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Energy Efficient Power Aware Multipath Dynamic Source Routing–A Survey

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Abstract— Mobile Ad-hoc Networks (MANET) are consisting of nodes that have limited battery power so the energy efficiency is one of the primary metrics of interest. Energy efficient routing is a major issue in MANET. In this paper energy efficient dynamic source routing algorithms for Ad hoc network are surveyed.

Keywords: energy efficiency; Ad hoc network; Dynamic Source Routing; Ant colony Optimization, power aware routing

I. INTRODUCTION

Ad hoc networks are the autonomous systems consist of mobile nodes that communicate with each other using wireless communication. Here a node can be a PDA, a laptop, a mobile phone or another communication device with some characteristics that are limited storage capacity, limited bandwidth and ,limited battery power. An ad hoc network typically refers to any set of networks where all devices have equal status on a network and are free to associate with any other ad hoc network devices in link range.[1][2]

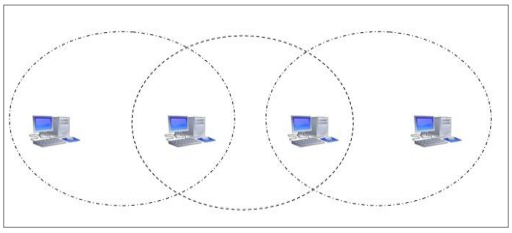

Figure 1 Ad hoc network with four nodes

Ad hoc network do not have any pre-existing infrastructure. They are self-organized, self-configured, and self-controlled networks. This type of network can be set up or deployed anywhere and anytime because it poses very simple setup and no or minimal central administration. The network is characterized by the absence of central administration devices such as base stations or access points. Furthermore, nodes are free to move in any direction, and therefore will change its links to other devices frequently. The primary challenge in building a wireless ad hoc network is to equipping each device to continuously maintain the information required to properly route traffic. This means if link breakages occur the network has to stay operational by building new routes.

A. Multi-hopping: Multi-hopping is a technique which allows virtual extension of the transmission range for each node. This means to say that a node can send a packet to another node not in its range. Then the packets being sent flow through different nodes to reach its destination. It saves the energy that need to transmit packet in single hop. But to efficiently send packets the intermediate nodes that are taking part in forwarding packets should be well distributed in space.

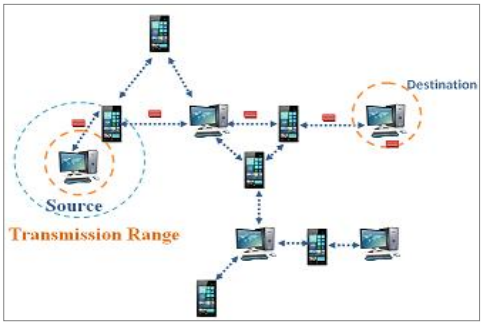

Figure 2 Multi-hopping in Ad hoc network

Multi-hopping increases the overall network capacity and performances. By using multi-hopping, one node can deliver data on behalf of another one to a destination node. Thus, the range radio problem is solved. The responsibilities for organizing and controlling the network are distributed among the terminals themselves.
In Figure 2, source node wants to send packets to a destination that is not present in range of source node. Using single hop it is not possible to send packet to destination. But with help of multi-hopping node can send packets to other nodes in between the path from source to destination.

B. Energy consumption in Ad hoc Network: Ad hoc networks do not have any central administration. So each mobile node is incorporated with routing mechanism. Nodes batteries have limited power supply moreover they are free to move anywhere in network which result in dynamic network but also increase the overhead of nodes which results in limited services and applications that can be supported by each node.[4][5] As each node is acting as both an end system and a router at the same time, additional energy is required to forward packets. Dynamic nature of Ad hoc network makes it more difficult for mobile nodes to make a suitable path from source to destination. Energy depletion in any node can interrupt al the communication process and again the path has to be chosen for the specified source to destination. So this regular route updation and route maintenance consumes a lot of energy of the battery which is limited. [18] document is a template. An electronic copy can be downloaded from the Journal website. For questions on paper guidelines, please contact the journal publications committee as indicated on the journal website. Information about final paper submission is available from the conference website.

II. DYNAMIC SOURCE ROUTING

Mobile networks have attracted significant interest in recent years because of their improved flexibility and reduced costs. Compared to wired networks, mobile networks have unique characteristics like frequent network topology changes, varying link capacity because of the impacts from transmission power, receiver sensitivity, noise, fading, and interference. Additionally, wireless mobile networks have a high error rate, power restrictions, and bandwidth limitations [1]. Routing is the process of selecting paths in a network along which network traffic can be sent. [2] In a mobile ad hoc network arbitrarily motion of nodes results in unpredictable and frequent topology changes. Additionally, since nodes in a mobile ad hoc network normally have limited transmission ranges, nodes cannot communicate directly with each other. Hence, routing paths in mobile ad hoc networks contain multiple hops, and each node in mobile ad hoc networks has the responsibility to act as a router. Because of the importance of routing protocols in dynamic multihop networks, a lot of mobile ad hoc network routing protocols have been proposed in the last few years. Routing protocols of MANETs fall into two main categories. First are Proactive protocols which are also known as table driven routing protocol in which every node periodically exchange the routing information and maintain network topology information in form of tables. Nodes continuously evaluate routes by flooding routing information across the network to all other reachable nodes and attempt to maintain up-to-date and consistent routing information. Therefore, a source node immediately gets a routing path when it needs one. On the contrary, reactive protocols build paths on-demand and Dynamic Source Routing (DSR) is an on demand routing protocol. The routing protocols that fall under this category do not maintain the network topology information. They obtain the necessary path when required. Hence they do not periodically exchange any routing information. [6] A route discovery operation invokes a route determination procedure. This discovery procedure terminates either when a route has been found or no route is available after examination for all route permutations. In a mobile ad hoc network, active routes may be disconnected due to node mobility. Therefore, route maintenance is an important operation of reactive routing protocols [1]. So DSR employs flooding to discover paths (Section A). Then, to manage situations in which current routes are broken, DSR implements a separate route maintenance procedure (Section B).

A. Route discovery

Route discovery consists of two sub-procedures: Route Request (RREQ) and Route Replay (RREP). Route discovery is the mechanism by which a node wishing to send a packet to a destination node finds a route. Route discovery is used only when a node attempts to send a packet to another node and does not already know a route to that node. [7]

- Let consider a node S which want to send packets to node D. S will check its "Route cache" if route is present. If no route is found, it will have to start a route discovery protocol to find a route to the destination. Else the cached route is used to send packet.
- Now node S will initiate Route Request and will broadcast RouteRequest (RREQ) packet with a unique identification number. This RREQ is flooded throughout the network. Each node on receiving the RREQ packet rebroadcast the packet to neighbor nodes except some conditions like if the node has forwarded this packet already or if the node is destination node or time to live has exceeded. Each node before forwarding appends its own address to packet.
- Now how the nodes will check if it has forwarded the packet already? Solution to this is also given that each RREQ packet has a unique identification number generated by source node and path it has traversed. A node on receiving the RouteRequest packet checks the sequence number in routing table to check the duplicate request. Duplicate request is discarded.

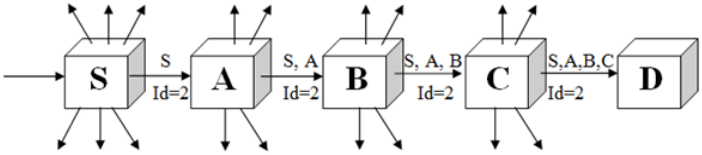

Figure 3 Route discovery: node S is the initiator, and node E is Destination

- Destination node on receiving the RREQ packet replies the source node through the reverse path the RouteRequest has traversed by sending RouteReply (RREP) message and cache the route in nodes.

B. Route maintenance

Route maintenance is the mechanism by which node S is able to detect, if the network topology has changed such that it can no longer use its route to D because a link along the route no longer works. When route maintenance indicates a source route is broken, S can attempt to use any other route it happens to know to D, or can invoke route discovery again to find a new route. Route maintenance is used only when S is actually sending packets to D.

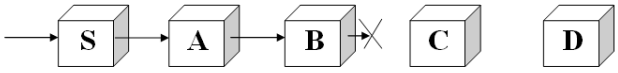

Figure 4 Route maintenance: node C is unable to forward a packet from S to D

- Using route discovery S will get the RouteReply from D. Now there is a path from S to D and S can send packets to D via selected route. Now when S will send packets and if the intermediate node C moves from its position and cause wireless link breakage. RouteError (RERR) message will be sent by intermediate node B to initiator S. Then source node S reinitiate route discovery for reestablishment of new route. The entries cached at intermediate nodes are removed when they get RERR message.

C. Ant Colony Optimization (ACO)

ACO, a famous swarm intelligence approach, has taken its inspiration from the social behaviors of real world ants. [19] The basic idea of the ant colony optimization meta heuristic is taken from the food searching behavior of real ants. In many ant species, ants walking to and from a food source deposit on the ground a substance called pheromone. [20] Other ants perceive the presence of pheromone and tend to follow paths where pheromone concentration is higher. Through this mechanism, ants are able to transport food to their nest in an effective way.

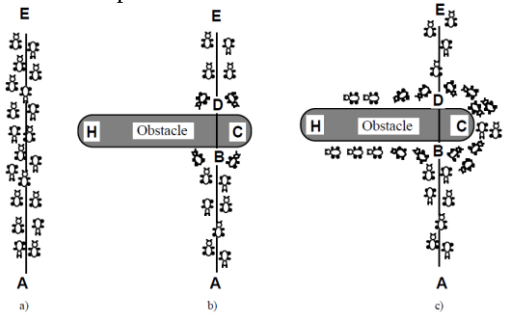

Figure 5 Real Ant Behavior

The concentration of pheromone on a certain path is an indication of its usage. With time the concentration of pheromone decreases due to diffusion effects. This property is important because it is integrating dynamic into the path searching process [20]. ACO can be used for routing. This approach consists to adaptive learning of routing tables in communication networks. Each ant in ACO considers two parameters to select its next hop. These parameters are saved at nodes in different data structure. The first one is the amount of pheromone deposited on the path to the next node, and the other is a kind of heuristic parameter such as the queue length associated with the link or some parameter decided. [19].

III.EXISTING ENERGY EFFICIENT ROUTING ALGORITHMS FOR MANET

Energy Efficient Routing Algorithms are not only to minimize the total energy consumption of the route but to maximize the lifetime of the network. In Ad hoc networks mobile nodes are powered by limited capacity batteries. Power failure of a mobile node affects not only the node but also its ability to forward packets and thus the overall network lifetime. In Ad hoc network energy consumption is done in two states. When nodes are transmitting or receiving packets called in active state and when a mobile node stays idle but listens to the wireless medium for any possible communication requests from other nodes called inactive state. In both state nodes consume some amount of energy. During active state energy consumption is more than inactive state. Active state protocols are divided into transmission power control approach which is to control energy consumed during transmission and receiving of packets. Second approach is load balancing

used to balance the energy usage of all mobile nodes by selecting a route with underutilized nodes rather than the shortest route.

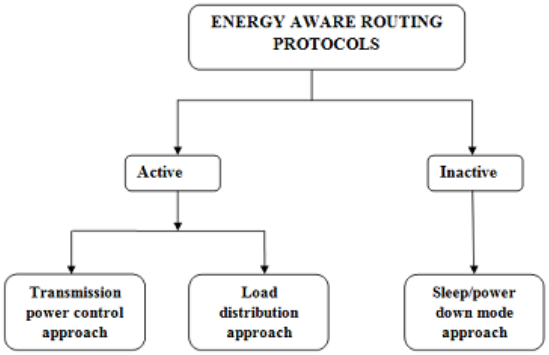

Figure 6: Energy Aware Routing Protocols

Further inactive state is when nodes are not doing anything just listening to other nodes so the approach used is to put nodes in sleep mode to retain it energy. Based on these different approaches many research works has been proposed. Energy efficient routing protocols proposed in [8],[9],[10] consider residual energy of nodes to increase lifetime of network. Algorithm proposed in [11] consider sleep time or power down mode approach to increase lifetime. Paper [12],[13],[14],[15],[16],[17] use transmission power approach to make energy efficient routing algorithm. S. Chettibi et al. proposed in [8] a multipath and energy-aware on demand source routing (MEA-DSR) protocol. The proposed algorithm exploits route diversity and information about batteries-energy levels for balancing energy consumption between mobile nodes. The choice of the primary route in this algorithm is dictated by minimal residual node energy to route length ratio. Meng Li et al. in [9] proposed An Energy-Aware Multipath Routing Protocol for Mobile Ad Hoc Networks. Proposed algorithm share the information among the physical layer, the MAC sub-layer and the network layer, EMRP efficiently utilizes the network resources such as the node energy and the link bandwidth. Power-Aware Source Routing (PSR) proposed by Morteza Maleki in [10] is a source-initiated (on demand) routing protocol for mobile Adhoc networks. In this algorithm route is discovered by minimized a defined cost function. Unlike the DSR not only mobility but also the energy depletion of nodes in PSR makes the route invalid, which initiates the route discovery. Giampaolo Bella et al. in [11] proposed a power-aware route maintenance protocol for Mobile Ad Hoc Networks (MANETs). Dynamic Path Switching (DPS), the proposed protocol puts an overloaded node to sleep state before a route link breaks because that node runs out of energy, and brings other suitable nodes into play. When the battery charge of a node reaches a stated level, the node can send a request to change to a sleep state to its neighbour. The request is honored only if some other paths are present to forward packets. Carla F. Chiasserini et al. in [12] proposed an algorithm BEE battery energy efficient routing for wireless ad hoc networks whose nodes are largely battery powered which balances the battery consumption among all network nodes. The scheme selects a route with low transmission energy in order to avoid battery inefficiencies due to the rate capacity effect, and to distribute the traffic load in a manner that nodes with low battery can benefit of the recovery effect. Ram Ramanathan et al. in [13] considered the problem of adjusting the transmit powers of nodes in a multihop wireless network. It adjust node transmit powers in response to topological changes and attempt to maintain a connected topology using minimum power. J.H. Chang et al. in [14] proposed an algorithm to maximize the lifetime of the ad-hoc network of wireless. Each node in network may adjust its power within a certain range that determines the set of possible one hop away neighbors. This paper rather than minimize the total consumed energy in reaching the destination proposed a class of flow augmentation algorithms and a flow redirection algorithm which balance the energy consumption rates among the nodes in proportion to their energy reserves. Vinay Rishiwal et al. presented in their paper [15] a power-aware routing protocol. The proposed algorithm maximizes the network lifetime & minimizes the power consumption during the source to destination route establishment. This algorithm takes special care to transfer both real time and non real traffic by providing energy efficient and less congested path between a source and destination pair. This scheme in Adhoc networks provides different routes for different type of data transfer and ultimately increases the network lifetime. Weifa Liang et al in [16] proposed a power aware algorithm that optimizes both the power consumption at each mobile node and the total transmission power consumption. PAMAS proposed by Suresh Singh et al. in [17] is a MAC-level protocol which avoids overhearing problem by power off radios in different cases such as when nodes does not have any packet to send and just hearing other nodes. Other case is if at least one neighbor node is transmitting and at least one neighbor is receiving, then node may power off. And if all neighbors of a node are transmitting and the node is not a receiver, it powers itself off. Baisakh et al. in [18] proposed an Energy Conscious DSR in MANET. The proposed algorithm select the path for the specified source to destination in such a way that all intermediate nodes will have higher level of energy at a given time instead of following minimum hop count method during the route discovery phase. This algorithm has two main phases energy saving phase and other is energy survival phase and these mechanisms are applied during route discovery and route maintenance respectively. Ant colony Optimization artificial Ants as a Computational Intelligence technique proposed by Marco Dorigo in [19] state the real ant behavior and how they could help human beings in many typical problems such as traveling salesman problem, routing problem, assignment problem etc. Variation of ant colony optimization techniques is also defined. Ehsan

Khosrowshahi Asl et al. In [20] proposed an Enhanced Multi-Path Dynamic Source Routing Algorithm (EMP-DSR). The proposed method uses an ant-colony optimization method to provide global information. This paper works on increasing end to end reliability to improve quality of service. Arafat S.M. Qaed et al. in [21] proposed a "Delay and Energy Conscious Routing Protocol" (DECRP) finds the efficient node and sends the data packets through that node. Ant colony optimization is used for routing to find efficient route to send packets.

IV. CONCLUSIONS

Lack of central administration in ad hoc network burden the nodes to maintain all routing information. Since nodes have limited energy they get out of energy results in interruption in communication link and decrease network lifetime. So the routing protocol must keep energy aspect in consideration. The traditional routing protocol of Ad hoc network is based on minimum hop count i.e. while selecting a path from as source to any destination, it selects the only path which is having minimum number of intermediate nodes among all possible paths and do not consider the energy aspect which plays an important role in routing. So the parameters that consider energy consumption during path established need to be considered for a energy efficient routing protocol to increase network lifetime.

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