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Swarm Intelligence based Energy Efficient Routing Protocol for Wireless Ad-hoc Networks

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ABSTRACT

Mobile Ad Hoc Networks are communication networks built up of a collection of mobile devices which can communicate through wireless connections. Mobile Ad-hoc network (MANET) has emerged as the self organized wireless interconnection for the various applications in random topology. However, achieving reliable multicast transmission in MANET is crucial due to the change in network topology caused by the node mobility. Wireless Networks are characterized by having specific requirements such as limited energy availability and reduced processing power. In this paper deals with the inability of the network to recover in case of failure networks, to reduce the maintenance overhead, increase the path stability, reducing the congestion in Mobile Ad-hoc network and with the inability of the network to recover in case of power problem in wireless network . Ant based routing protocols can add a significant contribution to assist in the maximisation of the network life-time, but this is only possible by means of an adaptable and balanced algorithm that takes into account the Wireless Sensor networks main restrictions.We are introducing a new concept of two ants, one acting as load agent and another as strategy agent to ensure better performance. The strategy agent is software acting as a processor which controls and guide the load agents as forward ants and backward ants.We are using a Backpressure technique for network activities as link failure and restoration of link information. We carry out these simulation results using NS 2.34.

Keyword: MANET, congestion, energy, QoS

1 Introduction

A mobile ad-hoc network (MANET) is a set of mobile nodes which communicate over radio and do not need any infrastructure. This kind of networks are very flexible and suitable for several situations and applications, thus they allow the establishing of temporary communication without pre installed infrastructure.Routing is the task of directing data packets from a source node to a given destination. This task is particularly hard in Mobile Ad Hoc Networks, due to the mobility of the network elements. In this paper, we describe an algorithm which draws inspiration from Swarm Intelligence to obtain these characteristics. More especially, we consider ideas from ant colonies and the Ant Colony Optimization framework. The networks are becoming more and more complex and are desirable that they can self-organize and self- configured, adaptive to new situations in terms of traffic, services, network connectivity, etc. To support new paradigm distributed way. In this paper we present a new approach for an on-demand ad-hoc routing algorithm, which is based on swarm intelligence. Ant colony algorithms are a subset of swarm intelligence and consider the ability of simple ants to solve complex problems by cooperation. The interesting point is, that the ants do not need any direct communication for the solution process, instead they communicate by stigmergy.

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, see [3, 1] for more information.

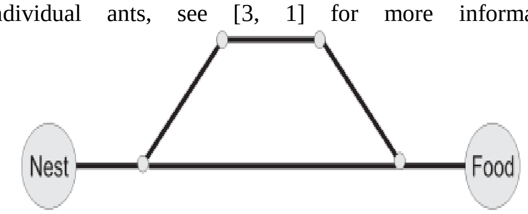


Fig 1: Ants scenario with two routes.

The basic idea of the ant colony optimization met heuristic is taken from the food searching behavior of real ants. When ants are on they way to search for food, they start from their nest and walk toward the food. When an ant reaches an intersection, it has to decide which branch to take next. While walking, ants deposit pheromone1, which marks the route taken. The concentration of pheromone on a certain path is an indication of its usage. With time the concentration of pheromone decreases due to diffusion effects.

This property is important because it is integrating dynamic into the path searching process. Figure 1 shows a scenario with two routes from the nest to the food place. At the intersection, the first ants randomly select the next branch. Since the below route is shorter than the upper one, the ants which take this path will reach the food place first. On their way back to the nest, the ants again have to select a path. 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 this one. 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 in mobile ad-hoc network topology, since in these networks the existence of links are not guaranteed and link changes occur very often.

2 System model descriptions

Swarm intelligence is a type of artificial intelligence based system on the collective behavior of decentralizes self organized system. Swarm intelligence appears in biological swarm of certain insect species. It gives rises to complex and thousands of autonomous swarm members.

A. Pheromone table: Paths are implicitly defined by the pheromone tables which are kept locally at each node. An entry of the pheromone table I at node I contain a value indication the estimated goodness of going from I over neighbor n to reach destination d. this goodness is a combined measure of path end to end delay and number of hops

B. Reactive path setup: When a source node s starts communication session with a destination node d, it broadcasts a reactive forward. At each node the ant either unicast of broadcast accordingly whether or not the current node has pheromone information for d. if information is available the ant chooses its next hop n with the probability Pnd which depends on the relative goodness if n as a next hop, expressed in the pheromone variable parameter which controls the exploratory behavior of the ants.

C.Proactive path maintenance and exploration: During the course of a communication session, source node send out proactive forward ants to update the information about currently used paths and try to find better paths. They follow pheromone and update routing tables in the same way as reactive forwards ants. Such continues sampling of paths and pheromone updating by ants is the typical mode of operation in ant inspired outing algorithms.

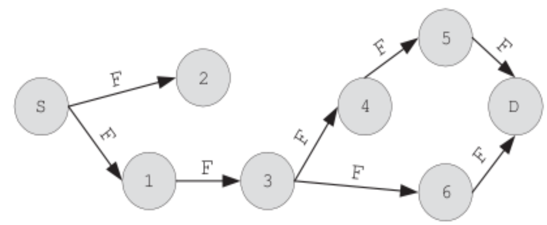
D. Stochastic data routing: Nodes in AntHocNet forward data stochastically According to the pheromone values. When a node has multiple next hops for the destination d of the data, it randomly selects one of them, with probability.

E. Link Failures: Nodes can detect link failures (e.g., a neighbour has moved away) when unicast transmissions fail, or when expected periodic pheromone diffusion messages were not received due to less available Bandwidth at node.

3 Description of the proposed Algorithm

The sequence of action in AntNet is as follows

1) Each network node lunch's forward ants to all destinations in regular time intervals.
2) The ant finds a path to the destination randomly based on the current routing tables.
3) The forward ant creates a stack, pushing in trip times for every node as that node is reached.
4) Backward ant generated after checking the received different ants, when backward ant pops the stack entries and follows the path in reverse.
5) The node tables of each visited are updated based on the trip times
6) The message ant is generated even power loss like as link failure occurs.



Following statements describe the functions of a node for each type of ant for path from source to destination

if (Forward ant)

{ Get the next node based on the value of gene position

if (the link is available and no loop caused) then

{ Update forward ant with network status (stack)

Send forward ant to the next node }

else if (no such link exist)

{ Create backward ant and load contents of forward

ant to backward ant (queue).

Send backward ant towards source along the same path

as forward ant }

}

if (backward ant)

{ if current node is source node

Store path and kill backward ant

Update routing table }

else

{ Forward backward ant on to link available on queue

Update routing table }

if (next node is not available)

Kill backward ant

Else

{if link failure then

Update forward ant with network status as failure and stop

sending information (data)

Send message ant to the previous node regarding link

failure update table for alternative path till path is recovered

or restore}

} // End of proposed algorithm

4 Analysis of system mode

The Mobile Ad-hoc Network (MANET) has available bandwidth B and no of nodes be n and distance between nodes is D and load at each node be L. The system model wireless network of five nodes shown in fig-2

• B = Total Available Bandwidth

• nj = Nodes Name

• Dij = Distance Between node nj and nj (estimated goodness of path between two nodes)

•Lj = Bandwidth Being Used at node nj.

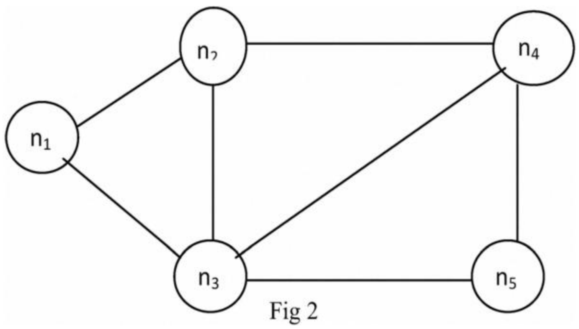


Fig 2

So in order to select path from nl to ns

It may select some of the path from

1. PI:nl-n2-n4-n5, or

2 .P2:nl-n3-n5, or

3 .P3:nl-n2-n3-n4-n5, or

4 .P4:nl-n2-n3-n5

In the fig-2 Distance Nij of path between nodes (i) to node (j) are as follows

D12=10, D13=15, D24=5, D23=15, D35=1O D34=20, D45=15

The load at the each node (Traffic Load)

LI=l0, L2=8, L3=16, L4=20, L5=5

The queue length of each node (Bandwidth Concept)

Q1=l0, Q2=8, Q3=16, Q4=20, Q5=5

Arrange the paths in ascending order with respect to Distance, load and queue length as follows in the table with their position. The sum of position of path

P1: (10+5+15) =30

P2: (15+10) =25

P3: (10+ 15+20+25) =60

P4: (10+15+20) =35

From above it is clear that the sum of position of pathP2 is minimum hence path P2 is selected. (Table 1).

Phermone table

Position	Path	Distance
1	n_1-n_2-n_4_n_5	***30***
2	n_1-n_3-n_5,	25
3	n_1-$n_2$$n_3$$n_4$$n_5$	60
4	n_1-n_2-n_3-n_5	35

5 Swarm Intelligence Ant Based Routing for WN

In this section we propose further improvements in the routing algorithm described in the previous section in order to reduce the communication load related to the ants and the energy spent with communications. We also propose new functions to update the pheromone trail. Since one of the main concerns in WN is to maximize the lifetime of the network, which means saving as much energy as possible, it would be preferable that the routing algorithm could perform as much processing as possible in the network nodes, than transmitting all data through the ants to the sink-node to be processed there.

To implement these ideas, the memory Mk of each ant is reduced to just two records, the last two visited nodes. Since the path followed by the ants is no more in their memories, a memory must be created at each node that keeps record of each ant that was received and sent.

Each memory record saves the previous node, the forward node, the ant identification and a timeout value. Whenever a forward ant is received, the node looks into its memory and searches the ant identification for a possible loop. If no record is found, the node saves the required information, restarts a timer, and forwards the ant to the next node. If a record containing the ant identification is found, the ant is eliminated. When a node receives a backward ant, it searches its memory to find the next node to where the ant must be sent.

The timer is used to delete the record that identifies the backward ant, if for any reason the ant does not reach that node within the time defined by the timer. The vector Ek was erased from the forward ants k, that now only carry the average energy till the current node (EAvgk), and the minimum energy level registered (EMink). These values are updated by each node that receives the forward ants. When the forward ant reaches the sink-node these values are used to calculate the amount of pheromone trail used by the corresponding backward ant:

$$\Delta T_k = \frac{1}{C - \left[{EMin_k - Fd_k} \middle/ {EAvg_k - Fd_k} \right]}$$

With these changes it is possible to reduce the ant's length by ~700%, and save on each ant hop the transmission of ~250 bytes. This is a significant achievement, since it allows the saving of precious energy levels on nodes. Calculating k _T only as a function of the energy levels of the path, as it is done in equation 4, can bring no optimized routes, since a path with 15 nodes can have the same energy average as a path with only 5 nodes. Therefore k _T must be calculated as a function of both parameters: the energy levels and the length of the path. This can be achieved by introducing the parameter Fdk in the equation 5, which represents the number of nodes that the forward ant k has visited. The equation used to update the routing tables at each node is now changed to:

$$T_k(r,s) = (1-\rho)\cdot T_k(r,s) + \left[\Delta T_k \Big/ \varphi \cdot Bd_k\right]$$

Where is a coefficient and Bdk is the travelled distance (the number of visited nodes), by backward ant k until node r. These two parameters will force the ant to loose part of the pheromone strength during its way to the source node. The idea behind this behavior is to build a better pheromone distribution (nodes near the sink node will have more pheromone levels) and will force remote nodes to find better paths. Such behavior is extremely important when the sink-node is able to move, since the pheromone adaptation will be much quicker.

6 Route Failure Handling

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.

7 Simulation Results

We evaluated the performance of Swarm Intelligence Based Energy Efficient Routing Protocol for Adhoc networks using Ns-2 and several measurement metrics were collected from our propose simulator to evaluate the performance of SIEERP. .Algorithm mostly selects the optimal path for transmission of packets from source to destination, implementation of two ants one as load agent and another strategy agent. The load agent uses the path information at each node to find the best path by considering the energy of each node. The strategy agent controls the behaviour of the load agents. This will lead in the improvement of the QoS. The Backpressure technique required to send a message Ant regarding the failure to the sender so that it will stop sending the message until the link failure is restored / recovered by using another alternative path. We investigate performance at various levels of mobility and node density, increasing network sizes, and different data traffic pattern. It observed that the curves decrease when the network density increases. In fact, the denser is a network, the higher is the number of nodes that compete for granting congestion in interfering links. The Fig.3 to Fig 10 show the throughput of all traffic flows, in comparison of single and double ant and with using the energy efficient routing protocol with available channel Bandwidth and Fig 11 shows the comparison of energy utilised by the nodes by using and not using the energy efficient routing protocol.

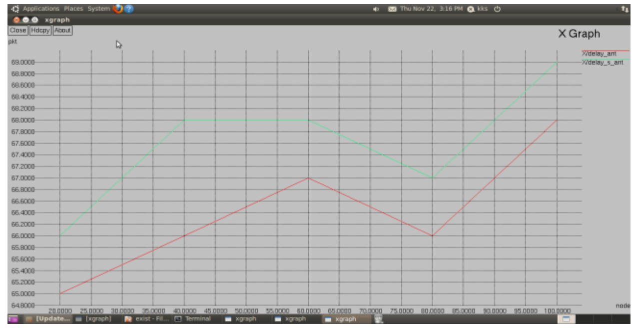


Fig 3

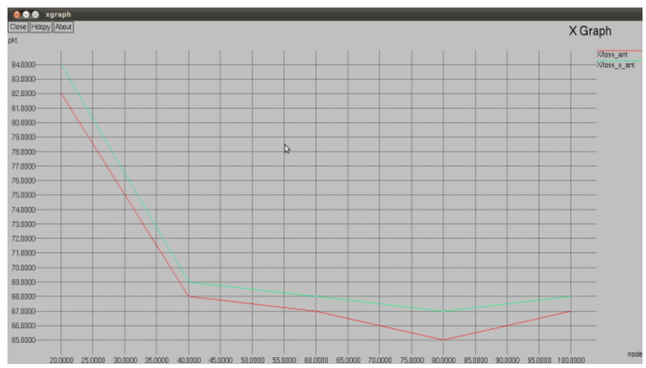


Fig 4

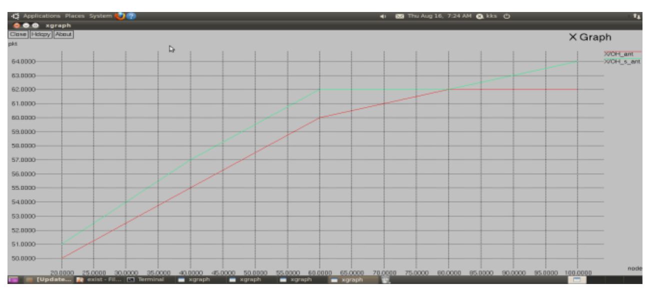


Fig 5

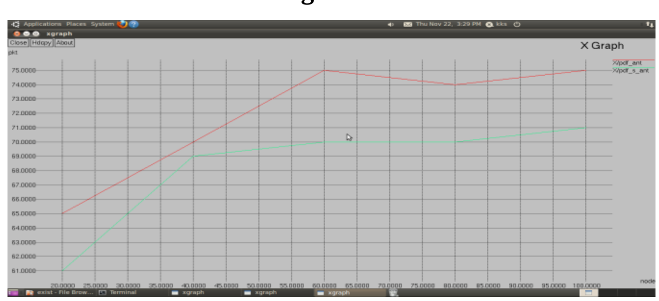


Fig 6

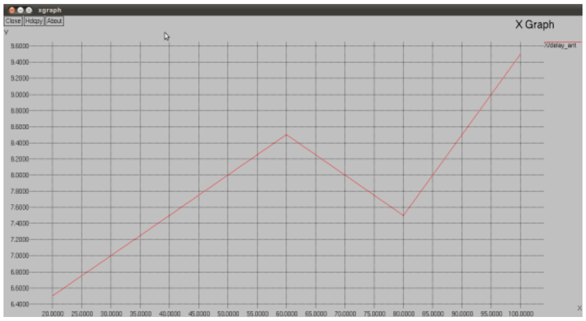


Fig 7

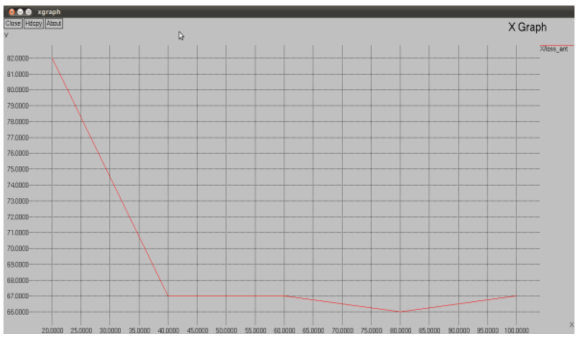


Fig 8

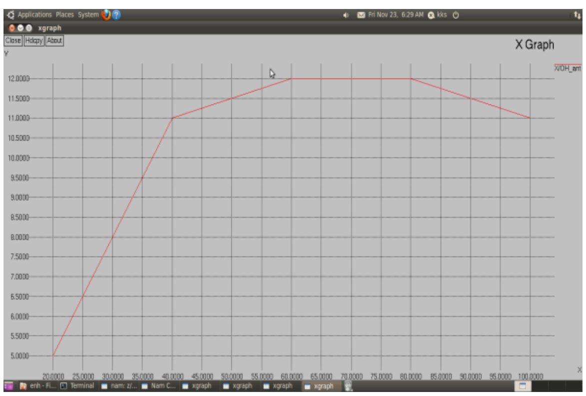


Fig 9

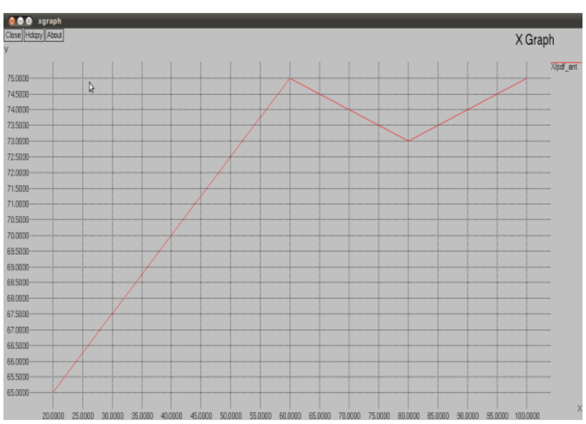


Fig10

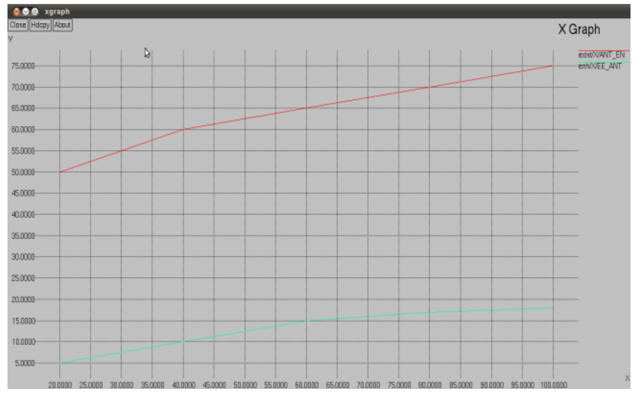


Fig11:

8 CONCLUSIONS

In this paper studied the application of the Ant Colony Optimization met heuristic to solve the routing problem in wireless networks. A basic ant-based routing algorithm was proposed, and several improvements, inspired by the features of wireless networks were considered and implemented. The resulting routing protocol, called Energy-Efficient Ant Based Routing uses lightweight ants to find routing paths between the sensor nodes and the sink nodes, which are optimized in terms of distance and energy levels. These special ants minimize communication loads and maximize energy savings, contributing to expand the lifetime of the wireless network. The experimental results showed that the algorithm leads to very good results in different

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