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Ant Colony Optimization Based Routing Scheme in Vehicular Delay Tolerant Networks

Nidhi Sonkar, Sudhakar Pandey, Sanjay Kumar

Abstract*: Delay Tolerant Networks finds its application in variety of environments and addresses issues like intermittent connection, long and variable delays and high latency. Vehicular Delay Tolerant Networks was introduced due to its various characteristic matches with DTNs. In particular class of VDTN there are two types of nodes: Stationary and Mobile nodes. Stationary nodes are deployed along the roadside and mobile nodes are constrained to move over the roads with variable speeds. This letter presents a new routing algorithm based on Ant Colony Optimization in Vehicular Delay Tolerant Network. We performed extensive simulation in ONE simulator and compare with Probabilistic Bundle Relaying Scheme to gauge the benefits of Ant Colony Optimization based scheme over Probabilistic Bundle Relaying scheme.

Keywords*: Delay Tolerant Network, Vehicular Delay Tolerant Networks, Ant Colony Optimization, Probabilistic Bundle Relaying scheme, Vehicular Adhoc Network.

I. INTRODUCTION

The Delay Tolerant Networks can be stated as, the networks that includes the conception of intermittent network that allows frequent partitions [1]. DTNs find its application in variety of environments and addresses issues like intermittent connection, long and variable delays and high latency[2]. These networks helps in making communication possible in scenarios where no direct end-to-end connection is possible, for example in mobile networks, or in extreme terrestrial environments where no proper infrastructure is available, for example in remote areas and space [3]. Vehicular Delay Tolerant Networks was introduced due to its various characteristic matches with DTNs. There are some architectures of vehicular network that have already invented, like VANETs (vehicular ad hoc networks), V2V(vehicle to vehicle) architectures, and V2I(vehicle to infrastructures) architectures [4]. VDTN can beat Vehicular Adhoc Networks (VANET) because it has store carry forward mechanisms, therefore without end to end connection message can be delivered to the destination [5]. The Vehicular Adhoc Networks topology can fluctuate between really dense to very sparse. In dense network topology there are multiple vehicles available in the path therefore it is easy to provide multi hop communication between source to destination[6]. However, such type of multi hop communications between source to destination could not possible in sparse network topology because less number of vehicles and irregular connectivity between nodes. Thus by applying store-carry-forward mechanisms of DTNs, VDTN enable communication in sparse network case [7]. VDTN can have two types of nodes: Stationary and mobile. The communication thus involved may be between mobile-to-mobile and stationary-to-mobile. Stationary nodes deployed along the roadsides of highways and the mobile nodes are attached over vehicles moving along the roads[8]. These mobile nodes opportunistically enter in the range of stationary nodes and work as relaying nodes for transferring bundles (messages) to destinations. All the stationary nodes are located sufficiently far away such that no direct communication is feasible. Vehicles with random velocity navigate along the road and the mobile nodes attached over them serve as relays employing store-carry-forward scheme for connecting any arbitrary Stationary Relay Stations[9]. In previous research[10] and[11] Probabilistic Bundle Relaying Scheme in Multi Hop and Multi Copy Vehicular Delay Tolerant Network find the novel routing algorithm based on velocity and time to reach the message to the destination, they decrease the delay but not optimized. Therefore, in this article we propose the new routing algorithm based on Ant Colony Optimization which can reduce the delay and increase delivery Probability as well optimized routing algorithm in Vehicular Delay Tolerant Network.

A. Ant Colonies:

ACO extends for Ant colony optimization [12], the algorithm of ACO is based on the process of finding food of real ants. They find the path to the destination of food that take minimum time we can called as shortest path. ACO uses this technique in networking to find the shortest path from source to the destination[13]. Ants uses the amount of pheromone to find the shortest path from their source (nest) to the destination of food. They deposit certain amount of pheromone in the path when they reach to the destination and that marked path is also used for going back to the nest and this time also they deposit pheromone on the path. Therefore, the ants that follow the shortest path also returns earlier. In this way amount of pheromone is also increase on the path frequently as compare to the ants that follow longer path[14]. We know the nature of pheromone is evaporation, therefore the pheromone deposit by ants can evaporate after some time by a certain amount of time. Therefore, the paths that are frequently visited by ants are only left as a mark for other ants and the paths that are rarely used by ants are disappear after some time.

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***Correspondence Author(s)
Nidhi Sonkar, Department of Information Technology, National Institute of Technology Raipur, Raipur, India.
Sudhakar Pandey, Department of Information Technology, National Institute of Technology Raipur, Raipur, India.
Sanjay Kumar, Department of Information Technology, National Institute of Technology Raipur, Raipur, India.

Hence the other ants can follow the frequently used path that is the shortest path because they directed to follow the shortest path according to pheromone deposit.

In ACO, a number of artificial ants build solutions to the considered optimization problem and exchange information on the quality of these solutions via a communication scheme that is pheromone deposit on the path of the journey performed[15]. In Vehicular Delay Tolerant Network, we are using Ant colony Optimization for routing to reduce the delay to transfer the message from source to destination, which is presented in Methodology Section. In VDTN paths are not fixed therefore it is the challenge to use Ant Colony Optimization based routing algorithm in VDTN. Every time some different path can be activated by moving vehicle along the road. Therefore, intermittent connectivity problem can be solve by ACO based routing algorithm. In this article we proposed the new ACO based routing algorithm in Vehicular Delay Tolerant Network that can minimize the delay and increase delivery probability. Ant Colony Optimization algorithm has been used in various field of wireless networks. In Mobile Adhoc Network ACO is used for routing[16] and in VANET for clustering and routing[17][18].

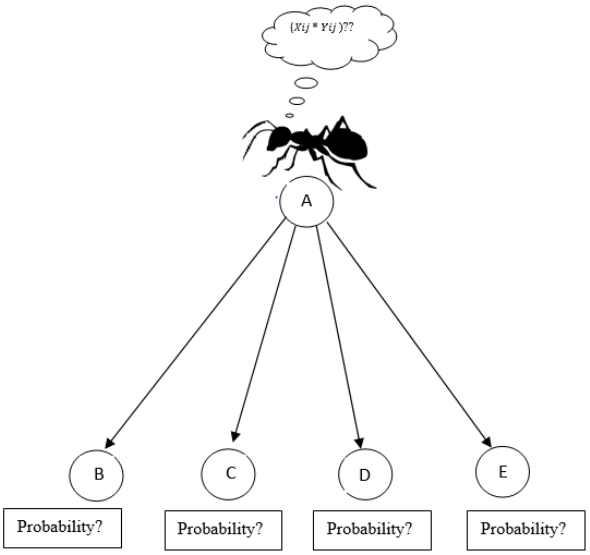

Fig 1: Ant Colony Optimization

II. MOTIVATION

The authors in [13] implemented network routing using Ant Colony Optimization. They find the shortest path using ACO algorithm from source to destination but the nodes are static here. Therefore in the era of wireless networking we have to use ACO in mobile nodes also where all the nodes are moving randomly. Therefore we are using Ant Colony Optimization in mobile network. Authors in [14] proposed a routing in vehicles by using ACO algorithm but, in this paper the problem is founded that when any intermittent connectivity found and long and variable delay arises this algorithm can't solve the problem. Delay Tolerant Network is known for solution of this type of problem, therefore we are using ACO based routing scheme in Vehicular Delay Tolerant Networks. In paper [10] Probabilistic Bundle Relaying Scheme in Multi Copy VDTN has been proposed this is one of the best algorithm for routing in VDTN. But, the Delivery Probability is less as compare to ACO based routing scheme in VDTN in this paper we compare both the algorithm and show the results.

III. ORGANIZATION OF PAPER

The paper work is followed by the literature review and after that Methodology which shows the proposed routing scheme. After methodology there is Simulation and Results which compares the ACO based scheme and PBRS scheme. Coming to last two sections concluded the complete work and describes the future work followed by references for details information about the particular topic.

IV. LITERATURE REVIEW

There are survey papers in Domain of Vehicular Adhoc Networks (VANETs) [19]. Those surveys describe the challenges in Vehicular Adhoc Networks without considering Delay Tolerant Networks features. Later, some authors in [20]offer an inclusive survey of routing protocols of Vehicular Delay Tolerant Networks. The authors in [21] give a new Probabilistic Bundle Relaying Scheme called PBRS in Two Hop Vehicular Delay Tolerant Network. And [11] also propose a novel Probabilistic Bundle Relaying Scheme (PBRS) called PBRS in Multi Hop Vehicular Delay Tolerant Network and [10] describes the Probabilistic Bundle Relaying Scheme in Multi Copy Vehicular Delay Tolerant Network. In this article, we present Ant Colony Optimization based routing algorithm in Vehicular Delay Tolerant Networks. The original scheme utilizes a parameter P, the Probability which defines the path that an ant can choose to transfer the message. This concept is using for improvement of the delivery probability and reduce mean transit delay in optimized way.

V. METHODOLOGY

Ant Colony Optimization algorithm is applied here in Vehicular Delay Tolerant Networks routing problem. Packets can be considered as a set of artificial ants and we simulate the packets from a source to the destination. Ants select the next node randomly by using the information from the routing table when they are transferring for the first time. The ants (packets) who reach successfully to the destination from the source deposit pheromone at the edges visited by them. Vehicular Delay Tolerant Networks are wireless mobile network there for pheromone can be a signal indicates that data successfully transferred to the destination and time to deliver the data from source to destination by that path. When other set of ants going to be transfer from source to destination, they can adopt the path by the deposit pheromone that previously visited ants left in the path that already reach successfully to the destination. Node i to node j is selected by ant with the probability calculated by following formula:

$$P_{ij} = \frac{X_{ij} \times Y_{ij}}{\sum X_{ij} \times Y_{ij}} \qquad (1)$$

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The probability can be find if the link between two nodes exist otherwise it will be zero. In the formula X_{ij} denotes the pheromone edge which between nodes i and j. $Y_{ij} = (1/dis_{ij})$, where distance between the nodes i and j is represented by dis_{ij}. When any ant reach to the destination it updates value of pheromone, this is the main characteristics of Ant Colony optimization. Though, this is must to perform evaporation action before adding the pheromone. Evaporation (ρ) of the pheromone can be implemented by following formula on the edge between node i and node j:

$$X_{ij} \leftarrow (1-\rho)X_{ij} \quad (2)$$

The pheromone updating in every time t=1,2,3….n by each ant is calculated by following formula:

$$X_{ij}(t+n) = \rho.X_{ij}(t) + \Delta X_{ij} \quad (3)$$

When some ant k does not pass any edge then amount of pheromone will be equal to zero. Or else, if the ant k passes some edge, it will drop the amount of pheromone. And the total cost of all the edges that passes by ant 'a' is inversely proportional to the amount of pheromone. That is represented in following paragraph.

$$X_{ij} = X_{ij} + \sum_{a=1}^{m} \Delta X_{ij}^{a} \quad (4)$$

$\Delta X_{ij}^{a}$is the pheromone amount left by ant when it visited the edge. It is calculated by the following expression:

$$\Delta X_{ij}^{a} = \begin{cases} 1/Co^{a} \\ 0 \end{cases}$$

Where Co^{a} is the cost of all the edges from starting node to the destination passed by ant 'a' on its path. This will allow for the better ant to leave more pheromone on the edge which is the route on the best path. When the number of packets increases the algorithm can be applied for congestion control also this is the advantage of Ant Colony Optimizations[22]. In the static network the congestion will occur in future because all the packets follow the same path calculated by the algorithm because that is the best path. Therefore some of the packets will have to wait for some time. However, in Vehicular Delay Tolerant Network all the nodes are dynamic so every time route can be changes from source to the destination therefore congestion problem will not occur in this network. Ant Colony Optimization can also solve the problem of congestion control and link failure. For congestion control, we know that for getting shortest path next node is selected randomly therefore every node select some other node not a particular node therefore, the congestion problem will not occur and network performance will be increase. And failure of link or interruption between two nodes which are the part of shortest path (which is the major problem of Delay Tolerant Networks), ACO can handle this problem easily by selection some other shorter route quickly.

A. Routing algorithm:

Set of Ants placed in Source node
  For (j=1 to A)
    Current_node = Source_node
    While (Current_node! = Destination_node)
      Calculate probability function for nodes
       according to formula (1)
      Choose the next_hop node
      Current_node= next_hop node
    End while
  End for
  Modify Pheromone according to formula (3)
Transfer the message by best route.

TABLE I: DESCRIPTION OF VARIABLES

VARIABLE	DESCRIPTION
L	Total Path length of an ant
P_{ij}	Probability of selecting node j from i
X_{ij}	Pheromone in the edge between node i&j
Dis_{ij}	Distance between node i&j
P	Pheromone Evaporation
T	Time
Co	Cost of edge
A	Number of Ants

VI. Simulation and Result

We have used well known opportunistic routing simulator, ONE Simulator[23], for evaluating the routing performance. Opportunistic Networking Environment (ONE) simulator is planned for assessing Delay Tolerant Network (DTN) routing protocols specifically. By using these users can create scenarios that can be based upon different movement models which can be synthetic as well as real world traces and produce an environment for implementing application protocol and routings. Evaluating experiments are supported by interactive visualization and post-processing tools and an emulation mode allows the ONE simulator to become part of a real-world DTN test bed. We carried out extensive simulation to study performance of ACO based routing scheme and PBRS routing scheme in Vehicular Delay Tolerant Networks, in order to compare both and gauge the benefits of ACO based routing scheme relative to PBRS routing scheme. The summary of the simulation parameters are listed in Table II.

TABLE II: PARAMETERS

Parameters	Value
Movement Model	Map Based Movement
Buffer Size	5-30 M
Message Size	100 b
Number of Nodes	20-100
Message TTL	300 min
Message Generation Interval	1-15 message/min
Transmit Range	100 m

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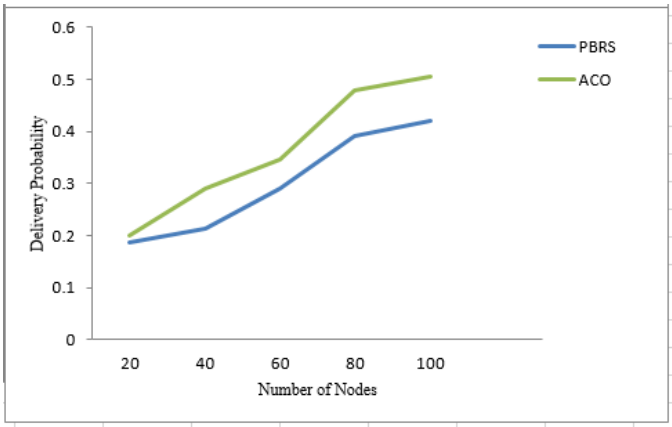

Fig 2: Delivery Probability v/s Number of nodes.

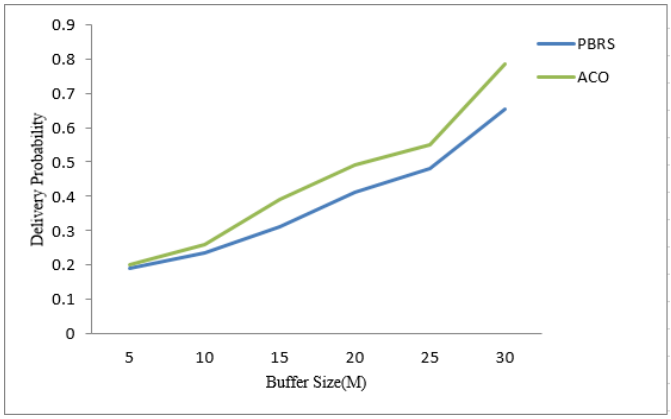

Fig 3: Delivery Probability v/s Buffer Size (M)

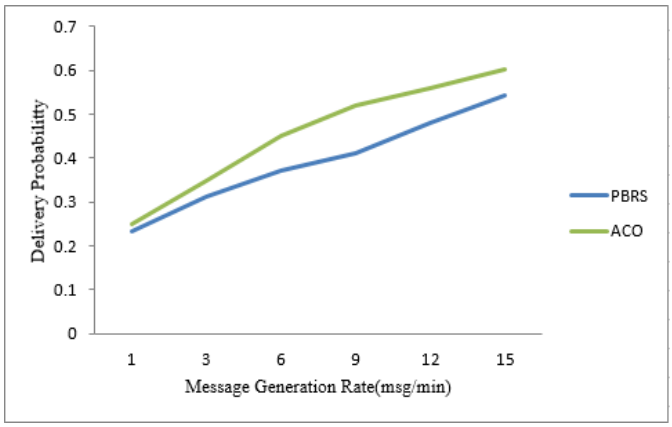

Fig 4: Delivery Probability v/s Message Generation Rate.

The introduction of concept of ACO based routing scheme has improved the performance of the routing in Vehicular Delay Tolerant Network. Fig. 2, shows that the delivery probability has significantly increase as compared to PBRS scheme when number of nodes increases. One of the reason for this increase is due to ACM routing algorithm find the best route by using pheromone and when number of nodes increases number of opportunities also increases to transfer message to the destination. But complexity also increases when more number of nodes are there but we can find the best and optimized route when we have more number of ways to solve the problems. Fig 3 shows delivery probability increases when buffer size increases as compared to PBRS routing scheme in Vehicular Delay Tolerant Networks because storage of copies of message increases therefore if message lost in the direction of other way multiple times source can send the message to the destination as buffer size is more. Fig 4 shows that delivery probability increases as compared to PBRS routing scheme when message generation rate increases. The reason is that the number of message increases and we have the best route for transferring the message we can send the messages as soon as possible.

VII. Conclusion

In Vehicular Delay Tolerant Networks, by implementing Ant Colony Optimization based routing algorithm for decreasing the problem that occur in other routing algorithms , we have concluded that this algorithm could increase the delivery ratio efficiently as compare to Probabilistic Bundle Relaying Scheme in optimized way. The main Problem of Network has solved in this algorithm is intermittent connectivity, convergence breakup etc.

Future Work

In future, we can solve the problem of congestion control by ACO algorithm in Vehicular Delay Tolerant Networks. In future, this research can be extended to the real world mobile networks with physical nodes that will give us to the accurate results.

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AUTHORS PROFILE

Nidhi Sonkar is a PhD Research Scholar in Department of Information Technology at National Institute of Technology, Raipur and completed her M.Tech in Department of Information Technology from National Institute of Technology, Raipur. Her research focuses on delay tolerant network.

Sudhakar Pandey received the PhD degree from Allahabad University. He is currently working as an Associate Professor in the Department of Information Technology, at the National Institute of Technology, Raipur, India. His research focuses on ad hoc networks, sensor networks, and cellular and mobile communication.

Sanjay Kumar received the PhD degree from National Institute of Technology, Raipur. He is currently working as an Assistant Professor in the Department of Information Technology, at the National Institute of Technology, Raipur, India. His research focuses on sensor networks, delay tolerant networks and mobile communication.