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Shortest and Energy Efficient Routing Protocol for MANET

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***Abstract*—** Tremendous traffic demands and emerging multimedia applications significantly increase the energy consumption of battery-powered mobile devices. In contrast with wired networks, energy consumption is an essential constraint in Mobile Adhoc Networks. Mobile devices have restricted battery lifetime and are most vulnerable to the energy constraints. Therefore, energy concerns have to be properly implemented while defining routing metrics. In this paper a Shortest and Energy Efficient Routing Protocol for MANET (SEERP) is proposed. It defines a strategy for selecting energy efficient route taking into consideration that in MANET, channel and energy capacity are scarce resources. SEERP chooses a routing path from source to destination based on the residual energy and number of hops. The traditional route request packet is altered to calculate the minimum energy of nodes.

***Keywords* –** MANET, Energy, protocol, shortest path, routing.

I. INTRODUCTION

Mobile Ad hoc Network (MANET) is a collection of wireless mobile nodes that dynamically form a network temporarily without any support of central management. It acts as an effective communication in dynamic operation environments such as military operations, emergency operation for disaster recovery, and for missions like search and rescue. Wireless networks with infrastructure have a strong asymmetric structure. Low level energy management strategies are often based on spending energy at the base station to conserve energy at the mobile node. This is not a viable approach in an ad hoc network as it has no such fixed elements. Moreover in an ad hoc network, nodes are highly interdependent and must cooperate to provide routing and other services, making it important to maximize the network lifetime.

Generally mobile devices are handy, small in size, and dedicated to perform certain set of functions; its power source may not be able to deliver power as much as the one installed in a fixed device. When a device is made to move freely, it would be hard to receive a continuous supply of power [1]. In order to conserve energy, a mobile device should be able to operate in an effective and efficient manner. It should be able to transmit and receive in an intelligent manner so as to minimize the number of transmissions and receptions for certain communication operations. Since the transmission power of a wireless device is proportional to the distance squared or even higher order in the presence of obstacles, multi hop routing will consume less energy than direct communication. However, multi hop routing introduces significant overhead topology management and medium access control [2]. The energy consumed when sending and receiving a packet is determined by various factors like

- Wireless radio propagation environment
- Interference from simultaneous transmissions
- MAC protocol operation
- Routing algorithm.

When a node fails to receive data, retransmission occurs resulting in higher energy consumption. Also some of the devices consume more power even in standby mode (ex: Bluetooth device can consume over 40% of the total energy when in standby mode). Hence, the essential objectives of routing metrics targeting at minimizing energy consumption are:

1. To minimize overall energy consumption
2. To maximize the time until the first node runs out of energy.

Because of their wide availability, low-cost and relatively stable property, wireless based interfaces have attracted considerable attention. The design and evaluation of energy-efficient communication protocols therefore requires practical understanding of the energy consumption behavior of the underlying network interface. The energy consumed by an interface depends on its operating mode:

- In the sleep state, an interface can neither transmit nor receive, so it consumes very little energy.
- In the idle state, an interface can transmit or receive data at any time, which requires both time and energy. It consumes more energy than it does in the sleep state, due to the number of circuit elements that must be powered.

- The energy consumed when the interface transmits, receives, idle or discards a packet can be described using an incremental component which is proportional to the size of the packet and a fixed component that reflects channel acquisition and overhead.

Rest of the paper is organized as; Section II contains the related work on designing energy efficient protocols. Section III contains the proposed energy efficient route selection strategy. Section IV describes the experimental results and discussion and Section V concludes research work with future directions.

II. RELATED WORK

Handy, M., Haase, M. et al described in [3], the Low Energy Adaptive Clustering Hierarchy (LEACH). It is a powerful, efficient protocol created to be used in sensor networks with continued data flowing (unstopped sensor activity). This is a protocol that uses a hierarchical topology and presents data aggregation mechanisms.

Intanagonwiwat et al [4] described Direct Diffusion, which is a data-centric protocol in which application is responsible to query the network for a specific phenomenon value. Sensor nodes that satisfy the specific query, starts transmitting their data. Based on sink node requests, this protocol does not consider the node's available energy when building their flood based routing scheme.

Li and Wan et al described a distributed protocol to construct a minimum power topology and developed an algorithm which directly finds a path whose length is within a constant factor of the shortest path [5].

A topology based on minimum spanning tree, called localized minimum spanning tree (LMST) was proposed by Liet al. [6]. It is a localized distributed protocol and generates a strongly connected communication graph.

An energy efficient dynamic path is maintained to send data from source to destination for MANET is proposed in Sheu, Tu, and Hsu [7]. Due to mobility existing paths may not be energy efficient. So, each node in a data path dynamically updates the path by adjusting its transmission power. Each node in the networks determines its power for data transmission and control packets transmission according to the received beacon messages from its neighbors.

III. ENERGY EFFICIENT ROUTE SELECTION

Some of the problems that may arise in wireless networks are asymmetrical links, redundant links, interference and dynamic topology. It has been seen that for a network to be truly efficient, transmission of data should not just use the shortest path, but also the least power consuming one. Power-save protocols therefore seek to maximize energy saving, while minimizing impact on throughput, latency, and route latency [7]. Minimum-energy routing can exploit exponential path loss by forwarding traffic using a sequence of low power transmissions rather than a single direct transmission.

To minimize the energy on active communication, the traditional approaches applied are Transmission power control, load distribution and Power Management whereas to minimize energy during inactivity, sleep/power-down approach is used. Table 1 shows the techniques of power aware routing protocols [11]. Most of the protocols are designed based on the energy related metrics like energy consumed per packet to provide the minimum power path which is used to minimize the overall energy consumption for delivering packet.

Table 1: Techniques of power aware routing protocols

Conditions	Name of Process	Purpose
Minimize Active Communication Energy .	Transmission power control	The total transmission energy is minimized by avoiding low energy nodes.
	Load distribution	Distribute load to energy comfortable nodes.
	Power management	Minimize the energy consumption by using separate channels for data and control
Minimize Inactivity Energy	Sleep/power-Down mode	Minimize the energy consumption when node in an idle state.

While considering various approaches to reduce communication energy consumption, it is also important to analyze whether the network interface contributes significantly to the overall energy consumption of a mobile system. The table 2 shows the Power saving techniques at ad hoc networks protocol layers [12]. Network-layer protocols make up the largest class of power-save protocols.

Table 2: Power saving techniques at ad hoc networks protocol layers

Protocol Layer	**Power Saving Techniques**
Application Layer	Adopt an adaptive mobile quality of service (QoS) framework.
Transport Layer	Avoid repeated retransmissions. Handle packet loss in a localized manner.
Network Layer	Consider route relaying load. Optimize size of control headers.
Data-Link Layer	Avoid unnecessary retransmission. Turn radio off (sleep) when not transmitting or receiving.

Analysis of the Proposed Protocol

In the proposed Shortest and Energy Efficient Routing Protocol (SEERP), minimum energy and hop count are taken into account. The hop count denotes the intervening devices where the data are transmitted from root node to the receiver node. Simply, the data path to each router establishes a hop. Hop count is suitable for determining the faults in a network and provides a basic metric of distance in a network.

Pseudo code:

- Source node creates a route request packet RREQ
- RREQ has RREQ ID, destination address, destination sequence number, source address, source sequence number, hop count, NminE
- A node receiving the packet, updates NminE only if its energy level is minimum than the current NminE. else NminE remains unchanged
- Check until RREQ reaches destination
- From the multiple RREQ received from different routes, energy efficient route is selected.
- If (NminE>= high && hopcount<=Low), select the route for communication
- A route reply RREP is generated and send back.
- The newly selected route is used to send data.

A network with 9 nodes deployed randomly on a plane is shown in Fig. 1. S represents the source node and D destination. Nodes have been randomly assigned different energy levels.

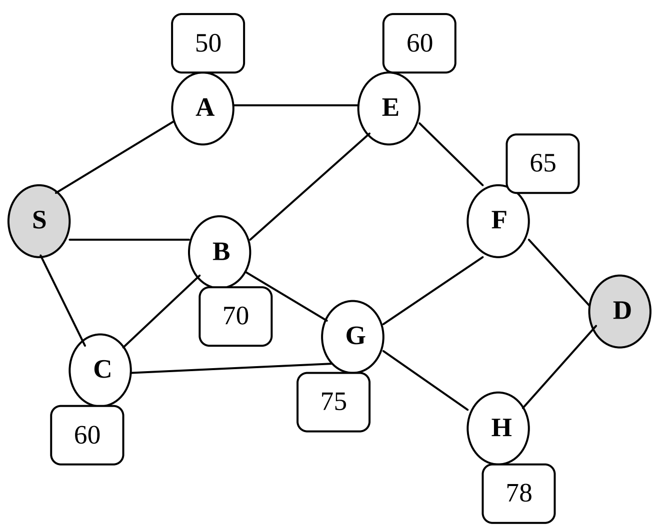

Figure 1: Example Network with energy level

The route request packet with RREQ ID, destination address, destination sequence number, source address, source sequence number, hop count and Minimum energy level (N_{minE}) from source node S is broadcasted to reach D from various routes (Figure 2).

RREQ ID	Destination Address	Destination Sequence Number	Source Address	Source Sequence Number	Hop Count

Figure 2: RREQ Packet Structure

Example Routes with hop count and minimum energy value:

S – A – E – F – D	Hopcount =3, N_{minE}=50
S – B – E – F – D	Hopcount =3, N_{minE}=60
S – B – G – F – D	Hopcount =3, N_{minE}=65
S – B – G – H – D	**Hopcount =3, N_{minE}=70**
S – C – B – E – F – D	Hopcount =4, N_{minE}=60

In the above example routes, the optimal route is selected by calculating the hop count and $N_{minE.}$ The route **S – B – G – H – D** is selected as it has minimum hop count and maximum $N_{minE.}$

IV. EXPERIMENTAL RESULTS

The simulation is done using NS2**.** Network Simulator 2 (NS2) is a discrete event simulator targeted at networking research. It provides support for simulation of TCP, routing and multicast protocols over wired and wireless networks.

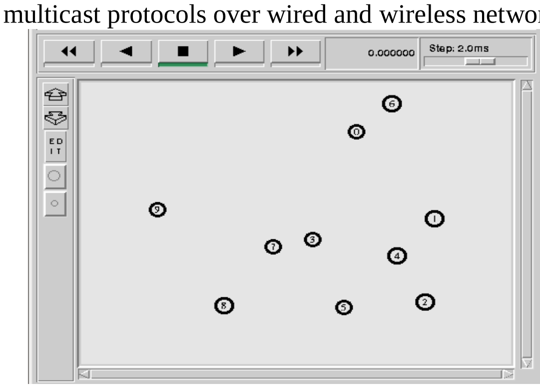

Figure 3: Nodes randomly deployed

Energy Consumption: Energy consumption is the amount of energy which is spent by the network nodes within the simulation time. It can be found by calculating each node's energy level at the end of the simulation, factoring in the initial energy of each one.

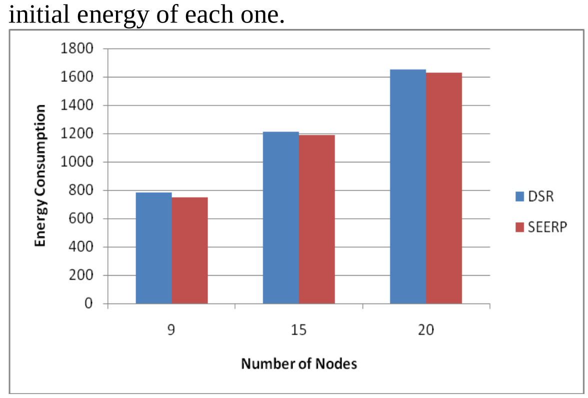

Figure 4: Energy Consumption

***Packet Delivery Ratio*: (PDR)** refers to the ratio of the data packets that were delivered to the destination node to the data packets that were generated by the source. This metric shows a routing protocol's quality in its delivery of data packets from source to destination. The higher the PDR ratio, the better the performance of the routing protocol. PDR is calculated by:

PDR = number of packets received/ number of packets sent * 100

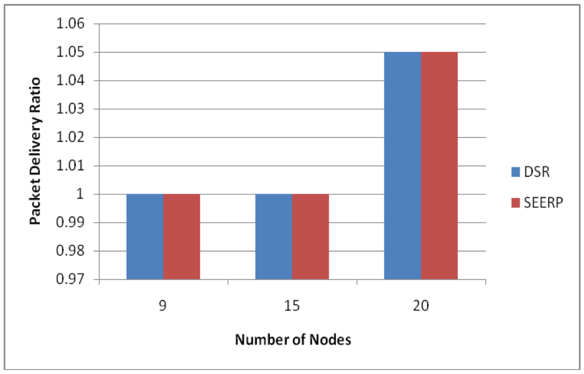

Figure 5: Packet Delivery Ratio

V. CONCLUSION

The performance of SEERP is evaluated on the basis of energy lifetime and average energy consumption of the network. The theme is to discuss the results of SEERP and its performance, compared to the existing routing protocols such as DSR. SEERP shows better results when compared with DSR, where SEERP shows an impressive performance in the form of improving the network lifetime (by reducing the energy consumption) and the network throughput.

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Authors Profile

Dr. R. Latha received her Doctorate Degree in Computer Applications for her research on Parallel and Distributed Simulation from Dr.MGR University. She is having 29 years of teaching and research experience as Faculty, Professor and Head of the Department in various Institutions. Currently she is the Controller of Examinations of St.Peter's Institute of Higher Education and Research, St.Peter's University.

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