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VOYAGING THROUGH VARIOUS ANT BASED ROUTING ALGORITHMS FOR MANETs

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ABSTRACT

Mobile ad hoc network (MANET) consists of many wireless nodes or devices, placed together in an ad hoc manner and without the support of fixed infrastructure. All the nodes which are present in the network are mobile and can enter and leave the network any time. MANET serves the effective, operational bandwidth and have limited battery power for the nodes. Many different routing protocols and algorithms are used to conclude this challenging property.The swarm intelligence algorithms are:- Ant Colony Optimization (ACO), Particle Swarm Optimization, Artifical immune systems, Artifical bee colony algorithms and many more. Ant Colony Optimization are more predicting in providing loop free, energy-aware, and multipath routing in mobile ad hoc networks. ACO routing algorithms use simple agents or artificial ants and these agents and ants demonstrate optimum paths between source and destination. These agents communicates indirectly with each other by means of stigmergy. This paper demonstrates a survey on different MANET routing protocols which are based on algorithm inspired by ACO.

Keywords*: *Ant Conoly Optimisation, Mobile Adhoc Networks, Multi-path, Pheromone, Routing.

I. INTRODUCTION

MANET is a collection of autonomous mobile nodes and these nodes communicate with each other through radio waves. Mobile nodes those are in direct radio range can communicate with each other directly, but those who are not indirect range can communicate each other by using another node as an intermediate to intercommunicate. In a MANET environment, each node acts as a host and many times act as a router. Routing is one of the problems of networking for delivering data from one node to the any other node in the network. Wireless ad-hoc networks are also called Mobile ad-hoc multihop networks without predetermined topology or central control. This is because Mobile Ad-Hoc networks can be characterized as having a dynamic, multihop, potentially speedy changing topology. MANET uses a peer-to-peer multihop routing instead of a static network infrastructure to provide network connectivity. Due to the limited transmission range of wireless network interfaces, multiple hops may be needed to exchange data between nodes in the network. Due to frequent changes, in network topology and limited resources, routing in MANET experiences link fail many times but for short intervals. Link unbalance and node mobility make routing an essential issue in MANETs. Applications of

MANET in several areas include: Commercial sectors, personal area network , collaborative and distributed computing, wireless sensor network, wireless mesh network and hybrid wireless network architectures. MANET works with different routing protocol as compared to fixed networkss. These protocols are mainly classified as Proactive, Reactive and Hybrid protocols. Proactive protocols are also known as table driven protocols. These protocols maintain routes for all the nodes, which are present in network. Proactive protocols react to topology changes, even if no traffic is involved in the network. Proactive routing protocols may consume bandwidth since control messages are sent out unnecessarily where there no data traffic. Distance vector (DV) protocol, Destination Sequenced Distance Vector (DSDV) protocol, Wireless Routing protocol, Fisheye State Routing (FSR) protocol are the examples of Proactive protocols. Reactive protocols are also known as on-demand routing protocols. Reactive protocols seek to set up routes on-demand. If a node wants to start communication with a node to which it has no route, the routing protocol will try to search such a route. Reactive protocol reduces routing overhead and consume less energy. One of the limitation of such protocol is that the source node needs to wait for the response of sending the route request. Because of this it produces huge control packets due to route discovery during topology changes which occurs frequently in MANETs and it obtains higher latency. The examples of this type of protocol are Dynamic Source Routing (DSR), Ad-hoc On Demand Routing (AODV), Ad-hoc On Demand Multipath Routing (AOMDV) and Associativity Based Routing (ABR) protocols. Hybrid protocol works with the combination of both reactive and proactive approaches. This protocol takes the advantage of both types of approaches into a single protocol. These are Various hybrid protocols like Zone Routing Protocol(ZRP),and Zone Based Link State (ZHLS). Figure 1 shows multiple nodes which are connected with each other in MANET environment where link between nodes show that they are in direct communication range of each other.

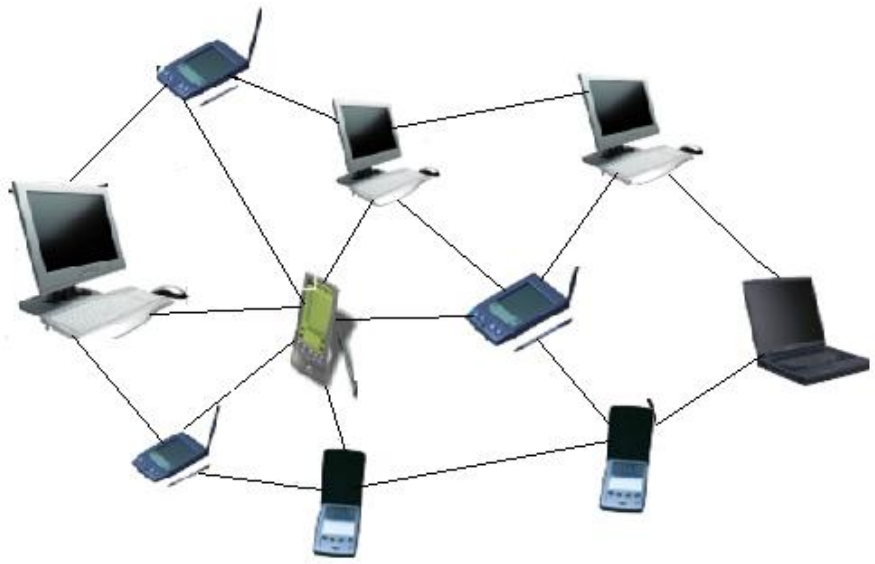

Figure 1 : Mobile AdHoc Network(MANET)

Ant Colony optimization (ACO) based Algorithms finding optimal paths that are based on the behavior of ants path searching capability. ACO uses swarm intelligent methods and comprise some metaheuristic optimizations

techniques.Optimization problems are of high importance both in the industrial world and in the scientific world. Ant Colony Optimization (ACO) takes inspiration from the behavior of ants taxon.Ants deposit pheromone on the ground in order to mark the favorable path that should be followed by other members of the colony. Ant Colony Optimization exploits a similar mechanism for solving optimization problems. Many ants can take different routes for searching for the same food source. The ants, which take the shortest path reinforce that path with more quantity of pheromone which helps other ants to follow that shortest path.More number of other ants are getting attracted because of this pheromone trail which makes the path stronger. The nature of ants is helpful in quickly identifying the shortest path. ACO uses stigmergy for communication.Stigmergy systems are rebound to the failure of individual agents and more significantly react extremely best to dynamically changing environment.

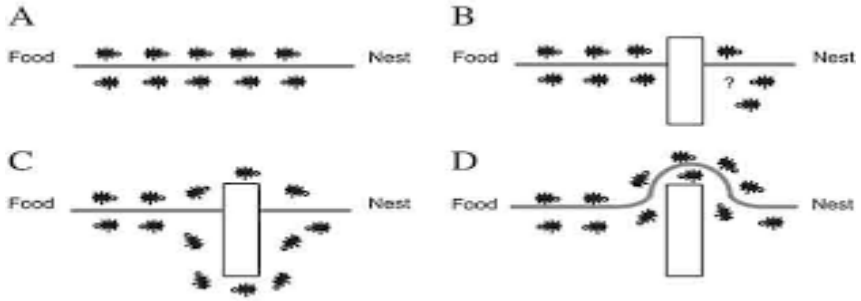

Figure 2 : Ants on the Shortest Path from Food to Nest and Nest to Food

Ant Colonies are capable to find the shortest path between their nest and the food source by depositing and reacting to the trail of pheromone which provide help to future ants towards optimal paths to food. Figure 2 shows how ants find the shortest path from nest to food.

II. CLASSIFICATION OF VARIOUS ACO ROUTING ALGORITHMS

Ant Colony Optimization(ACO) resolves many problems of MANET. MANET has dynamic topology and each node has limited resources such as battery processing power and on board memory. This is known as infrastructureless network.Various Routing Protocols are used in MANET which controls the journey of message packets from source to destination in a network. Each of these routing protocols are applied according to the network contexts. MANET categorized into different routing protocols Proactive, Reactive and Hybrid Protocols. These Algorithms are as follows:-

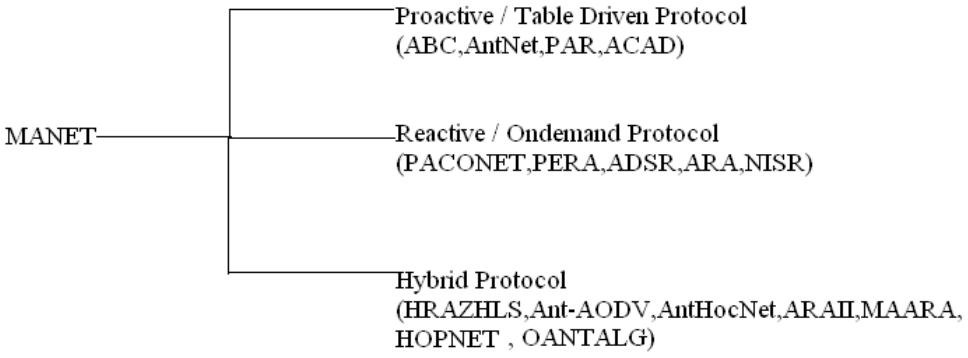

Figure 3 : Classification of Ant Based Routing Protocols for MANETs.

III. PROACTIVE/TABLE DRIVEN ANT BASED ROUTING PROTOCOL

3.1 Ant Based Control (ABC)

Ant Based Control model [22] is one of the ant Colony Optimization (ACO) based algorithm used for the telecommunication network. ABC uses fixed shortest path routes, and uses an alternative algorithmically based type of mobile agent for use with network management. In ABC algorithm a number of agents called ants are continuously exploring the network from the sources to destinations. Arriving at a node, they update the pheromones to their source node for its entire neighbor node, which corresponds to the probabilities for ants to select each neighbor node. ABC uses two ants 1. Exploratory ant 2. Actual ant. Exploratory ant makes a probabilistic decision for transmission and Actual ant makes a deterministic decision for transmission. Ants move from node to another node, selecting the next node to move to according to the probabilities in the pheromone tables for their destination node on arrival of a node, they update the pheromone table entry corresponding to their source node. They alter the table to increase the probability pointing to their previous node. Whenever ants reached their destination, they die. The increase in these probabilities is a decreasing function of the age of the ant.This ant based algorithm was compared with other algorithms for shortest path like Dijkstra's algorithm which is used for network management. Ant Based Control (ABC) has less failure than the other methods.

3.2 AntNet

AntNet [2] is used to find the shortest path to the destination node. AntNet uses a proactive routing approach for wired datagram network. AntNet is used in Wavelength routed optical network (WRON) and optical packet switching network (OPSN). Every node in Network maintains its own routing table and maintains the node movement statistics based on the traffic distribution over the network. The routing table contains the destination node, next hop node and Pheromone values. AntNet uses two sets of homogeneous mobile agents called forward ants and backward ants to update the routing tables. These mobile agents are small packets containing source IP address, destination IP address, packet ID and a dynamically growing stack consisting of node ID and node traversal time. A node which receives a forward ant for the first time creates a record in its routing table. During the route finding process ants deposit pheromone on the edges. The forward ant selects next node heuristically, which is based on pheromone value that is present in the routing table. The forward ants are used to collect information about traffic distribution over the network. When the forward ant reaches at the destination, it generates the backward ant and then dies immediatly. The backward ant reconstructs the path of a forward ant in the opposite direction. At each node backward and updates the routing table and additional table containing statistics about traffic distribution in the network. AntNet algorithm works within the self organizing environment.

3.3 Probabilistic Ant Routing (PAR)

This algorithm [35] uses two types of agents known as Forward Ants and Backward Ants. The forward ants (FANT) are probabilistic and explore the network to collect the network traffic information. When the FANT reach the destination, it is deallocated and the backward ant (BANT) inherits the stack contained in the FANT. The BANT is deterministic and FANT sent out on a high priority queue. The BANT reconstruct the path in the

network of the FANT. It utilizes this information to update the routing tables and other data structures periodically**.** This ant algorithm is a variant of reinforcement learning. The rules used to update the pheromone are as:

a. Increase the probability of the hope of the node from where the ant packet has immediately come from.
b. Decrease the probabilities of other hops.i.e provides the positive feedback from ant routing. This positive feedback quickly identifies the best path. i.e. provides the negative feedback.

3.4 Automatic Clustering Inspired by Any Dynamic (ACAD)

In this algorithm [5], clustering partition the unlabeled data into group of identical data. Each group called a 'cluster' consist of objects. This algorithm is a simple heuristic algorithm for automatic detection of optimal number of natural clusters. This algorithm is not biased towards the hyper sphere shaped of the cluster. Clustering Technique divides the data set into number of categories. a) Sequential b) hierarchical c) cost function optimization. In this algorithm, sequential technique, modified by drawing inspiration from an ant movement.This algorithm works with psedo ant. This pseudo ant is initialized at a random point of the data set. This pseudo ant searches for the nearest data point from its present location. This algorithm is very simple and can handle datasets with complex shaped clusters.

IV. REACTIVE /ON DEMAND ANT BASED ROUTING PROTOCOL

4.1 Ant Colony Based Routing Algorithm (ARA)

This algorithm [9] presents a new approach for an on demand ad-hoc routing algorithm, which based on swarm intelligence. Ant colony algorithms (ACO) are a subset of swarm intelligence and consider the ability of simple ants to solve difficult problems by group action. The interesting point is that the ants do not need any direct communication for the solution process, instead they communicate by stigmergy. Stigmergy means the indirect communication of individuals through modifying their environment. Many algorithms which are based on ant colony optimization(ACO) were introduced in recent years to solve different problems e.g. optimization problems. The expected overhead of ARA is very small, because there are no routing tables which are interchanged between the nodes. Unlike other routing algorithms, the Forward Ant (FANT) and Backward Ant (BANT) packets does not transmit much routing information.A unique sequence number is transmitted in the routing packets in the network. Route maintenance is performed through data packets,they do not have to transmit additional routing information. Ant Colony Based Routing Algorithm (ARA) only needs the information in the IP header of the data packets.

4.2 Probabilistic Emergent Routing Algorithm (PERA)

Probabilistic emergent routing algorithm (PERA) [3] is based on the swarm intelligence paradigm. In this approach, the process of route discovery is carried out by using a flooding approach to discover and maintain multiple paths between source destination pairs in the network. Route discovery in the algorithm is done by two types of agents or ants – forward ants and backward ants. These agents make and adjust a probability distribution at each node for the node's neighbors. The agent packets, or *Ants* are of a relatively small size. The probability associated with a neighbor reflects the relative likelihood of that neighbor forwarding and eventually delivering the packet. This algorithm, is compared to AODV and it has shown low overhead on link

failure.instead of buffering data packets until a new route is found, PERA delivers the data packet through with an alternative route.

4.3 Ant Dynamic Source Routing (ADSR)

This algorithm [17] consider the QoS parameter named as delay, jitter and energy. The dynamic source routing protocol is on demand routing protocol. In this Algorithm, mobile nodes are required to maintain route caches that contain the source route of which the mobile is aware.Entries in the route cache are continuously updated as a new route. This protocol has two major phases: Route discovery phase and Route maintenance phase.

In Route Discovery Phase if a node wants to send a packet, it checks the route cache to determine whether there is an entry to the destination or not. if a node doesnot have a route, it immediately initiates s route discovery by broadcasting.

Route Maintenance Phase is completed through the use of route error packets and acknowledgment.This acknowledgment are used to verify the correct operations of the route links. In the ADSR FANT and BANT packets are added in the route request and route reply of DSR. FANT and BANT are used to discover route in the network.

4.4 Nature Inspired Scalable Routing Protocol (NISR)

NISR[24] is based on TORA. Nature Inspired Scalable Routing Protocol (NISR) is a scalable routing protocol for MANETs that has been developed by improving TORA routing protocol. This improvement came from inspiration from bee and ant colonies.We draw an analogy between the routing in MANETs and finding source of food in ant and bee colonies. The results shows that the total delivered data, network life time in NISR are better than TORA routing protocol for a extensive range of number of nodes.

4.5 imProved Ant Colony Optimization routing algorithm for mobile ad hoc NETworks (PACONET)

In this technique [20], an improved ACO algorithm for routing in MANETs called PACONET is introduced this algorithm focuses on efficiency and effectiveness of the approach as a solution to the routing problem in a simulated ad hoc environment. The new approach in this paper considers mobility of nodes, route maintenance and link failure handling and has its performance evaluated using simulation with comparison to AODV. Hello messages are transmitted at an interval of Hello Interval seconds. Therefore, if a node fails to receive several Hello messages from a neighbor, a link breakage is detected and its routing table can be updated by deleting the entries in the routing table for that neighbor. PACONET performs well in different performance metrics. PACONET appears to be able to manage the traffic load better than AODV. It incorporates mobility which is a key feature to adapt to an ad hoc environment. The algorithm is also able to perform route maintenance and handle link failures.

V. HYBRID ANT BASED ROUTING PROTOCOL

5.1 Ant-Aodv

Ant-AODV [19] is a hybrid of both ant-based routing and AODV routing protocols to overcome their inbuilt drawbacks. This Hybrid approach increases the node connectivity,decreases the end-to-end delay and route discovery latency. Route establishment in conventional ant-based routing techniques is dependent on the ants

visiting the node and providing it routes. If a node wants to send data packets to a destination, then it does not have a knowledge of route, it will have to keep the data packets in send buffer till an ant arrive and provides it with a best route to that destination. In Ant Routing Algorithms implemented so far there is no local connectivity maintenance in AODV environment. On the other hand AODV takes too much time for connection establishment due to the delay in the route discovery process, where in Ant Based Routing when a node has a route to a destination it will start sending the data packets without any delay. This long delay in AODV before the real connection is established may not be applicable in real-time communication applications. Ant agents update the routes unceasingly, a source node can switch from a longer route to a newer and shorter route provided by the ants. This conducts to a considerable decrease in the average end-to-end delay as compared to both AODV and Ant-Based Routing.

5.2 AntHocNet

This purposed hybrid algorithm [6] is a hybrid algorithm, which combines reactive path setup with proactive path for maintenance and improvement. AntHocNet is based on a specific self-organizing behavior of ant colonies, the shortest path discovery and on the model of ant colony optimization. AntHocNet has observed that ants in a colony can converge over the shortest path among different paths connecting their nest to a food. AntHocNet does not maintain paths to all destinations in the network at all times, but sets up paths when they want to start the session. This algorithm uses a reactive path setup phase, where reactive forward ants are plunged from the source node in order to find multiple paths to the destination and reactive backward ants return to set up the paths and these paths are represented in pheromone tables and indicating their respective path quality.Data packets are routed sequentialy just like datagrams over the different paths present in the network with the help of these pheromone tables. When a data session is start, the paths are examined, maintained and improved proactively using different agents called as proactive forward ants and proactive backward ants. AntHocNet beatout AODV for delivery ratio and jitter and the differences increase for higher speeds.

5.3 Multi Agent Ant Based Routing (MAARA)

This Algorithm [25] creates a hybrid of both ant based routing and multi agent systems technique to overcome some of the inherent problems. This hybrid algorithm enhances the node connectivity and decreases the end-to-end delay and route discovery response time. Route establishment in conventional ant based routing method is dependant on the ants visiting the node. The expected overhead of MAARA is belittled, just because, no routing tables to be exchanged between the nodes.Just like other routing algorithms, the FANT and BANT packets do not transmit much routing information. Only a unique sequence number is transmitted in the routing packets. Route maintenance is performed through data packets. MAARA only needs the information in the IP header of the data packets. MAARA has a better delivery ratio than AODV, but a higher average delay. For the long distance areas, the difference in delivery ratio becomes bigger and AODV loses its advantage in delay whereas,MAARA leads AODV in such situations

5.4 Ant Routing Algorithm for MANET's based on adaptive improvement (ARAAI)

ARAAI [33] combines the advantage of proactive routing and reactive routing. This proposed algorithm provides multipath and offering adaptive control.It uses two routing tables, one table is a routing table that can be represented by columns like initial node, last node and heuristic value. Inital node records the leaving initial place of ants.The last node records the address of previous node and heuristic value is represented by local node energy information. Second table contains the neighbor's information and is represented as the connection between local and other nodes. When a source node wants to send data packets, it sees the routing table for any route to destination. If no route is found then discovery process is initiated.

5.5 Hybrid Ant colony optimization, routing algorithm for mobile adhoc Network (HopNet)

HopNet algorithm [34] is another hybrid ACO routing protocol based on ants nature of hopping from one zone to another zone.This algorithm is haighle scalable for large network as compared to other hybrid protocols. The algorithm has characteristics extracted from the ZRP and DSR protocols.This algorithm consists of the local proactive route discovery within a node's neighborhood and reactive communication between the neighborhoods of zones.The network is divided into zones which are the node's locality. The size of the zone is not determined locally, but by the radius length which is measured in number of hops. In this algorithm, an ant selects a node that helps in producing the best path from the source node to the destination node.An ant first selects a node that has not yet been visited by any other ants. The ant explores all the links adjacent to a node that has not yet been visited before selecting the next hop node. If there exists no such unvisited node than the ant searches for the next hop by considering the pheromone value.

5.6 Hybrid routing algorithm based on ant colony and ZHLS routing protocol for MANET (HRAZLS)

This ant algorithm [15] works with the Zone Based Hierarchical Link State (ZHLS) protocol that uses proactive routing scheme within a zone and reactive routing scheme outside the zone or between the zones. The whole network is divided into non overlapping zones. Route discovery occurs by Intrazone and Interzone routing. The IntraRT basic structure is a matrix whose rows are its neighbors and the columns are all identified nodes within its zone. In route discovery, Intrazone routing, each node periodically sends internal forward ants to its neighbors to maintain the Intrazone Routing table. This algorithm produces a better end to end delay results than AODV. This is imputed to the zone framework and the local intrusion routing table and Interzone routing table.

5.7 Orientation Based ANT Routing Algorithm (OANTALG)

In this paper [12] the given routing algorithm used orientation based distributed learning, which is influenced by the algorithms like ADAA, AntNet , PERA , MACA and AntHocNet. These provide formative of forwarding of message packets from the source node to the destination node in the direction of the target node. In this algorithm, all the links in the network are assumed to be bi-directional in nature, and all the nodes which are present in the network participate in the process of finding the path to the destination node. OANTALG uses set of artificial ants and replaces the typical routing table in traditional algorithms with the table of probabilities called the pheromone table.The result obtained by OANTALG is better than the other algorithms of MANET

with respect to various performance evaluation parameters like Average Path Length, Jitter, Packet Drop Ratio. OANTALG has shown better performance than HOPNET, AODV and DSR protocols.

TABLE 1: Comparison of Different ACO Algorithms

Algorithm	Ref.No.	Comparitive Algorithm	Metrics of analysis	Main Focus
ABC	[29]	PSO	Global optimization, Load Balancing	It works with circuit and Packet switched Network.
AntNet	[12]	Predictive Mechanism	Path Recovery time, Overhead	Add Mechanism to Quicken path convergence with prediction .it facilitate path establishment when Network changes.
PAR	[34-]	AODV	Packet Delivery ratio, End to End delay, Routing Overhead	Reduced End to End delay and provides high overhead for small network.
ACAD	[27]	FCM Algorithm, DCPSO Algorithm	Effectiveness	It automatically detects any shape of separated clusters, it handles complex shaped clusters.
ARA	[23]	AODV, DSDV, DSR	Packet Delivery Rate, Routing Overhead	This is highly adaptive, efficient, scalable and provides less overhead.
PERA	[17]	AODV	Throughput, Packet Delay	It uses limited bandwidth and low overhead as compared to AODV.
ADSR	[40]	DSR	Packet Delivery Ratio	This algorithm periodically monitor path and it needs control packet.
PACONET	[26]	AODV	Mobility Level, Traffic Load	This algorithm maintains route and handle link failure.
NISR	[31]	TORA	Network Lifetime, system Lifetime, Delivery data	This algorithm have good network lifetime as compare to TORA. It uses for multipath.
Ant-AODV	[33]	DSR, DSDV, AODV	Packet Delivery ratio, End to End delay, Routing Overhead	This algorithm suitable for the real time data and reduces route discovery latency.
AntHocNet	[6]	HopNet, AODV	Packet Delivery ratio, End to End delay	This protocol inspired by stigmergy driven shortest path

				and it is less efficient in routing overhead.
ARAAI	[41]	AODV,DSR	Route Discovery	This algorithm includes route discovery delay and less overhead.
MAARA	[32]	AODV	Packet Delivery ratio, End to End delay	This algorithm provides high connectivity and reduces end to end delay.
HopNet	[43]	AODV, DSR, ZRP, AntHocNet	Packet Delivery ratio, End to End delay	This is suitable for large network and decreases overhead.
HRAZHLS	[22]	HopNet, AODV	Packet Delay, Packet Delivery Ratio	This algorithm generates Error Ant and uses multipath.
OANTALG	[14]	HopNet, AODV, DSR	Average Path Length, Packet Drop Ratio, Jitter	This algorithm sends more number of packet than AODV, DSR, HopNet. It gives high throughput.

VI. CONCLUSIONS

Mobile adhoc network is highly dynamic by nature and have limited bandwidth that makes the routing task very difficult. A number of Ant Colony optimization algorithms are used with for routing in MANET. Different nat based MANET protocols are studied under various categories like Proactive protocol, Reactive protocols and Hybrid protocols. The agents in Ant colony Routing algorithms communicate indirectly through the stigmergy and provides positive feedback to a solution by laying pheromone on the path. This paper help in identifying the main focus of each algorithm i.e. the main key point involved in developing that algorithm. It also reviewed the various parameters involved in comparision purpose. One can easily gain the basics of working of various ant based MANET algorithms with the exhaustive study involved in this paper.

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