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RESEARCH ARTICLE

Swarm Intelligence for Network Communication Routing

Gauri Nagar[1], Arpit Sood[2], Monika Roopak[3]
[1]Student of BTECH CSE, Ansal Institute of Technology, India
[2]Student of BTECH CSE, Ansal Institute of Technology, India
[3]Senior Lecturer, Ansal Institute of Technology, India

[1] gauri.nagar91@gmail.com; [2] sood.arpit11@gmail.com; [3] monika.roopak@aitgurgaon.org

Abstract— In communications network research, there is currently an increasing interest for the paradigm of autonomic computing [3]. The idea is that networks are becoming more and more complex and that it is desirable that they can self-organize and self-configure, adapting to new situations in terms of traffic, services, network connectivity, etc. To support this new paradigm, future network algorithms should be robust, work in a distributed way, be able to observe changes in the network, and adapt to them.

Key Terms: - ACO-Ant Colony Optimization; ABC-Ant Based Control; MANET-Mobile Ad hoc Network; AODV- Ad hoc On-demand Distance vector Routing; TABR- Two Ant Based Routing Algorithm

I. Introduction

Nature's self-organizing systems like *insect societies* show precisely these desirable properties. Making use of a number of relatively simple biological agents (e.g., the ants) a variety of different organized behaviors is generated at the system-level from the local interactions among the agents and with the environment. The robustness and effectiveness of such collective behaviors with respect to variations of environment conditions are key-aspects of their biological success. These kinds of systems are often referred to with the term *Swarm Intelligence*. Swarm systems have recently become a source of inspiration for the design of distributed and adaptive algorithms, and in particular of routing algorithms. *Routing* is the task of directing data from sources to destinations maximizing network performance. It is at the core of all network activities. Several successful routing algorithms have been proposed taking inspiration from ant colony behavior and the related framework of *Ant Colony Optimization (ACO)* [4]. Examples of *ACO routing algorithms* are AntNet [5] and ABC [6].

II. Swarm Intelligence

Swarm Intelligence appears in biological swarms of certain insect species. It gives rise to complex and often intelligent behavior through complex interaction of thousands of autonomous swarm members. Interaction is based on primitive instincts with no supervision. The end result is accomplishment of very complex forms of social behavior and fulfilment of a number of optimization and other tasks [11].

The main principle behind these interactions is called stigmergy, or communication through the environment. An example is pheromone laying on trails followed by ants. Pheromone is a potent form of hormone that can be sensed by ants as they travel along trails. It attracts ants and therefore ants tend to follow trails that have high pheromone concentrations. This causes an autocatalytic reaction, i.e., one that is accelerated by it. Ants attracted by the pheromone will lay more of the same on the same trail, causing even more ants to be attracted.

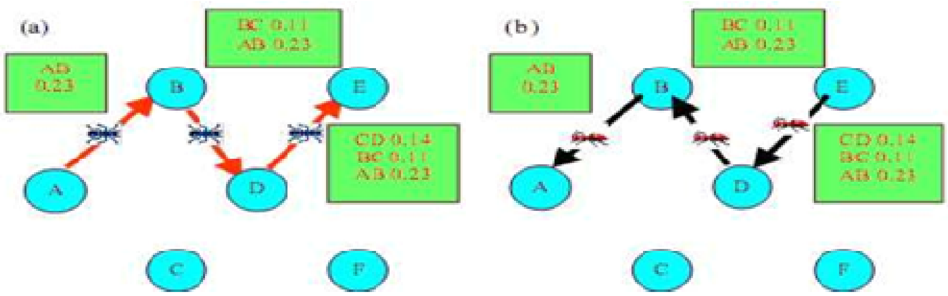
III. Routing Basics

Routing is the act of moving information across an internetwork from a source to a destination. Along the way, at least one intermediate node typically is encountered. Routing is often contrasted with bridging, which might seem to accomplish precisely the same thing to the casual observer. The primary difference between the two is that bridging occurs at Layer 2 (the link layer) of the OSI reference model, whereas routing occurs at Layer 3 (the network layer). This distinction provides routing and bridging with different information to use in the process of moving information from source to destination, so the two functions accomplish their tasks in different ways.

IV. Deterministic Routing

A. AntNet

In the AntNet[5] algorithm, routing is determined by means of very complex interactions of forward and backward network exploration agents (“ants”). The idea behind this sub-division of agents is to allow the backward ants to utilize the useful information gathered by the forward ants on their trip from source to destination. Based on this principle, no node routing updates are performed by the forward ants. Their only purpose in life is to report network delay conditions to the backward ants, in the form of trip times between each network node. The backward ants inherit this raw data and use it to update the routing table of the nodes.



a) Forward Ant Movement b) Backward Ant Movement

B. Ant-Based Control

Ant-based Control (ABC)[6] is another successful swarm intelligence based algorithm designed for telephone networks. This algorithm shares many key features with AntNet, but has important differences. The basic principle shared is the use of a multitude of agents interacting using stigmergy. The algorithm is adaptive and exhibits robustness under various network conditions. It also incorporates randomness in the motion of ants. This increases the chance of discovery of new routes. In ABC, the ants only traverse the network nodes probabilistically, while the telephone traffic follows the path of highest probability.

C. AntHocNet

AntHocNet’s design is inspired by ACO routing algorithms for wired networks. It uses ant agents which follow and update pheromone tables in a stigmergic learning process. Data packets are routed stochastically according to the learned tables. An important difference with other ACO routing algorithms is that AntHocNet is a hybrid algorithm, in order to deal better with the specific challenges of MANET[7] environments. It is reactive in the sense that nodes only gather routing information for destinations which they are currently communicating with, while it is proactive because nodes try to maintain and improve routing information as long as communication is going on.

V. Proposed Routing Algorithm

Swarm intelligence utilizes mobile software agents for network management. These agents are autonomous entities, both proactive and reactive, and have the capability to adapt, cooperate and move intelligently from one location to the other in the communication network. Swarm intelligence, in particular, uses stigmergy (i.e. communication through the environment) for agent interaction. Swarm intelligence exhibits emergent behavior where in simple interactions of autonomous agents, with simple primitives, give rise to a complex behavior that has not been specified explicitly.

The AntNet algorithm is a hybrid algorithm. It is reactive in the sense that nodes only gather routing information for destinations which they are currently communicating with, while it is proactive because nodes try to maintain and improve routing information as long as communication is going on.

This algorithm uses a single queue at each node to process both data packets and ant packets. We propose a two agent based policy. One agent acting as load agent and another as strategy agent to ensure better performance. The strategy agent controls and guides the load agents (forward ants and backward ants). The strategy agent maintains a separate queue for ant packets at each node. Thus reducing congestion in network and improving network bandwidth utilization.

A. Initialization of Routing Table

This module is used to generate all possible paths from a given node to all other nodes in the network. Initially, 'n' random paths are considered. This 'n' defines the population size. Forward ant is created for each path. It is allowed to explore the network and find paths to all the nodes in the network. Forward ant chooses the next node to visit, based on the value at that position and the pheromone concentration of the link.

B. Processing of Ants at each Node

On arrival of ant, it is required to find the type of ant (forward ant or backward ant). If forward ant, it explores path to destination and if backward ant retrace path to source by updating routing tables at intermediate nodes.

Following statements describe the functions of a node for each type of ant.

```
if (forward ant)
{
Get the next node based on the current node value
if ( link is available and no loop caused)
{
Update forward ant with network status(stack)
Send forward ant to the next node.
        }
        Elseif (no such link exists)
        {
Create backward ant and load contents of forward ant to backward ant.
Send backward ant towards source along 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 onto link available on backward ant stack
Update routing table
        }
        If (next node not available)
        Kill backward ant
}
```


C. Flow Graph

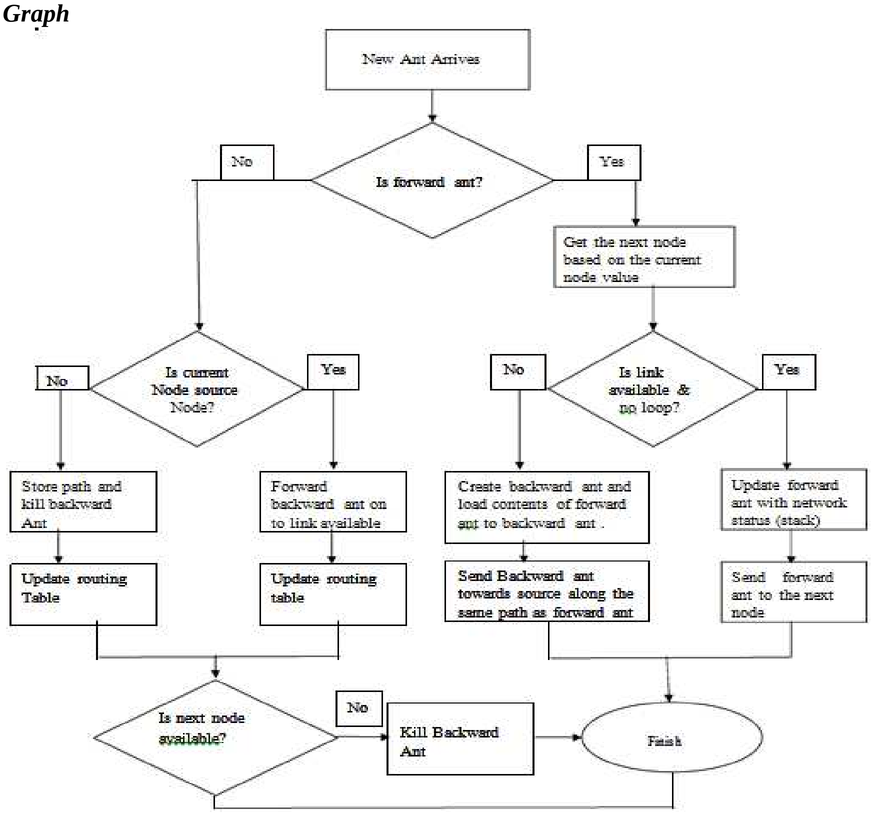


Fig-2

VI. NETWORK SIMULATOR

A **network simulator** is a piece of software or hardware that predicts the behavior of a network, without an actual network being present. A network simulator is a software program that imitates the working of a computer network. In simulators, the computer network is typically modelled with devices, traffic etc. and the performance is analyzed. Typically, users can then customize the simulator to fulfil their specific analysis needs. Simulators typically come with support for the most popular protocols / networks in use today, such as WLAN, Wi-Max , TCP, WSN etc.

There are a wide variety of network simulators, ranging from the very simple to the very complex. Minimally, a network simulator must enable a user to represent a network topology, specifying the nodes on the network, the links between those nodes and the traffic between the nodes. More complicated systems may allow the user to specify everything about the protocols used to handle traffic in a network. Graphical applications allow users to easily visualize the workings of their simulated environment. Text-based applications may provide a less intuitive interface, but may permit more advanced forms of customization.

A. Network Simulators Used Here

Ns-2 stands for Network Simulator version 2.

Ns-2

- Is a discrete event simulator for networking research
- Work at packet level.
- Provide substantial support to simulate bunch of
- Protocols like TCP, UDP, FTP, HTTP and DSR.
- Simulate wired and wireless network.
- Is primarily UNIX based
- Use TCL as its scripting language.
- ns-2 is a standard experiment environment in research community

.

VII. SIMULATION DETAILS

We evaluate the performance of Two Agent Based Routing Algorithm (TABR) through simulations. Several measurement metrics were collected to evaluate the performance of TABR.

The data packet delivery ratio is defined as the number of successfully delivered data packets to the number of data packets generated by the source. The former reflects the cost in transmitting control packet, and the other represent the efficiency of packet delivery. Node number defines the number of total mobile nodes in Network. We compare the data delivery ratio under different range of number of nodes in the network.

Another performance metric is the throughput. The throughput is defined as the percentage of successful delivery of packet of packets. The throughput is calculated on different number of iterations and with different number of nodes in the network

A. Detailed Simulation Results

In this section we present extensive simulation results obtained by varying several network parameters and workload configuration.

The following graph compares the Packet delivery ratio of AODV[10] a state-of-the-art MANET[7] routing algorithm and a de facto standard; AntHocNet, a Swarm intelligence based routing algorithm and Two Ant Based Routing Algorithm's performance by varying the number of nodes and calculating the Packet delivery ratio.

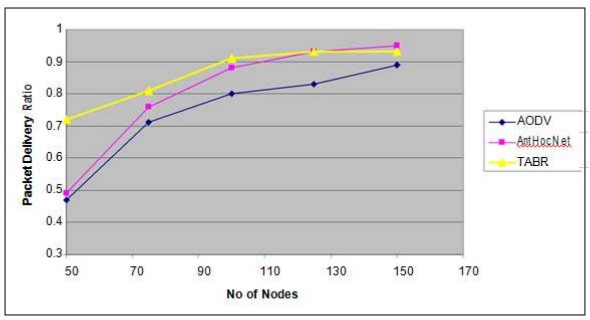


Fig-3 Packet Delivery Ratio

The following graph compares the throughput of Two Ant Based Routing Algorithm by varying the number of nodes in the graph and the number of iterations.

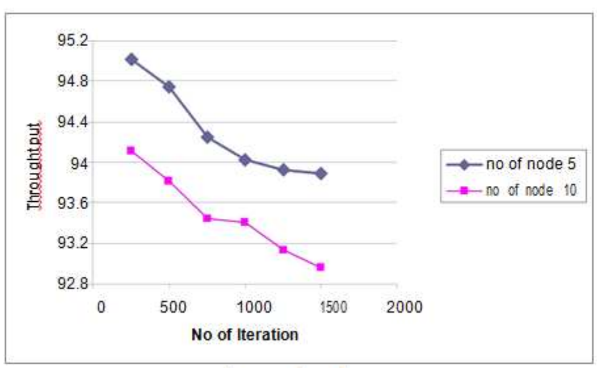


Fig-4 Throughput

The following graph shows the variation of throughput of Two Ant Based Routing Algorithm by varying the congestion in the network.

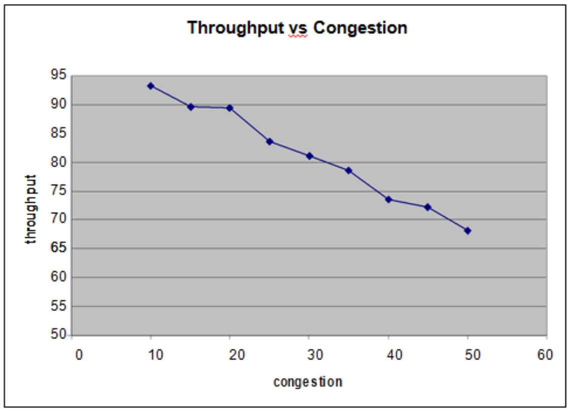


Fig-5 Throughput Vs Congestion

The following graph compares the percentage of packet successful transmitted, packet lost and acknowledge lost by varying the number of iterations.

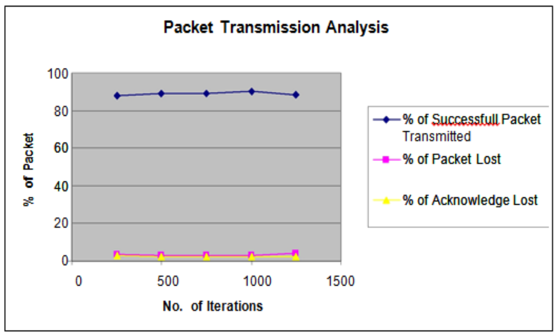


Fig-6 Packet Transmission Analysis

VIII. CONCLUSION

In this project we have described Two Ant Based Routing Protocol, a routing algorithm for Mobile Network which was inspired by ideas from Swarm Intelligence, and more specifically by the framework of ACO. The algorithm combines reactive and proactive behavior to deal with the specific challenges of Mobile Network in an efficient way. It is a hybrid algorithm. It is reactive in the sense that nodes only gather routing information for destinations which they are currently communicating with, while it is proactive because nodes try to maintain and improve routing information as long as communication is going on.

AntHocNet algorithm uses a single queue at each node to process both data packets and ant packets. We propose a two agent based policy. One agent acting as load agent and another as strategy agent to ensure better performance. The strategy agent controls and guides the load agents (forward ants and backward ants). The strategy agent maintains a separate queue for ant packets at each node. Thus reducing congestion in network and improving network bandwidth utilization. The simulation result shows that the proposed Two Ant Based Routing Protocol meets the required objectives.

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