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# Quality Of Service Issues By Ant Colony Alogorithm In Mobile Adhoc Network

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***Abstract:** A Mobile Adhoc Network is a self configuring network of wireless devices connected by wireless links. Quality of service is more difficult to guarantee in ad hoc networks than in most other type of networks, because the network topology changes as the nodes move and network state information is generally imprecise. This requires extensive collaboration between the nodes, both to establish the route and to secure the resources necessary to provide the QoS. Issues like limited availability of resources, insecure medium make QoS provisioning very challenging in such networks. The traditional MANET routing protocol does not employ power aware routing as well as feasible security features making QoS provisioning difficult. The biggest challenge in this kind of networks is to find a path between the communication end points satisfying user's QoS requirement. Nature-inspired algorithms (swarm Intelligence) such as ant colony optimization (ACO) algorithms have shown to be a good technique for developing routing algorithms for MANETs.In this paper, a new QoS algorithm for mobile ad hoc network has been proposed. The proposed algorithm combines he idea of Ant Colony Optimization (ACO) with Optimized Link State Routing (OLSR) protocol to identify multiple stable paths between source and destination nodes.*

***Keywords:** MANET, Routing Protocols, AODV, DSR, QoS, Ant Colony Optimization (ACO)*



## I. INTRODUCTION

The recent developments in various fields such as Medicine, Computer science and Information technology. In no other field has these developments been more evident than in field of wireless technology. There are two basic types of wireless networks that are of interest; the cellular concept and the Ad hoc concept. The cellular concept is basically the same as is used in cellular phone technology (GSM), and is a highly researched area. Though wireless systems have existed since the 1980's it is only in recent times that wireless systems have started to make inroads into all aspects of human life. Mobile Ad hoc Network is an autonomous system of mobile nodes connected by wireless links. Each node operates as an end system and a router for all other nodes in the network. A mobile Ad hoc Network is a self configuring network of mobile routers connected by wireless links –the union of which forms an arbitrary topology. An Ad hoc network is often defined as an "infrastructure less" network means that a network without the usual routing infrastructure, link fixed routers and routing backbones.[1]. A MANET is a distributed network that does not require centralized control, and every host works not only as a source and a sink but also as a router. This type of dynamic network is especially useful for military communications or emergency search and rescue operations, where an infrastructure cannot be supported. The nodes that make up a network at any given time communicate with and through each other. In this way every node can establish a connection to every other node that is included in the MANET. Examples of nodes can be personal devices like, our mobile phones, Laptops, Personal Data Assistants (PDA's), etc. Smaller and simpler devices also use wireless ad-hoc networking, like wireless headsets, hands free, etc.

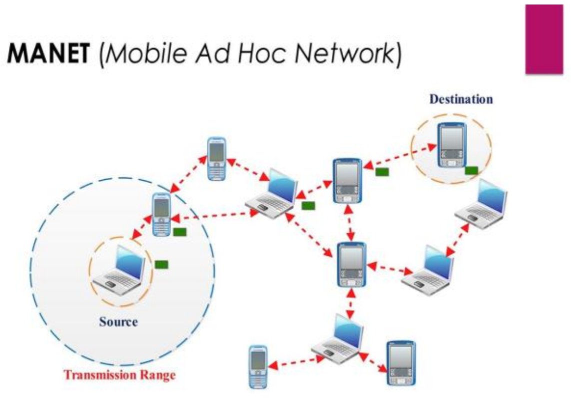


*Figure 1: MANET Infrastructure*

## II. ISSUES IN MANETS

If there are only two nodes to communicate with each other and are located very closely to each other, then no specific routing protocols or routing decisions are necessary. On the other hand, if there are a number of mobile hosts wishing to communicate, then the routing protocols come into picture, in this case some critical decisions have to be made such as which is the optimal route from the source to the destination which is very important because, the mobile nodes operate on battery power. Thus it becomes necessary to transfer the data with the minimal delay to loss less power. There will be kind of compression involved in which it could be provided by the protocol to loss less bandwidth. Further, there is need of encryption to protect the data from prying eyes. In addition to this, Quality of Service support is also needed so that the least packet drop can be obtained. The other factors which need to be considered while choosing a protocol for MANETs are as follows:

- ✓ Multicasting: The ability to send packets to multiple nodes at once. This is similar to broadcasting except the fact that the broadcasting is done to all the nodes in the network. This is important as it takes less time to transfer data to multiple nodes.
- ✓ Loop Free: A path taken by a packet never transits the same intermediate node twice before it arrives at the destination. To improve the overall performance in the routing protocol to guarantee that the routes supplied are loop free. This avoids any loss of bandwidth or CPU consumption.
- ✓ Multiple routes: If one route gets broken due to some disaster, then the data could be sent through some other route. Thus the protocol should allow creating multiple routes.
- ✓ Distributed Operation: The protocol should be distributed. It should not be dependent on a centralized node.
- ✓ Physical security: Mobile networks are more vulnerable to physical security threats such as eavesdropping and jamming attacks.
- ✓ On demand operation: Since a uniform traffic distribution cannot be assumed within the network, the routing algorithm must adapt to the traffic pattern on a demand or need basis, thereby utilizing power and bandwidth resources more efficiently.
- ✓ Unidirectional Link Support: The radio environment can cause the formation of unidirectional links. Utilization of these links and not only the bi-directional links improves the routing protocol performance.
- ✓ Entering/Departing nodes: A routing protocol should be able to quickly adapt to entering or departing nodes in the network, without having to restructure the entire network.

## III. QUALITY OF SERVICE PROVIDING QUALITY OF SERVICE (QoS)

Quality of service Providing Quality of Service other than best effort, is a very complex problem in MANETs, and makes this area a challenging area of future MANET research. Network's ability to provide QoS depends on the intrinsic characteristics of all the network components, from transmission links to the MAC and network layers. MANET characteristics generally lead to the conclusion that this type of network provides aweak support to QoS. Wireless links have a (relatively) low and highly variable capacity, and high loss rates. Topologies are highly dynamic with frequent links breakages. Random access-based MAC protocols, which are commonly used in this environment (e.g., 802.11b), have no QoS support. Finally, MANET link layers typically run in unlicensed spectrum, making it more difficult to provide strong QoS guarantees in spectrum hard to control. This scenario indicates that, not only hard QoS guarantees will be difficult to achieve in a MANET, but if the nodes are highly mobile even statistical QoS guarantees may be impossible to attain, due to the lack of sufficiently accurate knowledge (both instantaneous and predictive) of the network states. Further more, since the quality of the network (in terms of available resources reside in the wireless medium and in the mobile nodes: e.g., buffer and battery state) varies with time, present QoS models for wired networks are insufficient in a self-organizing network, and new MANET QoS model must be defined .

## IV. CATEGORIES OF EXISTING ROUTING PROTOCOLS FOR MANETs

Many protocols have been proposed for MANETs. These protocols can be divided into three categories: proactive, reactive, and hybrid. Proactive methods maintain routes to all nodes, including nodes to which no packets are sent. Such methods react to topology changes, even if no traffic is affected by the changes. They are also called table driven methods. Reactive methods are based on demand for data transmission. Routes between hosts are determined only when they are explicitly needed to forward packets. Reactive methods are also called on-demand methods. They can significantly reduce routing overhead when the traffic is lightweight and the topology changes less dramatically, since they do not need to update route information periodically and do not need to find and maintain routes on which there is no traffic. Hybrid methods combine proactive and reactive methods to find efficient routes, without much control overhead. Proactive Routing Protocols Proactive routing protocols described in [3, 6] attempt to maintain consistent and up-to-date routing information (routes) from each node to every other node in the network. Topology updates are propagated throughout the network in order to maintain a consistent view of the network. Keeping routes for all destinations has the advantage that communication with arbitrary destinations experiences minimal initial delay. Furthermore, a route could be immediately selected from the route table. However, these protocols have the disadvantage of generating additional control traffic that is needed to continually update stale route entries. Especially in highly mobile environments, communication overhead incurred to implement a proactive algorithm can be prohibitively costly. Typical and well-known examples of proactive routing protocols are destination-sequence distance vector (DSDV) [6] and optimized link state routing (OLSR). Reactive routing protocols Reactive routing protocols proposed in [2,4,5] establish routes only when they are needed. When a source node requires a route to a destination, it initiates a route discovery process by flooding the entire network with a route request (RREQ) packet. Once a route has been established by receiving a route reply (RREP) packet at the source node, some form of route maintenance procedure is used to maintain it, until either the destination becomes inaccessible or the route is no longer desired. These protocols use less bandwidth for maintaining the routing tables at every node compared to proactive routing protocols by avoiding unnecessary periodic updates of routing information. However, route discovery latency can be greatly increased, leading to long packet delays before a communication can start. Ad hoc on-demand distance vector (AODV) [4] and dynamic source routing (DSR) [2] are well-known examples of reactive routing protocols. Hybrid routing A hybrid routing protocol [7-9] attempts to combine the best features of proactive and reactive algorithms. It often consists of the two classical routing protocols: proactive and reactive. Hybrid protocols divide the network into areas called zones which could be overlapping or non-overlapping depending on the zone creation and management algorithm employed by a particular hybrid protocol. The proactive routing protocol operates inside the zones, and is responsible for establishing and maintaining routes to the destinations located within the zones. On the other hand, the reactive protocol is responsible for establishing and maintaining routes to destinations that are located outside the zones. The zone-based routing protocol (ZRP) [7] and sharp hybrid adaptive routing protocol (SHARP) [9] are well known examples of hybrid routing protocols. Proactive vs. Reactive vs. Hybrid Routing The tradeoffs between proactive and reactive routing strategies are quite complex. Which approach is better depends on many factors, such as the size of the network, the mobility, the data traffic and so on. Proactive routing protocols try to maintain routes to all possible destinations, regardless of whether or not they are needed. Routing information is constantly propagated and maintained. In contrast, reactive routing protocols initiate route discovery on the demand of data traffic. Routes are needed only to those desired destinations. This routing approach can dramatically reduce routing overhead when a network is relatively static and the active traffic is light. However, the source node has to wait until a route to the destination can be discovered, increasing the response time. The hybrid routing approach can adjust its routing strategies according to a network's characteristics and thus provides an attractive method for routing in MANETs. However, a network's characteristics, such as the mobility pattern and the traffic pattern, can be expected to be dynamic. The related information is very difficult to obtain and maintain. This complexity makes dynamically adjusting routing strategies hard to implement. B. Basic Routing Protocol families Distance vector routing protocols In distance vector routing protocols, every host maintains a routing table containing the distance from itself to possible destinations. Each routing table entry contains the next hop to the destination and the distance to the destination. Nodes only feed the estimated link costs for each destination (e.g. the number of hops to destination) to their neighbours, instead of flooding the whole network. All nodes calculate the shortest paths to the destinations using that broadcasted information. Link state routing protocols Link state routing protocols [10] keep a routing table for complete topology, which is built up by finding shortest path of link costs. Link cost information is periodically transmitted and received by all nodes using a flooding. technique, these periodic floods are called Link State Advertisements (LSA). Flooding means that a node sends out his information to all other neighbour nodes and they forward all received information to their neighbours and so on. Each node updates its table using the new link cost information gathered from these floods. Source routing protocols In source routing, all data packets carry their routing information as their header. The originating node could learn this routing information e.g. by means of a source routing protocol: When a node receives a (broadcast) route request packet for a destination it adds its own address to the header and then forwards the packet. The destination uses the recorded route in reverse order to send a route reply to the requesting node. Thus, the originating node is provided with the complete route to the destination. The routing decision is made at departure. Loops are avoided, since nodes can determine if they are already in the packet header.

## V. QUALITY OF SERVICE

Quality of Service (QoS) refers to a set of service requirements that needs to be met by the network while transporting a packet stream from a source to its destination [17]. Informally, it refers to the probability of a packet passing between two points in the network. The network is expected to guarantee a set of measurable pre-specified service attributes to the users in terms of end-to-end performance, such as delay, bandwidth, probability of packet loss, delay variance (jitter), power consumption etc. The wireless communication was originally developed for army use, because of its ease of mobility, installation and flexibility; later on it was made available to civilian use also. With the increasing demand and penetration of wireless services, users of wireless network now expect quality of service and performance comparable to what is available from fixed networks. Some of factors that influence QoS of Wireless Network include: 1. Throughput of Network Represents the total number of bits (in bits/sec) forwarded from wireless LAN layers to higher layers in all

WLAN nodes of the network. 2. Retransmission Attempts Total number of retransmission attempts by all WLAN MACs in the network until either packet is successfully transmitted or it is discarded as a result of reaching short or long retry limit..

### A. QoS METRICS

QoS metrics are base parameters of quality for a network. QoS parameters include bandwidth, delay, jitter, security, network availability, and battery life and packet loss. The important QoS metrics for multimedia applications are delay, jitter, loss, and throughput. End-to-end delay is the time between the arrival of a packet and its successful delivery to the receiver. Another metric, access delay, is the time between packet arrival and packet transmission by the sender. Jitter is the variation of delay and is an important metric for multimedia applications. Bandwidth is the measure of data transmission capacity and influences throughput, which is the amount of data successfully transmitted and received in unit time.

### B. QoS MODELS

Both of the services mentioned below are commonly implemented into routers of wired networks to improve the QoS and there for of interest. Especially is the resource reservation technique of great influence for several MANET solutions.

- ✓ Integrated services (int-serv) Int-serv identifies three main categories of service concerning the integration: the traditionally best-effort services, realtime services and controlled link-sharing services. Best-effort services are those we currently experience on the internet. They are characterized by absence of any QoS specifications. The network provides the quality that it actually can contribute. Examples of best-effort traffic are FTP, mail and FAX. Real-time services are services that have very critical requirements in terms of end-to-end delay, probability of loss and bandwidth. They usually require a guarantee from the network. Controlled link-sharing is a service that might be requested by network operators when they wish to share a specific link among a number of traffic classes. Network operators may set some sharing policies on the link utilization among these traffic classes; specifically some percentage of bandwidth may be assigned to each traffic class[4]. The int-serv QoS solution uses the resource reservation protocol (RSVP) to flood messages through the network, and reserves resources for every flow at every router hop from source to destination. Every router along the path must maintain soft states information. Int-serv requires a lot of signalling, therefore the overhead is a concern when the network scale increases.
- ✓ Differentiated services (diff-serv) Diff-serv is a light weight alternative to int-serv. The concept of diff-serv is to differentiate the user data from control and management information. A field in the header of the Internet Protocol (IP) Data Unit was designed for these purposes: the Type-of-Service (TOS) field. The octet dedicated to this field indicates the specific treatment that the packet expects to receive from the network. The TOS bits are divided up as follows: • 3 bits dedicated to priority of the datagram • 3 bits define the type of service (TOS) which correspond to QoS expected by the IP datagram • 2 bits are reserved for future use. Diff-serv does not maintain the state of each and every flow as Int-serv does, but rather discriminates the packets according to their priority. The edge routers classify the traffic type, while the individual routers that forward the data will decide the fate of the packets according to local policies of the packet types. Diff-serv is easier to maintain, more scaleable and has less signalling than int-serv.

### C. PROBLEMS RELATED TO QoS IN MANET

Because of the resource limitations and dynamic nature of MANET networks, it is especially important to be able to provide QoS. However the characteristics of these networks make QoS support a very complex process. QoS support in MANET includes issues at the application layer, transport layer, network layer, MAC layer and physical layer of the In Mobile multihop wireless networks, there are several unique issues and difficulties that do not apply to the traditionally wired internet infrastructure. The most important issues are listed below.

- ✓ Unpredictable link properties Wireless media is very unpredictable and packet collisions are an unavoidable consequence of wireless networks. Signal propagation faces difficulties such as fading, interference, and multipath cancellation. These properties of the wireless network make measurements such as bandwidth and delay of the link unpredictable.
- ✓ Node mobility Movement of nodes in the ad hoc network creates a dynamic network topology. Links will be dynamically formed when two nodes moves into transmission range of each other and are torn down when they move out of transmission range. Node mobility makes measurements in the network even harder and measurements as bandwidth is essential for QoS.
- ✓ Limited battery life There is limited power of the devices that establish the nodes in the ad hoc network due to limited battery life time. QoS should consider residual battery power and rate of battery consumption corresponding to resource utilization. The technique used in QoS provisioning should be power aware and power efficient.
- ✓ Hidden and exposed terminal problem In a MAC layer with traditionally carrier sense multiple access (CSMA) protocol, multihop packet relaying introduces the "hidden terminal" problems. The hidden terminal problem happens when signal of two nodes, say A and B, that are out of reach of each other's transmission range, collide at a common receiver, say node C. With the same nodal configuration, an exposed terminal problem will result from a scenario where node B attempts to transmit data (to someone other than A or C) while node C is transmitting to node A. In such a case, node B is exposed to the transmission range of node C and thus defers its transmission even though it would not interfere with the reception at node A. Carrier sense multiple access with

collision avoidance (CSMA/CA) reduces the effect of hidden terminal problem, but there is no solution for the exposed terminal problem today. Hidden and exposed terminal problem is not only a QoS problem, but is a recurring problem through the aspect of the MANET network.

- ✓ *Route maintenance:* The dynamic nature of the network topology and the changing behaviour of the communication medium make the precise maintenance of network state information very difficult. Because of this, the routing algorithms in MANET must operate on imprecise information. Since the nodes can join and leave the ad hoc network environment as they please, the established routing path may be broken at any time even during the process of data transfer. Thus, the need arises of routing paths with minimal overhead and delay. Since the QoS-aware routing would require reservation of resources at the routers (nodes), the problem of a heavily changing topology network might become cumbersome, as reservation maintenance with updates along the routing path must be done.
- ✓ *Security:* Without adequate security, unauthorized access and usage may violate QoS negotiations. The nature of broadcasts in wireless networks potentially results in more security exposure. The physical medium of communication is inherently insecure, so it is important to design aware routing algorithms for MANET. Because of the difficult properties of mobile wireless networks there has been a suggestion of using soft QoS. The definition of Soft QoS is that after a connection setup, there may exist transient periods of time when QoS specifications is not honoured. However we can quantify the level of QoS satisfaction by the fraction of total disruption time over the total connection time. This ratio should not be higher than a threshold. SWAN uses this technique and is discussed later in this paper. QoS adaptation can be done in several layers. The physical layer should take care of changes in transmission quality, for example by adaptively increasing or decreasing the transmission power. Similarly, the link layer should react to the changes in link error rate, including the use of automatic repeat request (ARQ). A more sophisticated technique involves an adaptive error correction mechanism that increases or decreases the amount of error correction coding in response to changes in transmission quality of desired QoS. As the link layer takes care of the variable bit error rate, the main effect observed by network layer will be a change in effective throughput (bandwidth) and delay. Again the SWAN protocol is a good example of these statements.

## VI. RELATED WORK

Quality of Service [13] (QoS) refers to a set of mechanisms able to share fairly various resources offered by the network to each application as needed, to provide, if possible, to every application the desired quality [14] (the network's ability to provide a service). The QoS is characterized by a certain number of parameters (throughput, latency, jitter and loss, etc.) and it can be defined as the degree of user satisfaction. QoS model defines architecture that will provide the possible best service. This model must take into consideration all challenges imposed by Ad-hoc networks, like network topology change due to the mobility of its nodes, constraints of reliability [9] and energy consumption [10], so it describes a set of services that allow users to select a number of safeguards (guarantees) that govern such properties as time, reliability, etc. New requirements (needs) for multimedia and real-time applications require few delay [9] and very high data rates which require (oblige) the use of new routing protocols supporting QoS. The AODV protocol (Ad-hoc on demand Distance Vector) is a reactive routing protocol based on the distance vector Principle, combining unicast and multicast [11] routing. In AODV, the path between two nodes is calculated when needed (if necessary), i.e. when a source node wants to send data packets to a destination, it finds a path (Discovery Phase), uses it during the transfer phase, and it must maintain this path during its utilization (Maintenance Phase). The finding and maintaining process of a path is based on the exchange of a set of control packets: RREQ (Route REQueset), RREP [1] (Route Reply), RERR (Route Error), RRepAck (Route Reply Acknowledgment) and Hello messages (Hello). RREQ is initiated by the source node to find a path in multicast mode [15]. RREP is used by an intermediate or destination node to respond to a request of path finding in unicast mode. Hello messages are used to maintain the consistency of a previously established path. Routing table is associated for each node in AODV protocol with containing: the destination address, the list of active neighbors, the number of hops (hop) to reach the destination, time of expiration after which the entry is invalidated, and so on. To avoid the formation of infinite loop, AODV uses the principle of sequence numbers, limiting the unnecessary transmission of control packets (problem of the overhead); these numbers allow the use of fresh routes following the mobility of nodes, as they ensure the coherence and consistency of routing information. The Dynamic Source Routing (DSR) is one of the purest examples of an on-demand routing protocol that is based on the concept of source routing. It is designed specially for use in multihop ad hoc networks of mobile nodes. It allows the network to be completely self organizing and self-configuring and does not need any existing network infrastructure or administration. DSR uses no periodic routing messages like AODV [3], thereby reduces network bandwidth overhead, conserves battery power and avoids large routing updates. Instead DSR needs support from the MAC layer to identify link failure. DSR is composed of the two mechanisms of Route Discovery Computer Science & Engineering: An International Journal (CSEIJ), Vol.1, No.3, August 2011 54 and Route Maintenance, which work together to allow nodes to discover and maintain source routes to arbitrary destinations in the network. DSR has a unique advantage by virtue of source routing. As the route is part of the packet itself, routing loops, either short – lived or long – lived, cannot be formed as they can be immediately detected and eliminated. This property opens up the protocol to a variety of useful optimizations. Neither AODV nor DSR guarantees shortest path. If the destination alone can respond to route requests and the source node is always the initiator of the route request, the initial route may the shortest. OLSR makes use of "Hello" messages to find its one hop neighbors and its two hop neighbors through their responses. The sender can then select its multipoint relays (MPR) based on the one hop node that offers the best routes to the two hop nodes. Each node has also an MPR selector set, which enumerates nodes that have selected it as an MPR node. Reactive routing protocols do not maintain routes, but build them on demand. As link-state protocols require database synchronization, such protocols typically use the distance vector approach, as in AODV and DSDV, or more ad-hoc approaches that do not necessarily build optimal paths, such as Dynamic Source Routing. OLSR uses Topology Control (TC) messages along with MPR forwarding to disseminate neighbor information throughout the network. Host and Network Association (HNA) messages are used by OLSR to disseminate network route advertisements in the same way TC messages advertise host routes.

## VII. PROPOSED WORK

ANT COLONY OPTIMIZATION Ant colony optimization (ACO) is a stochastic approach for solving combinatorial optimization problems like routing in computer networks. The idea of this optimization is based on the observation of how ants optimize food gathering in the nature. Ant colony optimization algorithms use artificial ants to iteratively construct a solution for an optimization problem. We can explain an ant colony optimization algorithm in the figure 1[4] as follows. Figure 1:2 Ant Colony Network The shortest path out of the above 12 paths is 1-3-8. Though some ants will move through other paths but the pheromone trail evaporation on 1-3-8 path would be lower in rate as compared to other paths and hence the ant follow rate on this path would be maximum. Since being the shortest path, the ants travelling on this path will return earlier and hence will make deep impression of pheromone trail faster and other ants will follow this shortest path with maximum pheromone amount. Any data travelling from its source to reach its destination would need to travel a number of intermediary nodes (these nodes can be servers or any service units). This can be seen as being in similar fashion like ants travelling from their colony to food source. Our foremost priority here is to formulate a technique in a manner such that the natural phenomenon of trail (stigmergy) can be implemented artificially for our purpose. What we would follow for our data packets would be a proactive model. In this model, the data packet would not be a function of conditioning and conditions but rather it would be a product of its choice, decision or self-awareness based on our implementation method of pheromone trail. The ACO meta heuristic is based on generic problem representation and the definition of the ant's behavior as shown in figure 2. ACO adopts the foraging behavior of real ants. When multiple paths are available from nest to food, ants do random walk initially. During their trip to food as well as their return trip to nest, they lay a chemical substance called pheromone, which serves as a route mark that the ants have taken [4]. Subsequently, the newer ants will take a path which has higher pheromone concentration and also will reinforce the path they have taken. As a result of this autocatalytic effect, the solution emerges rapidly. To illustrate this behavior, let us consider Figure 2. A set of ants moves along a straight line from their nest A to a food source B (Figure 2a). At a given moment, an obstacle is put across this way so that side (C) is longer than side (D) (Figure 2b). The ants will thus have to decide which direction they will take: either C or D. The first ones will choose a random direction and will deposit pheromone along their way. Those taking the way ADB (or BDA), will arrive at the end of the obstacle (depositing more pheromone on their way) before those that take the way ACB (or BCA). The following ants' choice is then influenced by the pheromone intensity which stimulates them to choose the path ADB rather than the way ACB (Figure2c). The ants will then find the shortest way between their nest and the food source. In most cases, an artificial ant will deposit a quantity of pheromone represented by $H\tau i, j$ only after completing their route and not in an incremental way during their advancement. This quantity of pheromone is a function of the found route quality. (a) (b) (c) Figure 2: Ants, searching for food Pheromone is a volatile substance. An ant changes the amount of pheromone on the path (i, j) when moving from node i to node j as follows: $\tau i,j = \sigma \, . \, \tau i,j + H\tau i,j$ ………………… (1) where $\sigma$ is the pheromone evaporation factor. It must be lower than 1 to avoid pheromone accumulation and premature convergence. At one point i, an ant chooses the point j (i.e. to follow the path (i, j)) according to the following probability: $Pi,j = ((\tau i,j)\ \alpha\ (\eta i,j)\ \beta\ ) / (\ \Sigma(i,k) \in C(\tau i,k)\ \alpha\ (\eta i,k)\ \beta\ )$ …………………… (2) where, • $\tau i,j$: is the pheromone intensity on path (i, j). • $\eta i,j$: is the ant's visibility field on path (i, j)(an ant assumes that there is food at the end of this path). • $\alpha$ and $\beta$ : are the parameters which control the relative importance of the pheromone intensity compared to ant's visibility field. .C: represents the set of possible paths starting from point i ((i,k) is a path of C)


*Figure 1.2: Ant Colony Optimization*

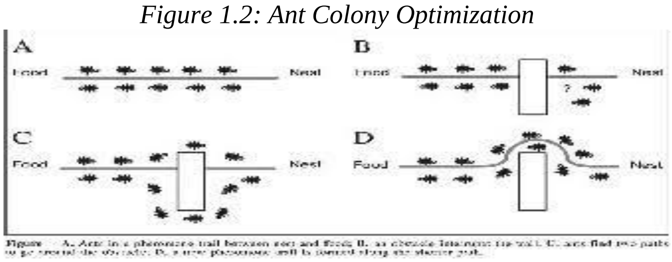


*Figure 2.1*

### A. PROPOSED ALGORITHM

The proposed approach has two phases namely path discovery phase and path maintenance phase. When a source node has to pass data to a destination node with QoS requirements it starts with the path discovery phase. Once the path is found, the data transfer will take place. While data transmission is going on, it is also required to maintain the path to the destination. This is very much desirable and required in mobile ad hoc networks and hence is done in the path maintenance phase. A. Path Discovery Phase

STEP 1: Let the source node S has data to send to a destination D with QoS requirements higher transmission rate, less delay and more bandwidth. A list of nodes that are progressively visited by the ant is called visited nodes list. This list forms the route R from the source node to destination node. STEP 2: Initially choose the source node S. The visited nodes list will be initialized to source node (S). STEP 3: S initiates a Path_Request_Ant to destination D through all its neighbors which are in 1-hop distance from S. The Path_Request_Ant containssource address, destination address, hop count and bandwidth. STEP 4: After that the pheromone evaporation of all the 1- hop distance nodes will be calculated. Each node (i) maintains a table called "PMtab" a table of Pheromones specifying the quantity of available pheromone on each link (Vi, Vj). This quantity is initialized to constant C. STEP 5: Then we calculate the pheromone evaporation of all the 2-hop distance nodes. STEP 6: At last we calculate the path preference probability value of each path from source S with the help of pheromone evaporation of every node. A node j from a set of adjacent nodes (j, k, …., n) of i is selected as MPR node such that it covers all the 2-hop distance nodes and its path preference probability is better than others. STEP 7: If calculated path preference probability value is better than the requirements, the path is accepted and stored in memory. STEP 8: When the Path_Request_Ant reaches the destination, it will be converted as Path_Reply_Ant and Forwarded towards the original source. The Path_Reply_Ant will take the same path of the corresponding Path_Request_Ant but in reverse direction. STEP 9: The path with higher path preference probability will be considered as the best path and data transmission can be started along that path. B. Path Maintenance Phase When the data transmission is going on, the paths are reinforced positively making it more desirable for further selection. Also when session is going on, the load on the selected path may increase causing more delay and less available bandwidth; Nodes might have moved causing link failures. In such case, the path preference probability will automatically decrease and hence alternate routes can be used which are found during route discovery phase. The alternate routes are also periodically checked for their validity even though they are not currently used.

*Experimental Setup*

The experimental setup is used for performance evaluation of these three ACO based ANTALG, Ant Chain and IACR routing algorithms. It measures the ability of protocols to adapt to the dynamic network topology changes while continuing to successfully deliver data packets from source to their destinations. In order to measure this ability, different scenarios are generated by varying the number of nodes. We use following scenario generation commands for generating cenario file:

./setdest –v 1 –n 20 –p 2.0 –M 10.0 -t 200 -x 500 -y 500; ./setdest –v 1 –n 50 –p 2.0 –M 10.0 -t 200 -x 500 -y 500; ./setdest –v 1 –n 80 –p 2.0 –M 10.0 -t 200 -x 500 -y 500; ./setdest –v 1 –n 100 –p 2.0 –M 10.0 -t 200 -x 500 -y 500.

Similarly, for connection pattern generation we use, cbrgen.tcl file. By using following commands the onnection pattern is generated:

ns cbrgen.tcl -type cbr -nn 20 -seed 1.0 -mc 16 –rate 4.0; ns cbrgen.tcl -type cbr -nn 50 -seed 1.0 -mc 16 –rate 4.0; ns cbrgen.tcl - type cbr -nn 80 -seed 1.0 -mc 16 –rate 4.0; ns cbrgen.tcl -type cbr -nn 100 -seed 1.0 -c 16 –rate 4.0;

The trace file is created by each run and is analyzed using a variety of scripts, particularly one called file *.tr that counts the number of successfully delivered packets and the length of the paths taken by the packets, as well as additional information about the internal functioning of each scripts executed. This trace file is further analyzed with AWK file and Microsoft Excel is used to produce the graphs.

Simulations are run by considering three ACO based ANTALG, Ant Chain and IACR routing algorithms. In order to get realistic performance, the results are averaged for a number of scenarios. We tried to measure the protocols performance on a particular terrain area of 500 m × 500 m from real life scenario at a speed of 10 m/s. The simulation time was taken to be of 25, 50, 75, 100, 125 and 150 seconds for Constant Bit Rate (CBR) traffic type with a packet size of 512 Byte. Also, we have considered nodes with Omni-Antenna and Two Ray Ground Radio Propagation method. Simulation parameters are appended in Table 1.

| Parameter | Value |
|---|---|
| Simulator | NS-2 |
| Protocols studied | ANTALG, Ant Chain and IACR |
| Simulation time | 25, 50, 75, 100, 125 and 150 seconds |
| Simulation area | 500 x 500 |
| Transmission range | 250 m |
| Node movement model | Random waypoint |
| Traffic type | CBR (UDP) |
| Data payload | 512 Bytes / packet |

*Table 1: Simulation Parameters*

*a. PERFORMANCE METRICS AND RESULT ANALYSIS*

In this paper, we have considered Packet Delivery Fraction (PDF), throughput in Bytes per second, and percentage routing overheads for evaluation of ANTALG, Ant Chain and IACR routing protocols. The simulation results obtained with the above mentioned simulation parameters are appended in Tables 2-4. The graph showing comparison between ANTALG, Ant Chain and IACR is shown in Figures 1-3.

| Simulation Time | Ant Chain | IACR | ANTALG |
|---|---|---|---|
| 25 | 87.20004444 | 95.03 | 90.64801 |
| 50 | 86.69843213 | 96.94 | 89.69489 |
| 75 | 83.17194855 | 98.65 | 82.2692 |
| 100 | 84.55499789 | 99.13 | 82.8119 |

| Simulation Time | Ant Chain | IACR | ANTALG |
|---|---|---|---|
| 125 | 84.09200578 | 92.56 | 80.30566 |
| 150 | 85.63825949 | 91.26 | 78.6672 |

*Table 2: Packet Delivery Fraction with varying Simulation Time*

| Simulation Time | Ant Chain | IACR | ANTALG |
|---|---|---|---|
| 25 | 85551 | 86271 | 86271 |
| 50 | 85983 | 84862 | 84862 |
| 75 | 85179 | 86167 | 86167 |
| 100 | 84530 | 86433 | 86433 |
| 125 | 84049 | 84826 | 84826 |
| 150 | 81914 | 86662 | 86662 |

*Table 3: Throughput (Bytes/sec) with varying Simulation Time*

| Simulation Time | Ant Chain | IACR | ANTALG |
|---|---|---|---|
| 25 | 8.157099491 | 5.955865 | 5.039928 |
| 50 | 7.888970695 | 6.216364 | 6.709233 |
| 75 | 7.964017681 | 6.20422 | 7.466405 |
| 100 | 7.850341975 | 5.763572 | 7.748653 |
| 125 | 7.910766565 | 6.643968 | 7.140962 |
| 150 | 7.820066869 | 6.354983 | 5.629428 |

*Table 4: Percentage Routing Overhead with varying Simulation Time*

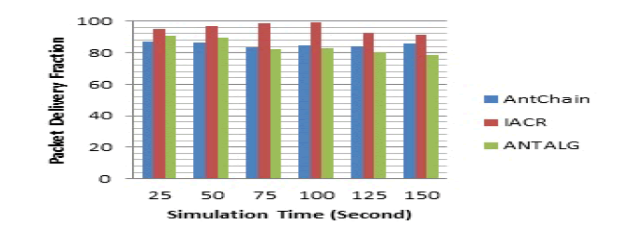


**Figure 1:** Packet delivery fraction of Ant chain, IACR and ANTALG.

*Figure 1: Packet delivery fraction of Ant chain, IACR and ANTALG*

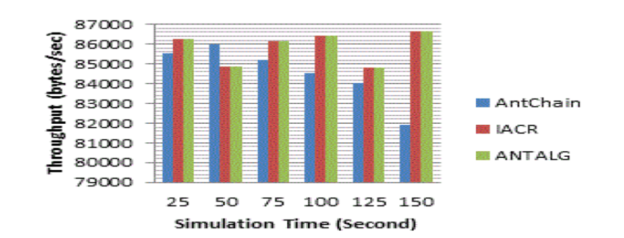


**Figure 2:** Throughput of Ant Chain, IACR and ANTALG.

*Figure 2: Throughput of Ant Chain, IACR and ANTALG*

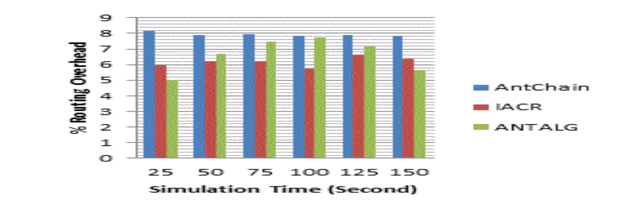


**Figure 3:** Percentage routing overhead of Ant chain, IACR and ANTALG.

*Figure 3: Percentage routing overhead of Ant chain, IACR and ANTALG*

### *b. PACKET DELIVERY FRACTION (PDF)*

It is the ratio of the data packets delivered to the destinations to those generated by the sources.

Packet Delivery Fraction (PDF)=Total Packets Delivered to destination / Total Packets Generated.

Mathematically, it can be expressed as:

$$P = \frac{1}{c} \sum_{f=1}^{e} \frac{R_f}{N_f}$$

Where, P is the fraction of successfully delivered packets, C is the total number of flow or connections, f is the unique flow id serving as index, Rf is the count of packets received from flow f and Nf is the count of packets transmitted to f.

### *c. THROUGHPUT*

Throughput of the routing protocol means that in certain time the total size of useful packets that received at all the destination nodes. The unit of throughput is MBytes/s, however we have taken bytes per second. The throughput values obtained for the simulation parameters of Table 1 is tabulated in Table 3. The graph shown in Figure 2 indicates the throughput comparison of ACO based routing algorithms Ant Chain, IACR and ANTALG.

### *d. ROUTING OVERHEAD*

Routing Overhead of the routing protocol means Ratio of number of control packets to number of messages sent. Nodes typically have low computational capability and memory, and could not support diffusion communication which is widely deployed in the wired networks.

For example, distance-vector routing protocol uses the Bellman- Ford algorithm and link-state protocol use the Dijkstra's algorithm to calculate shortest (lowest cost) paths. So not only the network bandwidth consumed by the routing messages must be considered, but also how much processing power and memory is required in the nodes. The Routing Overhead values obtained for the simulation parameters of Table 1 is tabulated in Table 4. The graph shown in Figure 3 indicates percentage routing overhead of ACO based routing algorithms Ant Chain, IACR and ANTALG.

## VIII. CONCLUSION

The proposed routing strategy can be optimized to support multimedia communications in mobile ad hoc networks based on Ant Colony framework. The major complexity in mobile ad hoc network is to maintain the QoS features in the presence of dynamic topology, absence of centralized authority, time varying QoS Requirements etc. The challenges reside in ad hoc networks is to find a path between the communication end points satisfying user’s QoS requirement which need to be maintain consistency. The algorithm consists of both reactive and proactive components. In a reactive path setup phase, an option of multiple paths selection can be used to build the link between the source and destination during a data session. For multimedia data to be sent, we need stable, failure-free paths and to achieve that the paths are continuously monitored and improved in a proactive way. This proposal is based on ant-like mobile agents to establish multiple stable paths between source and destination nodes. Ant agents are used to select multiple nodes and these nodes use ant agents to establish connectivity with intermediate nodes. In future, this work can be extended for multicasting by using swarm intelligence with other QoS objectives such as load balancing, energy conservation.

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