Analysis of Greedy Decision Making for Geographic Routing for Networks of Randomly Moving Objects

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ABSTRACT

Autonomous and self-organizing wireless ad-hoc communication networks for moving objects consist of nodes, which use no centralized network infrastructure. Examples of moving object networks are networks of flying objects, networks of vehicles, networks of moving people or robots. Moving object networks have to face many critical challenges in terms of routing because of dynamic topological changes and asymmetric networks links. A suitable and effective routing mechanism helps to extend the deployment of moving nodes. In this paper an attempt has been made to analyze the performance of the Greedy Decision method (position aware distance based algorithm) for geographic routing for network nodes moving according to the random waypoint mobility model. The widely used GPSR (Greedy Packet Stateless Routing) protocol utilizes geographic distance and position based data of nodes to transmit packets towards destination nodes. In this paper different scenarios have been tested to develop a concrete set of recommendations for optimum deployment of distance based Greedy Decision of Geographic Routing in randomly moving objects network.

Key Words: Greedy Decision, Mobility Model, Position Unaware Routing, Position Aware Routing, Greedy Packet Stateless Routing, Beacon Interval, Transmission Range, Node Density.

1. INTRODUCTION

Networks of randomly moving objects are mostly ad-hoc in nature. In these networks nodes move in a free and random manner. Each node has its own transmitter and receiver to communicate with each other without any aid of centralized management or infrastructure like base stations in cellular telephony. Each node takes its own routing decision so it must acts both as a router and a host. Each participating node (hop) should be capable of performing all the procedures of a routing protocol and takes part in the data forwarding process. However, no part of it should be affected by the limitation of node recourses.

In the usual operation of ad-hoc networks, the network topology changes frequently and unpredictably, and is limited in many resources (bandwidth, power, energy), but it is expected to perform fast [1].These constraints in the moving object networks in combination with mobility make routing a very difficult and challenging task.

The main objectives of all categories of routing protocol have the common aim to decrease the network overhead, minimize the transmission delay and increase the network throughput. In the moving objects networks such as,

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VANETs (Vehicular Ad-hoc Networks), the most difficult task is to develop a routing protocol which can perform efficiently in all network conditions. One protocol will perform well in the high mobility environment but may suffer from the end to end delay or in contrast another routing protocol could be efficient in terms of the packet delivery ratio but not suited for the high mobility scenario and so on. It is not easy to precisely compare the existing routing protocols for moving object networks like VANETs, or even claim which one is the best in all environment situations [2].

In the literature no existing routing protocol perform efficiently in all circumstances; therefore most of the concentration of researchers is on developing hybrid routing schemes, in which characteristics of different routing protocols are merged to get the desired results [3].

In this paper, the Greedy Decision method is analyzed. The Greedy Decision method is a distance-based position aware technique for geographic routing, the analysis presented in this paper considers different performance metrics (network parameters) such as beacon interval, transmission range and node density in a particular deployment. Different types of scenarios have been tested in this paper using simulations for thorough analysis of Greedy Decision for Geographic Routing.

This paper is organized as follows: In Section 2, we presented the background of geographic routing schemes and their performance. Section 3 describes methodology for analyzing Greedy Decision making using of the random way point mobility model. Section 4 includes simulation results and discussion, and Section 5 concludes this paper.

2. BACKGROUND

Position based routing is based on the general idea that a node should be addressed on its geographical location. Whenever a node want to locate some other node then it will search it on the bases of its geographical location. Also if a node has a packet to be sent to another node, then the required forwarding decision to select next hop, is entirely based on the location of the source node's neighbors (nodes within its transmission range). The sender does not have any information other than one hop neighbor and the next hop selection is only based on the location of the node, this is characterized as state less routing, which takes the forwarding decision based on local knowledge. Position based routing protocols are mostly stateless, so there is no need to create and maintain a global routing path from the sender to the destination. Location-based routing protocols are used to prevent the occurrence of additional overhead. In addition, they may be used to prevent the occurrence of route discovery delay which is an essential disadvantage of conventional topology base routing protocols, while in location-based routing protocol, these features add to their new values. Thus, location-based routing protocols are very simple, and can achieve better scalability and a low cost of routing, as well as better performance and stability of the frequent topology change.

2.1 Mobility Models

A mobility model mimics the pattern of movement of a node. Mobility model has a great impact on the evaluation of the performance of an ad-hoc network protocol. Two types of mobility models are used in simulation based studies:

(1) Traces (Real-life mobility observations of the node).

(2) Synthetic (attempts to realistically present the movement of a node).

In this paper the random way point mobility model is used. The random way point mobility model is the most popular synthetic mobility model for Ad-hoc networks

2.1.1 Random Way Point Mobility Model

Wireless communication networks are mostly simulated using Random Waypoint Mobility Model. Random Waypoint Mobility Model is a convex set with an area of $A \in R^2$ in which waypoints are uniformly distributed i.e.

$P_i \sim U(A)$. A node moves from one waypoint P_i to another waypoint P_{i+1} with a speed $v=1$. The process can be defined by the sequence:

$(P_0,P_1), (P_1,P_2), (P_2, P_3)\ldots\ldots$

Two main parameters of Random Waypoint Model are Pause times and Velocity per leg (leg is the distance between two waypoints). Pause time is the time a node waits at each waypoint before it moves to the next one and is denoted by. Whereas velocity per leg is the velocity with which a node moves between two waypoints.

This model includes pause (silence) times between changes in destination and speed [4]. A mobile node initiates the movement by residing in one location for a particular period of time. This is also known as pause/silence time. Once this pause duration elapses, the mobile node selects a destination randomly in the simulation area and a speed which is evenly distributed between a minimum speed and a maximum speed. The mobile node then moves toward the newly selected destination at the desired speed. Upon arrival at the selected destination, the mobility node pauses for a pre-defined time period before repeating the process.

Fig. 1 presents a sample movement pattern of a mobility node using the Random Waypoint Mobility Model initiating at a randomly chosen point or position. The speed of the mobile node is evenly selected between 0 and 10 m/s for this particular example.

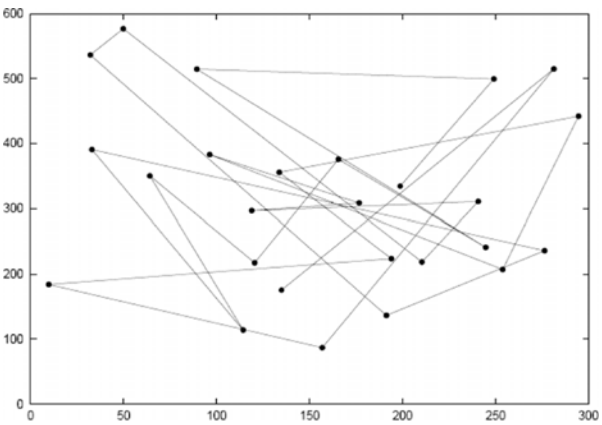

FIG. 1. A SAMPLE MOVEMENT PATTERN OF A MOBILITY NODE USING THE RANDOM WAYPOINT MOBILITY MODEL

2.2 Greedy Packet Forwarding Strategy

In the case of greedy packet forwarding strategy, a node tries to select next hope among its neighbors that are nearer to the destination, according to some geometric criteria. This node, mainly encounters two possible cases. In the first case, no neighbor exists nearer to the destination than the node itself [5]. In the second case, one or more than one neighbours are available nearer to the destination than the node itself. First case indicates the local maxima problem of greedy strategies, in literature many recovery strategies (such as face routing) based on geometric rules have been proposed to provide the solution.

In the second case, where more than one, neighbors are present nearer to the destination, the mobile nodes have to make a decision based on greedy forwarding algorithm to select the best-next-hop node that makes positive progress towards the destination. Criteria for selection can be the candidate, having shortest distance with the destination (greedy), or can use MFR or NFP techniques which use the projected distance on the source-destination-line. Alternatively angles of the selected node with the source or destination can be one of the criteria such as in compass routing. Fig. 2 depicts possible scenarios for node selection in greedy forwarding techniques

In Fig. 2, source node S has many suitable candidates as relay node towards destination. "H" is NFP (Nearest with

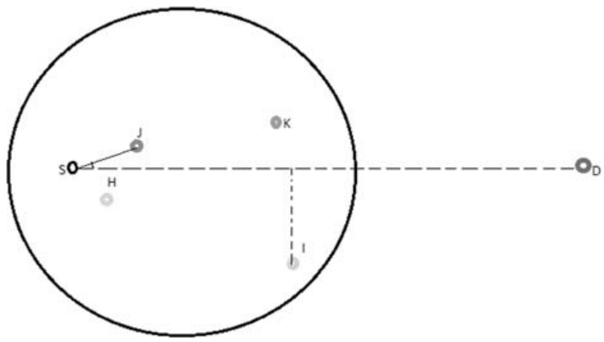

FIG. 2. GREEDY FORWARDING VARIANTS: SOURCE NODE HAS MANY CHOICE FOR THE SELECTION OF NEXT HOP TO REACH DESTINATION

Forwarding Progress), "I" is MFR (Most Forward Progressing Node within Radius), "CR" has the minimum angle with destination (compass routing), and "K" has the minimum distance with the destination (greedy).

3. METHODOLOGY

This section presents development of a customized module in Mat LAB for analyzing Greedy Decision Strategy for Geographic Routing [6-7]. The module is capable of taking local decision based on Greedy Technique where mobility of the nodes is presented as random way point mobility model. This whole procedure is also explained in Fig. 3.

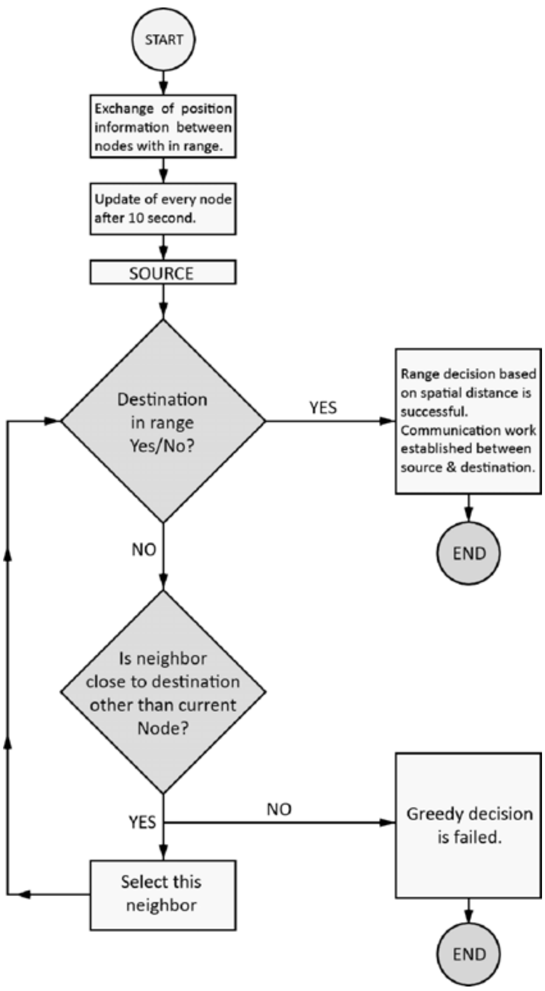

FIG. 3. FLOW DIAGRAM CONTAINING STEPS OF COMPLETE ANALYSIS OF GREEDY DECISION

According to this implementation the hop selection is accomplished by exploiting the participating nodes location information. All nodes of the network have a local table in which all neighbors of the node are listed by name or ID and position. A broadcast message (beacon message) refreshes the table of each node within a regular time interval. Beacon interval is the maximum time interval ratio between transmissions of beacon messages among nodes [6].

We have selected fixed source node and destination nodes. All other nodes of the network have been generated randomly which follow the pattern of random way point mobility model.

We assume that every node is aware of its own position, and position of destination is fixed and globally known. Position of neighborhood is circulated through beacon packets which are being broadcasted by every node after predetermined (fixed) interval. Position information of node itself and of destination is the responsibility of location server. Radio range is symmetric and same for every node. For selection of next hop source node will go through its routing table where all the information about the neighbor's in its transmission range is present.

At the start of simulation, a predefined number of nodes are randomly generated other than the Source and Destination node. At time "t", the source node decides to send data to destination. For selection of next hop it will look up to its local table where the location information of all its neighbors is present. Then the source node calculates the distance of every neighbor from the destination. It chooses the neighbor having minimum geographic distance from the destination as a next hop. All the nodes between the source and destination that have been selected as a next hop will perform the same procedure. It continues until the final destination reached or Greedy failure occurs.

4. RESULTS AND DISCUSSION

As introduced earlier in section 1, the aim of this paper is to analyze different performance parameters including beacon interval, transmission range and node density using three different scenarios.

4.1 Scenario-1: Effect of Beacon Interval on Success Ratio

In our simulation, we have observed that success ratio increases if we decrease the beacon interval time, as nodes will be updated frequently so position information of nodes will be much more accurate, hence success ratio increases. This is also shown in the graphical results presented in Fig. 4.

4.2 Scenario-2: Effect of Network Density on Success Ratio

Network density indicates number of nodes in the network. In our simulation we have observed that success ratio increase with the increase of network density and failure rate of the greedy decision increase in sparse network. This is also shown in graphical results presented in Fig. 5.

4.3 Scenario-3: Effect of Node Transmission Range on Success Ratio

Transmission range defines the maximum limit of node connectivity between their neighbors. We have observed that as we decreases the transmission range, chances of not having a neighbor closer than the node itself increases (local maxima problem) hence success ratio decreases. This is also shown in graphical results presented in Fig. 6.

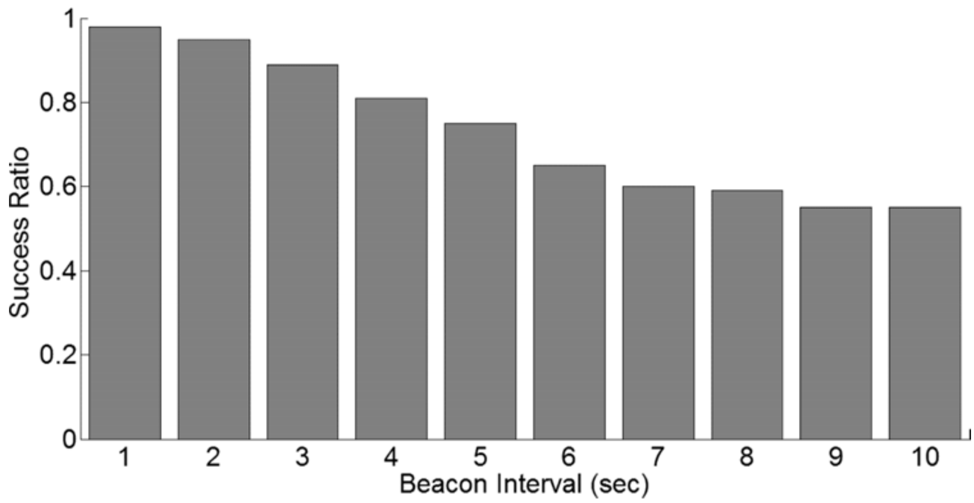

FIG. 4. SUCCESS RATIO OF GREEDY DECISION VS BEACON INTERVAL

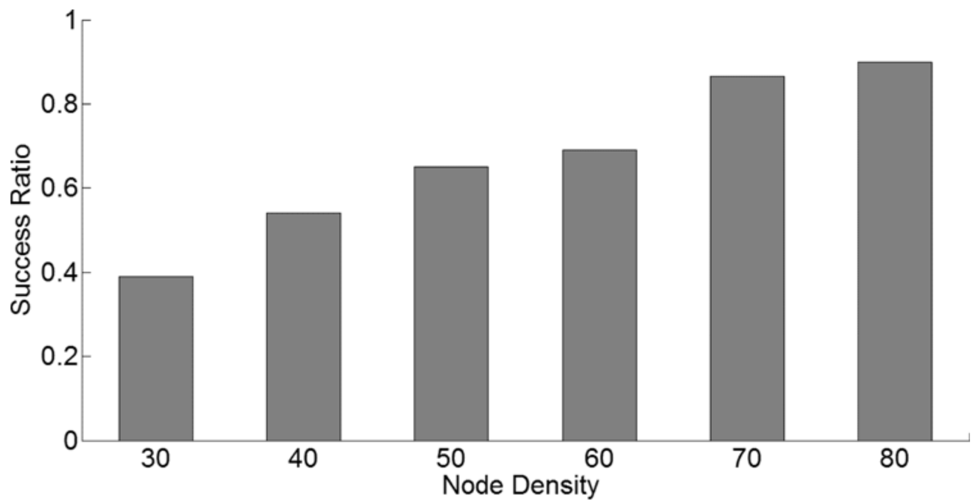

FIG. 5. SUCCESS RATIO OF GREEDY DECISION VS NETWORK DENSITY

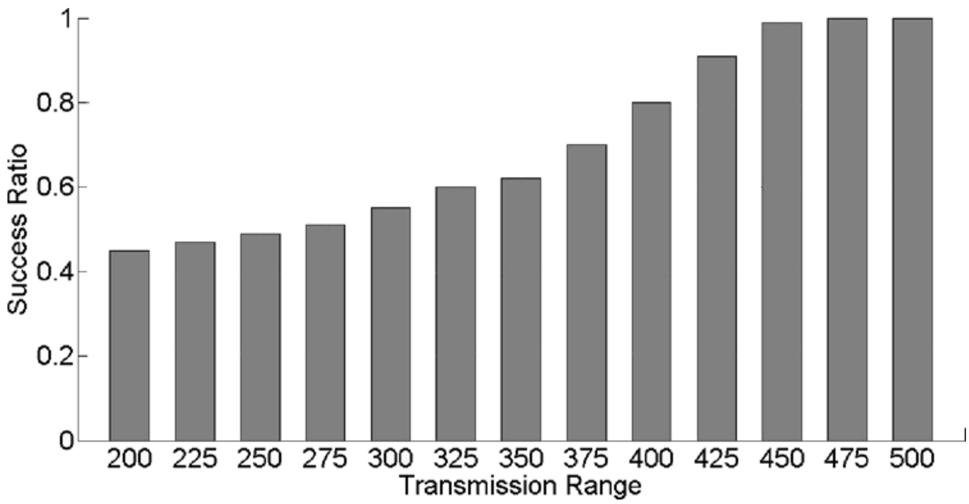

FIG. 6. SUCCESS RATIO OF GREEDY DECISION VS TRANSMISSION RANGE

5. CONCLUSION

In moving object networks a single node often moves in a random manner. Its path is unpredictable. Hence taking decision for the next hop selection to forward data is very difficult .Frequent topology changes makes this task more challenging. An effort has been made in this research to study the effect of mobility on the greedy decision. Different parameters have been tested to see how they affect the success ratio. Results show that Greedy Decision is a success in highly populated networks while in sparse networks chances of decision's failure increases. Signal with high transmission range cover more area hence directly proportional to success ratio. Position information which is transmitted through beacon packet should be accurate to increase the performance, increase in time interval between beacons can decrease performance of the greedy decision in moving objects networks. For future direction it would be interesting to study link duration between different nodes.

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