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Survey of Energy Efficient Routing Protocols in MANETs

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ABSTRACT: A Mobile Ad hoc Network (MANET) is an autonomous collection of mobile nodes forming a dynamic network and communicating over wireless links. The mobile nodes act as a not only host but also as a router to forward data and control packets to other nodes in order to reach the destination. Each mobile node in the network is driven by a limited energy resource i.e. battery power. Due to dynamic behavior of nodes, topology changes frequently cause more power consumption and reduce node's lifetime. Effective energy utilization and finding an efficient path between source and destination node are the major challenges in a wireless mobile network. Many methodologies have been proposed in the literature implementing an energy-efficient routing. This paper presents some of the work minimizing energy consumption in order to enhance the lifetime of the network.

Keywords: Mobile Ad hoc Network (MANET), Routing, Protocol, Energy Efficient

I. INTRODUCTION

A Mobile Ad hoc Network (MANET) is a collection of mobile nodes that form a dynamic infrastructure-less communication network wherever it is required. The nodes in the network not only act as hosts but also as routers that discover and maintain routes to other nodes in the network. Mobile Ad Hoc Networks (MANETs) are becoming the crucial medium of present day communication owing to theirself-configuring, easily deployable and infrastructure-less nature. These networks are particularly suitable for emergency situations like warfare, floods and other disasters where infrastructure networks are impossible to operate. Since mobile nodes move in various directions causing existing links to break and the establishment of new routes, routing in such networks is a challenging task.

Since nodes are powered by batteries with a limited energy supply, thus energy efficiency is an important consideration in such an environment.Energy-saving techniques aimed at minimizing the total power consumption of all nodes in the group (minimize the number of nodes used to establish connectivity, minimize the control overhead and so on) and at maximizing the life span should be considered. As a result of the energy constraints placed on the network's nodes, designing energy efficient routing protocols is a crucial concern for MANETs, to maximize the lifetime of its nodes and thus of the network itself. A few of the routing protocols along with their strengths and weaknesses have been discussed in the paper.

The rest of the paper is organized as follows. In Section II, survey of some of the energy aware routing protocols have been presented. Section III concludes the paper and gives possible future directions in this research field.

II. SURVEY OF ENERGY BASED ROUTING PROTOCOLS

One important goal of routing protocol is to keep network functioning as long as possible along with establishing correct and efficient routes between pair of nodes [1]. This goal can be accomplished by minimizing mobile nodes' energy not only during active communication but also when they are inactive. However, significant energy savings can be obtainedat the routing level by designing minimum energyrouting protocols that take into consideration the efficient metric for route selection such as node energy, battery level, energy drain rate etc. The energy-aware routing protocols avoid overusing of certain nodes and save overall energy consumption in the network thus reducing the link breakages due to energy depletion of the nodes. A few of the energy aware routing protocols are surveyed below:

A first approachproposed by Scott and Bambos for energy-efficient routing is known as

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Minimum Transmission Power Routing (MTPR)[2].This mechanism uses a simple Energy Metric (EM), represented by the total energy consumed to forward the data along the route. Although this metric can reduce the total power consumption of the overall network, it does not consider the remaining energy of the nodes and thus it may not be able to extend the lifetime of each node. Therefore, min-max battery cost routing (MMBCR) scheme was suggested by Singh et al. [3] which consider remaining power of nodes as the metric to extend the lifetime of each node. MMBCR selects the nodes which have high residual power to participate in routing as compared to the nodes with low residual battery capacity. It extends the lifetime of each node but does not guarantee that total transmission power is minimised over a chosen route. To address this problem, conditional max-min battery capacity routing (CMMBCR) scheme was proposed by Toh[4] . It is a hybrid approach combining MTBR and MMBCR schemes, using the former as long as all nodes in a route have sufficient remaining energy (over a threshold) and the latter when all routes to the destination have at least a node with less energy than the threshold. However, it does not guarantee that the nodes with high remaining power will not break down even when heavy traffic is passing through the node. Kim et al. [5] proposed a new metric, energy-drain-rate, which is defined as the rate at which energy of a node is consumed at a given node at time t. This metric is combined with the value of the remaining energy of a node to determine which nodes can be part of an active route. They described new route finding mechanisms for MANETs, called the minimum drain rate (MDR) and the conditional minimum drain rate (CMDR). MDR extends node battery life and the duration of paths, while CMDR minimises the total transmission power consumed per packet.

Subramanian et al. [6] proposed Multipath Power Sensitive Routing (MPSR) Protocol for Mobile Ad hoc Networks that establishes multiple paths between a source destination pair and switches between the paths based on the remaining power of each node and the hop count. Traffic is equally distributed over all nodes in the network. Thus the nodes remain alive for longer time which increases the stability of the network.Murugan and Shanmugavel[7] proposed energy-based time delay routing (EBTDR) and highest energy routing (HER) by modifying DSR routing protocol. These algorithms are energy efficient and increase the operational lifetime of an ad hoc network. In EBTDR, nodes introduce a delay in forwarding the packets, which is inversely proportional to the remaining energy level of the node, while in HER, the route is selected based on the energy drain rate.

Mitra et al. [8] proposed a stability aware dynamic source routing (SA-DSR) protocol that exploits the transient availability of the intermittently sleeping nodes by introducing dynamic power management (DPM) awareness in the routing decisions. The protocol utilises a DPM module that puts wireless nodes into a sleep mode when the node is not transmitting or receiving data. SA-DSR finds stable routes and thus ensures acceptable network connectivity. Veerayya et al. [9] proposed a Stability-based, QoS-capable Ad-hoc On-demand Distance Vector (SQ-AODV) for enhanced QoS in wireless ad hoc networks. The protocol utilises a cross-layer approach, in which residual node energy is used for route selection and maintenance, and for quickly adapting to network conditions.

Rishiwal et al. [10] proposed a QoS based power aware routing protocol (Q-PAR) which selects anenergy stable QoS constrained end to end path. The selected route is energy stable and satisfies the bandwidth constraint of the application. The Q-PAR protocol is divided into two phases. In the first phase of route discovery, the bandwidth and energy constraints are built into the DSR route discovery mechanism. In the second phase of link failure, a repair mechanism was invoked to search for an energy stable alternate path locally. The protocol enhances the network lifetime and improves the overall efficiency of packet delivery.

Misra et al. [11]proposed an Energy-Aware Ant-Based routing (EAAR) protocol, which incorporates the effect of power consumption in routing a packet. In addition, it also exploits the multipath transmission properties of ant swarms and hence increases the battery life of a node.

Yitayal et al. [12] proposed energy aware routing protocol called a balanced battery usage routing protocol (BBU-AODV) which uses residual energy, hop count and energy threshold as a cost metric to extend the network life time and fairly balance the energy consumption among the nodes on the network. Smail et al.[13]proposed an ad hoc on-demand multipath routing with lifetime maximization (AOMR-LM), which utilizes the residual energy of the nodes to classify the path. Two parameters - the energy threshold β and the coefficient α are used to classify the nodes and to

ensure the preservation of node energy. The best classified paths are selected to balance the energy consumed between the different paths of a multipath.

Senthilnathan Palaniappan and Chellan [14], have proposed Energy efficient stable routing using QoS monitoring agents. Stable and energy efficient paths have been established using different link reliability metrics like probabilistic link reliable time, link expiration time, link received signal strength, link packet error rate, and residual battery power. During route discovery, fuzzy logic technique is used to select energy efficient stable path, which takes all metrics as input and based on fuzzy rules, route selection is estimated. The residual battery power of the node is evaluated and used by the fuzzy system as major criteria in producing energy efficient path. One of the drawback of this protocol is when number of nodes increases in network, frequent route disconnection occurs which decreases the packet delivery ratio.

Jipeng Zhou[15], proposed Ant colony-based energy control routing protocol which uses an ant colony optimization algorithm to select optimal path. Path selection is based not only on hop count and energy of node but also minimum and the average energy of paths. Based on path quality such as its number of hop count, nodes energy, and an amount of delay, a value of pheromone is decided. This value is used to select path while sending the data packet. Proposed protocol is evaluated in three different mobility models i.e. Random walk, Random waypoint, and Reference point group. The number of dead nodes is more in proposed protocol when nodes speed is higher, this is because node changes its position frequently and makes topology unstable which causes route rediscovery and consume more nodes energy.

In [16], Taha et al. proposed an efficiency energy routing protocol, called FFAOMDV(AOMDV with the Fitness Function) for MANET. Fitness function is applied to AOMDV routing protocol in order tooptimize energy consumption. The fitness function is used to find the optimal path from asource node to a destination node to reduce energy consumption. The simulation resultsshow that the proposed FF-AOMDV protocol performs better in metrics such as throughput, packet delivery ratio and end-to-end delay.

Yamazaki et al. [17]proposed a simple flooding scheme to transmit a route request (RREQ) message based on the remaining power of its own node without using control packets and complex calculations. The proposed scheme is applied to Ad hoc On-Demand Distance Vector(AODV) routing protocol and the results showthat the proposedscheme is superior to conventional schemes in static and mobile scenarios. The scheme performed better in terms of energyefficiency (bits/J), including throughput and energy consumption. Next, as the number of flooding times is made uniform in theproposed scheme, all nodes have almost the same battery replacement time. As a result, when the nodes are static, thelifetime in the proposed scheme is longer than that in the conventional scheme.

III. CONCLUSION

In this paper, some of the energy efficient routing protocols have been surveyed with their advantages and disadvantages.A protocol can hardly satisfy all requirements. In other words, one routing protocol cannot be a solution for all energy efficient requirements that are faced in MANETs, but rather each protocol is designed to provide the maximum possible requirements, according to certain required scenarios.Hence designing energy efficient routing protocol is major demand in mobile ad hoc network to improve network lifetime. Energy efficiency, robustness, security, reliability, and scalability are the further attention in this area of research. Hence new routing protocols can be implemented to address these issues in mobile ad hoc network

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