Route Search Optimization Technique using Ant Colony Optimization

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ABSTRACT
In Ad-Hoc networks the mobile nodes communicate with each other using multi-hop wireless links. The main drawback of such network is that there are no stationary infrastructures to route the packets. Hence, routing protocols have to adapt quickly and elegantly to frequent and unpredictable changes in network technology and they have to do so while conserving the memory, power and bandwidth resource. The Ant Colony Optimization technique implemented upon such networks have helped the nodes in finding the routes to different nodes in an optimized way same as ants find the optimum route to its food. The techniques provided so far have considered the search space utilized by a node as the space occupied by all the nodes that are present in the network which requires message passing among all the nodes that are present in the network consuming plenty of bandwidth and power only to find the routes to different nodes. If we divide the search space among the nodes forming clusters then the number of messages communicating will be reduced thereby reducing the bandwidth occupied and power consumed.

Key words
Mobile Ad-hoc Networks, Optimal Route Searching ,Ant Colony Optimization.

1. INTRODUCTION
Mobile Ad-hoc Networks have grown in popularity over the recent advancements in technology as they possess the ability to provide instant wireless networking solution in places/situations where no pre-deployed infrastructure exists. MANETs prove to be an attractive solution in a wide of environments ranging from scattered military deployment to simple network of a group of notebooks in an office meeting. In all cases, there is a need for a group of nodes (laptops, desktops, pdas, cell phones, etc) to group together and create a network which can offer services like file-sharing, messaging, resource sharing, etc. Hence the primary goal in a mobile network is to efficiently establish one or more routes between two nodes so that they can communicate reliably. We are all familiar with swarms in nature. The word swarm conjures up images of large groups of small insects in which each member performs a simple role, but the action produces complex behavior as a whole. The emergence of such complex behavior extends beyond swarms. Similar complex social structures also occur in higher-order animals and insects that don't swarm: colonies of ants, flocks of birds, or packs of wolves. These groups behave like swarms in many ways. Wolves, for example, accept the alpha male and female as leaders that communicate with the pack via body language and facial expressions. The alpha male marks his pack's territory and excludes wolves that are not members.

Several areas of computer science have adopted the idea that swarms can solve complex problems. For our purposes, the term swarm refers to a large group of simple components working together to achieve a goal and produce significant results. Swarms may operate on or under the Earth's surface, under water, or on other planets.

Optimization Algorithms are becoming increasingly popular in engineering design activities, primarily because of the availability of affordability of high speed computers. They are extensively used in those engineering design problems where the emphasis is on maximizing or minimizing a certain goal. For example, optimization algorithms are routinely used in aerospace design activities to minimize the overall weight simply because every element or component adds to the overall weight of the aircraft.

Thus optimization is a term used for either minimization or maximization of an objective.

As we know the mobile ad-hoc networks consist of the nodes that are required to perform the functions without any proper infrastructure with limited resources that is battery power and bandwidth.
This paper proposes an algorithm to find out the optimal route from each of the nodes to other nodes along with conserving these resources.

2. RELATED AND PROPOSED WORK

2.1 AD-HOC NETWORKS

In an Ad-Hoc network, each node works as a host as well as a router. This needs each node to maintain some form of information regarding the network around it along with some algorithm governing the sending and receiving of data packets. This Algorithm together with the supporting information regarding network condition is called a routing protocol.

Routing Protocol in ad hoc network has to adapt quickly and elegantly to frequent unpredictable changes in network topology, and they have to do so while conserving memory power and bandwidth resources. When ad-hoc networks are scaled up, they generally encounter excessive overhead in routing messages, caused due to growing number of nodes and amplified by higher node mobility. Growing Networks also lead to excessive routing table sizes, which typically have to be broadcasted to other nodes again adding to network overhead.

2.1.1 Classification of Ad Hoc Protocols

Ad-hoc routing protocols

Hierarchical protocols | Flat protocols

Proactive	Reactive	Hybrid	Proactive	Reactive	Hybrid
STAR	CERP	ZHLS	FSR	AODV	ZRP
MMWN		SLURP	FSLS	DSR	
CGSR		DST	OLSR	ROAM	
HSR		DDR	TBRPF	LMR	

Figure 1: *TAXONOMY OF AD-HOC ROUTING PROTOCOLS*

The above Figure 1 presents a Hierarchical overview of ad-hoc routing protocols. It has to be noted that there are many different axis along which to classify ad-hoc routing protocols. Lang maintains that a classification along the hierarchical or flat networks structures is not valid since a flat network structure is not really a property in itself, but rather the absence of hierarchical property"Ref.[1]". However since some networks generally lend themselves better to hierarchical networks and vice-versa, a network designer may find a classification along the hierarchical or flat network structure axis on basis that it yields *useful information*, even though such classification can be argued to be logically incorrect.

2.1.1.1 Flat Routing Protocols

In flat routing protocol all hosts are treated equally and therefore host can be used to forward packets between arbitrary sources and destinations. In general a set of homogenous processes is applied at each host. These processes include information collection, mobility management and routing.

2.2.1.2. Hierarchical Routing Protocol

To permit scaling hierarchical techniques are usually applied. The major advantage of hierarchical routing is the reduction of routing table storage and processing overhead "Ref.[2][3]". Among hierarchical routing scheme the cluster based algorithm divides the given graph into a number of non-redundant clusters that may overlap with each other. Each node within the same cluster can communicate with each other directly by sending message but communicates to another node in another cluster through cluster head.

1.2 Ant Colony Optimization

Less than a hundred years ago the building of termite mounds, the nest building of the social wasps and ability of ants to converge on source food were considered somewhat magical aspect of nature. How could these simple, seemingly uncommunicative creatures be responsible for such epic feats of construction and organization? Biologists have over the last century unraveled many of these mystery and provided the foundation for fields of research variously known as collective intelligence, swarm intelligence and emergent behavior.

2.2.1 Stigmergy and Self –Organization

In 1959, Grasse published the result of a study of termites in which he noted that the termites tended to follow a set of very simple rules when constructing there nest "Ref.[4]"..

-First, the termites move around random, dropping pallets of chewed earth and saliva on any slightly elevated patch of ground they encounter. This soon cause small heaps of moist earth to form.

- These heaps of salivated earth encouraged other termites to drop more pallets in the same place. Soon the biggest heaps start to develop in columns, which will continue to be built until a certain height is reached.
- If the columns were built close enough to other columns, the termites will start climbing each column and start building diagonally towards the neighboring columns.

Stigmergy, therefore is a mechanism which enables an environment to structure itself through the activities of the agents in the environment.

2.2.2. Swarm Intelligence and the Ant Colony

Ants have always been the fascinating subject for human beings. Several scientific books "Ref.[5][6]". and pure literature books "Ref.[7]" on ants have met with surprising public success. Individually they are remarkably simple creatures with limited memory and behavior that sometime seem to have random component. But collectively, ants consistently achieve remarkable feats of cooperation, coordination and construction. Document examples of these achievements include:

1. Emigration of a colony
2. Formation of chain bridges
3. Building of ant nests
4. Preferentially exploiting the richest available food source

2.2.3 . The AntNet Routing Algorithm

The AntNet routing algorithm is a direct extension of simple ant colony optimization algorithm. Ant net is even closer to the real ants behavior that inspired the development of the ACO met heuristic than the ACO algorithms.

The ant net algorithm and its main characteristics can be summarized as follows.

-At regular intervals and concurrently with the data traffic from each network node artificial ants are asynchronously launched towards destination nodes selected according to the traffic distribution.

-Artificial ants act concurrently and independently and communicate in an indirect way through the pheromones they read and write locally on the nodes.

-Each artificial ant searches for minimum cost path joining its source and destination.

-Each artificial ant move step by step towards its destination node. At each intermediate node a greedy stochastic policy is applied to choose the next node to move to. The policy makes use of

1.Node artificial pheromones
2.Node-local-artificial pheromones
3.Node-local problem dependent heuristic information
4.The ant's memory.

-While moving the artificial ants collect information about the time length, the congestion status, and the node identifiers of the following path.

-Once they are arrived at the destination the artificial ants go back to there source nodes by moving along the same path as before but in opposite direction.

- During this backward travel node local model of the network status and the pheromones stored at on each visited node are modified by the artificial ants as the function of the path they followed and of its goodness.

- Once they have returned to there source node the artificial ants are deleted from the system.

2.3. Optimization

Optimization Algorithms are becoming increasingly popular in engineering design activities, primarily because of the availability of affordability of high-speed computers. They are extensively used in those engineering design problems where the emphasis is on maximizing or minimizing a certain goal. For example, optimization algorithms are routinely used in aerospace design activities to minimize the overall weight simply because every element or component adds to the overall weight of the aircraft.

Thus optimization is a term used for either minimization or maximization of an objective.

2.3.1 Optimization Algorithms

The above optimization problems reveal the fact that the formulation of engineering design problems could differ from problem to problem. Certain problems involve linear terms for constraints and objective function and certain other problems involve non linear terms for them. In some problems, the terms are not explicit function of the design variables. Unfortunately there does not exist a single optimization algorithm, which will work in all optimization problems equally efficiently. Some algorithms perform better on one problem but may perform poorly on other problems. That is why the optimization literature contains a large number of algorithms each suitable to solve a particular type of problem. The choice of algorithm for an optimization problem is, to a large extent, dependent on the users experience in solving similar problems.

2.3.2. Single variable optimization algorithms

Because of there simplicity, single variable optimization techniques are discussed first. These algorithms provide a good understanding of the properties of the minimum and maximum points in a function and how optimization algorithms work iteratively to find the optimum point in a problem. The algorithms are classified into two categories-direct methods and gradient based methods. Direct methods do not use any derivative information of the objective function; only objective function values are used to guide the search process. However, gradient based methods use derivative information (first and/or second order) to guide search process. Although engineering optimization problems usually contain more than one design variables, single variable optimization algorithms are mainly used as unidirectional search methods in multivariable optimization algorithms.

2.3.3. Multi-variable optimization algorithms

A number of algorithms for unconstrained, multivariable optimization problems are discussed next. These algorithms demonstrate how the search for the optimum point progresses in multiple dimensions. Depending on weather the gradient information is used or not used, these algorithms are also classified into direct and gradient based techniques.

2.3.4. Constrained optimization algorithms

Constrained optimization algorithms are described next. These algorithms use the single variable and multivariable optimization algorithms repeatedly and simultaneously maintain the search effort inside the feasible search region.

2.*3.5. Specialized optimization algorithms*

There exist a number of structured algorithms, which are ideal for only a certain class of optimization problems. Two of these algorithms- integer programming and geometric programming are often used in engineering design problems. Integer programming methods can solve optimization problems with integer design variables. Geometric programming methods solve optimization problems with objective functions and constraints written in a special form.

2.3.7. Non traditional optimization algorithms

There exist a number of other search optimization algorithms which are comparatively new and are becoming popular in engineering design optimization problems in the recent past. Two such algorithms are

- Genetic Algorithms.
- Simulated Annealing .

2.4 Related Work

Tarek H. Ahmed "Ref.[8][9]" from University of Duisburg-Essen, Germany proposed a model which combines ant colony behavior and queuing network analysis to evaluate End-to-End packet delay in MANET. He proposed a framework for routing algorithm based on ACO algorithms and Kleinrocks delay analysis to find the best route with minimum end to end packet delay in a mannet. And concluded that the considered ant algorithm is able to cope with the given dynamic network.

Chao Gui and Prasant Mohapatra "Ref.[10][11]" from University of California defined routing optimality using different metrics such as path length, energy consumption along the path, and energy aware load balancing among the nodes. He then propose a framework of Self-Healing and Optimizing Routing Techniques (SHORT) for mobile ad hoc networks and concluded that SHORT improves routing optimality by monitoring routing paths continuously, and gradually redirecting the path towards a currently more optimal one.

Mohammad Mursalin Akon and Dhrubajyoti Goswami ”Ref.[12][13]” Concordia University, Montreal in his paper “A New Routing Table Update and Ant Migration Scheme for Ant Based Control in Telecommunication Networks propose mobile agents that are more advanced than those found in the previous literatures. The paper included a new migration scheme for the ant-like mobile agents and a new routing table management scheme. Simulation results show that our proposed schemes can ultimately result in better load balancing and better performance within telecommunication networks.

2.5. Proposed Work

The metric used to evaluate the available protocols in an ad-hoc network can be classified into

- Scenario metric
- Performance metric.

This paper proposes a technique where metrics such as :

- Routing overhead ratio
- Average power expended is reduced.

This paper suggests an algorithm that aims at finding the optimal route from all the nodes to all other nodes in the minimum possible hops for route searching taking into consideration the battery power thereby reducing the bandwidth as well as the batter power.

2.5.1. Algorithm for optimal route discover

Step 1: Using round trip time calculate the distance of all the nodes present within the network

Step 2: Find the average of the Round trip time value to determine the threshold.

Step 3: Using K-MEANS clustering cluster the nodes within the threshold values.

Step 4: Each node sends message to all other nodes within the cluster.

Step 5: Tables of the nodes for each other node present in the cluster is obtained.

Step 6 : Tables are exchanged among the nodes.

Step 7: After exchanging the table use the table for finding the optimum route to each node present within the network.

Step 8 Calculate the hop count from every node to all other nodes in the network

3. RESULTS

3.1 Data sets :

RTT Values: where a node periodically sends hello messages to all the nodes which comes back to the source node calculating the time needed to travel to and from the node. This measurement is treated as the metric to calculate the distance between two nodes as well as the nodes that are within its reachable range.

3.2 Parameters:

Here the average value of all the RTT values received by hello message is considered as the threshold value that decides the 1 hop nodes of the source node i.e the immediate neighbor of it, so that the threshold can be calculated even when there are only two nodes within its reachable range.

3.3. Comparison of the random search for route optimization to the proposed algorithm

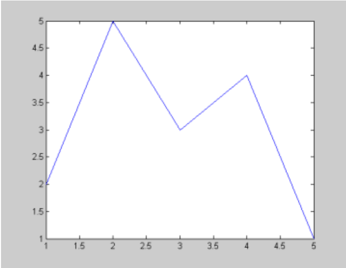


Figure 2 : Routing overhead ratio with random hop count.

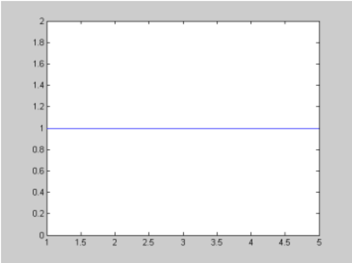
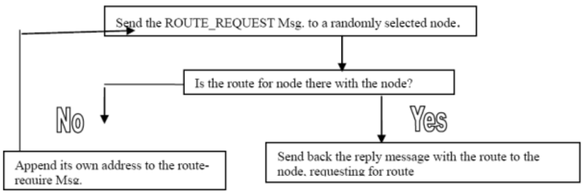


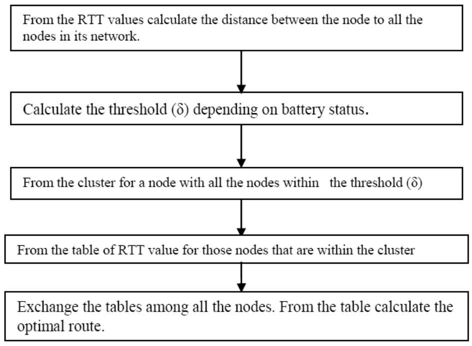
Figure 3: Routing overhead ratio with single hop count.

3.4. State Flow Diagram

Random Search :



2. Proposed Work: -



4. CONCLUSION AND FUTUREWORK

The above algorithm aims at proposing a technique, which reduces the routing overhead ratio. The ad-hoc network when used in places affected by natural calamity or in cases of defense services where these resources are scarcely available there are even conditions where for days together the battery cannot be replaced or where the communication means required is fast reliable and optimal. The algorithm hence aims at conserving the hop counts by reducing the search space for the node for searching the optimal route for a node to other nodes. Here the searching of the nodes is done by multicasting the ROUTE_REQUEST packet instead of broadcasting technique thereby reducing the search space due to which the routing overhead ratio is also reduced for the route searching which in turn reduces the bandwidth consumption and the random search for the route is confined to the neighboring node to each of the node within a given threshold. After acquiring the route to each of the node the tables are exchanged and the different routes to all the nodes in the network are acquired. The optimal route is calculated on the basis of RTT values calculated through hello message.

The optimal route is also guided by other factors like

1. Signal stability strength
2. Message Overhead
3. Attenuation
4. Signal fading
5. Signal Overlapping etc.

These values are calculated by the artificial ants, generated by the node in the ant colony implementation on the ad-hoc network that is sent on the routes calculated above. Taking into account the above factors the probability for selecting next hop for a node to other node is calculated basing on the priority and the requirement for the route. These routes in the tables are now associated with the pheromone amount deposited where the pheromone amount associated with the routes is basing upon their quality of services. The best route available is thus associated with the highest pheromone count.

The above given algorithm is more suitable for a network with few nodes or scarcely populated nodes. With scalability or huge networks with large no of nodes lot of memory is used in storing the tables and exchanging of those tables. In future these factors can be focused while searching for optimal route along with efficient management of battery power by a node with the help of which a node can be active for a longer period of time.

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