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A Review on Clustering in MANET Using Mobile Agents

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Abstract- A mobile ad hoc network (MANET) consists of a set of mobile hosts. The mobile hosts are capable of communicating with each other without the assistance of base stations. The nodes of MANET intercommunicate through single hop and multi hop paths in a peer to peer form. Intermediate nodes between two pairs of communication nodes act as routers. Mobile agent is a program segment which is self controlling. They navigate from node to node not only transmitting data but also doing computation. They are an effective paradigm for distributed applications, and especially attractive in a dynamic network environment. A routing algorithm with multiple constraints is proposed based on mobile agents. It uses mobile agents to collect information of all mobile nodes. The algorithm has stronger routing stability and lower probability of link failure because it selects links with large link expiration time. Multi path strategy reduces the time consumption of re routing. Also, the source node can utilize the best path to perform the data transmission to meet two QoS requirements (remaining battery and bandwidth) in order to extend the survival time of network. The mobile agent based routing algorithm is more effective and robust than AODV. Studies on mobility models have indicated that temporally and spatially correlated mobility models with geographic restrictions are nearer to real life scenario when compared to fully-random models.

Keywords: adhoc network, MANET, Self controlling, QoS factors, Multipath strategy.

I. INTRODUCTION

A mobile ad-hoc network is categorized under infrastructure less network where a number of mobile nodes communicate with each other without any fixed infrastructure between them.

Further more, all the transmission links are established through wireless medium [1]. The functioning of MANET depends upon the trust and cooperation between the nodes. Each node can individually act as a router or a host for transmitting data packets to other nodes which are not in the range of direct transmission.

MANET is one of the recent active fields and has received marvelous attention because of its self-configuration and self maintenance capabilities [2]. MANET is widely used in military purpose, disaster area, personal area network etc. Ad hoc network offer great flexibility, higher throughput, lower operating cost and better coverage because of collection of independent nodes [3].

A Mobile ad hoc networks consist of mobile nodes, which can

Communicate with each other ad nodes are enter and leave the network anytime due to the short transmission range of MANETs [2][3], routes between nodes may consist of one or more hops. Thus each node may either work as a router or depend on some other node for routing. Figure 1.1 shows a simple ad hoc network with three mobile node using wireless interfaces. Node A and C are out range from each other's. The Node B will act as a router and these three nodes together form and ad hoc network.

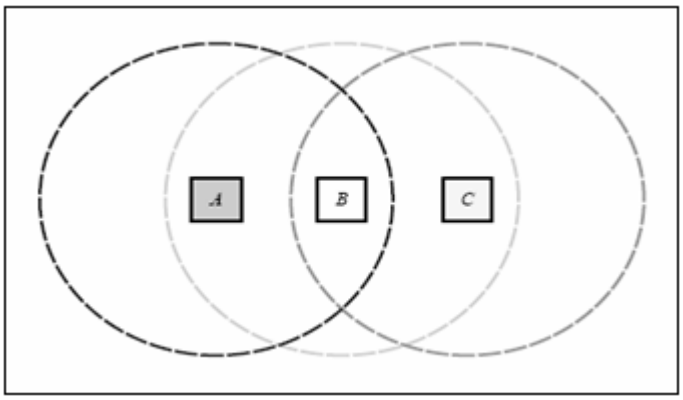

Fig 1.1 Mobile Ad hoc network with 3 mobile nodes

In this paper, we discuss Clustering of ad hoc nodes on the basis of mobile agents. Since the size of an ad hoc network is boundless, portioning the network into clusters makes it more manageable. Intra and Inter cluster interaction holds the key to hierarchical network service architecture like QoS and multicast.

Swarm Optimized Ant Clustering (SOAC) is a Swarm Intelligence based concept used as optimization tool for optimal cluster formation in MANET. It works on the principle of collective intelligence and emergence. It's application in graphs and networks involves swarming agents (ants) hopping node to node, analyzing a set of local variables exposed by the nodes and changing the color of the node. A group of neighboring nodes with the same color collectively form a cluster.

The SOAC algorithm is limited to node coloring only. A simple token based election algorithm can be used to elect cluster-head among nodes of similar color in radio distance to each other. The cluster-head formation results in an immediate elimination of state information being stored in nodes of same color.

II. CHALLENGES IN MOBILE AD-HOC NETWORKING

MANET is a collection of wireless mobile nodes, which dynamically form a temporary network, without using any existing network infrastructure or centralized administration. These are often called infrastructure-less networking since the mobile nodes in the network dynamically establish routing paths between themselves. Current typical applications of a MANET include battlefield coordination and onsite disaster relief management as shown in Fig 1.

1. End-to-End service over Hop-by-Hop infrastructure

Current trend in networking shows a paradigm shift towards end-to-end service. Given the plethora of network services either implemented or in the stage of development, it is nearly impossible to design a networking infra-structure keeping all of them in mind. Such an attempt will result in huge information being stored per hop to understand and route traffic and this will result in an explosion of state information per hop.

The right way to approach the problem is to concentrate on designing a networking infrastructure which will satisfy a few basic requirements and constraints. *Then* various end-to-end services can then be built over that infrastructure.

2. Quality of Service guarantees in MANET

The current MANET protocols don't address this topic directly. To better understand the Quality of Service in MANET[], it is imperative that we understand how Quality of Service is currently provided in wire-line networks. In the field of packet-switched networks and computer networking, the traffic engineering term **Quality of Service** (**QoS**) refers to the probability of the telecommunication network meeting a given traffic contract, or in many cases is used informally to refer to the probability of a packet succeeding in passing between two points in the network. Many on demand QoS routing protocols have been proposed for MANETs [4] .

A traffic contract (**SLA**, **Service Level Agreement**) specifies the assurances for the ability of a network/protocol to give guaranteed performance/throughput/latency bounds based on mutually agreed measures, usually by prioritizing traffic. Broadly speaking there are two types of service which require QoS: (1) **Elastic** and (2) **Inelastic**.

Inelastic service, meaning that they require a certain level of bandwidth to function - any more than required is unused, and any less will render the service non-functioning.

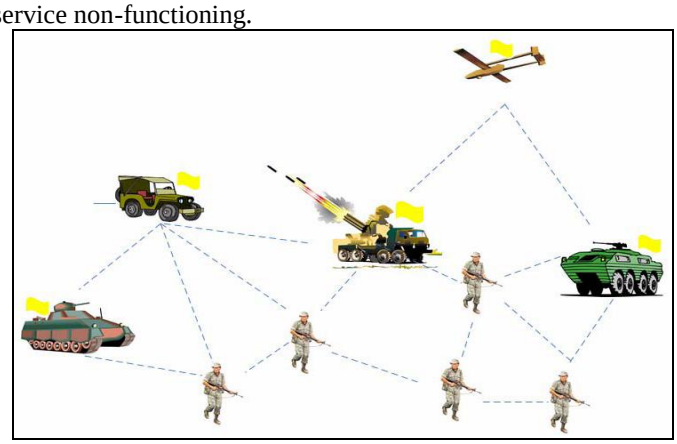

Fig 1.2 Example of MANET in battlefield communications

By contrast, *elastic* applications can take advantage of however much or little bandwidth is available. MANET is expected to provide QoS for Elastic services.

In general QoS is the result of "**coordinated effort"** between various network entities. Such an effort initiative may be formally defined in the form of **SLA** between network entities in the case of wire-line networks. For MANET the concept of QoS would result from "**coordinated effort"** between various nodes.

III. ROLE BASED ROUTING IN CLUSTERED MANET

Ad-hoc mobile nodes, though they appear homogeneous, play specific roles. The number of possible roles is finite and is a relatively small set {**OBS**, **SRC**/**SINK** and **FWD**}.

Let R be set of roles.

R = {OBS, SRC/SINK, FWD}

OBS = acts as an OBSERVER, uses the broadcast nature of nodes to sniff into neighbor transmissions.

SRC/SINK = acts as a packet SOURCE or SINK.

FWD = acts as a FORWARDING ENGINE. neighbor transmissions.

SRC/SINK = acts as a packet SOURCE or SINK.

FWD = acts as a FORWARDING ENGINE. Let the number of nodes in the experimental frame be N.

Let the nodes be numbered as $T_1 ... T_N$

At any point of time the nodes can be in any 1 or more roles as defined in the following Table 1.1.

The total number of available Cumulative Roles is given by:

$$C^3_1 + C^3_2 + C^3_3 = 7$$

Out of these 7 Cumulative Roles, not all are valid.

Table 1.1 Table of Roles

CASE	Cumulative Role(s) at any given time t	Valid
1	OBS+SRC/SINK+FWD	NO
2	OBS+SRC/SINK	NO
3	OBS+FWD	NO
4	SRC/SINK+FWD	YES
5	SRC/SINK	YES
6	FWD	YES
7	OBS	YES

The **Cumulative Role(s)** may or may not vary over time. Identification of time-invariant (or mostly time-invariant) Cumulative Roles will pave the way to Role based Routing in MANET.

IV. RELATED WORK

4.1. Mobile Ad-hoc Networks

A mobile ad hoc network (MANET) is a collection of mobile devices forming a temporary network in the absence of fixed infrastructure. Each node has a wireless interface and communicates using it. Because nodes may move in to and out of the radio range of other nodes, routing information may change frequently. For example, in Figure 4.1, node A has two

paths to node E: ABDE and ACDE, however, these two paths would become unavailable should node E move out of range of node D. If node E subsequently moves close enough to node A, then node A might be able to communicate with E directly. Alternatively, node E might enter the communication range of node C, so ACE would become a valid path. Such routes must be discovered quickly and with low overhead.

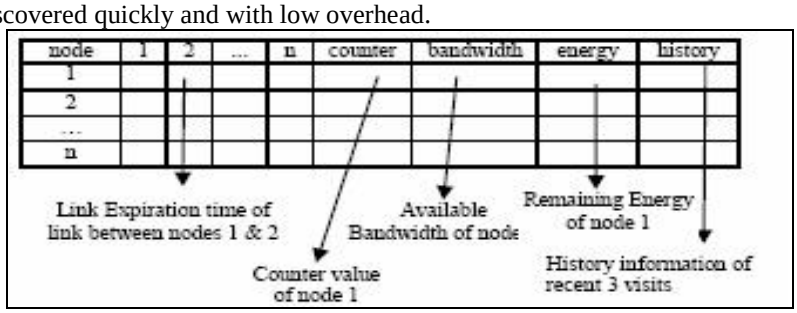

Fig 4.1 Structure of a node

4.2 MANET Routing Protocols

Routing in an MANET typically consists of two phases: route discovery and route maintenance. Route Discovery is the mechanism by which a node S intending to send a packet to destination D obtains a route to D. Route Maintenance is the mechanism by which node S is able to detect, while using a route to D, that one or more links along the route have failed. When a broken link is discovered, the source can use another route or can re invoke Route Discovery. MANET routing

protocols are commonly classified into two categories – proactive and demand based. Proactive routing continually maintains information on all available paths using periodic updates so when a packet needs to be sent, routes are known and can be used immediately. The proactive method takes little time to discover routes but must maintain routing information for unused paths. Demand based routing, rather than maintaining paths between all nodes at all times, invokes a route discovery procedure on demand. Demand based schemes use less network bandwidth as they avoid sending unnecessary routing information but they typically take longer to discover routes.

The Ad hoc On demand Distance Vector (AODV) algorithm is a demand based protocol. Using distance vectors, each node stores available routes for known destinations. AODV floods a 'Route Request' (RREQ) message to its neighbors to discover new routes. Each RREQ message propagates through the network until it reaches the destination or a node that has a fresh route to the destination. AODV uses only the shortest path to transfer data and does not require nodes to store routes to destinations they do not communicate with.

Dynamic Source Routing (DSR) is also demand based and, like AODV, uses only the shortest discovered path. When a node wants to send a message, it broadcasts a route request message to its neighbors which add their own addresses and rebroadcast the message until it reaches the destination which replies using the discovered path. When a failed link is detected, a message is sent to the source and the route is discarded. DSR then rebroadcasts to discover a new route. DSR supports both bidirectional and unidirectional links.

The Cluster Based Routing Protocol (CBRP) is another demand based protocol that divides the MANET nodes into a set of clusters. One host is elected as each cluster's 'head' which maintains the cluster's membership information. The need for inter cluster routing is discovered using the membership information and is performed by the cluster heads. CBRP is useful for large scale MANETs since the clustering reduces the number of routing messages needed.

Optimized Link State Routing (OLSR) [4] is a proactive protocol. Each node selects a set of neighbours as multipoint relays (MPRs) which periodically announce their existence to
the network. MPRs are used to find routes in the network. Unlike CBRP, OLSR selects MPRs dynamically.

Topology Broadcast using Reverse Path Forwarding (TBRPF) [6] is another proactive protocol that uses shortest paths. Each node maintains a 'source tree' of shortest paths to its reachable nodes and announces a part of its source tree to its neighbours using a combination of periodic and triggered updates. To decide which part of the source tree to send, a node in computes its 'reportable node set' (RN). Node i puts node u in RN if it determines that some neighbor j may select node i to be the next hop on a shortest path from j to u.

The Fisheye State Routing protocol (FSR) [7] is also a proactive protocol. A 'center' node in the MANET stores link state information for all nodes. This node periodically sends the information for all nodes to its hop neighbors (r = 1,2,..). This is done at different frequencies based on the value of r. In FSR, nodes can obtain the entire network topology and therefore compute efficient routes.

4.3. Mobile Agents

Mobile agents are software entities that act on behalf of their creators and move independently between hosts. In general, a mobile agent executes on a machine that hopefully provides the resources or services that it needs to do its work. If a machine does not contain the needed resources or services, the mobile agent can transfer itself to a new machine. Lange and Oshima enumerate several benefits of using mobile agents. Of particular interest to MANET routing are:

• Mobile agents are able to upgrade protocols in use by moving to a destination and setting up communications operating under revised policies.

• After being dispatched, mobile agents become independent of the process that created them and can operate asynchronously and react dynamically and autonomously to environmental changes.

• Mobile agents can reduce network load and latency by running remotely.

Recently, a number of mobile agent systems have been developed to address applications in areas including telecommunication services, Ecommerce and personal assistance. Included among these are Agent TCL, ARA, Concordia, and Aglets. All such systems provide common functions including agent migration, inter agent communication and security. One potential drawback of using mobile agents is that the agents require an "execution environment" in which to run. This has become less of an issue in recent years as mobile devices become more capable and the execution environments become somewhat leaner.

4.4. Routing Using Mobile Agents

Early work on routing in dynamic networks using mobile agents by Kramer et al.concentrated on route discovery using agents to continuously track the network topology and update routing tables at all mobile hosts reached. When a route is requested, an agent is sent to discover routes to the destination. These agents analyze the routing tables on the hosts they arrive at and either return a discovered route to the
sender or move on to another machine if no route is found. Unfortunately, this method increases network load significantly because mobile agents are constantly moving through the network. Other limitations of Kramer, etal's work are that it is difficult to determine the appropriate number of agents to use and it is not possible to have multiple application specific routing algorithms concurrently in use.

V. SWARM OPTIMIZED ANT CLUSTERING

Swarm Optimized Ant Clustering (SOAC) is a Swarm Intelligence based concept used as optimization tool for optimal cluster formation in MANET [8]. It works on the principle of collective intelligence and emergence. It's application in

graphs and networks involves swarming agents (ants) hopping node to node, analyzing a set of local variables exposed by the nodes and changing the color of the node. A group of neighboring nodes with the same color collectively form a cluster. The SOAC algorithm is limited to node coloring only. A simple token based election algorithm can be used to elect cluster-head among nodes of similar color in radio distance to each other. The cluster-head formation results in an immediate elimination of state information being stored in nodes of same color. It also results in marked improvement in "good-put" as IP & TCP/UDP headers are immediately replaced by labels used for switching. This also gives the node a chance to better utilize the resources using directed smart antennas and getting rid of local network state information.

Benefits of Swarm

SOAC utilizes local interaction without centralized control. Global representation of the parameters is not required. The algorithm is based on a simple set of rules making it a low computation over-head.

VI. AD-HOC NETWORKING WITH SWARM INTELLIGENCE (ANSI)

ANSI (Rajagopalan, Jaikaeo & Shen, 2003) is a hybrid combination of both proactive and reactive routing. The objective of ANSI is to leverage the potential of proactive routing with the flexibility and scalability of a purely reactive routing. Each node maintained and managed the connectivity with neighbors located within a zone radius in a pure proactive approach. The zone radius is dependable on the whole network size and mobility. For a bigger size or a higher mobility network, the zone radius is set to be larger so that the amount of proactive activity can be increased. In norm, the zone radius is about two-hop range.

Reactive method is only applied when the destination node is not located within the zone radius of the source node. In this case, ANSI resonate the route discovery mechanism used in AntNet where forward ants would be broadcast in search of the destination node.

Because each node maintains routes to every other node within its zone radius, the network does not incur high delay for route discovery or route setup. It provides good reliability especially in high mobility network. Nevertheless, due to the proactive nature, every node in ANSI creates high overhead as periodic updates need to be frequently broadcast. This may not be efficient in terms of power consumption and bandwidth utilization as nodes need to be active all the time for proactive activities.

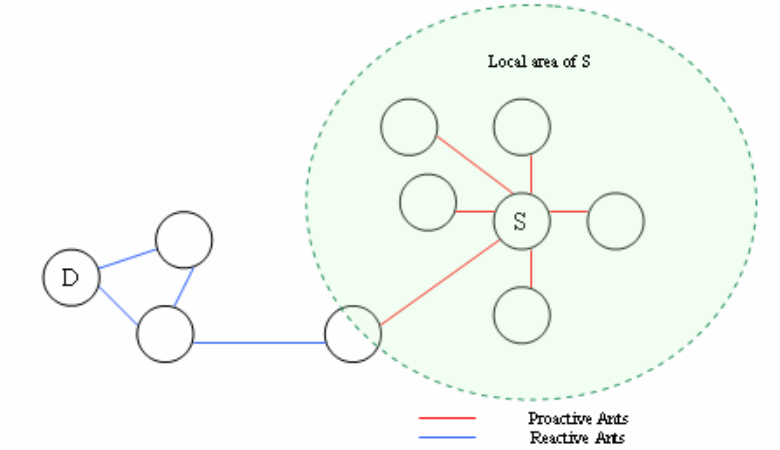

Fig. 5.1. Proactive and reactive scheme in ANSI

VII. TERMITE

This routing algorithm (Roth & Wicker, 2003) adopts the analogy of termites instead of ants. Each network node is an analogy to a termite hill. The more termites passing through a node, the more pheromone would be collected at the node, making it a preferred next-hop node for other packets. There are five types of packets used in Termite. These are data, hello, RREQ, RREP and seed. Data packets are routed following the pheromones of each outgoing links. Each node will increase the pheromone of the previous node that the packet came from.

There is no flooding involve in Termite. A limited number of RREQ packets perform a random walk over the network in search for the destination. The reply packet is routed by following the pheromone trail left by the request packet. However, such random walk may sometimes results in the destination not being found or poor route being discovered.

Termites also adopt the hello mechanism. Hello packets are broadcast at regular interval until a reply is received. A reply is sent by all nodes who hear the hello. Seed

VIII. CONCLUSION

In this paper, I have proposed a management solution to accomplish stable structure and overcome faults. This solution can be applied on several MANET clustering protocols. The main objective consists respectively in ensuring the stability of the clusters and in reducing the re-clustering. We achieved this objective by implementing each CH job in a mobile agent and distributing the agents among some member nodes. The advantages of this idea are: (1) distributing the load among nodes reduces the failure possibility and hence avoids re-clustering. (2) Overcoming the nodes mobility by employing mobile agents and benefiting by their migration. (3) When a job carrier fails, only one job is temporarily unavailable while

when the CH fails, in other algorithms, all the jobs are unavailable. (4) Distributing the jobs among 4 nodes allows member nodes to request services from these 4 nodes at the same time, i.e. up to 4 jobs can be executed in parallel. Simulations showed that the proposed solution achieved stable structure by reducing the undecided time, reducing the packets loss, and overcome the faults that result from mobility.

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