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A Review on Ant Based Routing Protocols for Manet

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Abstract*— Due to the dynamic nature of MANETs, route maintenance is quite difficult task. Routing is the process by which we choose paths in a network along which the source can send data packets towards destination. It is an important aspect of network communication because the characteristics like reliability, throughput, and congestion depends upon the routing information. An ideal routing algorithm is one which is able to deliver the packet to its destination with minimum amount of delay and network overhead. The nodes update the routing tables by exchanging routing information between the other node in the network. The ACO meta heuristic is based on generic problem representation and the definition of the ant's behaviour. ACO is based on the foraging behaviour of real ants. Main objective of this review is to study various ant based routing protocols for MANETs.

Keywords*— Ant Colony Optimization, Mobile Adhoc Network, ants, quality of services, routing, route, hybrid.

I. INTRODUCTION

A mobile ad-hoc network consists of a collection of mobile nodes which can communicate with each other with the help of wireless links. There is no pre-existing communication infrastructure in MANETs.[1] As there is no fixed infrastructure and centralized control in MANETs therefore nodes can join or leave the network at any time . All nodes are supposed to be equal in processing power. Any node can act either as a host or as a router to direct the packet from source to destination. There is requirement to self configure the network by means of the cooperation among the mobile devices. All nodes acts as routers and are capable of discovering and maintaining routes to propagate packets to their destinations.[2]

There are a lots of advantages promised by this type of network in terms of cost and flexibility compared to network with infrastructures. MANETs are used for a great variety of applications such as data collection, medical applications and seismic activities. But unfortunately, bandwidth and energy of nodes in MANET are limited. These resources constraints pose a set of non trivial problems; in particular, routing and flow control. Thus over multiple hops information can be routed from source to destination.[3]

Particularly the routing function is a challenging task in these type of networks because the network structure is constantly changing and the network resources are limited. Routing algorithms lack of adaptability to limited resources, frequent topological changes, energy availability reduces network performance.[3]

Optimization techniques can be used to find out an available optimal path from source to destination. This is not necessary that the optimal path should be always the shortest one, but it should always be the feasible path which gives the best possible path from source to destination. There are a number of optimization techniques in order to find out optimal path. Ant Colony Optimization is one of these optimization techniques.[1]

II. ANT COLONY OPTIMIZATION(ACO)

The ACO meta heuristic is based on generic problem representation and the definition of the ant's behavior. ACO is based on the foraging behavior of real ants. When there are multiple paths from nest to food, then initially ants do random walk. When they walk towards food as well as when they return to nest, they release a chemical substance which is called pheromone which serves as a route mark that the ants have taken. The newer ants will choose the path which has higher pheromone concentration and also will reinforce the path they have taken.[3]

III. MANET CHARACTERISTICS

A few characteristics of MANETs are as follows:

1) The packet should be forwarded via one or more intermediate nodes, when a node tries to send information to other nodes which is out of its communication range.

2) In MANET, each mobile node is an independent node. Each node can function as both a host and a router.

3) Nodes are free to move arbitrarily in the network with varying speeds thus, the network topology may change randomly and at unpredictably. The nodes in the MANET establishes their own network dynamically as they travel around.

4) The nodes at MANET are mobile with low power storage, less CPU capability and small memory size.

5) There is no centralized control of the network operations, the overall control of the network is distributed among the nodes. The nodes in a MANET should cooperate with each other and communicate among themselves.

6) Any entity with the appropriate equipment and adequate resources can access the wireless communication medium. Access to the channel cannot be restricted.

IV. MANET CHALLENGES

Some of the challenges faced in MANETs are discussed below:

1) Dynamic topology: The topology of MANETs is dynamic, due to which the trust relationship among nodes may be disturbed. Also if some nodes are detected as compromised, trust may be disturbed.

2) Overhead in Routing: As the nodes often changes their location within network, So therefore sometimes some stale routes are generated in the routing table which causes unnecessary routing overhead.

3) Packet losses: Ad hoc wireless networks experiences a much higher packet loss due to factors such as frequent path breaks due to mobility of nodes and increased collisions due to the presence of hidden terminals etc.

4) Frequent route changes: The network topology is highly dynamic due to the movement of nodes, hence frequent path breaks occurs in on-going session. This situation often leads to frequent route changes.

5) Hidden terminal problem: The hidden terminal problem refers to the collision of packets at a receiving node due to the simultaneous transmission of those nodes that are not within the direct transmission range of the sender, but are within the transmission range of the receiver.

6) Security threats: The wireless mobile ad hoc nature of MANETs brings new security challenges to the network design.

7) Quality of Service (QoS): Providing different QOS levels in a constantly changing environment will be a challenge. Due to inherent stochastic feature of communications quality in MANET, it becomes difficult to offer fixed guarantees on the services offered to a device.

8) Limited bandwidth: As compared with infrastructured networks wireless link continue to have significantly lower capacity. Moreover, the realized throughput of wireless communication after accounting for the effect of noise, interference conditions, multiple access and fading etc. is often much less as compared with radio's maximum transmission rate.

9) Limited power supply: Power supply of nodes is restricted in MANETs due to which several problems are caused. When a node finds that it has only limited power supply then it may behave in a selfish manner.

V. VARIOUS ANT BASED ROUTING PROTOCOLS FOR MANETS

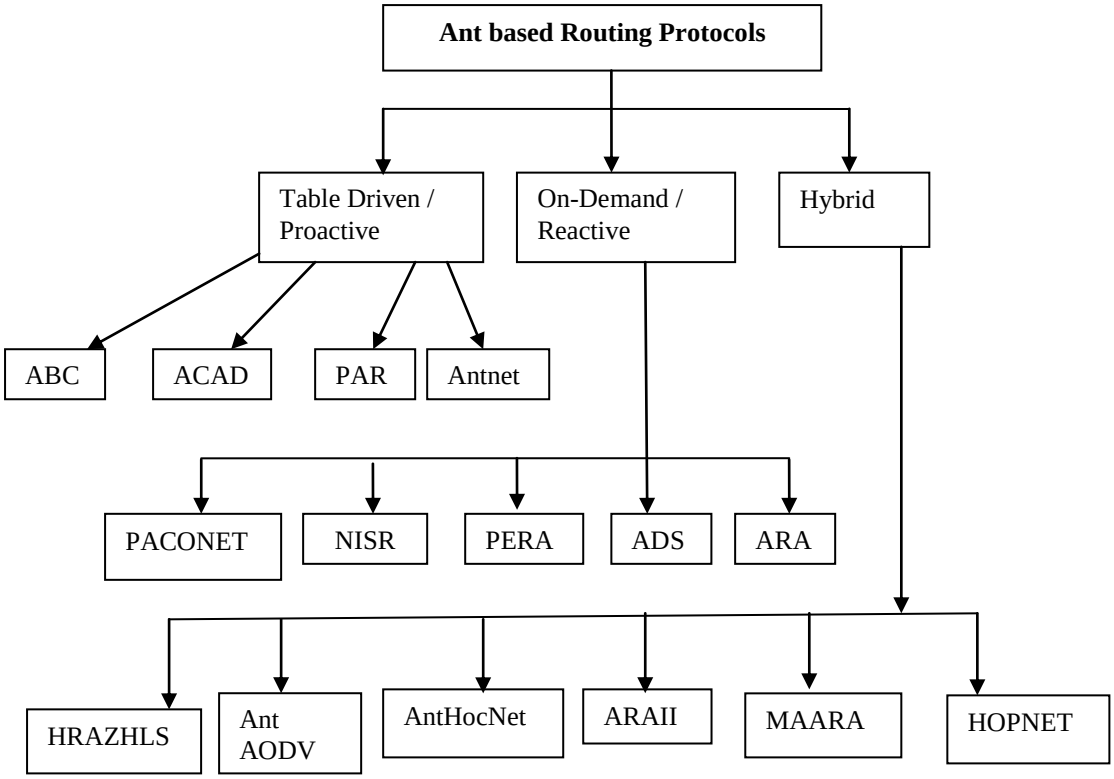

Fig. 1 Ant based routing protocols

1. Table driven/proactive ant based routing protocols:

A. Ant based control (ABC)

In the ABC routing scheme, following procedure is adopted by the ants, groups of exploratory ants make probabilistic decisions about selection of path by making the deterministic decisions i.e. by choosing the link with the most pheromone in the column corresponding to the destination. Exploratory ants are used for source updates. Each source

node issues a group of exploratory ants. Each of these ants goes toward a randomly selected destination. The routing table at each node contains neighbours as rows and all possible destinations as columns and each entry corresponds to the amount of pheromone on the link towards a particular neighbour for a particular destination.

B. AntNet

The AntNet frame work was an ACO based algorithm used for routing of packets in telecommunication networks. The ant used in this algorithm carry in its memory the identification of each node that it passes by. As stated above, the ants lay down a hint of routing called as pheromones while traveling to find food. The other ants detect these pheromones and follow the same path of the mark produced by the other ants. Thicker the pheromone trail, the more likely other ants will follow the path. In fact, all of the ants movements are based on immediate reactions to its surroundings or to its fellow ants. This indirect communication makes ants to represent a highly structured and complex social organization.

C. Probabilistic ant routing (PAR)

The probabilistic ant routing algorithm uses two kinds of agents forward and backward ants. The forward ants are probabilistic and explore the network to collect the network traffic information. They are routed on normal priority queues means they use the queues same as normal data packets. When the forward ants reach the destination, it is deallocated and the backward ant inherits the stack contained in the. The is deterministic and is sent out on high priority queue. The backward ants retrace the path and utilize this information to update the routing tables and other data structures periodically.

D. Automatic clustering inspired by ant dynamics (ACAD)

ACAD is a simple heuristic algorithm which can detects any number of well separated clusters of any shape automatically for e.g. convex and/or non-convex. The algorithm draws inspiration from the dynamics of ants and iteratively partitions the data set based on its proximity matrix. It is different from the existing ant colony based clustering techniques. As ants go along a path, they deposit a chemical substance which is called as pheromone to which other ants are attracted. This pheromone decays over time. This is the aspect of ant dynamics that has been used in this technique.

2. On demand/reactive ant based routing protocols:

A. The ant-colony-based routing algorithm (ARA)

In ant-colony-based routing algorithm (ARA) for MANETs, the network agents (ants) are only transmitted on demand and are flooded through the entire network in a similar manner as in AODV. The routing table entries do not contain probabilities rather than it stores pheromone concentrations, which are transformed into probabilities later on.
ARA works in the following three phase :

Route discovery phase: In this phase, new paths are discovered. The new routes creation requires the use of Forward ants, which establishes the pheromone track to the source node backward ants, which establishes the track to the destination node.

Route maintenance: Once the forward ants and backward ants have established the pheromone tracks for the source and the destination node, the pheromone value is also increased by subsequent data packets. Data packets are used to maintain the path, so no overhead is introduced. Pheromone values are keep on changing. When a node relays a data packet toward destination to a neighbor node, it increases the pheromone value for that entry. The same happens in the opposite direction.

Route failure handling: ARA recognizes a route failure through a missing acknowledgement on the MAC layer and to deactivate that link by resetting the pheromone concentration to 0. Then, the routing table is checked for different links towards the destination and the packet gets relayed accordingly.

B. Probabilistic emergent routing algorithm (PERA)

The probabilistic emergent routing algorithm (PERA) has been proposed in which the routing table stores the probability distribution for the neighboring nodes. This probability associated with a neighbours reflects the relative likelihood of that neighbor forwarding and eventually delivering the packet forwarded to it to the destination node.

C. Ant dynamic source routing (ADSR)

ADSR takes into consideration of three QoS parameters namely as delay, jitter and energy. dynamic source routing (DSR) protocol is an on-demand routing protocol that is based on the idea of source routing. There is requirement for mobile nodes to maintain route caches that contain the source routes of which the mobile is aware. Entries in the route cache are continuously updated as new routes are learnt.

D. Improvised ant colony optimization algorithm MANETs (PACONET)

The improvised ant colony optimization algorithm for MANETs is called as PACONET which uses two kinds of mobile agents, forward ants and backward ants. Forward ants are transmitted in a controlled broadcast manner to determine new routes. Backward ants establish the path based on the information gathered by forward ants. These mobile agents leave certain amount of pheromone at the time they depart from the node.

E. A nature inspired scalable routing protocol for MANETs (NISR)

Temporally Ordered Routing Algorithm (TORA) is the base protocol for NISR protocol which is a reactive multipath routing protocol that discovers all paths between source and destination and finally selects the shortest one with fewer hops. NISR protocol is developed by inspiration from bee and ant colonies. Ants and Bees help each other to find food sources, update quality of paths to these food sources continuosly and determine pheromone of paths. Bees are responsible to discover new food sources and update information about quality of food sources during the time whereas ants determine pheromone of paths.

3. Hybrid ant based routing protocols:

A. Ant-AODV

This algorithm overcomes the shortcomings of the AODV. It is hybrid in nature to some extend. This algorithm decreases the end to end delay and latency in route discovery and increases the connectivity between the nodes. Ant AODV supports on demand route discovery to the destination node if they do not have recent route entries.

B. AntHocNet

AntHocNet can be considered a hybrid algorithm, since it contains both reactive and proactive elements. It is reactive because it only gathers routing information about destinations that are involved in communication sessions. It is proactive because it tries to maintain, improve and extend routes while the communication session is going on. This hybrid architecture improves the efficiency by focusing the efforts on ongoing sessions.

C. Ant routing algorithm for MANETs based on adaptive improvement (ARAAI)

ARAAI will combine advantage of proactive routing and reactive routing providing multi-path, and offering adaptive control. The algorithm use two tables one is routing table that can be represented as: initial node, last node, and heuristic value. ''Initial node'' contains the leaving initial place of ants and ''last node'' contains the address of the previous node. The heuristic value is local node energy information collection. Second routing table contains the neighbor information and is represented as connection between local and other nodes.

D. Multi agent ant based routing algorithm (MAARA)

Multi agent ant based routing algorithm (MAARA) is a hybrid algorithm which has properties of ant based routing and multi agent systems. The algorithm is proactive, since the nodes establish path only when there is a need to transmission of data between a source and destination. It is reactive means that the nodes maintain routing table till the end of the communication session. The routing algorithm consists of 5 phases as: route updation, route discovery, route maintenance, data routing, and route failure.

E. HOPNET

HOPNET is a hybrid ant colony optimization routing protocol based on ants hopping from one zone to the next. HOPNET is highly scalable for large networks compared to other hybrid protocols. This algorithm contains the local proactive route discovery within a node's neighbourhood and reactive communication between the neighbour-hoods. There is a division of network into zones which are the node's local neighbourhood. A routing zone contains the nodes and all other nodes within the specified radius length measured in hops.

F. Hybrid routing algorithm based on ant colony and ZHLS routing protocol for MANET (HRAZHLS)

HRAZHLS uses the zone based hierarchical link state (ZHLS) protocol that uses proactive routing scheme within a zone and reactive routing scheme outside the zone i.e. between the zones. The network is divided into non overlapping zones. The zone size depend on, network density, transmission power, node mobility and propagation characteristics. Each node knows its physical location by geo-location techniques such as global positioning system (GPS). The nodes can be categorized as interior and gateway nodes. The algorithm has two routing tables, intrazone routing table (IntraRT) and interzone routing table (InterRT).

VI. ANALYSIS OF VARIOUS ENERGY AWARE ACO ALGORITHMS

Algorithm	Routing approach	Type of ants	Problem	Energy aware	Path type
ARAAI	Hybrid (More the proactive behaviour)	Forward ants and backward ants	Route discovery Delay	Yes	Multipath
ADSR	Reactive	Forward ants, backward ants	Extra control packets are required periodically to monitor the condition of the paths	Yes	Single path
NISR	Reactive	Scout bees & ants	Hop count may increase	Yes	Multiple path

VII. LITERATURE SURVEY

A. Taxonomy of various ant colony algorithms

The authors Gurpreet Singh, Neeraj Kumar, Anil Kumar Verma in 2012 provides [2] a taxonomy of various ant colony algorithms with advantages and disadvantages of each others with respect to various metrics.

B. Management of MANET's resources

The authors Osama H. Hussein, Tarek N. Saadawi, and Myung Jong Lee *in 2005* introduces [10] a resource management application of a probabilistic based ant routing algorithm for mobile ad hoc networks (ARAMA) that is inspired from the ant's life. The goal of their work was to present ARAMA ability to manage MANET's resources while considering the dynamic characteristics of MANETs and the need for low control overheads, by achieving fair network resources distribution,. In this algorithm, the parameters like the nodes' (processing power,node's energy, . . .) and links' (bandwidth, . . .) are measured and collected in the nodes' indices. Also they used a path index to measure the path total resources and serves to minimize the forward control packet (ant) size. The concepts of negative backward ant destination trail are introduced to enhance the performance of the algorithm.

C. Cost enabled route discovery

The authors Sarala.P, Kalaiselvi. D in 2010 enhanced [11] The MPDSR(Multipath dynamic source routing protocol) protocol with ant colony optimization method to provide multipath route information using global link information. EMPDSR provides QoS factors such as end to end reliability. Network traffic, battery power and bandwidth factors make an influence over the route discovery process. The EMPDSR protocol is integrated with fuzzy cost estimiation techniques. Distance, network traffic, bandwidth and battery power metrics are used in the fuzzy cost enabled multipath dynamic source routing protocol.

D. Route optimization in MANETS

The authors Young-Min Kim, Eun-Jung Lee, and Hong-Shik in 2011 proposed [4] an ant colony optimization (ACO) referred to as A-ESR which is based on energy saving routing for energy efficient networks. Firstly the proposed A-ESR algorithm re-formulates the energy-consumption minimized network problem into a simpler one by using the concept of traffic centrality. Ans then, it solves the re-formulated problem by 1) letting the flow to autonomously be aggregated on some specific heavy-loaded links and 2) switching off the other light-loaded links. The authors Gianni Di Caro, Frederick Ducatelle and Luca Maria Gambardella in 2005 [12] describes an algorithm known as AntHocNet for routing in MANETs. The algorithms is a hybrid algorithm that combines reactive path setup with proactive path probing, maintenance and improvement. AntHocNet is based on the ant colony optimization framework. Monte Carlo sampling is used to learn the path using ant-like agents which communicates in a stigmergic way. By extensive set of simulation experiments, they compare AntHocNet with AODV which is a reference algorithm in the field.

The authors Pankaj Vidhate, Yogita Wankhade in 2013 [1] in order to find out best possible paths used Ant Colony Optimization , along with Genetic Algorithm which helps in providing the globally optimal solution from all the best possible paths which were produced by Ant colony optimization. This proposed algorithm known as GA-API overcomes the delay in packet delivery by producing the shortest path and also overcomes the problem of communication interruption due to node or link failure by finding multiple paths between pair of source and destination nodes.

E. Improving QOS in MANET using ACO

The work is implemented by Ankur Jain and Ritu Choudhary [5] in 2014 , in order to improve quality QoS in MANET used Ant Colony Based Routing. If during setup phase protocol doesn't cares for load parameters or conditions at the stations, in that case these protocols are not able to take profit of less loaded stations of network, Thus multipath routing using ACO in their work can overcome the above stated problem, providing features of load balancing and protection from route failure, successful packet transfer, overall throughputs and average end-to-end delay by distribution of traffic in between set of different paths/channels.

The authors V. Saritha, G. Vedha, A. Bhiwal, A.S. Chawla, P. Venkata Krishna in 2010 proposed [6] a QOS enabled ant colony based multipath routing (QAMR) algorithm which is based on the foraging behaviour of ant colony for selecting path and transmitting data. In their approach, Based on the stability of the nodes and the path preference probability, the path is selected. They considered following QOS parameters delay,hop count and bandwidth along with number of hops and path preference, the stability of node probability factors.

F. Load balancing

The authors S. Soundararajan, R.S. Bhuvaneswaran in 2012 in Order [7] to overcome the issues such as link failures and node's high mobility, more message overheads implements an efficient multi-path routing protocol ABMRLBCC (Ant Based Multi-path Routing for Load Balancing and Congestion Control) based on Ant Colony Optimization is proposed. The multipath routing algorithm sets up path only when it is needed at the start of a data session. The forward ants are launched by the source in order to find multiple paths to the destination, and backward ants return the source to set up the paths .The forward ant sets up a reactive path which provides the routing information of a node. For each ant the best path is selected based upon the number of hops and travel time. The proposed approach outperforms in terms of better packet delivery ratio and reduced end-to-end delay.The authors Deepender Dhull, Swati Dhull in 2013 in order [8] to solve the traffic engineering multicast problem which optimizes many objectives simultaneously offered a design on Ant

Based Multicast Routing (AMR) algorithm for multicast routing in mobile ad hoc networks. Apart from the existing constraints such as distance, delay and bandwidth, the algorithm calculates one more additional constraint in the cost metric which is the product of average-delay and the maximum depth of the multicast tree. Moreover it also attempts to reduce the combined cost metric. By reducing the number of group members that participate in the construction of the multicast structure and by providing robustness to mobility by performing broadcasts in densely clustered local regions, this proposed protocol achieves packet delivery statistics which are comparable to that with a pure multicast protocol but with significantly lower overheads. By this protocol we achieve increased Packet Delivery Fraction (PDF) with reduced overhead and routing load. The authors N.Umapathi, N.Ramaraj, R.Adlin Mano in 2012 proposed [9] AntHocNet an algorithm for routing in mobile adhoc networks. This algorithm is a hybrid algorithm that combines proactive and reactive behavior to compute end to end delay, packet delivery ratio and overhead by varying the speed of the mobile nodes. The algorithm is based self organized algorithm of ANT colony optimization (ACO). The bit error rate of ANT algorithm in accordance with other algorithms (AODV, DSDV, DSR, TORA…) is computed including time delay packet loss and power consumption.

VIII. CONCLUSION

Ant Colony algorithms allow for optimum route discovery in wireless networks that makes them more suitable for MANETs. In this paper, various ant colony routing algorithms with their respective advantages and disadvantages have been studied. Applications of ant colony algorithms to solve the routing problem in MANET have been addressed.

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