



Clustering Approach Based on ant Colony Optimization

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Abstract— A mobile ad-hoc network (MANET) is formed by a cluster of mobile hosts, each installed with a wireless transceiver, without the assistance of base stations. Various Clustering algorithms have been proposed to partition the network into small and manageable clusters and hence provide efficient resource management which enhances network performance. Ant Colony Optimization (ACO) is inspired by the foraging behaviour of real ant. ACO is meant to find optimal and shortest routing solution for many difficult problems such as Travelling salesman problem, Graph colouring problem... etc. In this paper, a new approach of clustering has been introduced based on ACO. This approach leads to formation of clusters which partition the network into number of non overlapping clusters. An algorithm based on ACO for the selection of Cluster Head and Gateway node is also proposed.

Keywords—: MANET, Cluster, Routing, Clustering, ACO, Clusterhead and Gateway node.

I. INTRODUCTION

Mobile Ad hoc Network (MANET) is an infrastructure-less network which consists of a collection of wireless mobile hosts to form a temporary network without the aid of any base station. Since bandwidth is limited in an ad hoc network, it is important to construct a virtual backbone consisting of only a subset of nodes that have the privilege to forward packets. Such a virtual backbone called *spine* plays an important role in routing, broadcasting and connectivity management in wireless ad hoc networks. An effort should be made to keep this backbone thin and connected [2]. The most popular method that developed to provide resource management over mobile ad hoc networks is clustering. This technique based on partitioning the network in smaller and manageable groups each group called cluster. Clustering offers several benefits when it used with MANETs such as it enhances routing process and mobility, Stabilizes dynamic network topology, helps to perform more efficient resource allocation, provides hierarchical routing architecture. This techniques dividing nodes of a self-organized network like MANET into a number of overlapped or disjointed clusters. According to Cluster Based network scheme, we have three types of mobile node in MANET [3].

1. *Cluster Head*: can be defined as a local coordinator for its cluster. Cluster Head keeps in regular contact with member nodes and gateway nodes of neighbouring clusters. It performs inter-cluster routing, data forwarding and many other operations.
2. *Gateway Node*: is a mobile node that acts as a communication medium between the clusters, can access neighbouring cluster and forward information between clusters.
3. *Cluster Member or Ordinary Nodes*: is the one neither a Cluster Head nor Gateway. A cluster member used to communicate with the Cluster Head of its cluster and update its table information according to its corresponding cluster Head.

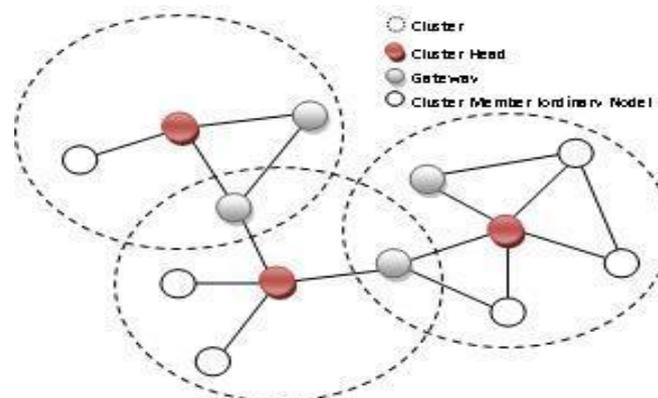


Fig.1 Cluster heads, Gateways and ordinary nodes in MANET [3].

A brief introduction to clustering mechanism has been discussed in section II. Route discovery process of an on demand cluster based routing is described in section II-A, and how a routing is carried out is explained with the help of fig 2 in section II-B. In section III basic introduction of ACO is given. In section IV a new optimized approach based on ant

Colony Optimization has been introduced for formation of non overlapping cluster and an algorithm using ACO is proposed for finding cluster Head and gateway node.

II. CLUSTERING MECHANISM

Clustering techniques is designed by defining structural partitioning of nodes inside particular network as shown in fig. 1. This mean; for particular network, the nodes will grouped to define set of clusters based on specific techniques to specify [3]:

1. Cluster formation phase.
2. Cluster maintenance phase.

According to clustering concepts in MANET, group of several mobile nodes form cluster and out of these grouped nodes one node must be elected which leads the whole cluster known as Cluster Head (CH) and is responsible for the resource demand and distribution member nodes of the cluster. Remaining nodes of cluster are the member nodes also referred as Ordinary Nodes (CN) except Cluster Gateways (CG) or gateway nodes which are the nodes that act as a communication medium between more than one clusters.

The MANET can be maintained and managed by partitioning the network into clusters. Based on certain criteria or property a method used for grouping the nodes based is known as Clustering. The implementation of clustering schemes in MANET helps in improving the routing by reducing the size of the routing table and decreasing transmission overhead by updating the routing tables after topological changes occur. Cluster based routing is a reactive routing. Reactive routing is also known as on-demand routing. Reactive routing has two main processes involved in it -route discovery and Packet routing [4].

A. Route Discovery

If a node needs to find a route to another destination node, first it must discover a route that is needed to reach the destination node and then route the packet to that node. Unlike proactive routing, paths are maintained only until they are needed. Route Discovery is the mechanism whereby a node A wishing to send a packet to a destination D obtains a source route to D. Similar to other MANET protocols, the way S finds a route (or multiple routes) to D is also done by flooding, however, because of the clustering approach the number of nodes that are disturbed are much less in general. Essentially in Route Discovery, cluster heads are flooded in search for a source route. To perform Route Discovery, the source node A sends out a Route Request Packet (RREQ), with a recorded source route listing only itself initially. Any node that forwards this packet will append its own ID in this RREQ. Each node forwards a RREQ packet only once and it never forwards it to a node that has already appeared in the recorded route. In CBRP, the RREQ will always follow a route with the following pattern to reach destination D:

A CH1,G1,CH2,G2,G3,CH3 D[5].

B. Packet Routing

Ordinary nodes are cluster members but they do not have neighbors belonging to different clusters. Gateway nodes are nodes in a non-cluster head state located at the boundary of a cluster. They are used for routing to a node from a different cluster. Networks select a set of nodes that can serve as the backbone of the network. A network can contain a number of clusters and each cluster has cluster head and cluster members, which are at one hop away from the cluster head. The cluster Head of one cluster is connected to another cluster directly or through the gateway nodes [4]. The gateway nodes and the cluster heads together manage the routing mechanism of the network. In MANET, whenever a data packet is send to a destined node we have to carry out a route discovery process. In a route discovery a route request packet (RREQ) is flooded over the network. In this each and every node of the network participate which lead huge bandwidth and energy uses. Finally it reduces network performance. In order to utilize our most scarce resources (energy, bandwidth etc), clustering as a best known solution was proposed. In Clustering based routing only two nodes that participate in flooding of route request packet (RREQ). Those are Cluster Head (CH) and Cluster Gateway (CG). Hence the less the number of nodes participating in routing decision the more the network performance will increase. Routing mechanism is show in following fig 2.

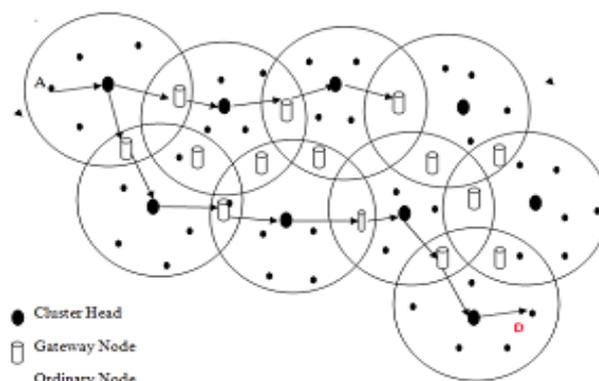


Fig.2 Flooding of RREQ packet over cluster head(CH) and gateway node(GN) to find route from source node a to destination node D.

III . ANT COLONY OPTIMIZATION

Ant Colony Optimization (ACO) is an adaptive technique to find partial solutions for the problems where identifying exact solution is either difficult or impossible. ACO is inspired by the foraging behaviour of ants. When ants search for food, they wander randomly and upon finding food return to their colony while laying a chemical substance called pheromone on the path . Many ants may travel through different routes to the same food source. The ant which travel the shortest path to the destination reaches first to the destination and thus when it starts moving back to its nest it follows the same path as it is the only path with high pheromone concentration. Thus when it moves back to the nest it further increases the concentration of pheromone on that path .Subsequently more ants are attracted by this pheromone trail, which reinforces the path even more. Ants are simple agents that interact via indirect communication known as stigmergy. Stigmergy is an indirect form of communication where individual agents leave signals in the environment and other agents sense them to drive their own behaviour. This form of communication is local wherein simple agents interact locally without having any global information. Since these bio-inspired networks are scalable, it will be helpful for further research also [4].

ARA [1] is one of the ant colony optimization based routing algorithm that works in an on demand way. It sets up multiple paths between source and the destination. At start of session, Forward ants will be broadcasted by sender to all its neighbors. Each Forward ant has a unique sequence number to avoid duplicates. A node receiving a Forward ant for the first time creates a record consists of destination address, next hop, pheromone value in its routing table. The node interprets the source address of the Forward ant as destination address, the address of the previous node as next hop, and computes the pheromone value depending on the number of hops the Forward ant needed to reach the node. When the Forward ant reaches destination, the destination node extracts the information and then destroys the Forward ants. A Backward ANT is created and sent towards the source node, the path is established and data packets are sent. Data packets are used to maintain the path ,so overhead is reduced.

IV . PROPOSED APPROACH

Although there are number of approach present for cluster formation in Adhoc networks but they suffers from limitation like overhead due to transmission of large number of packets .Here we are presenting a new approach which can divide the complete networks into non overlapping clusters.

The algorithm for cluster formation can be explained as follows

1. Initially each node will broadcast a forward ant packet with a hop limit of 1(neighbour node) .With every node accepting atmost 1 forward ant and rejecting the forward ant packets received afterwards.
2. Every node which will be getting a forward ant as in step 1 will produce a backward ant packet back to the source. Hence leading to the formation of disjoint clusters as shown in fig. 3 a.
3. After step 2 the Cluster Head can be decided by counting the number of backward ant received on each node in the cluster. The node with maximum number of backward ant packet will be the Cluster Head.
4. Thus each node in the cluster can be assigned a Cluster Head id corresponding to the id of the cluster head decided from the step 3.

The gateway for inter cluster transmission of packets can be decided by using following steps.

1. The Cluster Head will broadcast a forward ant packet with a hop limit following condition
Cluster Head id (Sending node) != Cluster Head id (Receiving node)
2. If the condition in the step 1 is met then a backward ant is produced from the receiving node back to the source and the id corresponding to the source of backward ant will be set to the id of gateway node for transmitting packets between two clusters.

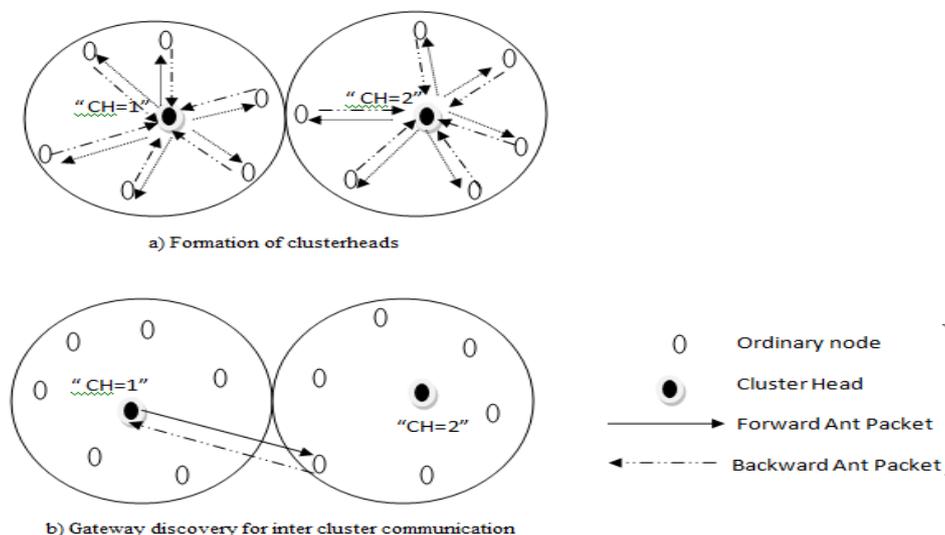


Fig.3. a) Formation of cluster head b) Gateway discovery for inter cluster communication.

V . CONCLUSION

Clustering algorithm comes with number of benefits and enhances the performance of network due to less bandwidth utilization. Cluster Head (CH) and Cluster Gateway (CG) forms the main backbone of the cluster based network. Hence a new optimized approach based on Ant Colony Optimization has been introduced for formation of non overlapping cluster and an algorithm using ACO is proposed for finding cluster Head and Gateway node.

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