IJCTA, 9(27), 2016, pp. 219-225 ISSN: 0974-5572

Location Aware Routing for MANET using Genetic Algorithm

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ABSTRACT

One of the key technological challenges of Mobile Ad-hoc networks is that they necessitate new types of routing protocols. In ad hoc networks there are no devoted router nodes: so the mission of routing needs to be achieved by the user nodes, which can be mobile, unpredictable and have restricted battery power and other resources. This throws a wide chance for the researchers to come up with modern routing protocols. The aim of this paper is to propose an innovative routing protocol LOCA-GAMNET based on location information of each node in the network. This promises better performance by reducing the number of packets dropped and increased packed delivery ratio.

Keywords: MANET, Routing, Genetic Algorithm, Optimization, Dynamic topology, Position based Routing.

1. INTRODUCTION

A key trait of potential wireless networks is the capability to habituate and survive even without a fixed infrastructure. An ad hoc network is a collection of possibly mobile devices or nodes that can establish communications, without a fixed infrastructure or central administration. Nodes in these networks are capable of information collection, processing, communication, and even without a pre-existing network infrastructure. Conversely, they will have to focus on the following issues:

- Dynamic nature of the network,
- Radio interference,
- Node addition, movement and failures,
- Quality of Service (QoS) levels in a changing environment,
- Limited energies of the nodes, and
- Limited bandwidth.

Thus, these heterogeneous nodes with their limited power and different data rate requirements depend mainly on intelligent network routing and bandwidth allocation. The routing techniques used in these networks are entirely different from those used in the conventional networks, as they have to pay attention to the above stated issues.

In order to attain seamless network architecture and to play an important role in next generation wireless networks and services numerous protocols have already been proposed. In this paper a location aware routing protocol LOCA-GAMNET (Location Aware Genetic Algorithm for Mobile Ad hoc Network) is proposed.

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The rest of the paper is organized as section II, discusses the categories of routing protocols, section III, gives the description of the previous study, section IV, presents the description of LOCA-GAMNET algorithm and the simulation results obtained when compared with AODV and section V, giving the concluding remarks.

2. CATEGORIES OF ROUTING PROTOCOL

Routing protocols for MANETs can be broadly classified in two categories:

2.1 Topology-based Routing and

2.2 Position-based routing.

2.1. Topology-based Routing

In topology-based protocols, link information is used to make routing decisions. They are further divided in:

2.1.1 Reactive protocols

2.1.2 Proactive protocols

2.1.3 Hybrid protocols

2.1.1. Source-initiated (Reactive or On-demand)

These types of protocols create route only when the source requests a route to a destination .They create a route through a route discovery procedure. In which route request packets are flooded throughout the network starting with the immediate neighbors of the source. Once a route is formed or multiple routes are found for the destination, the route discovery process comes to an end .A route maintenance procedure maintains the continuity of the route for the time span it is needed from the source. [1] Some of the examples of the source- initiated routing protocols are DSR, AODV, and TORA etc.

2.1.2. Table-driven(Proactive)

These types of routing protocols always maintain up-to-date information on routes from each node to every other node, means that a source node to every possible node in the network. Routing information is stored in the routing table of each mobile node and route update packets are propagated throughout the network to keep the routing information as update as possible. All protocols have the common goal of reducing route maintenance overhead as much as possible. Some of the examples of Table driven routing protocols are DSDV, OLSR, and FSR etc. [1]

2.1.3. Hybrid Protocols

Hybrid routing protocols are the third category of routing protocols in the MANET that combine the advantages and remedy the shortcomings of both proactive and reactive routing protocols. Generally, these protocols exploit hierarchical network architectures. Proper proactive and reactive routing approaches are utilized in different hierarchical levels, respectively. Some hybrid routing protocols for MANET are Zone Routing Protocol (ZRP), Zone-based Hierarchical Link State routing (ZHLS).

2.2. Position-based Routing

These protocols make use of the nodes' geographical positions to make routing decisions. Nodes are able to obtain their own and destination's geographical position via Global Positioning System (GPS) and location services.[2] This approach has become practical by the rapid development of hardware and software solutions for determining absolute or relative node positions in MANETs. One advantage of this approach is that it requires

limited or no routing path establishment/maintenance which constitutes a major overhead in topology based routing methods. Another advantage is scalability. It has been shown that topology based protocols are less scalable than position-based protocols.[3] Examples of position-based routing algorithms include: POSANT (Position Based Ant Colony Routing Algorithm), BLR (Beaconless Routing Algorithm), and PAGR (Power Adjusted Greedy Routing).

3. PREVIOUS STUDY

In order to better understand the need for position based algorithm, it is required to know a glimpse of the previous works that were carried out to attain seamless network architecture. The following are the various routing protocols that were proposed and published:

a. GAMNET (Genetic Algorithm for Mobile Ad hoc Network)

b. MOBI-GAMNET (Mobility Predicted GAMNET)

c. SECU-GAMNET (Secured GAMNET)

3.1. GAMNET–Genetic Algorithm for Mobile Ad hoc Network

This algorithm was designed by the impulse of Genetic Algorithm to optimize routing in MANET. By selecting the appropriate values for parameters such as crossover, mutation, and population size, the genetic algorithm improves and tries to optimize the routes by increasing the packet delivery ratio.[4] Simulation results indicate its better performances compared to other methods. It was observed that the algorithm GAMET outstrips AODV in terms of packet delivery ratio. It enthused us in further study to reduce the number of packets dropped at longer interval.

Simulation result shows that the PDR of GAMNET is higher than AODV. It is also observed that the difference in PDR reduces as time of simulation increases.[5]. It was also observed that during initial time (0 – 100 ms), the number of packets dropped by GAMNET is less than that of AODV. But as time increases, the number of packets dropped by AODV is lesser than GANET. [5]

3.2. MOBI-GAMNET-Mobility Predicted GAMNET

Because of high mobility of nodes, the network topology of MANETs changes very fast, making it more difficult to find the routes that message packets use. In order to address the issues that was noticed in GAMNET, mobility of nodes was considered as a key factor in this work.GAMNET was tailored to get the location information of the mobile nodes. It identifies the nodes that promise maximum Expiration Time (ET) and use it for routing. Using the motion parameters (such as speed, direction, and the communication distance) of two neighbours, it is possible to determine the duration of time two nodes remain connected [6]. One of the global problems in MANET called “Link Breakage” was addressed. This would much reduce the occurrence of RERR while transmitting packets along the generated routes with reduced dropped packets and increased PDR. [6].

3.3. SECU-GAMNET-Secured GAMNET

Packet Frequency was considered as an evaluation criteria to overcome the DoS attack. Every node maintains a table to store the source nodes and the frequency of its package. If the frequency steps over ^{3}, a purification inception is assumed to judge whether the frequency is reasonable or suspicious. [1]

$$^3 = P_{one} / P_{tota}l \quad [1]$$

P_{one}-Number of packets received from one neighbor node P_{total}-Number of Packets received from all neighbornodes.

4. RELATED WORKS

4.1. User Mobility

To effectually forecast the user's mobility, user movement patterns need to be analyzed and mobility models ought to be designed. Many such mobility models exist and can be used in our algorithm.

Fluid flow is a model that ignores the individual users but consider the network as a whole. The movement patters of the users in a particular location are categorized which can help optimize the network's utilization and design at a macroscopic level. However, fluid-flow provides no insight on a smaller scale, nor will it give any predictions as to specific user movements for any specific user. [8]

Markovian mobility[8] is a model where user movements are predicted through past movements. At large computational cost, every inter-cell movement probability is defined for each user. An extension of the Markovian model, created at perhaps even greater cost, is the activity-based model. In this model, parameters such as time of day, current location, and predicted destination are also stored and evaluated to create movement probabilities. An even more complex activity-based scheme might provide better results, but would not be implementable on a large scale due to its immense costs.

*Cowling Selective Prediction*is[8] a model where predictions are only made in regions where movements are easily foreseeable. To promote this scheme, Cowling advocates a network where the base station (BS) learns the mobility characteristics of the region, in addition to the cell movement probabilities

Emir Halepovic, et al,[9]in their paper "Characterizing and Modelling User Mobility in a Cellular Data Network" provides an in-depth analysis of sample user movement and call traffic. They conclude that majority of users in a particular location seem to be stationary compared to some other locations. Majority of those users have a home cell. It may be actual home or office or other places where the users stay for a long period of time. [9]

5. LOCATION AWARE GAMNET

Based on the related works analysed, we propose a model called Location Aware GAMNET, which would resourcefully generate routing protocol by considering the nodes found in location where less user mobility is identified.

Consider a mobile ad hoc network composed of N nodes distributed in a given geographical region. We want to design a routing protocol that allows any source node S to send to any destination node D a set P = {p1, p2, …, pm}

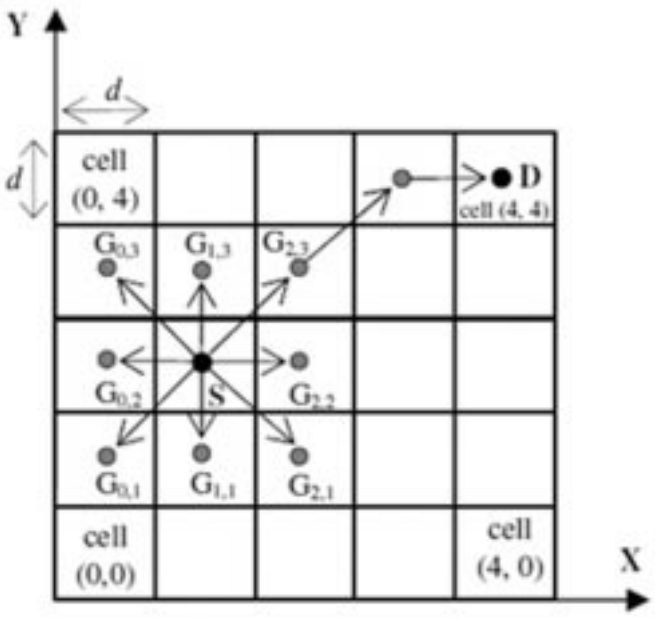

Figure 1: 2D Grid View of the Geographical Area of a MANET[11]

of m packets in over n cell-disjoint paths with the largest possible n. The m packets could correspond to the same packet sent in multiple copies in which case the objective would be to increase reliability. The m packets could alternatively correspond to pieces of a divided up large data message sent in parallel in order to reduce the message transmission delay. The proposed solution to this problem views the geographical region where the MANET nodes are located as a virtual k×k two-dimensional grid of cells as shown in figure 1. Two grid cells are called neighbor cells if they have a common side or a common corner. Therefore each grid cell has eight neighbor cells. A path in the 2D-grid is a sequence of neighboring grid cells.

Where,

S - Source node

D - Destination node

d - Length of side

$G_{x,y}$ - Gateway node in cell (x, y)

Two nodes are called neighbor nodes if they are located in neighbor cells. The value of d is selected depending on the transmission range r (all nodes are assumed to have the same transmission range r) such that each node can communicate directly with all nodes located in neighboring grid cells. This requirement is met if d satisfies the condition $r \geq 2d\sqrt{2}$. This can be seen by noticing that the farthest apart points in two neighboring grid cells are two diametrically opposite corners at distance 2d in each of the two dimensions. These two farthest apart points are at distance: $2d\sqrt{2}$. [10]

Considering the above model, the following figure 2 is used for empirical calculation in this paper. The model has Gate ways (cells) with colors where green represents the HOMECELLS with most null mobility, Yellow represents moderate mobility, and red represents the locations with high mobility.

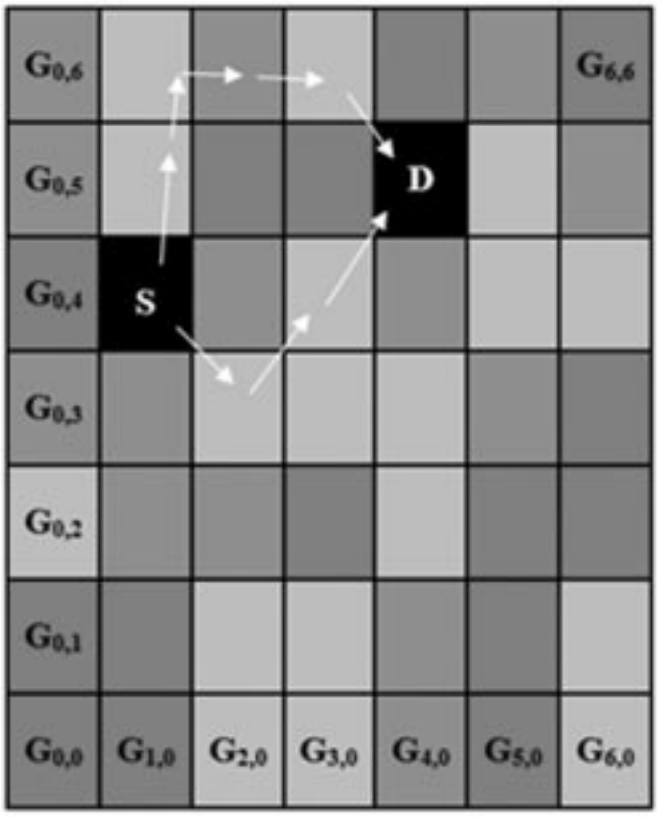

Figure 2: Empirical Model Showing GWs

When S the Source Node intends to send packets to D the Destination node, S will first identify the Gate Ways (GWs) those with Green color adjacent to it. Later it broadcast the RREQ to all the nodes those are within this GW. In the above model, we identify 2 possible routes:

R1 : $S \rightarrow G_{1,5} \rightarrow G_{1,6} \rightarrow G_{2,6} \rightarrow G_{3,6} \rightarrow D$

R2 : $S \rightarrow G_{2,3} \rightarrow G_{3,4} \rightarrow D$

Here the most promising one will be the route generated using R2 because it uses the nodes in the location those with nodes of no or less mobility.

5.1. LOCA-GAMNET

In genetic based algorithm, the fitness function affects directly the convergent speed. The fitness value of a chromosome is the value of the fitness function for the solution represented by the chromosome. [11] The algorithm LOCA-GAMNET initially selects a Parent Route by applying a simple Fitness function.

5.2. Gateway Selection in LOCA-GAMNET

Gateway selection is a prime stage of LOCA GAMNET which aims to find the parent route for the genetically inspired algorithm GAMNET. Here the source node deducts the neighboring gateways and broadcast the RREQ to those with green color which promises the availability of no or less mobile nodes called the HOME CELLS. If no greenGatewaysfound, orange Gateways are chosen and RREQ is broadcasted.

```
Gateway Select(S, <RREQ>)
{
        // Node S invokes this procedure whenit intends a packet transfer
        for each (adjacent G_i,j from the Source node)
        {
                if(G_c is green)
                {
                        Broadcast RREQ to all neighboring Nodes within G_c
                }
                else if (G_c is orange)
                {
                Broadcast RREQ to all neighboringNodes within G_c
                }
        }
}
```

Figure 3: Gateway Select Procedure

5.3. Performance of LOCA-GAMNET

In a MANET of N nodes located in a $k \times k$two-dimensional grid, the average packet delivery probability P_d satisfies:

$$P_d \geq 1 - \left\lceil 1 - \left(1 - \left(1 - 1/k^2\right)^N\right)^{k+3}\right\rceil^8 \quad [2]$$

A packet will be delivered if at least one of the eight paths is not broken. For a path to be non-broken we need to have for each of the grid cells along that path at least one MANET node located in that cell. If in total there are N nodes and if we assume node mobility is such that a node is equally likely to be located in any of the k^2 cells at any given time, then the probability that a given node is located in a given grid cell is: $1/k^2$.

Probability that a given grid cell does not host any of the N nodes is $P_{empty} = (1 - 1/k^2)^N$

The probability that a given grid cell hosts at least one node is

$$P_{\text{non empty}} = 1-(1 - 1/k^2)^N$$

The probability that each of the l cells along a path ð of length l hosts at least one gateway node is $P_{\text{delivery on } \pi} = (1-(1 - 1/k^2)N)^l$

6. CONCLUSIONS & FUTURE WORK

LOCA-GAMNET tries to overcome the issues encountered in our previous study. Link breakage is one of the issues faced in GAMNET and SECU-GAMNET which reduces the performance of the algorithm by increasing the number of packets dropped. The cause for dropping of packets was because of the link-breakage. Link breakage is a key issue that occur when the nodes move from their position. LOCA-GAMNET proposed in this work aims to reduce the link-breakage by efficiently using the nodes which are less mobile by considering GPS Location and understanding the mobility pattern in different locations. One of the issues still to be addressed in LOCA-GAMENT is when no availability of green or orange gateways found adjacent to the source node.

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