A Probabilistic technique to Data Transmission setback using Ant Colony Optimization

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Abstract *— Due to the drastic improvement in the data transfer(switching) technology, users face major problems in sending and receiving data in a decisive manner. This is because of the enormous amount of data being sent by numerous source to the server. To overcome this difficulty, a probabilistic technique known as Ant Colony Optimization (ACO) algorithm to find the optimal path by graphically representing the flow of packets. The packet flow can be represented as the path of the network. This pheromone based communication of artificial ants is often used as a dominant method. Using ACO topology it is easier to analyze the blocking probability as well as the traffic load in the network. This paper presents an intelligent and effective way of designing a simulated mathematical model to view the probability analysis of network trafficking in a communication system.*

Keywords *— Blocking probability, Ant colony optimization, traffic load, pheromones.*

I. INTRODUCTION

A communication system consists of large number of networks and extensive information exchange(transfer). In the past few years' data transferring has become so simple and accessible that data which involves large bytes of memory can easily be sent elementarily. Those vast data are breached into small units known as packets. Packets are further divided into two different entity known as payload and header. Payload consists of the actual information that needs to be sent to the destination while the header has the IP address of the router through which its being transmitted. By virtue of this technology huge data are being transmitted from different parts of the world. Due to this the server finds it difficult to manage these enormous amount of data which is being received within few seconds, because of this there might be a chance of losing information due to lack of resources and complexity of networks. The higher the grade of service higher the probability to lose the information. Put into terms this is known as networking trafficking, which causes failure of server. This traffic is caused by transmitting packets in similar path, which intern results in data consisting of different IP address travelling through the same path to a single node at the same time will result in server to malfunction. This algorithm helps to overcome this uncertainty using a topology known as Ant Colony Optimization (ACO). This is an optimization technique mainly used to solve difficult computing problems. One of the major problem is found in Local Area Network (LAN). These issues are called complex optimization problems. This technique is used to find the optimal(shortest) and adequate path for packets to travel keeping in regard with blocking probability and accuracy of data delivery. ACO Topology optimization is a dynamic tool to select a relevant structure to reduce the trail-and-error effect. Time traversed in selecting an optimal path can be minimized. This topology was inspired by the behavior of ants seeking the path between colony and food. Ants leave biological trails knows as pheromones to find the shortest path to their path between food and nest. ACO topology follows the exact computing logic. The durability of the pheromone is inversely proportional to the length of the path, longer the path less probable to choose that path and vise-versa. Initially the strength of the pheromone is high since it is a fresh trail, that's considered without vaporization. As the packets are traversed through many nodes, the strength decreases which leads to evaporation. This decay leads to a decrease in the amount of pheromone. The rate at which the pheromone decrease is called the evaporation rate. The total amount of pheromone on each edge is given by current pheromone level and the new amount to be added. The analysis of optimal path is done by cost graph. This consists of distance between two node connected to each other in a complex manner. Considering the cost graph, pheromone graph is designed. The pheromone between two nodes is given by the reciprocal of the distance between them. However, it is obvious to have multiple ant going on one edge of the node, hence calculate the total amount of pheromone as sum of individual pheromone between two nodes. The probability of choosing the path is directly proportional to pheromones of that path multiplied by shortest path divided by the sum of multiple of those terms from that node. Probabilities are calculated and information are send to that node, the path which has the greatest probability, this is in the case where a single ant that goes on a single edge. This condition is not satisfied if there are multiple ants on the same edge, therefore the information has to be prioritized on how to send through that particular path, this is done by ROULETTE WHEEL. This method is used find the cumulative sum of probabilities. This is done to pick the destination based on the range of the random value generated. Random number is between [0,1]. The random number 'r' must lie in between the cumulative sum of that particular path. Hence the packets are delivered in an organized manner without resulting in network traffic.

II. MATHEMATICAL MODEL

- Notations used

  ΔT_{Ij}^{k} denotes the amount of pheromone

  L_k: length of the path on kth ant
  ρ: evaporation rate of pheromone
- Objective
  To develop a mathematical model using ant colony optimization topology for finding the optimal path to transfer a packet and to analyze the blocking probability as well as traffic load graphically.
- Proposed model
  Amount of pheromone is given by

$$\Delta T_{Ij}^{k} = \left\{\frac{1}{L_k}, Kth\ path\ tends\ on\ edge\ i,j.\right.$$

(1)

Where L_k is the length of the path found on Kth ant.
$\frac{1}{L_k}$ is the shortest path where pheromone is deposited by the ant.

COST GRAPH

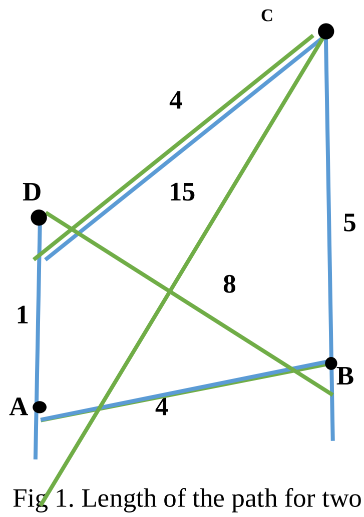


Fig 1. Length of the path for two different ant

Consider a cost graph with four nodes A, B, C, D respectively
let the two ants be green and blue as shown in fig.1. the total length of each ant is given by

L1=4+5+4+1=14,
L2=4+8+4+15=3

As per Eq. (1) the pheromone of each ant is given by the reciprocal of length on each ant. This is depicted using pheromone graph

$$T_{Ij}^{1} = \frac{1}{14}\ (blue\ ant)$$

$$T_{Ij}^{2} = \frac{1}{14}\ (green\ ant).$$

PHEROMONE GRAPH

1.WITHOUT EVAPORATION

The amount of pheromone between each node if multiple Ant goes on one edge, then we calculate the sum of Pheromone. Consider an ant at point 'A', this is done to find the optimal Path. here rate of evaporation (ρ) is taken as unity which signifies "without evaporation" condition.

consider an ant at point A, since the ant has three paths to choose as shown in fig.2. the ant prefers the path with higher pheromone level deposited.
the path A→ B will be taken since it has greater pheromone level of 0.1. as

$$T_{Ij}^{k} = \sum_{k=1}^{m} \Delta T_{Ij}^{k}\ ,\ \text{without vaporization} \qquad (2)$$

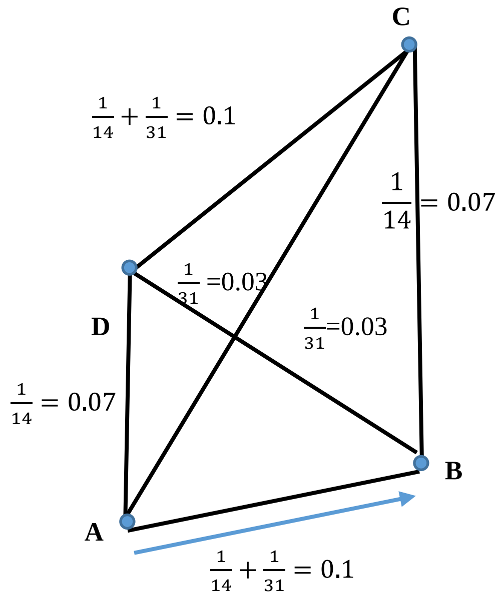


Fig 2. Total amount of pheromone between nodes without vaporization

2.WITH EVAPORATION

Let us Consider $\rho = = 0.5$ i.e. 50% of the pheromone level is vaporized every time when the ant traverses the graph.

$$T_{Ij}^{k} = \sum_{k=1}^{m} \Delta T_{Ij}^{k} \; + (1-\rho)T_{Ij} \text{ , with vaporization} \quad (3)$$

The evaporation removes the pheromone level and deposits new level depending on the graph. Rate of evaporation is multiplied with total pheromone level. Here the T_{Ij} is unity i.e. k=1. This term intern is multiplied with total pheromone value as shown in fig.3. here A B has higher pheromone deposition.

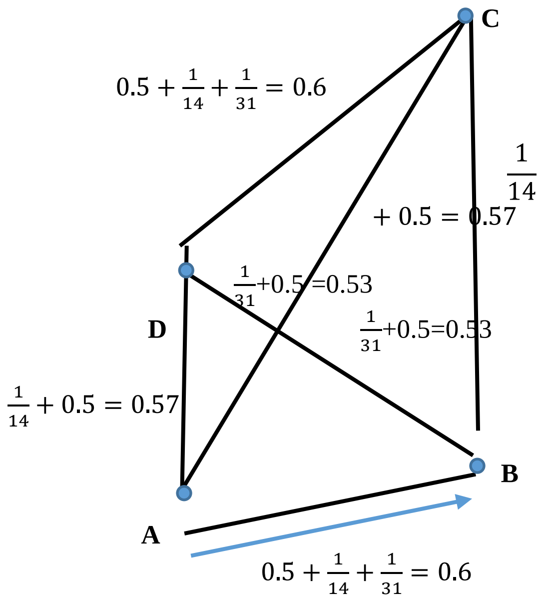


Fig 3. Total amount of pheromone between nodes with vaporization

To simulate this using MATLAB we plot xnode vs ynode in this graph along x-axis and y-axis respectively. This pheromone graph consists of 10 nodes which also implies that it has 10 ants. These are randomly placed using rand function on MATLAB. initially the pheromone level is unity.

The distance between nodes it calculated by Euclidean distance formula. Here p and q are x and y axis distance respectively.

$$d(p,q) = d(q,p) = \sqrt{(p1-q1)^2 + (p2-q2)^2 + .. + (pn-qn)^2} \quad (4)$$

3.

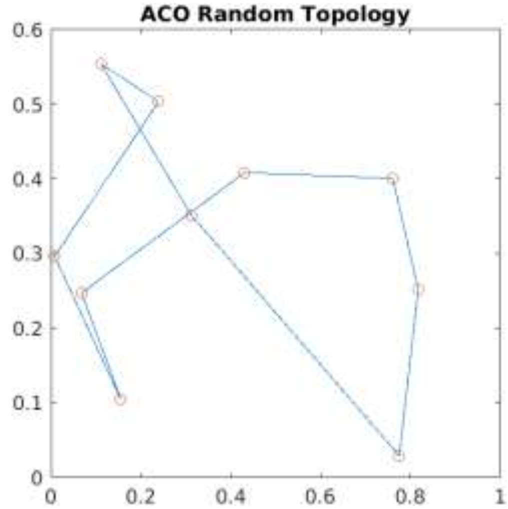


fig 4. Simulated graph of ACO topology

PROBABILITY OF CHOOSING THE IDEAL PATH

$$P_{Ij} = \frac{[T_{Ij}]^{\alpha}[n_{Ij}]^{\beta}}{\Sigma([T_{Ij}]^{\alpha}[n_{Ij}]^{\beta})} \quad (5)$$

- T_{Ij} *is the pheromone level*
- n_{Ij} *inverse of path (shortest path)*
- α and β are the quantity factor usually =1

consider a graph where distance is given as follows and pheromone level is unity. To proceed for finding an ideal path, probability technique is used. Hence the probabilities are calculated as per the above formula.

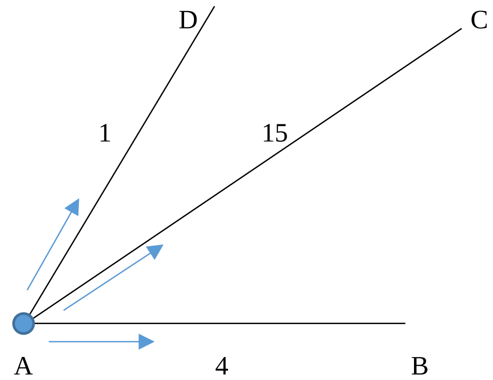


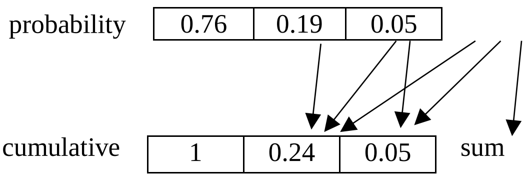
fig 5. Probability of choosing an ideal path

$$P_1 = \frac{1}{1+\frac{1}{15}+\frac{1}{4}} = 0.07595\times100=75.75\%$$

$$P_2 = \frac{\frac{1}{4}}{1+\frac{1}{15}+\frac{1}{4}} = 0.189\times100=18.9\%$$

$$P_3 = \frac{\frac{1}{15}}{1+\frac{1}{15}+\frac{1}{4}} = 0.056 \times 100 = 5\%$$

ROULETTE WHEEL helps us to determine the path to choose when we have over one probability.



To pick the destination, we use MATLAB function known as
rand for generating random numbers (0,1)

0.24< r ≤ 1.00 A → D

0.05< r ≤ 0.24 A → B

0.00< r ≤ 0.05 A → C

Fig.5 depicts a graph of simulation time vs total packets; this graph shows the time interval of packets being traversed over the topology.

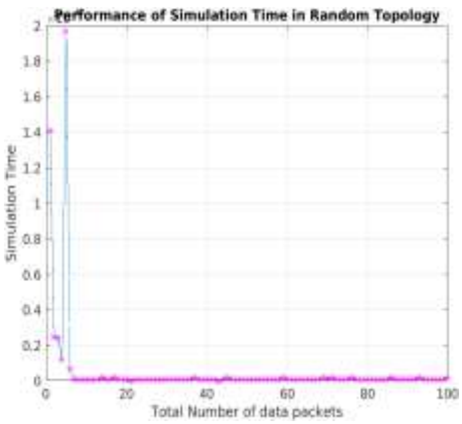


Fig 6. Performance of simulation time in random topology

This graph depicts the relationship between the total packets passing vs reject (i.e. prohibits a packet from passing). After rejecting a packet, it sends an ICMP destination unreachable message back to the client. This happens when there is excess of users transmitting packets or excess packets traversing the network.

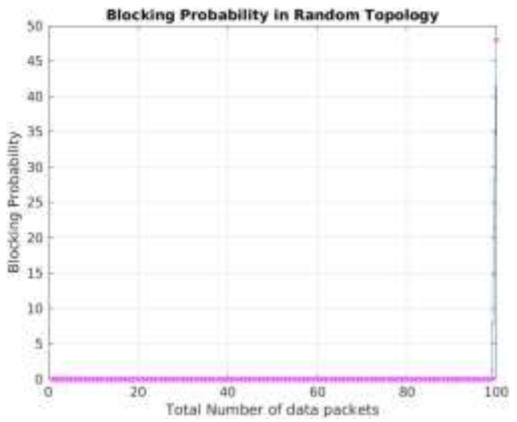


Fig 7. Blocking probability in random topology

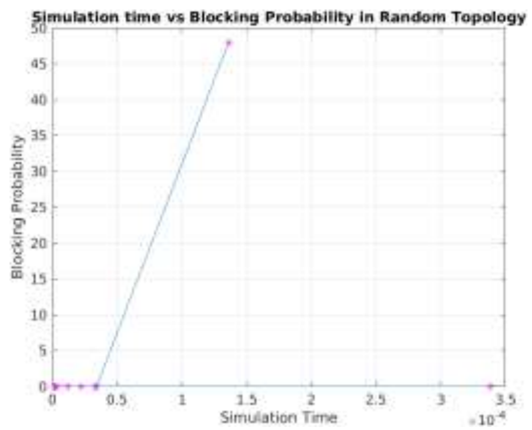


Fig 8. Simulation time vs blocking probability

No of packets α blocking probability

Here traffic load depicts the number of packet moving across a network in a given point of time. As the number of packets across a network increases the possibility of blocking a packet increases.

Here the blocking probability is zero for lower traffic load, as the packets in a network increases, the traffic at a particular time interval increases. which result in blocking of that packet(as shown in the graph when traffic is 100% in a network the blocking probability is 48).

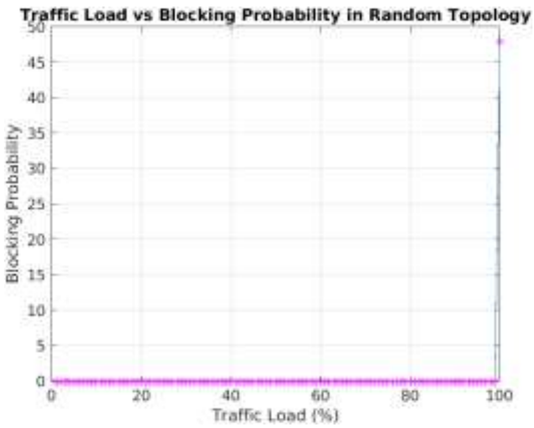


Fig 9. Traffic load vs blocking probability

III. RESULT AND DISCUSSION

The probability of choosing an ideal path depends upon the pheromone level on each path(T_{Ij}) as well as the shortest path(n_{Ij}). Fig.1 and fig.2 shows the relationship between length of the path and pheromone level, whereas in fig.3 we calculate the probability of choosing the ideal path. with the help of Roulette wheel which helps us to analyze the over probability condition (two or more path from a single node). In fig.4 we graphically represent 10 nodes and calculate the distance between them using Euclidean formula. We also depict the blocking probability and traffic load by considering 100 packets of data which are traversed over the network. Fig.5 and fig.7 tells us about the relationship between simulation time and ACO topology as well as the simulation time and blocking probability respectively. Fig6 shows the relationship between the blocking probability and total no. of packets. Fig.8 tells at what percentage of packets in a network is blocked. All simulation results are included here. This is a simulated model that holds an edge over the analytical model since they are more accurate in general, using MATLAB the mathematical model is converted into code to simulate and analyze packets being transmitted using ant colony optimization technique and how the excessive traffic load hikes the blocking probability.

IV. CONCLUSION

This paper aims to find the optimal path in a network using ACO topology, this is a probabilistic technique where packets are transferred efficiently by minimizing the traffic load. This model also helps us to analyze the blocking probability and traffic load based on their simulation time respectively. This mathematical model requires simulated statistics, it has low implementation complexity and highly reliable.

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