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QOS IN MANET USING SWARM INTELLIGENCE

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ABSTRACT

Mobile devices are able to communicate through wireless connections because mobile ad hoc networks help to build a communication network by which these devices can communicate in absence of wires. Routing is the process of directing/routing data packets from a starting node to a given destination node within a network.
This task is a bit complex in Mobile Ad Hoc Networks: due to the mobility of the network components and the lack of centralized control, routing algorithms needs be robust and adaptive and should be able to work in a decentralized and self organizing manner. In this paper, we describe an algorithm which draws inspiration from Swarm Intelligence to achieve these characteristics. More specifically, we borrow ideas from ant colonies and from the Ant Colony Optimization framework. In an extensive set of simulation tests, we compare our routing algorithm with a state-of-the-art algorithm, and show that it can perform better over a wide range of different scenarios and for a number of different evaluation measures. In particular, we show that it scales better with the increasing number of nodes in the network.

Keywords: (MANET, SI, ACO)

I. INTRODUCTION

History:

Beni & Wang has introduced “swarm intelligence” in the context o cellular robotic system, in 1989. “The emergent collective intelligence of groups of simple agents” (Bonabeau et al., 1999) is a Swarm Intelligence.
A Mobile Ad hoc Network (MANET) is a collection of autonomous self-organized nodes (mobile devices). For MANETs many conservative routing algorithms have been projected. Swarm Intelligence (SI) recently captured a lot of attention in researches on network routing. For MANET routing lots of innovative researches have planned the implementation of Swarm Intelligence. Swarm Intelligence (SI) specifies to complex behaviors that are outcome of extremely easy individual behaviors and relations, which is frequently observed in natural world, particularly observed in common insects like bees, ants, fishes etc. Even though every personality possesses some cleverness and merely follows basic policies using limited information obtained from the surroundings. From scattered Swarm Intelligence (SI) in biological systems Ants routing similar vital mechanisms and turns away to turn into an exciting explanation where routing is a difficult task. Because its dynamic and adaptive nature Ants based routing is ahead additional. Researchers have proposed a number of algorithms based on swarm intelligence. We study bio Inspired routing protocols for MANETs, in this paper. Routing solutions try to reduce control traffic and deal with the behavior of the network, to protect both bandwidth and power at nodes.

The method of routing execution in a network is a major issue which affects the performance the network. Routing algorithms employed in conventional wired networks are impractical in ad hoc networks due to their inability to adapt to the changing topology in a mobile environment. Generally, routing is the process of discovering, selecting, and maintaining paths from a source node to destination node in order to deliver data packets. The goal of every routing algorithm is to direct traffic from source to destination, maximizing network performance whilst minimizing cost. This is the main challenge in MANET. Because the MANET possesses dynamic and random characteristics. Nodes movement is arbitrarily and at variant speed, often results in connectivity problems. The high degree of mobility and the arbitrarily movement of nodes in MANET causes links between hosts to break frequently.

Routing protocols for MANETs are classified into three categories [4][16] proactive, reactive and hybrid. Proactive routing protocols exchange control packets among mobile nodes and continuously update their routing tables. This results in high overhead, congestion of the network and requires huge memory. The advantage of proactive protocols is that nodes possess correct and updated information. Reactive routing protocols establish a route to the destination as and when it is required.

The advantage of these protocols is that the routing tables are not continuously updated thus avoids overhead. The aim of these protocols is to save time in the route discovery process, since the reactive protocols are designed to reduce the latency which is critical in this kind of protocols. Hybrid protocols use a combination of both proactive and reactive protocols to maintain routes.

Researchers have proposed several routing protocols designed to provide communication in wireless environment, such as AODV [6], DSDV[5], ZRP[7], LAR[8], OLSR and DYMO[9] etc. Nature inspired routing protocols have been becoming the focus of research because they achieve the complex task of routing through simple agents that traverse the network and gather routing information in an asynchronous fashion.

The first algorithm that presented a detailed scheme for MANET routing based on ant colony principles is *ARA* [10]. The algorithm has its foundation in *ABC* [11] and AntNet[12] routing algorithms for fixed networks, which are inspired by the pheromone laying behavior of ant colonies. The algorithm floods ants to the destinations while establishing reverse links to the source nodes of the ants. *AntHocNet* has been recently proposed which is a hybrid algorithm having both reactive and proactive properties. The algorithm tries to adapt most of the features of the original *AntNet* and shows promising results in the simulation tests over *AODV*. Termite is another MANET routing algorithm inspired from termite behavior. Recently, Wedde, Farooq and Zhang have proposed a novel routing algorithm for fixed networks which is inspired by foraging principles of honey bees. The algorithm is simple but delivers the same/better performance as that of AntNet [17].

This paper examines the qualitative comparisons and challenges of routing protocols for MANET based on the technique of Swarm Intelligence. The rest of the paper is organized as follows.

Section II introduces the Swarm Intelligence.

Section III discusses the Ant Colony based algorithms.

Section IV discusses [15]Bee inspired routing techniques. Finally

Section V represents the conclusion of this paper.

II.SWARM INTELLIGENCE

Swarm Intelligence [1] is based on the term of self planned system and joint behavior in decentralized systems which is similar to an artificial intelligence technique. Some biological insects like bees, ants, wasps etc are considered in Swarm. The attempts of an ant colony for collecting food and the speedily synchronized flight of a group of birds through very tiny visual communication, constructing nests, etc are a few of the examples of appearance in natural world. In fields like Artificial Intelligence, networking, telecommunications, process optimization, software testing, routing, Robotics etc Swarm Intelligence has set up huge applicability.

In nature several animals live in large swarms like insect colonies, bird flocks or fish schools. The reason is that in the swarm each animal is more effective for evolution than single individuals. Many social insects like ants, bees, termites, or wasps live in colonies or hives. They exhibit an astonishingly well-developed social behavior and are capable of self-organizing, even in the absence of a central leader like a queen/king. Honey bees communicate locations of food sources by the language of dance that is understood by all other honey bees in a group. While many insects use a form of indirect communication called stigmergy. **Stigmergy** works by leaving traces in the environment that can be understood by other insects.[14]Termites use stigmergy to build complex nests by simple rules. A termite constructing a nest deposits material like a mud ball and invests it with pheromones, a chemical that can be smelled by other termites. The smell of pheromones encourages other termites to deposit their material close to freshly deposited pheromones. This way, a group of termites can manage to synchronize so that they all can work on the same spot.

2.1 Ant Colony System

Ant Colony Optimization (ACO) is a branch of a newly developed form of Artificial Intelligence called Swarm Intelligence. In groups of insects, which live in colonies, such as ants and bees, an individual can only perform simple tasks on its own, the colony's cooperative work is reason behind the intelligent behavior it shows.

The characteristics of ants are similar to the characteristics of MANETs. This helps us to apply the food searching characteristics of ants for routing packets in MANETs effectively.

The basic principle of an ant routing algorithm is depositing of pheromone/leaving traces on the path followed by the ant. They follow simple rule of following the path having higher concentration of pheromone. The pheromone concentrations on a path help other ants to find their way to the food source. Thereby more ants follow the same path and more and more pheromone is deposited on the path which is the shortest and most effective route to the food source. It was found that the pheromone-trail-following behavior leads to the shortest path which is followed by other ants of the colony. When a previously found short route gets blocked/ lengthened due to an obstacle in the route, the alternate short route get strengthened with higher pheromone content due to shorter end-to-end travel time and more ants move to this route. Hence the path can also dynamically adapt to fast changes in the environment. Figure 1 shows the scenario in which the best route between two choices is chosen by ants.

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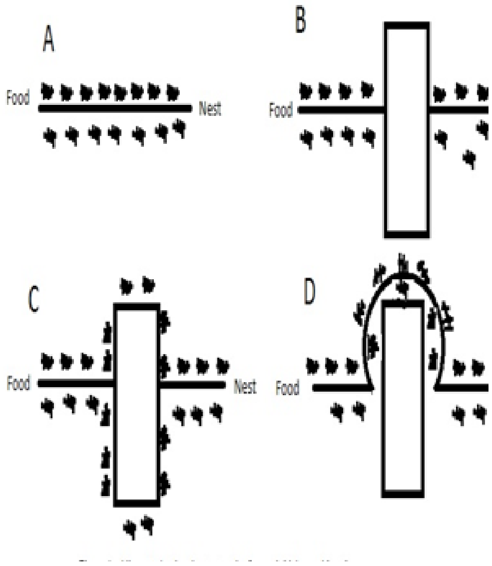

Figure 1 : All ants take the shortest path after an initial searching time

On the basis of Figure 2 (a), (b) and (c) in comparison with routing of packets in MANETs, we can define the Ant routing basic principle as follows:

1. Each network node sends a number of discovery packets which are called forward ants (F-ANT), are sent towards the destination nodes of the network as shown in Figure 2(a).

2. The routing tables maintained at each node are replaced with stochastic tables, which select next hop according to the weighted probabilities available.

3. Accordingly, ants deposit pheromone on the crossed links, that is, in the nodes routing tables are changed for selection of the next node in the network.

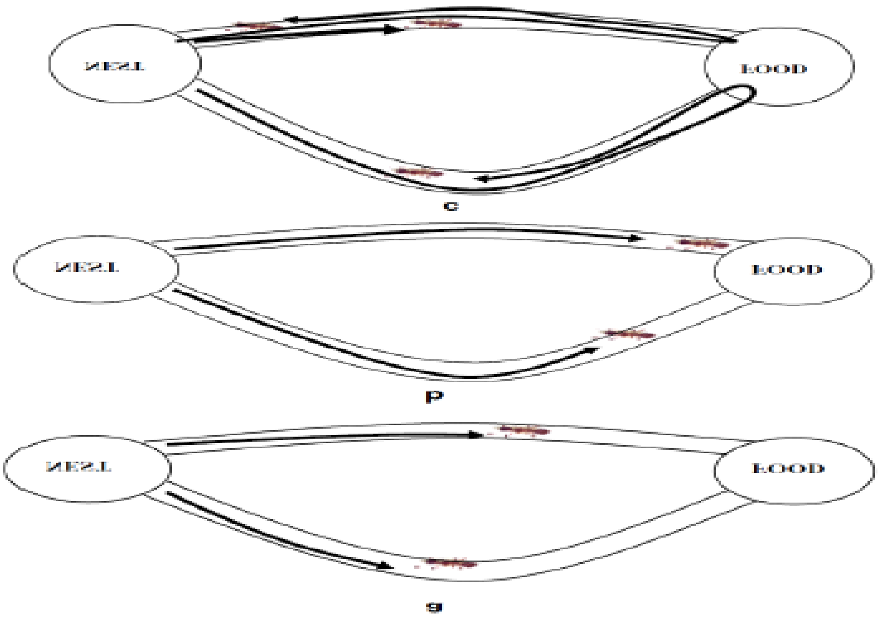

Figure 2: Basic ant route system

4. When forward ant (F-ANT) reaches the destination node, it generates a backward ant (B-ANT) and then dies. Similarly in MANETs routing, the new packet created and sent back to the source node will propagate through the same path selected by the forward ant (F-ANT). This is shown in Figure 2(c).
5. Now backward ant (B-ANT) deposits pheromone on the crossed links. It means that it updates the routing table of the nodes along the path followed by forward ant (F-ANT).
6. After arrival to the source node, the backward ant (B-ANT) dies.

III. BASICS AND BACKGROUND

The ant colony optimization meta-heuristic is a particular class of ant algorithms. Ant algorithms are multi-agent systems, which consist of agents with the behavior of individual ants.

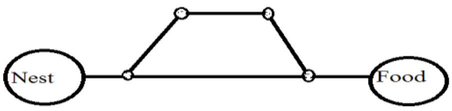

Figure 3. All ants take the shortest path after an initial searching time.

3.1. Basic ant algorithm

The basic idea of the ant colony optimization meta heuristic is taken from the food searching behavior of real ants. When ants are on their way to search for food, they start from their nest (source) and walk toward the food (destination). When an ant reaches an intersection (intermediate node), it has to decide which branch to take next. While walking, ants deposit *pheromone*1, which helps them mark the route taken. The concentration of pheromone on a particular path is an indication of its degree of usage. With time the concentration of pheromone tends to decreases due to diffusion effects. This property is important because it is integrating dynamics into the path searching process. Figure 1 shows a scenario with two routes from the nest to the food place. At the intersection, for the first time ants randomly select the next branch. As the below route is shorter than the upper one, the ants which take this path will reach the food place (destination) first. On their way back to the nest (source), the ants again have to select a path at the intersection. After a short time the pheromone concentration on the shorter path will be higher than on the longer path, because the ants using the shorter path will increase the pheromone concentration faster. The shortest path will thus be identified and eventually all ants will only use the shorter path only. This behavior of the ants can be used to find the shortest path in networks. Especially, the dynamic component of this method allows a high adaptation to changes due to mobility in mobile ad-hoc network topology, since in these networks the existence of links are not guaranteed and link changes occur very often.

3.2. Simple ant colony optimization meta-heuristic algorithm

Let $G = (V,E)$ be a connected graph with $n = |V|$ nodes. The simple ant colony optimization meta-heuristic can implemented to find the shortest path between a source node v_s and a destination node v_d on the graph G. The path length is given by the number of nodes on the path. Each edge $e\ (i, j) \in E$ of the graph connecting the nodes v_i and v_j has a variable $\phi_{i,j}$ (artificial pheromone), which is modified by the ants when they visit the node. The pheromone concentration, $\phi i, j$ is an indication of the usage of this edge.

An ant located in node Vi uses pheromone $\phi i,j$ of node $Vj \in Ni$ to compute the probability of node Vj as next hop. Ni is the set of one-step neighbors of node Vi.

$$P\ i,j = \begin{cases} \dfrac{\phi i, j}{\sum_{j \in N_i} \phi i, j} & \text{if } j \in N_i \\ 0 & \text{if } j \in N_i \end{cases}$$

The transition probabilities $p_{i,j}$ of a node v_i fulfill the constraint:

$$\sum_{j \in N_i} p_{i,j} = 1,\ i \in [1,N]$$

During the route finding process, ants deposit pheromone on the edges. In the simple ant colony optimization meta-heuristic algorithm, the ants deposit a constant amount $\Delta\phi$ of pheromone. An ant changes the amount of pheromone of the edge $e\ (v_i, v_j)$ when moving from node v_i to node v_j as follows:

$$\varphi_{i,j} := \varphi_{i,j} + \Delta\varphi \qquad (1)$$

Like real pheromone the artificial pheromone concentration decreases with time to inhibit a fast convergence of pheromone on the edges. In the simple ant colony optimization meta-heuristic, this happens exponentially:

$$\varphi_{i,j} := (1 - q) \cdot \varphi_{i,j},\ q \in (0, 1) \qquad (2)$$

IV. THE ROUTING ALGORITHM

In this section we discuss the adaptation/feasibility of the ant colony optimization meta-heuristic for mobile ad-hoc networks and describe the **A**nt colony based **R**outing **A**lgorithm (ARA). The routing algorithm is similarly constructed as many other routing algorithms and consists of three phases.

4.1. Route Discovery Phase

The first phases being the route discovery phase new routes are created. The creation of new routes is achieved by the use of a *forward ant* (FANT) and a *backward ant* (BANT). A FANT is an agent which establishes the pheromone track to the source node.

In contrast, a BANT establishes the pheromone track to the destination node. The FANT is a small packet having a unique sequence number. Nodes are able to distinguish between duplicate packets on the basis of the sequence numbers and the source address of the FANT.

A forward ant is broadcasted by the sender (source) and will be relayed by the neighbors of the sender (see figure 3). A node receiving a FANT for the first time, creates a record in its routing table. A record in the routing table is a triplet and consists of (destination address, next hop, pheromone value). The node interprets the source address of the FANT as destination address, the address of the previous node as the next hop, and computes the pheromone value depending on the number of hops the FANT needed to reach the node. Then the node relays the FANT to its neighbors node. Duplicate FANTs are identified through the unique

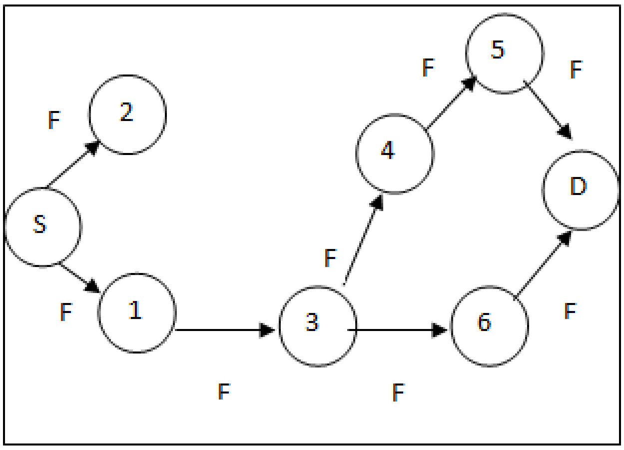

Figure 4. Route discovery phase. A forward ant (F) is send from the sender (S) toward the destination node (D). The forward ant is relayed by other nodes, which initialize their routing table and the pheromone values.

Sequence number and destroyed by the nodes. When the FANT reaches the target node, it is processed in a special manner. The target node extracts the information from the FANT and destroys it. Subsequently, it creates a BANT and direct it towards the source node (see figure 5). The BANT has the same function as the FANT, i.e. establishing a path to this node. When the sender receives the BANT from the destination node, the path is established and data packets can be transmitted.

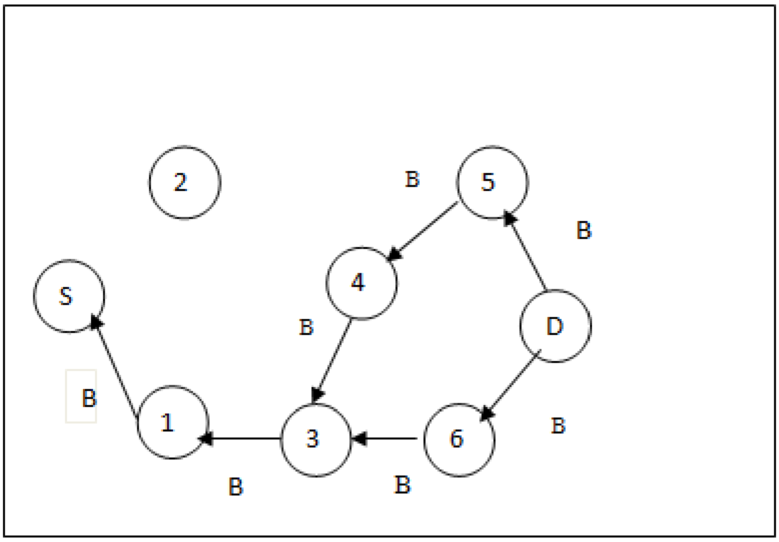

Figure 5. Route discovery phase. The backward ant (B) has the same task as the forward ant. It is send by the destination node toward the source node.

Figures 4 and 5 schematically depict the route discovery phase. In the depicted case, node 3 has two ways for the path, via node 4 and over node 6. In our case, the forward ant creates only one pheromone track toward the source node, but the backward ant creates two pheromone tracks toward the destination node. So multi-path routing is also supported by ARA.

source and destination nodes, subsequent data packets are used to maintain the path. Similar to the nature, established paths do not keep their initial pheromone values forever. When a node v_i relays a data packet toward the destination v_D to a neighbor node v_j, it increases the pheromone value of the entry (v_D, v_j , ϕ) by $\Delta\phi$, i.e., the path to the destination is strengthened by the data packets. In contrast, the next hop v_j increases the pheromone value of the entry (v_S, v_i, ϕ) by $\Delta\phi$, i.e. the path to the source node is also strengthened. The evaporation process of the real pheromone is simulated by regular decreasing of the pheromone values, which is performed according to equation 2.

The above method for route maintenance could lead to undesired loops. ARA prevents loops by a very simple method, which is also used during the route discovery phase. Nodes can recognize duplicate receptions of data packets, based on the source address and the sequence number. If a node receives a duplicate packet, it sets the DUPLICATE ERROR flag and sends the packet back to the previous node. The previous node deactivates the link to this node, so that data packets cannot be send to this direction any more.

4.3. Route Failure Handling

The third and last phase of ARA handles routing failures, which are caused especially through node mobility and thus very common in mobile ad-hoc networks. ARA recognizes a route failure through a missing acknowledgement. If a node gets a ROUTE ERROR message for a certain link, it first deactivates this link by setting the pheromone value to 0.

Then the node searches for an alternative link in its routing table. If there exists a second link it sends the packet via this path. Otherwise the node informs its neighbors, hoping that they can relay the packet. Either the packet can be transported to the destination node or the backtracking continues to the source node. If the packet does not reach the destination, the source has to initiate a new route discovery phase.

4.4. Properties of ARA

According to [3] a routing algorithm for mobile ad-hoc networks should fulfill the following requirements:

• **Distributed operation:** In ARA, each node owns a set of pheromone counter2 $\phi_{i,j}$ in its routing table for a link between node v_i and v_j . Each node controls the pheromone counter independently, when ants visit the node on route searches.

• **Loop-free:** The nodes register the unique sequence number of route finding packets, FANT and BANT, so they do not generate loops.

• **Demand-based operation:** Routes are established by manipulating the pheromone counter $\phi_{i,j}$ in the nodes. Over time, the amount of pheromone decreases to zero when ants do not visit this node. A route finding process is only run, when a sender demands.

• **Sleep period operation:** Nodes are able to sleep when their amount of pheromone reaches a threshold. Other nodes will then not consider this node. Additionally, ARA has the following properties:

• **Locality:** The routing table and the statistic information block of a node are local and they are not transmitted to any other node.

• **Multi-path:** Each node maintains several paths to a certain destination. The choice of a certain route depends on the environment, e.g., link quality to the relay node.

• **Sleep mode:** In the sleep mode a node snoops, only packets which are destined to it are processed, thus saving power.

4.5. Overhead of ARA

The expected overhead of ARA is very small, because there are no routing tables which are interchanged between the nodes. Unlike other routing algorithms, the FANT and BANT packets do not transmit much routing information. Only a unique sequence number is transmitted in the routing packets. Most route maintenance is performed through data packets, thus they do not have to transmit additional routing information. ARA only needs the information in the IP header of the data packets.

V. CONCLUSION

To discover a trail among the communication end points pleasing user's QoS requisite which want to be keep stability is the major challenges exist in ad hoc network. The algorithm consists of both reactive and proactive components. In a reactive path setup phase, an option of multiple paths selection can be used to build the link between the source and destination during a data session. For multimedia data to be sent, we need stable, failure-free paths and to achieve that the paths are continuously monitored and improved in a proactive way. Our previous work [8] also guaranteed QoS based proactive routing using flooding technique by best utilization of network resources. This proposal is based on ant-like mobile agents to establish multiple stable paths between source and destination nodes. Ant agents are used to select multiple nodes and these nodes use ant agents to establish connectivity with intermediate nodes. In future, this work can be extended for multicasting by using swarm intelligence with other QoS objectives such as load balancing, energy conservation, etc.

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