALUES*
Number of nodes	20,30,40,50
Area size	600*600
Mobility model	Random Way Point
Traffic type	CBR
Transmit Power	1.0 J
Receiver Power	0.5 J
Idle Power	0.3 J
Initial Energy	10 J
Routing Protocol	DSR/EPAR
Simulation Energy	100s

Packet Delivery Ratio of EPAR is higher than DSR in Figure 5. The EPAR protocol selects the highly honest nodes and the nodes having high energy to deliver the packets to destination. But DSR protocol randomly selects the intermediate nodes. So it contains low honest nodes and the hence nodes having low energy delivers the packets to destination.
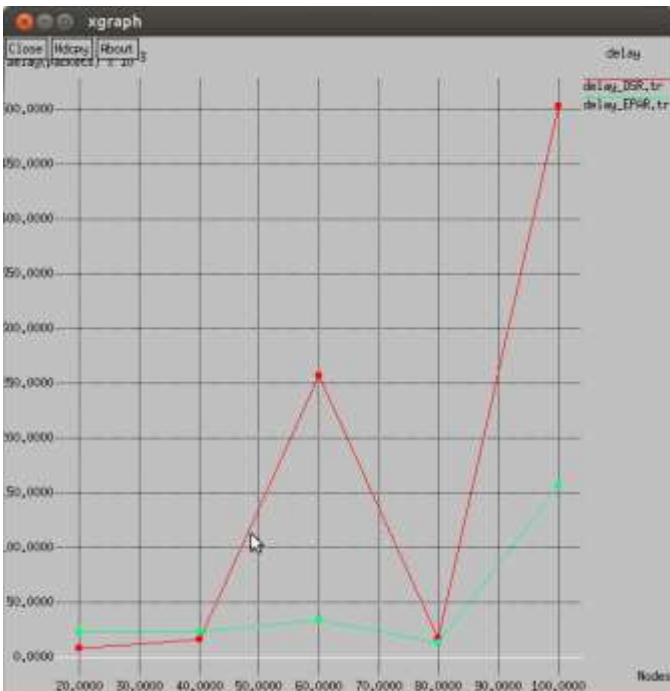
Figure 5 Nodes versus Packet delivery ratio

Delay of EPAR is lower than DSR in figure 6. The EPAR protocol selects the highly honest nodes and the nodes having high energy to deliver the packets to destination so that no node is died due to power exhaustion that automatically reduces delay. But DSR protocol randomly selects the intermediate nodes. So it contains low honest nodes and the hence nodes having low energy delivers the packets to destination.

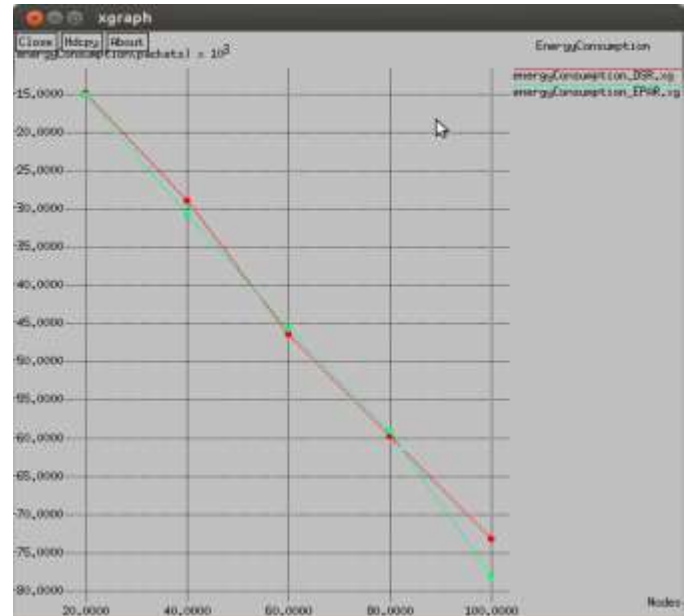**Figure 6 Nodes versus Delay**

Figure 7 Nodes versus Energy Consumption

In figure 7 energy consumption of EPAR is lower than DSR that is consumed power of networks using EPAR decreases significantly when the number Energy consumption of EPAR is lower than DSR that is consumed power of networks using EPAR decreases significantly when the number of nodes exceeds 80. The EPAR protocol selects the highly honest nodes and the nodes having high energy to deliver the packets to destination. But DSR protocol randomly selects the intermediate nodes. So it contains low honest nodes and the hence nodes having low energy delivers the packets to destination. But DSR protocol randomly selects the intermediate nodes. So it contains low honest nodes and the hence nodes having low energy delivers the packets to the destination.

5. Conclusion

This proposed work mainly deals with the problem of maximizing the network lifetime of a MANET that is the time period during which the network is fully working. An original solution called EPAR is presented which is basically an improvement on DSR. And considered the mobility factor due to which packet loss ratio decreases and increases the throughput in the network. This work is evaluated by including different nodes into consideration and network lifetime and packet delivery ratio and delay is measured. From the various graphs, we can successfully prove that our proposed algorithm quite outperforms the traditional energy efficient algorithms in an obvious way. The EPAR algorithm outperforms the original DSR algorithm.

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