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Energy Aware Dynamic Source Routing In Wireless Ad Hoc Networks

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***Abstract*— Wireless ad hoc networks are featured by dynamic topology (infrastructure-less), multi-hop communication, limited resources (bandwidth, CPU, battery, etc.) and limited security. These characteristics put special challenges in routing protocol design. The one of the most important objectives of MANET routing protocol is to maximize energy efficiency, since nodes in MANET depend on limited energy resources. The primary objectives of MANET routing protocols are to maximize network throughput, to maximize network lifetime, and to maximize delay. The aim of energy-aware routing protocols is to reduce energy consumption in transmission of packets between a source and a destination, to avoid routing of packets through nodes with low residual energy, to optimize flooding of routing information over the network and to avoid interference and medium collisions.DSR protocol has been deployed for finding optimal path between a pair of nodes,for detecting the misbehaving nodes Genetic Algorithm and Ant Colony Optimization technique has been used.**

Keywords— ***Wireless ad hoc networks, Genetic Algorithm, Ant Colony Optimization technique, MANET, Energy Aware Dynamic Source Routing.***

I. INTRODUCTION

The problem of energy efficiency in MANETs can be addressed at different layers. In recent years, many researchers have focused on the optimization of energy consumption of mobile nodes, from different points of view. Some of the proposed solutions try to adjust the transmission power of wireless nodes, other proposals tend to efficiently manage a sleep state for the nodes. Finally, there are many proposals which try to define an energy efficient routing protocol, capable of routing data over the network and of saving the battery power of mobile nodes. Such proposals are often completely new, while others aim to add energy-aware functionalities to existing protocols. Energy-Efficient routing is an effective mechanism for reducing energy cost of data communication in wireless ad hoc networks. The energy efficient routing protocols for MANET try to reduce energy consumption by means of an energy efficient routing metrics, residual energy of a path (metric 1) is defined as the minimum energy level of any node in the path and the energy consumed along a path (metric 2) which is defined as the sum of the weights on the edges along the path[1].

Operational lifetime can be defined as the time until network partitioning occurs due to battery outage. In order to achieve the objective of maintaining connectivity as long as possible, the distribution of network tasks among its nodes should be equal so that they all decrease power at the same rate and eventually run out of energy at approximately the same time. The network must be designed to achieve the simultaneous failure of the nodes (due to a lack of energy), so that communication requirements are met. This leads to consider as the operational lifetime of such networks their relative lifetime, rather than the absolute lifetime of their devices. The useful lifetime of ad-hoc networks can be significantly lower than the network's devices lifetime, but from an engineering and application perspective the former time span is much more interesting and meaningful. For instance, a case could be envisaged in which some nodes have fully charged batteries but are unable to establish successful communications because they belong to disconnected parts of the network or must communicate with nodes that are turned off due to a lack of energy. In such a scenario, the absolute lifetime of a network will be longer compared to the useful life span, but this is not of practical interest [2]. RMECR finds minimum energy cost routes, where the energy cost of packet forwarding from a node is a function of the remaining battery energy of the node, reliability of the physical link, and required energy for packet transmission. RMECR can reduce the overall energy consumption in the network by finding minimum energy cost routes. It can also find reliable routes in which constituent links require less number of packet retransmissions due to packet loss. Furthermore, RMECR can balance the traffic load in the network and increase the network lifetime by finding routes in which nodes are likely to have more residual battery energy.

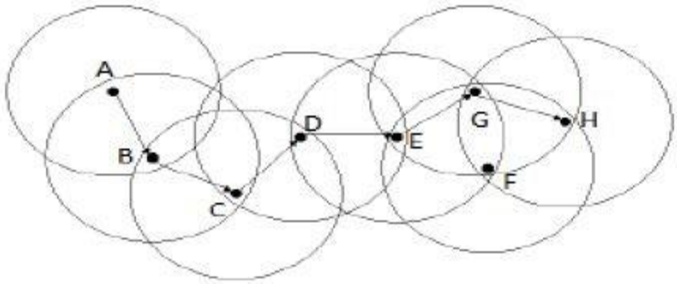

Figure 1. Routing in MANET

II. Related Work

The DSR is a reactive routing protocol, in which a node issues a route request only when it has data to send. Route requests are flooded through the network, each node appending its own address to each request it receives, and then re-broadcasting it. Each new request includes a unique ID, which forwarders use to ensure they only forward each request once. The request originator issues new requests for the same destination after an exponentially increasing back-off time. Route requests are issued with increasing time-to-live (TTL) values, to minimize the range and cost of flooding. The destination issues a route reply in response to every forwarded request it receives. Each reply, which includes the route which was accumulated as the request was forwarded through the network, is source-routed back to the originator along the reverse route. The source node chooses a route using information from the route replies it receives, and source-routes data along this route. Our implementation stores the results of route replies in a link cache, which stores information about each link separately. A node runs Dijkstra's shortest-path algorithm on its link cache to find the best route to a destination.DSR uses feedback from the link layer to react to link failures[1].

III. Dynamic Source Routing

DSR designed specifically for use in multi-hop wireless ad hoc networks of mobile nodes. It is a very simple and efficient routing protocol. The protocol is composed of the two main mechanisms of "Route Discovery" and "Route Maintenance".

A. Route Discovery

Whenever a source node requires a path to the destination node. First of all, the source node searches for a valid route to the destination in its route cache. If the source node finds a valid route to destination then it puts the route into packet's header and uses this route to send its data packet but if source does not find the same in cache then it initiates the route discovery process by broadcasting a route request (RREQ) message. The route request message contains the address of the source and the destination, and a unique identification number. The intermediate nodes put their address on the header and forward the packet. When the destination node receives the request message then it has the whole hop sequence of path. As a result it sends back the route reply (RREP) message which contains the proper hop sequence.

B. Route Maintenance

It is used to handle route breaks. When a node encounters any problem regarding transmission at its data link layer, it removes the route from its route cache and generates a route error message which is sent to each originator node that has sent a packet routed over the broken link. The originator node removes this link from its route cache. If one route cache contains another source route, the node sends the packet using this route. Otherwise, it will initialize a new Route Request. Acknowledgment messages are used to verify the correct operation of the route links.

IV. Optimization Method

A. Genetic Algorithm

A genetic algorithm (GA) is a local search technique used to find approximate solutions to optimization and search problems. Genetic algorithms are a particular class of evolutionary algorithms that use techniques inspired by evolutionary biology such as inheritance, mutation, selection, and crossover (also called recombination).Genetic algorithms are typically implemented as a computer simulation, in which a population of abstract representations (called chromosomes) of candidate solutions (called individuals) to an optimization problem, evolves toward better solutions. The evolution starts from a population of completely random individuals and occurs in generations. In each generation, the fitness of the whole population is evaluated, multiple individuals are stochastically selected from the current population (based on their fitness), and modified (mutated or recombined) to form a new population. The new population is then used in the next iteration of the algorithm. A set of chromosomes forms a population , which is evaluated and ranked by fitness function.

B. Swarm Intelligence pdf3

Swarm Intelligence (SI) [1] is an Artificial Intelligence technique based on the study of collective behaviour in decentralized, self-organized systems. The expression "swarm intelligence" was introduced by Beni & Wang in 1989, in the context of cellular robotic systems. Swarm intelligence is "The emergent collective intelligence of groups of simple agents" (Bonabeau et al., 1999). It gives rise to complex and often intelligent behaviour through simple, unsupervised interactions between a total numbers of autonomous swarm members. Usually there is no centralized control structure dictating how the individual agents should behave, but local interactions between such agents often lead to the emergence of a global behaviour. Swarm is considered as biological insects like ants, bees, wasps, fish etc. The quick coordinated flight of a group of birds with very little visual communication and the concerted effort of an ant colony in gathering food, building nests, etc are some of the vivid examples of emergence in natural world. SI has found immense applicability in fields like Robotics, Artificial Intelligence, process optimization, telecommunications, routing, software testing, networking etc.

C. Ant-Colony Optimization

The Ant Colony Optimization (ACO) is a metaheuristic algorithm, based on generic problem representation and the definition of the ant's behaviour. ACO adopts the foraging behaviour of real ants. When multiple paths are available from nest to food, ants do random walk initially. During their trip to food as well as their return trip to nest, they lay a chemical substance called pheromone, which serves as a route mark that the ants have taken [7]. Subsequently, the newer ants will take a path which has higher pheromone concentration and also will reinforce the path they have taken. As a result of this autocatalytic effect, the solution emerges rapidly.

V. PROPOSED ALGORITHMS

A. Genetic Algorithm

Network simulation is done by using DSR protocol and dijkstra's shortest path algorithm. After the simulation number of different paths are selected for the same source and destination pair and also packet delivery ratio, end to end delay, number of packets dropped are calculated for the selected path. Apply the fitness function, crossover, mutation on the chosen path.

B. Ant Colony Optimization

Step 1: Calculate the probability of selection of newly generated path that are obtain by applying genetic algorithm for the given source-destination pair. The path will be selected with the higher probability.

Step 2: The backward ant accumulate the pheromone and also the evaporation of pheromone take place, now we calculate the updated pheromone after the evaporation.

Step 3: The path with the higher path preference probability will be considered as the best path and the data transmission can be started along that path.

Evaluation of fitness function

The fitness function F(x) is defined as follows:

$$F(x) = PDR / k - k*[NO+AD+PD]$$

NO = Normalized Overhead
AD = Average End to End Delay
PD = Number of Packet Drop
PDR = Packet Delivery Ratio

k = Proportionality constant used for the optimization of fitness function.
Value of k lies between 0 and 1.

C. Energy-Aware routing Algorithm

The DSR implementation, on the other hand, adds the source route header to data packets before inserting them into the queue. On a transmission failure or a received route error, a node removes and drops all enqueued packets which include the broken link in their source route. This ensures that the node experiencing the transmission failure does not spend additional time and spectrum retransmitting more packets over the broken hop. Minimum hop shortest path routing is done by using dijkstra's shortest path algorithm. RMECR extends the operational lifetime of the network since it considers the remaining battery energy of nodes.

For RMECR the battery cost of a link is defined as "the fraction of the residual battery energy of the two nodes of the link which is consumed to forward the packet". Link weight is calculated as

$$W_{i,j} = E_{i,j} / B_i$$

B_i = residual battery energy of node i.

$W_{i,j}$ = link weight of i,j.

$E_{i,j}$ = expected energy consumed by node i to transmit a packet to node j over the link(i,j).
For finding Minimum Energy Cost Path (MECP) , link weight is formulated for RMECR algorithm.

VI. Conclusion

The proposed methods present in this paper enhance the performance of DSR routing protocol. The use of genetic algorithm as well as Ant Colony Optimization to find the best path doubly ensures that the correct path has been found out. Finding reliable routes can enhance the residual energy of nodes and considering the residual energy of nodes can eventually lead to an increase in the operational lifetime of the network.

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