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A SURVEY ON STIGMERGETIC CONTROL PROTOCOLS FOR DISTRIBUTED AD HOC WIRELESS NETWORK

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ABSTRACT

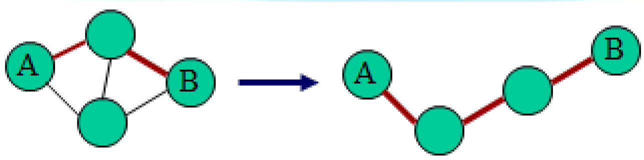
A MANET is an autonomous collection of mobile devices connected via wireless links where these network is decentralized, where all network activity including discovering the topology and delivering messages must be executed by the nodes themselves, i.e., receiving and forwarding of data will be incorporated into mobile nodes. A vital challenge, which is considered as heart of building a MANET, is finding the shortest path from source node to destination node. Therefore, developing a MANET goes hand in hand with developing a good routing protocol to find the optimal path in such a dynamic network. In this paper we review, a collection of ant colony algorithms which monitor traffic and provides an optimal solution of good path. Moreover, we discuss the general principles and applications of swarm intelligence routing.

KEYWORDS
Ad hoc, Ant Colony, Stigmergy, Swarm intelligence.

1. INTRODUCTION

A MANET is built dynamically by a loosely connected domain of routers. These routers may communicate over wireless channels with asymmetric reachability, may be mobile, and may join and leave the network at any time [1]. The system was designed to self-organize, self-configure, and detect radio connectivity for the dynamic operation of a routing protocol without any support from fixed infrastructure. This network uses multi-hop radio relaying. The routing and resource management are done in a distributed manner in which all nodes coordinates to enable communication among them. This requires each node more intelligence so that it can function both as a network host for transmitting and receiving data and as a network router for routing packets from other nodes. Since ad hoc networks can be deployed quickly it finds applications in many areas, such as battle field surveillance, collaborative and distributed computing, earth quake monitoring and tsunami monitoring. However their low battery power, bandwidth constraint, quality of service, network lifetime raises several issues to these autonomy requirements. So while designing a protocol these issues should be taken into account, mainly mobility of nodes from one place to another should be considered while designing the protocol. Since the network topology is dynamic, when a link goes down, all paths that use that link are broken and have to be repaired.

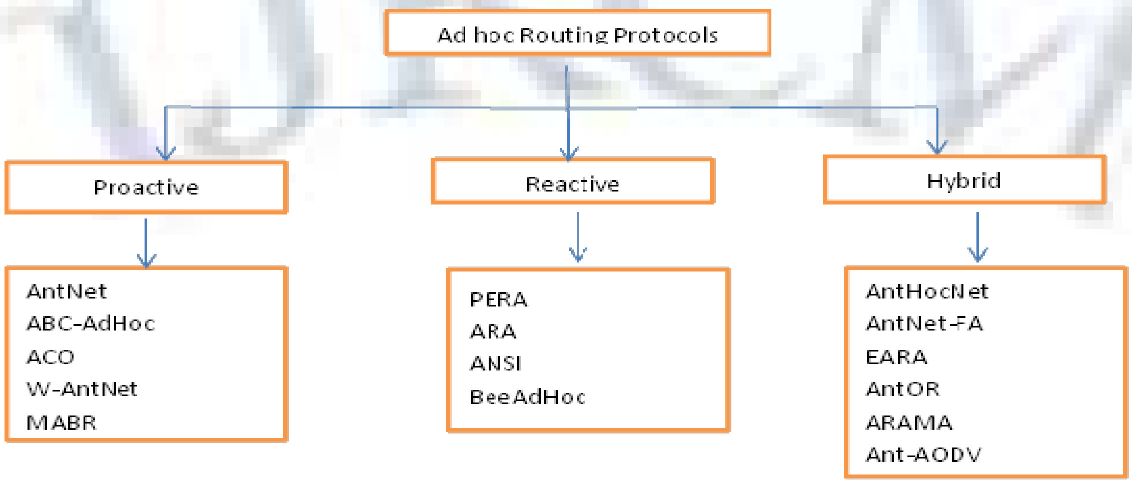
FIG 1: FREQUENT CHANGES OF TOPOLOGY



Routing protocols for ad hoc wireless network can be classified into several types based on different criteria. In proactive protocols, every node maintains the network topology information in the form of routing tables by periodically exchanging routing information. Routing information is generally flooded in the whole network. Whenever a node requires a path to a destination, it runs an appropriate path finding algorithm on the topology information it maintains, whereas, the reactive protocols do not maintain the network topology information. They obtain the necessary path when it is required, by using a connection establishment process. Hence these protocols do not exchange routing information periodically. Hybrid protocols combine the features of both above two categories.

Swarm intelligence looks at nature as a source of inspiration, studying the collective behavior and properties of complex, self-organized, decentralized systems with social structure as fish schools, bird flocks, ant colonies and animal herds. The aforementioned systems are organized in small societies (swarms) [4]. Grass's used the term *stigmergy* to describe this particular type of communication in which the "workers are stimulated by the performance they have achieved". The two main characteristics of stigmergy that differentiate it from other forms of communication are the following. Stigmergy is an indirect, non-symbolic form of communication mediated by the environment insects exchange information by modifying their environment; and Stigmergic information is local: it can only be accessed by those insects that visit the locus in which it was released (or its immediate neighborhood). In section 2 we present the basics and the background of ant colony optimization meta-heuristic. In section2, 3, and 4 we present an algorithm for proactive, reactive and hybrid algorithm respectively. Section 5 present conclusions.

FIG. 2: CATEGORIZATION OF SWARM ROUTING PROTOCOLS



2. PROACTIVE BASED ALGORITHM

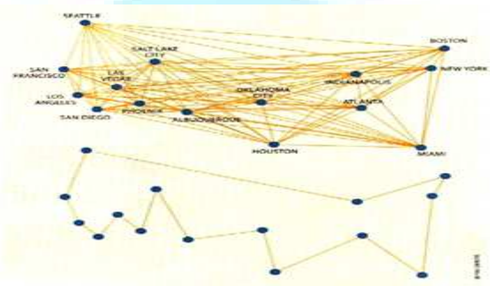
2.1 Ant Colony Optimization (ACO)

The ACO Ant Colony Optimization (ACO) metaheuristic, especially due to the fact that the ACO algorithm [2] was inspired by the behavior of an authentic ant colony, more specifically real ants in a food search process. When ants are out searching for food, they leave their nest and walk toward the food. When an ant reaches a crossroad, it must decide which way to follow. While walking, ants deposit pheromones, leaving behind tracks of the route taken. Ants can smell pheromone and they are more likely to follow paths characterized by strong pheromone concentrations. The pheromone trails allow ants to find their way to the food source, or back to the nest. The same pheromone can be used by other ants to find the location of the food sources discovered by their mates. Based on this approach, there are many successful applications about the combinatorial optimization problems such as the Traveling Salesman Problem (TSP), Vehicle Routing Problem (VRP) and routing algorithms in mobile ad hoc networks. The ACO algorithm has three important steps (1). Generate solution (2). Update action probability (3). Pheromone update with these steps ACO can be implemented on every discrete optimization problem. At first all solutions will be distinct and then we should compute probability and update pheromone for each of them.

2.2 ACO for the travelling Salesman Problem

In the traveling salesman problem, a set of cities is given and the distance between each of them is known. The goal is to find the shortest tour that allows each city to be visited once and only once. In more formal terms, the goal is to find a Hamiltonian tour of minimal length on a fully connected graph. In ant colony optimization, the problem is tackled by simulating a number of artificial ants moving on a graph that encodes the problem itself: each vertex represents a city and each edge represents a connection between two cities. A variable called pheromone is associated with each edge and can be read and modified by ants. Ant colony optimization is an iterative algorithm. At each iteration, a number of artificial ants are considered. Each of them builds a solution by walking from vertex to vertex on the graph with the constraint of not visiting any vertex that she has already visited in her walk. At each step of the solution construction, an ant selects the following vertex to be visited according to a stochastic mechanism that is biased by the pheromone: when in vertex *i*, the following vertex is selected stochastically among the previously unvisited ones. In particular, if *j* has not been previously visited, it can be selected with a probability that is proportional to the pheromone associated with edge *(i, j)*. At the end of an iteration, on the basis of the quality of the solutions constructed by the ants, the pheromone values are modified in order to bias ants in future iterations to construct solutions similar to the best ones previously constructed.

FIG. 3: TRAVELLING SALES ANT



3. REACTIVE BASED ALGORITHMS

3.1 Probabilistic Emergent Routing Algorithm (PERA)

Probabilistic Emergent Routing algorithm (PERA), (Baras and Mehta) is purely reactive algorithm; forward ants are only sent out at the start of a communication session, or when all existing routing information is out of date. They are flooded through the network towards the destination. For every copy of the forward ant that reaches the destination, a backward ant is sent to the source, so that multiple paths are created at the route setup time.in simulation studies, PERA is found to have a performance that is comparable to AODV itself.

3.2 Ad hoc Networking with Swarm Intelligence (ANSI)

ANSI proposed by (Sundaram Rajagopalan) [5] is a hybrid routing protocol for hybrid ad hoc networks comprising of both proactive and reactive routing components. Pure MANET (mobile) nodes in ANSI use only reactive routing, and choose routes deterministically, while nodes belonging to more capable, infrastructured networks use a combination of both proactive and reactive routing and perform stochastic routing when multiple paths are available. The outline of the process of ANSI routing is as follows:

When a route to a destination D is required, but not known at a node S, S broadcasts a forward reactive ant to discover a route to D. When D receives the forward reactive ant from S, it source-routes a backward reactive ant to the source S. The backward reactive ant updates the routing table of all the nodes in the path from S to D, allowing for data transfer from S to D. When a route fails at an intermediate node X, X first checks if there are other routes which can be used to route the packet to D. If not, then ANSI buffers the packets which could not be routed and initiates a route discovery to find D by using a forward reactive ant to perform local route repair. Additionally, X sends a route error message back to the source node S. Nodes belonging to more capable; infrastructure networks maintain routes to their connected components proactively, by periodic routing updates using proactive ants. Nodes belonging to more capable, infrastructured networks also use stochastic routing when multiple paths are available. In addition, each node in the infrastructure collects information about which mobile nodes are connected to which infrastructure node. When a route at D is known at a MANET node S, ANSI deterministically chooses the best next hop to reach the destination. If S is part of a highly capable infrastructure, then S may choose to perform stochastic routing to the destination D, depending on the availability of multipath routes.

4. HYBRID BASED ALGORITHM

4.1 An Adaptive Nature-Inspired Algorithm for Routing in Mobile Ad Hoc Networks (AntHocNet)

AntHocNet [6] is a hybrid multi-path algorithm designed along the principles of ACO-based routing in ad-hoc networks. The algorithm has four major phases: reactive path setup, stochastic data routing, proactive path maintenance and exploration, and handling link failures. The reactive path setup phase has reactive forward ant-like agents launched by the source in order to find multiple paths to the destination. Similarly, backward ant-like agents return to the source to set up the paths. The path setup phase creates a number of good paths between the source and the destination, which can be used for subsequent routing. The forwarding of data packets takes place stochastically. When a node has multiple hops for the destination of the data, it will randomly select one of them with a probability calculated as a function of their quality. This procedure leads to automatic load balancing.

The next phase is of proactive path maintenance and exploration where some control packets are sent in the network to improve the quality of the paths. In order to guide the path of the forward ants better, the algorithm also makes use of hello packets, which are short messages broadcasted by the nodes after a constant interval of time. These messages are also used to detect broken links. An updated view of its immediate neighbors is maintained by AntHocNet in order to detect link failures in the soonest possible time. It broadcasts a link failure notification message when a broken link is identified. Including the above, other ACO-based routing schemes such as AntNet devised for ad-hoc networks, were not targeted towards energy conservation. AntHocNet emerges as a reactive, adaptive, multipath and proactive algorithm (hybrid).it is reactive because it has agents operating on-demand to set up routes to destinations. It is proactive because it has agents collecting information and these agents can discover new routes which serve as alternatives if a link fails. It is a multipath because it provides different routes to send information to the destination. It is adaptive because it adapts to traffic conditions and networks. However, AntHocNet is less efficient in terms of routing overhead.

4.2 Ant Routing Algorithm for Mobile Ad hoc networks (ARAMA)

Ant Routing Algorithm for Mobile Ad hoc networks (ARAMA) proposed by (Osama H. Hussein) has many advantages. ARAMA is a reliable and survivable routing algorithm. ARAMA has many of the on-demand and table routing advantages and at the same time avoids many of their drawbacks. In addition, ARAMA is self-built and self-configured optimization algorithm that matches the characteristics of MANETs. It depends on probability routing tables, thus providing a high number of redundant and already graded paths to the destination, which increases the survivability of the algorithm. When the best path fails (due to mobility, node battery depletion, etc.), the algorithm immediately uses the next available path. These paths increase the survivability of the algorithm. The updating of the tables is done on demand and is done mainly in the nodes, which leads to the best paths. This lowers the overhead comparable to both table driven algorithms and on demand algorithms. Both table driven and on demand algorithms updates needed and unneeded paths to the destination. In ARAMA, every path discovery packet (ant) generated at the source will result in number of receptions/transmissions proportional to the distance (number of hops) from the source to the destination. This number in the ARAMA case is less than the case of other algorithms, which depend on flooding. In these algorithms, every path discovery results in a number of reception/transmissions proportional to the number of nodes in the network.

ARAMA is a suitable routing algorithm for managing the energy usage in MANETs. ARAMA is a dynamic routing algorithm with controlled routing overheads. The routing packets are concentrated in the best paths regions. This allows better optimization with lower number of packets. In addition, old explored, unexplored, and bad region are visited with lower rate. This controlled overhead increases the scalability of ARAMA. In addition, ARAMA is self-built and self-configured optimization algorithm that matches the characteristics of MANETs. The algorithm can use different parameters in the optimization process. In this paper, the number of hops and the batteries' remaining energy has been applied as optimization parameters. The algorithm has the ability to continuously check for better paths in the network with controlled overheads, which make the algorithm more suitable for network resources management. ARAMA combines many advantages of the on-demand-based and table-based routing algorithms. The redundant paths increase the survivability of the algorithm.

5. CONCLUSION

Ad hoc networks consist of large sets of resource-constrained nodes. The design of effective, robust, and scalable routing protocols in these networks is a challenging task. On the other hand, the relatively novel domain of swarm intelligence offers algorithmic design principles, inspired by complex adaptive biological systems that well match the constraints and the challenges of ad hoc networks. Therefore, a number of routing protocols for ad hoc network have been developed in the last years based on SI principles, and, more specifically, taking inspiration from foraging behaviors of ant and bee colonies. In this paper, we have presented a rather extensive survey of these SI-based algorithms for routing in ad hoc networks. Note that although these routing algorithms show promising results, but should be implemented very carefully. Some parameters such as number of ants, evaporation rate, etc are influence in the simulation results. If these parameters select carefully, these algorithms are very well substituting for traditional routing protocols.

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