Congestion Control in Networks using Real Life Analogy and Reverse Ant Colony Optimization

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Abstract -In recent years, mobile computing has enjoyed a tremendous rise in popularity. The devices need to be interconnected to share data, hardware and software. It creates a need of efficient routing in the network. A routing protocol becomes more efficient when it is assisted with a congestion control facility. Congestion is the main reason for loss of packets and wastage of resources in a network. Congestion control provides assurance for uninterrupted service without getting important data lost. TCP (Transmission Control Protocol) is known for its reliable nature and quality of service but the control overhead in TCP is not suitable for a highly dynamic network. So there is a need of light weight protocol which can work in a dynamic environment to control congestion. This paper is focused towards finding an optimal solution towards congestion control using real life analogy and reversing the behavior of artificial ants. The basic ACO will be revisited and analyzed to see how a node with lesser pheromone concentration can provide a promising solution towards congestion.
Keywords— Congestion, ACO, Ant colony, Pheromone.

I.   INTRODUCTION

This is an era of interconnected world. The devices are getting smarter and smarter day by day. The continued minimization of mobile computing devices and the extraordinary rise of processing power available in mobile laptop computers combine to put more and better computer-based applications into the hands of a growing segment of the population. There are more than billion wireless devices in use. With the increasing number of devices in the network there are possibilities of multipath in the network. Moreover the devices are mobile so the whole scenario is highly dynamic. The data transmission speed has increased significantly over years due to improvement in routing strategies. Now we are provided with vast range of routing protocols which are broadly classified as: Proactive, Reactive and hybrid routing protocols.

Congestion in a network may occur at any interval if the load on the network (the no of packets sent to the network) is greater than the capacity of the network (The no of packets network can handle)

Network Load > Capacity of Network

Congestion is the main reason for wastage of resources like memory, time, bandwidth and energy. It degrades the network performance as shown in Fig 1. Congestion control is necessary for quality of service in the network.

Although the problem of congestion is common in every type of network but in MANET it has severe effects. Each node in a MANET behaves as independent router so while sending data packets from source to destination, there is a possibility of occurring congestion at any node incurring high packet loss and long delay. The congested node may die out of energy. This will result in connection failure.
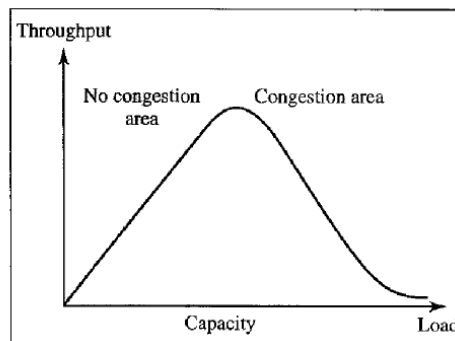

Figure 1: Throughput Vs Load

II.   BACKGROUND

ACO is a soft computing paradigm which is based on approximations and probabilities. It is nature inspired just like genetic

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algorithm. This section provides brief overview of working principle behind ACO.

A. Ant Colony Optimization

The basic concept of ACO [3] is taken from the behavior of real ants. It is a population based search technique used for solving many combinatorial problems. Initially, each ant traverses the area in random manner while searching for food leaving a chemical substance in its path. This chemical substance is called pheromone which is the basis of local information at each node. The amount of pheromone is deposited depends on the number of ants on that path and length of that path. The shorter path will receive higher amount of pheromone. The newer ants will take a path which has higher pheromone concentration and will further reinforce the path they have taken. This colony behavior is auto catalytic. Ants are simple agents that interact via indirect communication known as stigmergy. Stigmergy is an indirect form of communication where individual agents leave signal by changing the environment and other agents sense them to drive their own behavior. The idea behind ant algorithms is to use a form of artificial stigmergy to coordinate societies of artificial agents.
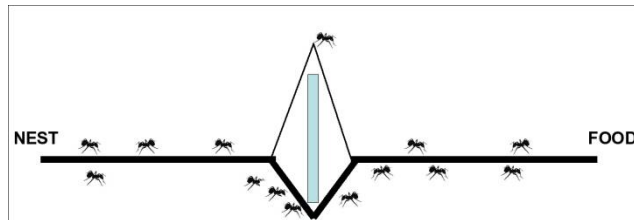

Fig -1: Ant Colony Behavior [16]

The above behavior can be used in networking. A network can be viewed as directed graph imitating the path taken by ants. The real ants can be forged by using small ant packets. The chemical substance "pheromone" can be forged defining the probability value at each node. The pheromone trails in ACO serve as distributed, numerical information which the ants use to probabilistically construct solutions to the problem being solved and which the ants adapt during the algorithm's execution to reflect their search experience [1].The pheromone is a volatile substance so it needs to be updated during arrival of each ant packet.

B. Working of ACO

This section summarizes step by step procedure of working principle behind basic ACO. Here we assume an arbitrary network as a collection of nodes.

1) Initially the source will broadcast ant packets over the network.

2) Each ant packet form node (i) while travelling the network selects the next node (j) on the basis of probability function, as in (1)

$$p_{ij} = \frac{[\tau_{ij}]^{\alpha} * [\eta_{ij}]^{\beta}}{\sum_{k \in N_i} \left[[\tau_{ik}]^{\alpha} * [\eta_{ik}]^{\beta} \right]} \tag{1}$$

Where:

α and β are control parameters

p_{ij} is the probability of node j to be selected by ant coming from node i

τ_{ij} is the pheromone intensity

N_i is the set of nodes

η_{ij} is the heuristic function based on local information

3) Each ant packet received by any node updates the pheromone (local information), as in (2), on the basis on residual energy.
Revised pheromone:

$$\tau_{ij}(t+1) = (1-\rho)\tau_{ij}(t) + \Delta \tau_{ij}(t) \tag{2}$$

Where

ρ is pheromone evaporation rate

$\Delta \tau_{ij}(t)$ is pheromone enhancement

ACO parameters can be adjusted according to the network specification. We can modify the control parameters, heuristic function and pheromone enhancement according to our need. This property enhances the domain of problems which can be solved using this meta-heuristic technique.

III. RELATED WORK

Continuous work has been carried out in networking for making efficient, reliable and secure networks. Many researchers have exploited various network parameters to guarantee QoS in networking. The field of Congestion control always fascinated worldwide network engineers to provide a promising solution to reduce packet loss. Most of the related work is based on multipath routing; location based routing, swarm intelligence and Ant Colony optimization. Here some of these related research works are discussed.

Dhriti Sundar Maity et. Al. in [5] presented the Ant Colony Optimization for MTSP and Swarm Inspired Multiple Data Transmission with Congestion Control in MANET using Total Queue Length. The proposed algorithm using path pheromone scents constantly updates the goodness of choosing a particular path by measuring the congestion using hop-distance and queue length into the network. Javed Parvez et. al. in [10] summarized key challenges in provisioning predetermined levels of such Quality of Service (QoS). They also identified functional areas where QoS models are currently defined and used. They have presented a comprehensive overview of the state-of-the-art research work on QoS support in MANETs. S.Leemaroselin et. Al. in [13] reviewed several congestion control techniques in MANET and also tabulated the main differences between different schemes of congestion control. Hong, Sung-Hwa et al. [6] proposed the WSN (Wireless Sensor Network) algorithm which is applied sensor node that has low power consumption and efficiency measurement. Moreover, the efficient routing protocol is proposed in their paper. The proposed algorithm reduces power consumption of sensor node data communication. Authors in [9] presented a survey on various congestion control techniques in MANET. They compared the new congestion control algorithm like EXACT with TCP congestion control. They also discussed the related application areas of congestion in MANET. Authors in [12] presented the AntHocNet routing algorithm, which applies ACO routing in MANET and tested it using a highly dynamic network in urban scenario. AntHocNet is a concrete example of how ACO routing techniques can be adapted to work in highly challenging environments. Their algorithm combines ACO routing with other approaches to learning in order to get adaptivity and robustness while maintaining an efficient working. Authors in [8] proposed a solution to improve fairness and increase throughput in wireless networks with location information. Their approach consists of a multipath routing protocol, Biased Geographical Routing (BGR), and two congestion control algorithms, In-Network Packet Scatter (IPS) and End-to-End Packet Scatter (EPS), which leverage BGR to avoid the congested areas of the network. They tested their result using NS2. Authors in [14], Selcuk Okdem and Dervis Karaboga, proposed a routing approach using an Ant Colony Optimization algorithm for Wireless Sensor Networks consisting of stable nodes. They also implemented it to a small sized hardware component as a router chip.

Authors in [15] described Ant Colony based routing for mobile ad-hoc networks towards improved quality of services. Their proposed algorithm combines the idea of Ant Colony Optimization (ACO) with Optimized Link State Routing (OLSR) protocol to identify multiple stable paths between source and destination nodes. They mainly focused on multipath routing for multimedia traffic to guarantee a stable route. Snehal Sarangi, Biju Thankchan [16] proposed a scheme for sensor networks which results in energy efficient routing across the network. The concept of this model is based on the fact is greater the distance travelled to send data more is the consumption of sensor energy. The algorithm is done by using concept of PSO (Particle Swarm Optimization) and compared with the results of genetic algorithm.

IV. PROPOSED ALGORITHM

The basic idea behind this algorithm is that when we use ACO for path selection, the artificial ants selects the path with maximum pheromone concentration. But this can make the node crowded after sometime leading to congestion. So there is a simple but effective method to avoid it by using Reverse Ant colony optimization. This approach will find a node with lesser pheromone concentration during congestion. This path may not be the optimum one but surely it will have less traffic and prevent packet loss without any interruption in the service. This idea is based on real life analogy: we prefer to choose a road less travelled which may be a longer route. But this can prevent us getting stuck in a severe traffic jam. The proposed algorithm works as follows:

A. Initialize network characteristics.
B. Implement Simple ACO by forwarding ant packets at regular intervals. These ants packets while traversing the network will do the following tasks:
  1) Update pheromone

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2)   Choose route on the basis of probability function

C.   In case of normal traffic, the node with highest pheromone concentration will be selected.

D.   To avoid congestion, Reverse ACO will be used by selecting the node with a lesser concentration i.e. Threshold(τij) < SelectedNode(τij) < Max(τij). It will avoid the overcrowding of some nodes and distribute the traffic.

To implement the above steps, we need to modify the probability function and define a new parameter i.e. threshold for node selection.

V. CONCLUSIONS

A congestion free network ensures lower packet drop and better resource utilization. The paper attempts to achieve the same. This paper presents a novel approach inspired by real life situations. It is a combination of basic ACO with its opposite effect to select node with less pheromone to distribute traffic and preventing a single node being congested. It is an approximation algorithm based on probability theory. The proposed algorithm is simple to implement and capable of improving network performance. It adjusts network parameters dynamically to control congestion and route packets accordingly. Further Research on the proposed algorithm is open for the interested researchers and practitioners.

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