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An Efficient Genetic Approach Based Geocasting Protocol for Video Streaming in MANET

Saranya.S, P.D.R. Vijayakumar

Department of Computer Science and Engineering, Info Institute of Engineering, Coimbatore, Tamil Nadu, India.

ABSTRACT: Today's need and trend of communication is supported by the primary services called group oriented services. In recent years, such services are provided with the help of MANETs. There are constraint while developing multicast routing protocols which starts with the residual energy of the battery of a mobile node is finite (before recharging is done). Genetic Algorithm (GA) presents an improved solution for the multi-constrained multicast routing problem. GA allows for self-configuration systems and maintains state information about the neighbouring network. And we obtain the alternative path or backup path to avoid reroute discovery in the case of link failure or node failure. By choosing proper fitness function and values for metrics such as initial population size, crossover and mutation that closely relates to the chosen scenario, the genetic algorithm optimizes the routes in terms of selected metrics. To implement this group communication, we propose an Efficient Geographic Multicast Routing protocol (EGMP) with the help of virtual zone based structure along with the GA for better efficiency in communication. This EGMP protocol deals with the position information which is used to construct zone structure, multicast tree and multicast packet forwarding. The performance metrics such as Packet Delivery Ratio (PDR), End to End delay and Control Overhead of EGMP are also evaluated through simulations and quantitative analysis by varying number of nodes, zone size and group size. In order to overcome problems such as performance degradation or network partition, data can be replicated in mobile nodes. The replicas ensure that the performance is not degraded. However, chances are that some nodes may not cooperate and rather behave selfishly. The selfishness of some of the nodes may lead to the performance degradation in terms of accessing data. In this paper, we examine the impact of selfish nodes in a mobile ad hoc network from the perspective of replica allocation. We term this selfish replica allocation. In particular, we develop a selfish node detection algorithm that considers partial selfishness and novel replica allocation techniques to properly cope with selfish replica allocation. The conducted simulations demonstrate the proposed approach outperforms traditional cooperative multicast routing protocol and replica allocation techniques in terms of packet delivery ratio, throughput, loss, data accessibility, communication cost, and delay.

KEYWORDS: EGMP, degree of selfishness, zone structure, performance metrics.

I. INTRODUCTION

A mobile ad-hoc network (MANET) is a self-configuring network of mobile devices connected by wireless links. Applications include the exchange of messages among a group of soldiers in a battlefield, communications among the firemen in a disaster area, and the support of multimedia games and teleconferences. With a one-to-many or many-to-many transmission pattern, multicast is an efficient method to realize group communications.

In MANET unicast routing, geographic routing protocols [1] [5] have been proposed for more scalable and robust packet transmissions. The existing geographic routing protocols generally assume mobile nodes are aware of their own positions through certain positioning system (GPS), and a source can obtain the destination position through some type of location service [9]. In [6], an intermediate node makes its forwarding decisions based on the destination position inserted in the packet header by the source and the positions of its one-hop neighbours learned from the periodic beaconing of the neighbours.

Power awareness is crucial in a mobile wireless network,particularly in a MANET. Nodes need to reduce their powerconsumption to prolong their battery lifetime. Therefore, thetransmission power should be carefully chosen since the largetransmission power level leads to the waste of battery energy.Several heuristic algorithms for constructing source-based energy-efficient multicast trees have been developed [1]. Sincemost multimedia applications are delay-sensitive, end-to-enddelay should be considered in multicast routing to providebetter QoS. However, energy-efficient multicast routing hasnot always considered the delay metric. Furthermore, thedesign of quality of service (QoS) multicast routing withmulti-constrained metrics, i.e., multi-constrained minimumcost multicast problem [2], and degree-constrained least-costmulticast routing [3], has not always considered the energyconsumption. Therefore, these QoS multicast routing schemescannot be directly used in MANETs.

Network partitions can occur frequently, since nodes move freely in a MANET, causing some data to be often inaccessible to some of the nodes. Hence, data accessibility is often an important performance metric in a MANET [4].Data are usually replicated at nodes, other than the original owners, to increase data accessibility to cope with frequent network partitions. A node may act selfishly, i.e., using its limited resource only for its own benefit, since each node in a MANET has resource constraints, such as battery and storage limitations. A node would like to enjoy the benefits provided by the resources of other nodes, but it may not make its own resource available to help others. Such selfish behaviour can potentially lead to a wide range of problems for a MANET. We address the problem of selfishness in the context of replica allocation in a MANET i.e., we shall refer to such a problem as the selfish replica allocation.

In this paper, we propose an efficient geographic multicast protocol (EGMP)along with GA which can scale to a large group size. The protocol is designed to be comprehensive and self-contained, yet simple and efficient for more reliable operation. Instead of addressing only a specific part of the problem, it includes a zone-based scheme to efficiently handle the group membership management, and takes advantage of the membership management structure to efficiently track the locations of all the group members without resorting to an external location server. The zone structure is formed virtually and the zone where a node is located can be calculated based on the position of the node and a reference origin. By making use of the location information, EGMP could quickly and efficiently build packet distribution paths, and reliably maintain the forwarding paths in the presence of network dynamics due to unstable wireless channels or frequent node movements. Although genetic algorithms can be seen as not adequate for supporting delay-sensitiveapplications in MANETs because they may involvea large number of iterations, new hardware implementationsof genetic algorithms [5] have shown their ability of fastcomputation. In this regard, the proposed genetic algorithmis quite promising for multicast routing in MANETs. The proposed algorithm is a source-based algorithm which takes into account energy consumption as well as end-to-end delay in route selection. The proposed algorithm applies crossover and mutation operations directly on trees, which simplifies the coding operation and omits the coding/decoding process. Heuristic mutation technique can improve the total energy consumption of a multicast tree. A series of experiments was performed to verify the convergence performance, Successful Ratio and running time of the proposed algorithm. The results demonstrate that the proposed algorithm is effective and efficient.

We devise novel replica allocation techniques with the developed selfish node detection method. They are based on the concept of a self-centred friendship tree (SCF-tree) and its variation to achieve high data accessibility with low communication cost in the presence of selfish nodes. The technical contributions of this paper can be summarized as follows:

- Recognizing the selfish replica allocation problem: We view a selfish node in a MANET from the perspective of data replication, and recognize that selfish replica allocation can lead to degraded data accessibility in a MANET.
- Detecting the fully or the partially selfish nodes effectively: We devise a selfish node detection method that can measure the degree of selfishness.
- Allocating replica effectively: We propose a set of replica allocation techniques that use the self-centred friendship tree to reduce communication cost, while achieving good data accessibility.
- Verifying the proposed strategy: The simulation results verify the efficacy of our proposed strategy.

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II. PROPOSED ALGORITHM

A. EFFICIENT GEOGRAPHIC MULTICAST ROUTING PROTOCOL (EGMP)

EGMP supports scalable and reliable membership management and multicast forwarding through a two-tier virtual zone-based structure. At the lower layer, in reference to a pre-determined virtual origin, the nodes in the network self-organize themselves into a set of zones as shown in Figure 1, and a leader is elected in a zone to manage the local group membership. At the upper layer, the leader serves as a representative for its zone to join or leave a multicast group as required. As a result, a network-wide zone-based multicast tree is built. For efficient and reliable management and transmissions, location information will be integrated with the design and used to guide the zone construction, group membership management, multicast tree construction and maintenance, and packet forwarding. The zone-based tree is shared for all the multicast sources of a group. To further reduce the forwarding overhead and delay, EGMP supports bi-directional packet forwarding along the tree structure. That is, instead of sending the packets to the root of the tree first, a source forwards the multicast packets directly along the tree. At the upper layer, the multicast packets will flow along the multicast tree both upstream to the root zone and downstream to the leaf zones of the tree. At the lower layer, when an ontree zone leader receives the packets, it will send them to the group members in its local zone.

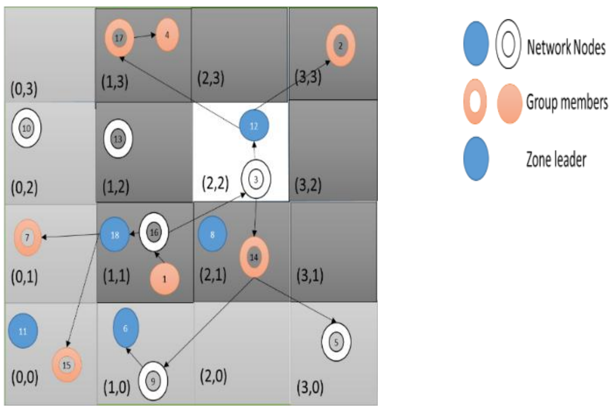

Figure. 1 Zone Construction

In EGMP, we assume every node is aware of its own position through some positioning system (GPS [10]) or other localization schemes. Some of the notations to be used are:

zone: The network terrain is divided into square zones.

r: Zone size, the length of a side of the zone square. The zone size is set to r .rt/ • ã2, where rt is the transmission range of the mobile nodes.

- **Zone ID**: It is an identification of a zone. A node can calculate its zone ID (a, b) from its position coordinates (x, y) as:
  $a = \frac{[x-x0]}{r}$, $b = \frac{[y-y0]}{r}$
  where (x0, y0) is the position of the virtual origin. For simplicity, we assume all the zone IDs are positive.
- **Zone centre**: For a zone with ID (a,b), the position of its centre (ac, bc) can be calculated as:
  xc = x0 + (a+0.5) × r,
  yc = y0 + (b+0.5) × r.
  A packet destined to a zone will be forwarded towards the centre of the zone.
- **zLdr**: A Zone leader. The local zone group membership will be managed by elected zLdr in each zone and taking part in the upper tier multicast routing.
- **Tree zone**: Tree zone can be used for forwarding multicast packets. It may have group members or just helps to forward the multicast packets for zones with members.
- **Root zone**: The root where it is located at the zone of multicast tree.
- **Zone depth**: The distance to the root zone can be calculated by using depth of a zone. For a zone with ID (a, b), its depth is:

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depth = max(│a0 - a│,│b0 - b│);
where (a0,b0) is the root-zone ID. For example, in Figure 1, the root zone has depth zero, the eight zones immediately surrounding the root zone have depth one, and the outer seven zones have depth two.

B. NEIGHBOUR TABLE CONSTRUCTION AND ZONE LEADER SELECTION

A leader is elected with minimum overhead for efficient management of states in a zone. As a node employs periodic BEACON broadcast to distribute its position in the underneath geographic unicast routing, to facilitate leader election and reduce overhead, EGMP simply inserts in the BEACON message a flag indicating whether the sender is a zone leader. With zone size $r \leq rt/\sqrt{2}$, a broadcast message will be received by all the nodes in the zone. To reduce the beaconing overhead, instead of using fixed-interval beaconing, the beaconing interval for the underneath unicast protocol will be adaptive. A non-leader node will send a beacon every period of Intvalmax or when it moves to a new zone. A zone leader has to send out a beacon every period of Intvalmin to announce its leadership role. When receiving a beacon from a neighbour, a node records the node ID, position and flag contained in the message in its neighbour table. The zone ID of the sending node can be calculated from its position, as discussed earlier. To avoid routing failure due to outdated topology information, an entry will be removed if not refreshed within a period TimeoutNT or the corresponding neighbour is detected unreachable by the MAC layer protocol. A zone leader is elected through the cooperation of nodes and maintained consistently in a zone. When a node appears in the network, it sends out a beacon announcing its existence. Then it waits for an Intvalmax period for the beacons from other nodes. Every Intvalmin a node will check its neighbour table and determine its zone leader under different cases: 1) Theneighbour table contains no other nodes in the same zone, it will announce itself as the leader. 2) The flags of all the nodes in the same zone are unset, which means that no node in the zone has announced the leadership role. If the node is closer to the zone centre than other nodes, it will announce its leadership role through a beacon message with the leader flag set. 3) More than one node in the same zone have their leader flags set, the one with the highest node ID is elected. 4) Only one of the nodes in the zone has its flag set, then the node with the flag set is the leader.

C. GENETIC ALGORITHM

Coding

The representation of candidate solutions is critical for designing a well-performed genetic algorithm. A number of representations for a tree, such as one-dimensional binary code [13], Pr¨ufer numbers [3] and sequence and topology encoding (ST encoding) [14], have been developed. However, these representations are likely to generate illegal trees (e.g., ST encoding), or have poor locality (e.g., Pr¨ufer numbers), or have low efficiency that the required search space increases remarkably with the increase of the network size (e.g., one dimensional binary code). Recent studies on network optimization avoid these problems by directly manipulating trees, i.e., using a data structure of a tree to describe the chromosome. With this method, a tree directly represents a chromosome. Therefore, the coding/decoding operations are omitted. In our study, we use the tree structure coding method, in which a chromosome represents a multicast tree directly.

Initial Population

Two issues should be considered in the process of population initialization:
(1) Population size *Np*; (2) the method of population formation. *Np*is set by the system. In the proposed algorithm, the formation of initial population (random multicast Steiner trees) is based on the random depth-first search algorithm .The searching process begins at s andrandomly selects an unvisited node for next visit. This process terminates when all destinations have been visited.

Fitness Function

The fitness function should reflect the individual performance: the "good individual" has bigger fitness than the "bad one". The definition of the fitness function is as follows:

$$f(T) = \left[\frac{a}{cost\,(T)}\right] \pi_{vt \in D}\ \phi(delay(pt\,(s, v_t)) - \delta \quad (1)$$

Where

$$cost(T) = \sum_{vi \in T} c_i^T \ = \sum_{vi \in} b[k_1\ (r_i^{'})^{\beta} + k_2]\ (2)$$

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$a$is the positive real weighting coefficient. $\delta$is the maximum allowable delay from s to vt, where $vt\in D$. cos(T) is the energy cost of tree T . $\Phi(\cdot)$ is a penalty function. The value $\gamma(0 < \gamma < 1)$ determines the degree of penalty: the smaller the value of γ, the higher the degree of penalty. In our experiments, we set $\gamma = 0.5$.

$$\Phi(Z) = \begin{cases} 1, & \text{if } Z \le 0, \\ \gamma, & \text{if } Z > 0 \end{cases} \qquad (3)$$

This letter reduces the energy consumption of a multicast tree to maximize the network service time. In Eq. (2), cTi is the energy cost of vi, b is a positive real coefficient, and $r_i$is the maximum distance between $v_i$and v_j, where $v_j\in B(vi)$. $B(vi)$ is the set of immediate succeeding nodes of vi on T . Note that the energy cost of leaf nodes is zero. Particularly, we set $k_1 = 1$, $k_2 = 0$, $b = 1$ and β=2 in our experiments.

Selection of Parents

In the proposed genetic algorithm, an elitist model is adopted as the selection operator. First, selects the best individuals and directly copy them to the next generation. Later, selects the rest by the roulette wheel selection model. The probability for selecting a parent Ti, denoted as $p(Ti)$, is given by:

$$p(T_i) = \frac{f(T_i)}{\sum_{j=1}^{N_p} f(T_j)} \qquad (4)$$

Crossover Scheme

Based on the roulette wheel selection, a pair of chromosomes is selected as the parents to produce a single offspring. Let Ta and Tb be the selected parents. The crossover operator generates a child $Tc$by identifying the same links between Ta and Tb, and retaining these common links in Tc. According to the definition of fitness function, the “better” individual has higher probability of being selected as a parent. Thus, the common links between two parents are more likely to represent the “good” traits. However, retaining these common links in Tcmay generate some separate sub-trees. Therefore, links are needed to be selected to connect these sub-trees into a multicast tree. The process of connecting separate sub-trees is as follows. First, two separate sub-trees are randomly selected among these sub-trees. Then, the selected sub-trees are connected by the least-delay path to form a new sub-tree. The connecting process repeats until a multicast tree is constructed. In order to find the least-delay path between two sub-trees, we add two nodes. One node is connected to all of the nodes of one sub tree with links which have zero delay associated with them. Similarly, the other node is connected to all the nodes of the other sub-tree with zero-delay links. Hence, the least-delay path between two sub-trees is the least-delay path between the two added nodes. Clearly, there are no routing loops in the multicast tree with this connecting method. The same links of Ta and Tb are retained in Tc. Then, all sub-trees are connected with least-delay paths which are denoted as dot lines in Tc.

Mutation

When a new offspring is produced, the mutation operation is performed according to the mutation probability pm. First, mutation procedure randomly selects a subset of nodes and breaks the multicast tree into some separate sub-trees by removing all the links that connect these selected nodes and their farthest child node on T . Then, it re-connects these separate sub-trees into a new multicast tree with least-delay paths. *RandomDFS*() denotesrandom depth-first search algorithm, Ng is the number ofgenerations, *Noptimal*is the number of the best individuals.

Analysis of convergence

According to the Theorem 2.7 in [2], the proposed algorithm could finally converge to the global optimal solution. For a large-scale network, it is time-consuming to obtain the optimal solution to this NP-complete problem. This can be overcome by setting an appropriate iteration time for the genetic algorithm. In this way, we can obtain a near-optimal solution within a reasonable time limit.

D.HANDLING SELFISHNESS NODE

We devise novel replica allocation techniques with the developed selfish node detection method. They are based on the concept of a self-centred friendship tree (SCF-tree) and its variation to achieve high data accessibility with low communication cost in the presence of selfish nodes. The SCF-tree is inspired by our human friendship management in the real world. In the real world, a friendship, which is a form of social bond, is made individually. With the help of SCF tree, we aim to reduce the communication cost [7], while still achieving good data accessibility. The technical contributions of this paper can be summarized as follows:

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1) Detecting selfish nodes,
2) Building the SCF-tree,
3) Allocating replica. At a specific period, or relocation period, each node executes the following procedures

- Each node detects the selfish nodes based on credit risk scores.
- Each node makes its own (partial) topology graph and builds its own SCF-tree by excluding selfish nodes.
- Based on SCF-tree, each node allocates replica in a fully distributed manner.

Detecting Selfish Node The notion of credit risk can be described by the following equation:

$$\text{Credit Risk}=\frac{expected\ \ risk}{expected\ \ value} \qquad (5)$$

Each node calculates a CR score for each of the nodes to which it is connected. Each node shall estimate the "degree of selfishness" for all of its connected nodes based on the score. First, selfish features may lead to the selfish replica allocation problem were both expected value and expected risk are determined.

Building SCF-Tree The SCF-tree based replica allocation techniques are inspired by human friendship management in the real world, where each person makes his/her own friends forming a web and manages friendship by himself/herself. He/she does not have to discuss these with others to maintain the friendship. The decision is solely at his/her discretion. The main objective of our novel replica allocation techniques is to reduce traffic overhead, while achieving high data accessibility. If the novel replica allocation techniques can allocate replica without discussion with other nodes, as in a human friendship management, traffic overhead will decrease.

Allocating Replica After building the SCF-tree, a node allocates replica at every relocation period. Each node asks non-selfish nodes within its SCF-tree to hold replica when it cannot hold replica in its local memory space. Since the SCF-tree based replica allocation is performed in a fully distributed manner, each node determines replica allocation individually without any communication [8] with other nodes. Since every node has its own SCF-tree, it can perform replica allocation at its discretion. Replica can be allocated at each node in descending order of its own access frequency. This is quite different from existing group-based replica allocation techniques (e.g., DCG) where replicas are allocated based on the access frequency of group members. Each node Ni executes this algorithm at every relocation period after building its own SCF-tree. At first, a node determines the priority for allocating replicas. The priority is based on Breadth First Search (BFS) order of the SCF-tree.

III. CONCLUSION

There is an increasing demand and a big challenge to design more scalable and reliable multicast protocol over a dynamic ad hoc network (MANET). In this paper, we propose genetic based efficient geographic multicast protocol, GA-EGMP, for MANET. The scalability of GA- EGMP is achieved through atwo-tier virtual-zone-based structure, which takes advantage of the geometric information to greatly simplify the zone management and packet forwarding. A zone-based bi-directional multicast tree is built at the upper tier for more efficient multicast membership management and data delivery, while the intra-zone management is performed at the lower tier to realize the local membership management. The positioninformation is used in the protocol to guide the zone structure building, multicast tree construction, maintenance, and multicast packet forwarding. Compared to conventional topology based multicast protocols, the use of location information in GA-EGMP significantly reduces the tree construction and maintenance overhead, and enables quicker tree structure adaptation to the network topology change. Additionally, EGMP makes use of geographic forwarding for reliable packet transmissions, and efficiently tracks the positions of multicast group members without resorting to an external location server. We have also proposed a selfish node detection method and novel replica allocation techniques to handle the selfish replica allocation appropriately. The proposed strategies are inspired by the real-world observations in economics in terms of credit risk and in human friendship management in terms of choosing one's friends completely at one's own discretion. We applied the notion of credit risk from economics to detect selfish nodes. Every node in a MANET calculates credit risk information on other connected nodes individually to measure the degree of selfishness. Since traditional replica allocation techniques failed to consider selfish nodes, we also proposed novel replica allocation techniques.

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