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LIRANT: An Improved Ant Colony Optimization mechanism with Least Interference Routing for Enhancing Throughput of MANET

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Abstract- A collection of mobile devices forms a network called Mobile Adhoc Network (MANET) which establishes communications with the help of intermediate nodes without a fixed infrastructure. The quality of the MANET depends on many parameters like delay, jitter, bandwidth and throughput. Though there are many techniques available for improving the performance through guaranteeing higher throughput, MANET is in need of new techniques for improving throughput which could lead towards higher goodput. There are various interferences exist which affects the throughput. In this research work, the throughput of the networks is increased by the proposed mechanism named as LIRANT which considers the interference of the nodes during the communication. This technique is implemented by having the Ant Colony Optimization along with the least interference routing technique. The simulation result shows that after incorporating the improved least interference routing with ACO, MANET performs well with increased throughput.

Keywords – MANET, ACO, interference, throughput

1. INTRODUCTION

The previous decade has encountered an exponential development in the utilization of wireless networks since they empower mobility - a characteristic quality that isolates them from other wired networks. The idea of ad hoc was at first produced for military applications yet right now is being considered for some, business applications including home systems administration, nomadic computing, organizing for debacle alleviation, pursuit and-safeguard operations, and for substantial open occasions, for example, conventions and conferences. These systems, because of their capacity of dealing with node failures and quick changes in topology, give users ubiquitous correspondence, computing ability, and data access regardless of location. Mobile Adhoc Network (MANET) is a standout amongst the most developing advances today because of its convenience and versatility. MANET is a network of autonomous devices which could communicate among the network without having an infrastructure or centralized administration. The nodes of MANET form the network dynamically without having any predefined network configurations or server setup. Moving the data from one device to another is one of the significant research challenges in the computer networks. Establishment of paths for data communication among the nodes is the responsibility of the nodes which initiate the communication.

It is a significant challenge to provide reliable high-speed end-to-end communication in ad hoc networks given their dynamic network topology due to the mobility (random movement) of the hosts, decentralized control, power and bandwidth limitations, multi-hop connections, and non-uniform characteristics of signal propagation in wireless channels [1].

Routing protocols can be categorized as centralized or distributed, adaptive (dynamic) or fixed (static), and reactive or proactive or combinatorial (hybrid). In a centralized routing, all decisions are made at a designated node such as a network control center, where as in a distributed routing protocol, each node shares the responsibility in making the routing decision. In adaptive routing protocols, such as the distance vector routing and link state routing, the routing decision may change as the network condition changes, such as congestion on a link or change in topology (link or node failure). In fixed or non-adaptive routing protocols, such as the shortest path routing and flooding, in contrast, the decision is not based on the measurements or estimates of network traffic or topology. Proactive routing protocol maintains regular and up to date routing information about each node in the network by propagating route updation at fixed time intervals throughout the network when there is a change in network topology. Reactive routing protocols establish the route to a destination only when there is a demand for it. Many routing protocols in wireless network are fundamentally derived from two algorithms, Distance Vector (DS) routing and Link state (LS) routing.

The existing algorithms developed with ACO consider only the shortest path but not the interferences. Literatures state that though the shortest path is chosen for higher throughput, the interferences have impact on the performance. This research work concentrates on enhancing throughput through bio inspired algorithms like Ant Colony Optimization (ACO). The proposed research work extends OPTANT [2] by improving the Least Interference Routing (LIR) algorithm.

2. BACKGROUND

ACO routing algorithms take inspiration from the behavior of ants in nature and from the related field of ACO to solve the problem of routing in communication networks [3]. The main source of inspiration is found in the ability of certain types of ants to find the shortest path between their nest and a food source using a volatile chemical substance called pheromone. Ants traveling between the nest and the food source leave traces of pheromone as they move. They also favorably go in the track of high pheromone concentrations. Since shorter paths can be completed faster, they receive higher levels of pheromone earlier, attracting more ants, which in turn lead to more pheromone. This positive reinforcement process allows the colony as a whole to converge on the shortest path. It forms the basis of most of the work in the field of ACO. Figure 1 demonstrates the behavior of the ants. Moreover, the ability to solve these problems in a distributed way is important in communication networks, as these usually operate without a point of central control [3]. Early work on ACO routing includes the Ant-Based Control algorithm (ABC) [4] for circuit-switched wired networks and the AntNet algorithm [5] for packet-switched wired networks.

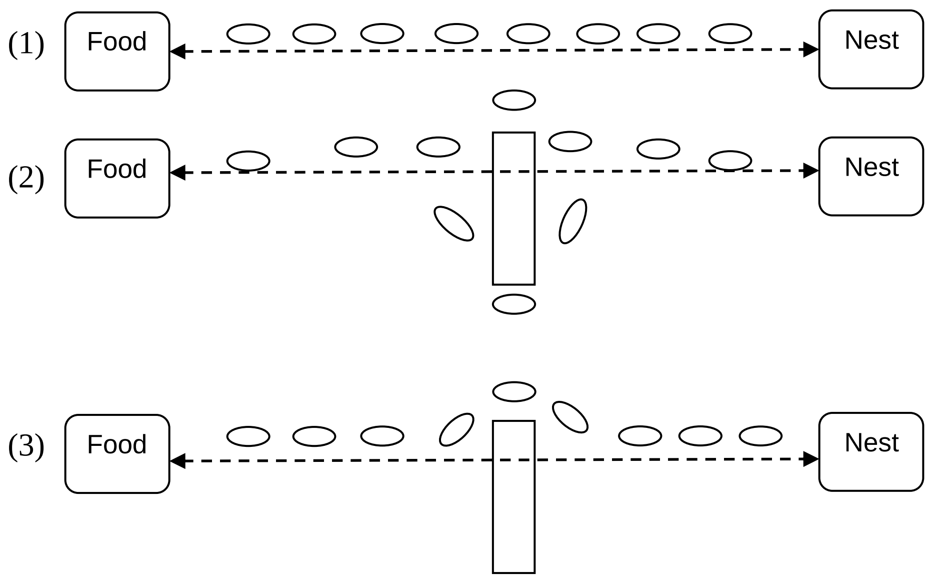

Figure 1. Behavior of Ants

The main idea behind these algorithms is that nodes in the network periodically and asynchronously send out artificial ants towards possible destination nodes of data. Ants are small control packets, which have the task to find a path towards their destination and gather information about it. Like ants in nature, artificial ants follow and drop pheromone. This pheromone takes the form of routing tables maintained locally by all the nodes of the network. They indicate the relative quality of different routes from the current node towards possible destination nodes. Ants normally take probabilistic routing decisions based on these pheromone tables, giving a positive bias to routes of higher pheromone intensity, to balance exploration and exploitation of routing information.

Mohammad et al. [6] designed an on-demand routing algorithm called source update for MANETs using a meta-heuristic based on the ACO search technique. They just applied an on-demand routing strategy and use the ant colony optimization metaheuristic search technique to determine the best route to forward packets for all pairs of nodes. It was noticed that the percentage of communication among the ants is much higher than the percentage of computation by an ant. MANETs are communication intensive applications. However, they claimed that it did not degrade the performance of the algorithm indicating a fast convergence rate in finding the best paths. A QoS algorithm for MANET was proposed by Bibhash Roy et al. [7]. The algorithm combined the idea of Ant Colony Optimization

(ACO) with Optimized Link State Routing (OLSR) protocol to identify multiple stable paths between source and destination nodes and also consists of both reactive and proactive components.

Anuj et al. [8] analyzed various routing protocols implemented based on ACO. Ant-AODV [9] is a hybrid protocol that is able to provide reduced end-to-end delay and high connectivity as compared to AODV. The main goal of the ant algorithm here is to continuously create routes in the attempt to reduce the end-to-end delay and the network latency, increasing the probability of finding routes more quickly when required. Ant-AODV [9] is a hybrid protocol that is able to provide reduced end-to-end delay and high connectivity as compared to AODV. The main goal of the ant algorithm here is to continuously create routes in the attempt to reduce the end-to-end delay and the network latency, increasing the probability of finding routes more quickly when required. Ant Dynamic Source Routing (Ant-DSR) [10] is a reactive protocol that implements a proactive route optimization method through the constant verification of cached routes. Ant-DYMO [11] is a hybrid protocol that uses an ant-based approach in its proactive phase while DYMO is the basis for the reactive one. HOPNET [12] is a hybrid routing algorithm for MANETs which involves Swarm Intelligence to solve routing problems. The algorithm has features extracted from ZRP and DSR protocols. A self-configuring reactive routing protocol for Wireless Sensor Networks based on HOPNET AD-ZRP also consists of ZRP similar to HOPNET, but it is based on dynamic zones which, acting together with ACO, deals with the restrictions of WSNs and yet improves the route discovery and the route maintenance through pheromone [13].

A new minimum interference routing algorithm which does not use maxflow for critical edges detection was presented by Gustavo et al [14]. Modifications in Dijkstra's algorithm were pursued in order to find the paths with lowest capacities. After finding critical edges, weights are assigned to the edges and an algorithm to find the shortest path is applied.

3. LIRANT

ACO and LIR are considered for this research to enhance throughput in MANET. In LIR, the cost of the links here takes the possible interference into account. The interference generated by a node is considered to be the number of neighbors that can receive a transmission from that node [15] [16]. Therefore, the interference information can be calculated locally. In this research work the LIR is tuned further to consider another factor of interference that is the engagement of the node in a transaction. Two different weights are used based on the impact of the interference. If the node overhears the signal from other nodes, that is, if the node has neighbors whose signals could be sensed, then the weight for this particular interference (*SI*) is fixed as 1. For example, if a node has 3 neighbors then the interference is 3. If a node is in transaction or communication mode then the interference (*CI*) is 2. For example, if a node is in communication with two nodes then the interference is calculated as 4. The reason behind is that the mobile devices have limited memory and processing capacity. The interference of a node that overhears the signal of nearest nodes has lower impact on processing the requests from other nodes than the node which is being engaged in any transaction. The interference of a path (*PI*) is calculated by adding the interferences of all the nodes available in that particular path.

Interference of a node *i*

$$NI_i = \sum [(2 \times CI) + (1 \times SI)]$$

Interference of a path

$$PI = \sum_{i=1}^{n} NI_i$$

The ants as control packets traveling through the different nodes have the interference details which help in calculating the total interference of a node. Forward ants are begun at the source node to discover a way to the destination, retaining the way they utilized. Once it reaches the destination it is changed over to a backward ant. Backward ants go back along the retained way and update the pheromone tables. The interference is calculated locally by the nodes and the source node calculates the interference of each path which includes the individual interferences. From the Figure 2, N1 is the source node and N8 is the destination node. During the ACO execution, it is found that the path1 *P1(N1, N5, N8)* is the best path because of having less number of hops compared with other paths. But when considering the new proposed algorithm which combines OPTANT and improved LIR, the path *P2(N1, N2, N3, N8)* is chosen as the best path because P1 has higher interference than P2.

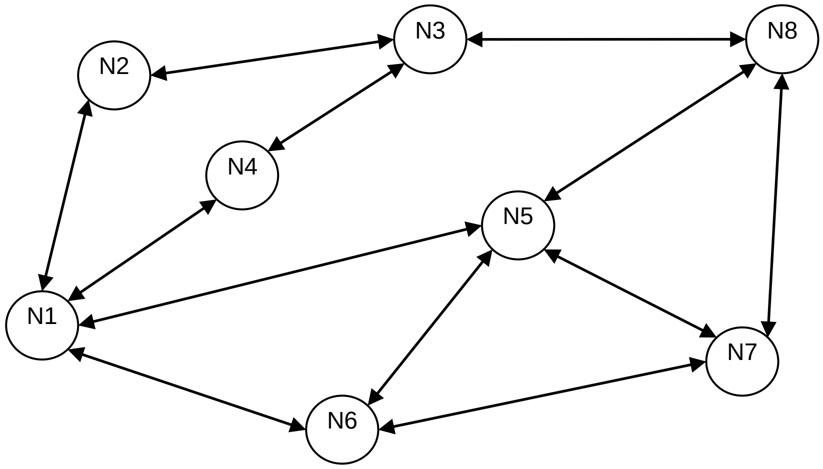

Figure 2. Example MANET

The decision of changing the path is taken when throughput of the current communication is going down. Finding the alternate path is executed through parallel ACO execution. The parallel execution of ACO helps in finding the best path without intruding the ongoing transaction.

Algorithm LIRANT
Start
Procedure ACO(); // Call procedure of ACO
If throughput < threshold Then // Check the throughput
For i=1 to p // For all the paths
PI_i = 0 // Initially PI is assumed as zero
Procedure ACO_Parallel() // Call procedure for parallel execution
Read SI, CI // Read the interferences from Ants
For j=1 to n // For all the nodes of a path
$NI_j \leftarrow (1*SI_j)+(2*CI_j)$ // Calculate the signal interference of the node j
$PI_i \leftarrow PI_i + NI_j$ // Calculate the interference of the path i
End
End
For i=1 to p
If $PI_i < PI_{i+1}$ then // Select the path having lower interferences
Path$\leftarrow PI_i$
End
Stop

The proposed research work is simulated as shown in Figure 3, using Network Simulator 2 with the following parameters:

Simulation time:	25, 50, 75, 100, 125 and 150 seconds
Number of nodes:	25, 50, 75 and 100
Simulation area:	1000 x 1000
Transmission range:	250 m
Traffic Type:	FTP
Node movement model:	Random waypoint

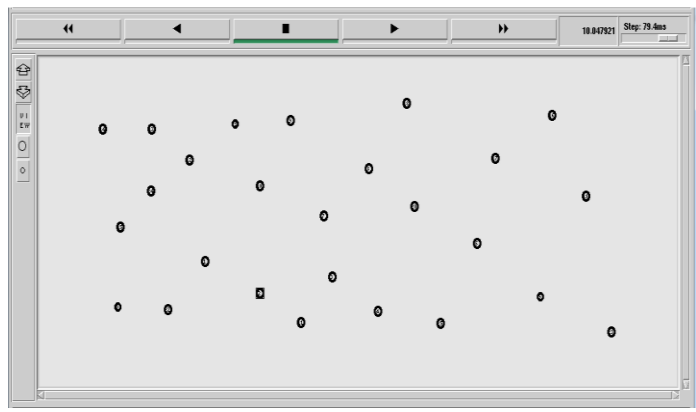

Figure 3. Simulation of LIRANT

The simulation results are compared with OPTANT which was implemented with ACO. During the simulation the proposed research work, LIRANT performs better than OPTANT. The placement of the nodes, load of the nodes and the interferences are dynamically and intentionally changed to assess the performance. The simulation results are shown in Figure 4.

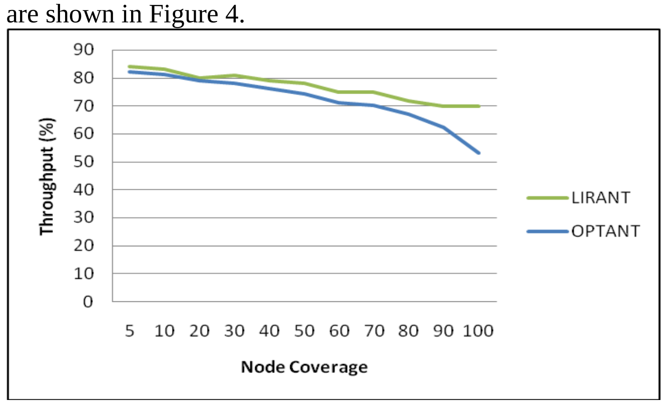

Figure 4. Comparison of LIRANT and OPTANT

4. Conclusion

As the growing number of applications of MANET create new challenges for researchers for achieving better performance. Increasing the throughput even at the time of mobility and increased density of the nodes is the main goal of this proposed research work. The strength of ACO is utilized in OPTANT and the LIRANT is proposed by overcoming the shortcomings of OPTANT. OPTANT was already compared with other ACO based algorithms projecting as a better performer and it is made as a benchmark for LIRANT. The proposed research work LIRANT guarantees increased throughput by having the improved LIR. Simulation results also confirm the performance of LIRANT. This research work in future, will consider the hops and other parameters to make it a best algorithm for MANETs.

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