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Survey on Energy Efficient Routing Techniques in MANET

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Abstract —*In Ad Hoc network, there is no any central infrastructure but it allows mobile devices to establish communication path. Since there is no central infrastructure and mobile devices are moving randomly, gives rise to various kinds of problems, such as security and routing. In this paper we consider the problem of routing. Routing is one of the key issues in MANET because of highly dynamic and distributed nature of nodes. Especially energy efficient routing is most important because all the nodes are battery powered. Failure of one node may affect the entire network. Since every mobile node has limited power supply, energy depletion has become the main threats to the lifetime of the ad hoc network. So routing in MANET should be in an efficient way. In this paper, we present a survey of such energy efficient routing algorithms.*

Keywords*- Energy conservation, lifetime, load balancing, manet, routing.*

I. INTRODUCTION

Mobile Ad Hoc Networks (MANET)[1,2] is a branch of wireless networking technology. It has its own features and significance in the communication field and getting popularity with time. The reason behind its popularity is that portable, mobile devices are increasing daily and the network technology that can provide facilities for such devices are getting popular. MANET is a self organizing and self configuring multi hop network which does not require any fixed infrastructure. Since the topology of the network is constantly changing, the issue of routing packets between any pair of nodes becomes a challenging task. Routes between nodes may contain multiple hops, which is more complex than the single hop communication. The aim of networking protocols is to construct an end-to-end(reliable) delivery services from a sender to a receiver. To establish an end-to-end communication, the sender needs to locate the receiver inside the network. Once a user is located, routing and forwarding algorithms must be provided to route the information through the MANET. The highly dynamic nature of a mobile ad hoc network results in frequent and unpredictable changes of network topology, adding difficulty and complexity to routing among the mobile nodes. The challenges and complexities, coupled with the critical importance of routing protocol in establishing communications among mobile nodes, make routing area the most active research area within the MANET[1] domain.

II. ROUTING PROTOCOLS FOR MANET

A routing protocol is used to discover routes between nodes. The primary goal of such an ad hoc network routing protocol is correct and efficient route establishment between a pair of nodes so that messages may be delivered in a timely manner. Route construction should be done with a minimum overhead and bandwidth consumption. In ad hoc networks, nodes do not have priori knowledge of topology of network around them, they have to discover it. The basic idea is that a new node announces its presence and listens to broadcast announcements from its neighbors. The node learns about new near nodes and ways to reach them, and announces that it can also reach those nodes. As time goes on, each node knows about all other nodes and one or more ways how to reach them.

Routing algorithms have to:

(a) Keep routing table reasonably small;

(b)Choose best route for given destination (this can be the fastest, most reliable, highest throughput, or cheapest route);

(c)Keep table up-to-date when nodes die, move or join;

(d)Require small amount of messages/time to converge.

The routing protocols may be generally categorized as (1)Table driven and (2)Source initiated on demand driven.

2.1.Table driven routing protocols

The table-driven routing protocols attempt to maintain consistent, up-to-date routing information from each node to every other node in the network. These protocols require each node to maintain one or more tables to store routing information, and they respond to changes in network topology by propagating updates throughout the network in order to maintain a consistent network view. As the routing information is usually maintained in tables, these protocols are referred to as Table-Driven protocols. The main characteristic of these protocols is the constant maintaining of a route by each node to all other network nodes. The route creation and maintenance are performed through both periodic and event-driven (e.g., triggered by links breakages) messages. Some of the table driven protocols are discussed briefly below.

The Destination-Sequenced Distance-Vector (DSDV) protocol is a distance-vector protocol with extensions to make it suitable to MANET. Every node maintains a routing table with one route entry for each destination in which the shortest path route (based on number of hops) is recorded. To avoid routing loops, a destination sequence number is used. A node increments its sequence number whenever a change occurs in its neighborhood. This number is used to select among alternative routes for the same destination. Nodes always select the route with the greatest number thus selecting the most recent information.

The Cluster head Gateway Switch Routing (CGSR) protocol differs from the previous protocol in the type of addressing and network organization scheme employed. Instead of a “fat" network, CGSR is a clustered multihop mobile wireless network with several heuristic routing schemes. By having a cluster head controlling a group of ad-hoc nodes, a framework for code separation (among clusters), channel access, routing and bandwidth allocation can be achieved. A cluster head selection algorithm is utilized to elect a node as the cluster head using a distributed algorithm within the cluster. The disadvantage of having a cluster head scheme is that frequent cluster head changes can adversely affect routing protocol performance since nodes are busy in cluster head selection rather than packet relaying.

The Wireless Routing Protocol (WRP) is a table-based protocol with the goal of maintaining routing information among all nodes in the network. Each node in the network is responsible for maintaining four tables: (a) distance table, (b) routing table, (c) link-cost table, and (d) message retransmission list (MRL) table. Each entry of the MRL contains the sequence number of the update message, a retransmission counter, an acknowledgment-required flag vector with one entry per neighbor, and a list of updates sent in the update message. The MRL records which updates in an update message need to be retransmitted and which neighbors should acknowledge the retransmission.

2.2.Source initiated on demand routing protocols

A different approach from table-driven routing is source-initiated on-demand routing. This type of routing creates routes only when desired by the source node. When a node requires a route to a destination, it initiates a route discovery process within the network. This process is completed once a route is found or all possible route permutations have been examined. Once a route has been established, it is maintained by some form of route maintenance procedure until either the destination becomes inaccessible along every path from the source or until the route is no longer desired. Some examples of source initiated on demand routing are briefly discussed below.

DSR is a loop-free, source based, on demand routing protocol, where each node maintains a route cache that contains the source routes learned by the node. The route discovery process is only initiated when a source node do not already have a valid route to the destination in its route cache; entries in the route cache are continually updated as new routes are learned. Source routing is used for packets forwarding.
AODV is a reactive improvement of the DSDV protocol. AODV minimizes the number of route broadcasts by creating routes on-demand, as opposed to maintaining a complete list of routes as in the DSDV algorithm. Similar to DSR, route discovery is initiated on-demand, the route request is then forward by the source to the neighbors, and so on, until either the destination or an intermediate node with a fresh route to the destination, are located. DSR has a potentially larger control overhead and memory requirements than AODV since each DSR packet must carry full routing path information, whereas in AODV packets only contain the destination address. On the other hand, DSR can utilize both asymmetric and symmetric links during routing, while AODV only works with symmetric links (this is a constraint that may be difficult to satisfy in mobile wireless environments). In addition, nodes in DSR maintain in their cache multiple routes to a destination, a feature helpful during link failure. In general, both AODV and DSR work well in small to medium size networks with moderate mobility.

TORA (Temporally-Ordered Routing Algorithm) is a highly adaptive, loop-free, distributed routing algorithm based on the concept of link reversal. TORA is proposed to operate in a highly dynamic mobile networking environment. It is source-initiated and provides multiple routes for any desired source/destination pair. The key design concept of TORA is the localization of control messages to a very small set of nodes near the occurrence of a topological change. To accomplish this, nodes need to maintain routing information about adjacent (1-hop) nodes. The protocol performs three basic functions: (a) route creation, (b) route maintenance, and (c) route erasure.

The Associativity-Based Routing (ABR) protocol is free from loops, deadlock, and packet duplicates, and defines a new routing metric for ad-hoc mobile networks. This metric Is known as the degree of association stability. In ABR, a route is selected based on the degree of association stability of mobile nodes. Each node periodically generates a beacon to signify its existence. When received by neighboring nodes, this beaconing cause their associativity tables to be updated. For each beacon received, the associativity tick of the current node with respect to the beaconing node is incremented. Association stability is defined by connection stability of one node with respect to another node over time and space. A high degree of association stability may indicate a low state of node mobility, while a low degree may indicate a high state of node mobility. Associativity ticks are reset when the neighbors of a node or the node itself moves out of proximity. A fundamental objective of ABR is to derive longer-lived routes for ad-hoc mobile networks.

III. LOAD BALANCING AND ENERGY CONSERVATION

Networks are complex systems, often routing hundreds, thousands, or even millions of data packets every second. Therefore in order for networks to handle large amount of data, it is important that the data is routed efficiently. Load balancing helps make networks more efficient. It distributes the processing and traffic evenly across a network, making sure no single device is overwhelmed. The bandwidth is utilized effectively. Load balancing aims to optimize resource use, maximize throughput, minimize response time, and avoid overload of any single resource.

Mobile devices rely on batteries for energy. Battery power is finite, and represents one of the greatest constraints in designing algorithms for mobile devices. Limitation on battery life, and the additional energy requirements for supporting network operations (e.g., routing) inside each node, make the energy conservation one of the main concern in ad hoc networking. However, in small mobile devices, networking activities have a major impact on energy consumption.
We present a survey on different efficient algorithms in the load balancing and energy below section.

In 2007, Rajib Mall and Prasant Kumar Patnaik proposed Power and Battery Aware Routing Protocol (PBAR)[3], which incorporates the effect of power consumption in routing a packet and also exploits charge recovery effect. A cost metric is proposed for routing, which has various factors like power consumption in transmitting a packet, residual battery capacity of a node and drain rate to increase the battery life of nodes and whole network. This metric ensures that a node with low residual battery capacity and higher traffic density is not selected for routing. All nodes except the destination node calculate their cost. During the route discovery phase, if source has data to send to a destination whose route is not known then it broadcasts a route request packet to its neighbors. The destination receives this packet and sends route reply to the source. During the data routing phase, once a route to destination is traced, the nodes (including the source) forward data packets as per routing tables and select the least cost route. The route maintenance is done by periodically flooding RREP packets from each of the destinations. Ns-2 network simulator was used for simulation purpose. The performance of proposed protocol i.e. PBAR was evaluated by comparing with AODV and MMBCR. The results showed that PBAR improved the network life as compared to AODV and MMBCR. AODV showed better PDR than PBAR in static network but as the mobility was increased, PBAR performed better than AODV. However, the average end-to-end delay of AODV was better than PBAR and average end-to-end delay of PBAR was better than MMBCR.

In 2008, M.Tamilarasi, S.Chandramathi, T.G.Palanivelu proposed a protocol MDSR(Modified Dynamic Source Routing)[4] for overhead reduction and efficient energy management for DSR protocol. The overhead was reduced by reducing the number of route reply packets and the header size of DSR data packets. Also the transmit power was tuned according to the distance between transmitting node and receiving node for power management. It is sufficient if the destination node sends the Route Reply through one selected route rather than through all the routes. Hence it is proposed to limit the number of Route Replies to only one. This is sent via the route through which the destination received the first Route Request, because it is the most active route for the particular source-destination pair at the moment of sending the request. Moreover this is the route through which the data packets can be transmitted fastest. Hence the same is chosen as the route for the data transmission, which can reduce the propagation delay to a great extant. Furthermore it leads to the decrease in control packets generated in the network and the increase in packet delivery ratio. GloMoSim (Global Mobile Simulator) was used for simulation purpose. The results showed better PDR than existing DSR. But as the mobility increases the modified DSR required almost the same number of control packets as the existing one. The end-to-end delay was reduced in modified DSR also an effective energy management was obtained as the distance of separation was less.

In 2008,Jung-Chun Kao and Radu Marculescu proposed a protocol PEMA[5] for solving scalability and overhead issues. The running time of PEMA (Predictive Energy Efficient Multicast Algorithm) depends on the multicast group size, not network size, this makes PEMA fast enough even for MANETs consisting of 1000 or more nodes. To accurately predict the communication energy consumption without the knowledge of network topology and route details, first lower and upper bounds are derived and after that predicted energy values become the weighted averages of these two bounds. Based on these predicted energy values, PEMA determines how to send packets to group members in an energy efficient way, without relying on any global information about the network. In PEMA[5], for any communication session, packets to be routed are constrained within a forwarding area rather than considering the entire network. The packets within the forwarding area can be routed arbitrarily, but any node outside the forwarding area is assumed to simply discard the received packets. During the simulation, PEMA is compared with MLU, MLiMST, and MIP. The results showed that, in terms of energy efficiency, PEMA performed better against those three and also provided good PDR.

In 2009, Vinay Rishiwal, Mano Yadav, S.Verma, S.K.Bajpai proposed a protocol PAR(Power Aware Routing)[6] which maximizes the network lifetime by minimizing the power consumption during the source to destination route establishment. This algorithm takes into account to transfer both real time and non real time traffic by providing energy efficient and less congested path between a source to destination pair. The algorithm focused on three parameters, accumulated energy of path, status of battery lifetime and type of data to be transfer. The algorithm selects less congested and more stable route for data delivery. It provides different routes for different type of data transfer and increases network lifetime. Ns-2 simulator is used for simulation purpose. The proposed protocol PAR[6] is compared with AODV and DSR for performance evaluation. The results showed that total energy consumption of PAR is better than AODV and DSR. PAR is good for large network of hundred nodes in heavy traffic conditions. Also PAR provides greater network life as compared to both AODV and DSR. The energy distribution is better in proposed algorithm than both AODV and DSR. In PAR, node termination rate is less as compared to AODV and DSR.

In 2011, Farukh Mahmudur Rahman and Mark Gregory proposed a protocol QBIECRA(Quadrant Based Intelligent Energy Controlled Multicast Routing Algorithm)[8], which includes quadrant based opportunistic routing, an intelligent energy matrix and energy status request messages with packet receipt acknowledgement notification. It balances the traffic uniformly across four intermediate nodes in any desired quadrant. Broadcast messages are reduced which improves channel efficiency and provides better bandwidth utilization. In quadrant based routing packets are transmitted towards the quadrant that the destination resides within. The proposed algorithm uses an intelligent energy matrix that creates a look up table including the key characteristics: reputation value, residual battery level and energy consumption. The proposed algorithm balances the traffic uniformly across four intermediate nodes in any desired quadrant. Due to the inclusion of the energy matrix and quadrant based routing, the number of broadcast messages decreases, reducing data flooding, providing improved channel efficiency and improves bandwidth utilization. Load balancing also increases the lifetime of intermediate nodes which provides improved route stability. The proposed algorithm also includes packet receipt acknowledgement notification which guarantees end-to-end packet delivery and provides reliable MANET routing. The simulation results show that intermediate node energy lifetime is improved which reduces packet loss rate and increases routing stability. However, the limitation is that the data transfer rate is slightly lower when compared with standard algorithms.

In 2014, Bhavna Sharma, Shaila Chugh and Vismay Jain proposed a protocol E-AOMDV(Energy based AOMDV) [11], that considers both the shortest path and the energy conservation in multipath way. An energy factor as that will use the products of the energy factors of all the nodes along different paths as the selection criteria. The amount of energy left at the neighbor nodes is taken into consideration when selecting one route from multiple routes. To achieve this, each node needs to report its energy level to its neighbors. The multi-path selection thus takes all the next hops from available paths, and checks the associated normalized remaining energy levels known to the node. The next hop with the highest energy level is selected. The energy usage at a node indicates the amount of broadcasting activities. Thus it can be regarded as an indication of traffic load at the node. While selecting the next hop according to the energy levels, load balancing among the neighbors is achieved. The simulations are taken out using Ns-2 simulator. The results showed that the proposed algorithm has better PDR than AOMDV and routing load is also less than AOMDV and an energy efficient algorithm.

IV. SUMMARY

This survey paper explores the idea of routing in MANET along with the algorithms on load balancing and energy efficient approaches. Energy is the crucial issue in a MANET. Therefore different energy efficient algorithms are discussed here briefly.

- The basic idea of PBAR[3] is to keep track of power consumption in routing packets and recent traffic density at each node.
- The basic idea of MDSR[4] is to reduce the end to end delay and the number of control packets which is the sum of route request, route reply and route error packets.
- The basic idea of PEMA[5] is energy savings in large scale MANETs. The routing decision of PEMA does not rely on the information about network topology or route details.
- The basic idea of PAR[6] is to discover an efficient routing scheme in MANETs which can support both real and non real time traffic.
- The basic idea of QBIECRA[8] is to balance the traffic uniformly across four intermediate nodes in any desired quadrant and to create an intelligent energy matrix that create look up table for reputation value, residual battery level and energy consumption.

- The basic idea of E-AOMDV[11] is to consider both the shortest path and energy conservation in a multipath way.

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