Analyzing the Behavior and Performance of Greedy Perimeter Stateless Routing Protocol in Highly Dynamic Mobile Ad Hoc Networks

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Abstract: The aim of this research paper is to analyze the performance of Greedy Perimeter Stateless Routing (GPSR) Protocol in highly dynamic mobile ad hoc networks. Routing of packets in Mobile Ad Hoc Networks (MANETs) remains an issue due to the error prone wireless channel and the dynamic network topology. As MANETs are often set up in challenging environments with high mobility, the selection of an appropriate routing protocol is very important to maintain good Quality of Service. Traditional topology based protocols like DSDV, DSR and AODV does not perform well, when the mobility is high in these networks. We often use location information to forward data packets in a hop-by-hop routing fashion in these networks via Geographic Routing. But still we are unclear about the performance of Geographic routing protocols in highly dynamic environments. Using simulation results we analyze the performance of one of the most popular Geographic routing protocols; the GPSR protocol in these highly dynamic networks. We consider many performance metrics like Throughput, Packet Deliver Ratio, Packet Drop Ratio and Traffic Overhead to evaluate the performance. For an accurate study on the behavior of the protocol we have focused on several variations of network parameters such as node movement, number of nodes and pause time.

[Varun G Menon, Jogi Priya P M, Joe Prathap P M. **Analyzing the Behavior and Performance of Greedy Perimeter Stateless Routing Protocol in Highly Dynamic Mobile Ad Hoc Networks.** *Life Sci J* 2013;10(2): 1633-1637]. (ISSN:1097-8135).http://www.lifesciencesite.com. 226

Keywords: ad hoc networks; analysis; Geographic routing; GPSR protocol; MANET; performance; routing; Quality of Service

1. Introduction

Geographic routing has become one of the most suitable routing strategies in wireless mobile ad hoc networks (MANETs) mainly due to its numerous advantages over the traditional topology based protocols like Destination Sequenced Distance Vector (DSDV) , Dynamic Source Routing (DSR) and, Ad hoc On Demand Distance Vector Routing (AODV). The major advantage of geographic routing is support for scalability of the network [5] [9]. Geographic routing uses location information to forward data packets, in a hop-by-hop routing fashion making use of the broadcast nature of wireless networks. Greedy forwarding is used to select next hop forwarder with the largest positive progress toward the destination while void handling mechanism is triggered to route around communication voids No end-to-end routes need to be maintained, leading to geographic routing's high efficiency and scalability.

One of the main issues with geographic routing is that it is very sensitive to the inaccuracy of location information [10] [12]. In the operation of greedy forwarding, the neighbor which is relatively far away from the sender is chosen as the next hop. If the node moves out of the sender's coverage area, the transmission will fail. Face routing strategy has been introduced as a recovery when the greedy forwarding algorithm fails.

A number of geographic routing protocols and algorithms have been proposed over these years with some variations. Each protocol tries to minimize the limitations of its predecessors and to improve its performance in mobile environments. One of the most popular and efficient geographic routing protocol is the Greedy Perimeter Stateless Routing (GPSR) [1] [2] protocol. This position based routing protocol uses the position of the router and packet's destination to forward a packet. Geographic routing protocols require that each node determine its own location and that the source has knowledge of location of the destination [6]. GPSR uses the information about the router's immediate neighbor in the network topology to make a greedy forwarding decision. Thus, without the knowledge of network topology or any prior route discovery all packets can be routed to the destination [18]. Although this protocol has a number of advantages, only very few studies have been done over its performance analysis in highly mobile ad hoc networks.

Our paper analyses the behavior and performance of GPSR protocol in highly mobile ad hoc networks. A number of performance metrics such as Packet Delivery Ratio, Throughput, Packet Drop Ratio and Traffic Overhead have been used to analyze the behavior and performance of Greedy Perimeter Stateless Routing protocol in dynamic networks.

2. Greedy Perimeter Routing Protocol (GPSR)

Greedy Perimeter Routing Protocol (GPSR) is a position based routing protocol i.e. it uses position of the router and packet's destination to forward a packet [3]. Geographic routing protocols require that each node determine its own location and that the source node has the knowledge of destination node location [1] [2].GPSR uses the information about the router's immediate neighbor in the network topology to make a forwarding decision. All the nodes have only partial information about the dynamic topology in MANETs [7] [13]. Thus, without the knowledge of network topology or any prior route discovery all packets can be routed to the destination. In ad-hoc network position based or geographic routing protocols scales better mainly for two reasons: 1) No need to keep the routing table up-to-date and 2) there is no need to have a global view of the network topology and its changes.

2.1 Algorithms

The GPSR protocol mainly consists of two forwarding methods; Greedy forwarding and Perimeter forwarding. Greedy forwarding is used whenever possible whereas perimeter forwarding is used in places where greedy forwarding fails.

2.1.1 Greedy Forwarding

In greedy forwarding the source node knows the geographic locations of the destination node. This information about the position will be integrated into the route request packet. Each node maintains a local table where the positions of the entire neighbor nodes in its range are listed. The node which have to treat the route request packet checks its local table for a node which is now nearest to the destination and forwards the data packet to the corresponding node. This method continues as long as possible, and in some cases until the packet reaches the destination. When the packet arrives at a node where it cannot find a neighbor node which is nearer to the destination with the greedy forwarding then a recovery strategy called the perimeter forwarding is used. Issues related to security of the network are also addressed using GPSR protocol [4] [17].

Using the GPSR protocol, each node in the network maintains a local table, in which all neighbors in its range are listed by name (ID) and position. A simple beaconing algorithm is used to provide all nodes with their neighbor positions. Each node transmits a beacon periodically to the broadcast MAC address, containing its own identifier (*e.g.,* IP address) and position [15] [16]. If a beacon from the neighbor is not received for a time longer than timeout interval , a GPSR router assumes that the neighbor has failed or gone out-of-range, and deletes the neighbor node from its local table This beaconing algorithm do represent pro-active routing protocol traffic, avoided by Dynamic Source Routing and Advanced On Demand Vector Routing. To minimize the cost of beaconing, GPSR piggybacks the local sending node's position on all data packets it forwards. In the header of a GPSR packet along with the destination address many more data are also listed. Table 1 represents GPSR packet header fields:

Table 1. The GPSR Header

Fields	Function
D	Destination Location
Lp	Location Packet Entered Perimeter Mode
Lf	First node encounter in the face of the planar graph
e0	First Edge Traversed on Current Face
M	Packet Mode: Greedy or Perimeter

2.1.2 Perimeter Forwarding

Packet mode will be changed into perimeter mode when a node reaches a point where with the Greedy Forwarding algorithm it is unable to find a neighbor node nearer to the destination.

For example consider figure 1, here *x* is

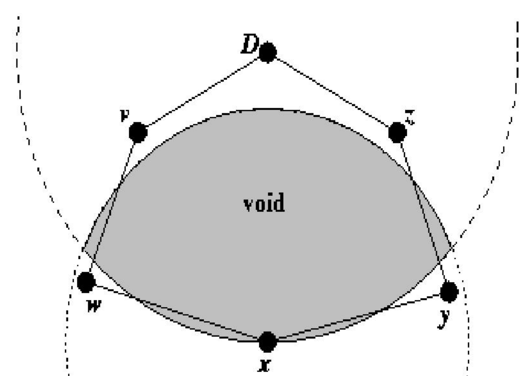

Figure 1: node x's void with respect to destination [1]

nearer to *D* than *w* and *y.* Although there exist two paths, (*x* -> *w* -> *v* -> *D*) and (*x*-> *y*->*Z* ->*D*), X will not choose to forward to w or y. Considering the location of destination *D, x* lies on local maximum. The packet mode will be set to perimeter mode and the second algorithm will be active. In perimeter mode forwarding the right-hand rule is applied to traverse the edges of a void. The right hand rule is used to find out a possible path around a void to the destination node [1] [14].

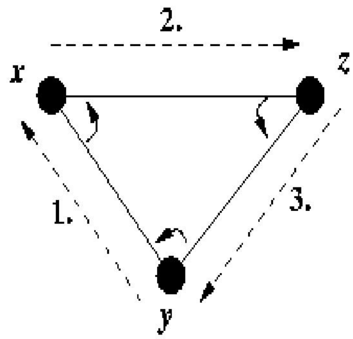

Figure 2: The right-hand rule(interior of the triangle)[1]

Right hand rule states that when arriving at node *x* from node *y*, the next edge to be traversed is the next one sequentially counter clockwise about *x* from edge (x, y). The right-hand rule traverses the interior of a closed polygonal region in clockwise order. In figure 2 edges are traversed in the order (*y* -> *x* -> *z* -> *y*). This cycle-traversing property is exploited to route around voids [8] [11].

In order to determine whether it can return to greedy mode, a field called Lp is considered in the GPSR packet header. The field Lp records the location where the packet entered the perimeter mode. In subsequent hops this location is used to determine whether the packet can be returned to greedy mode. The location of the current forwarding node is compared with Lp. The mode is set to greedy mode if the distance between the Lp and Destination *D* is greater than the distance between the forwarding node and the destination *D*.

GPSR also considers the case when the destination *D* is unreachable, if the node *x* (it is the location where greedy forwarding failed) and destination *D* are not connected by graph. GPSR can detect this as follows: the disconnected node *D* lies either inside an interior face, or outside the exterior face. The packet will traverse completely, eventually reaching this face, without finding any intersection point with the line *xD*, which is closer to the destination *D* than the location where the packet entered the perimeter mode. Then the first edge it took on this face is traversed for the second time by the packet. In order to notice the repetition of forwarding on this edge, a field e0 is employed in the GPSR packet header. This field records the first edge traversed. When the packet traverse the first edge for the second time, e0 shows that it is the second time, e0 shows that it is the second time the packet is forwarded on edge e0 and the packet will be dropped by GPSR as the destination is unreachable.

3. Results

To analyze the behavior and performance of Greedy Perimeter Stateless Routing Protocol in highly dynamic ad hoc networks, we used simulations using NS2.We initially analyzed the performance using various metrics like Throughput, Average Delay, Traffic Overhead, Packet Delivery Ratio and Packet Drop. Table 1 shows the various parameters used in our simulation.

Table 1. Simulation Parameters

Simulation Parameters	Value
Routing Protocol	GPSR
Topology	670m x 670m
Number of nodes	50, 75, 100, 125, 150
Scopr of nodes	250m
Antenna Type	Omni-directional Antenna
Radio propagation mode	Propagation/TwoRayGround
Queue type	Queue/DropTail/PriQueue
MAC Layer	IEEE 802.11
Buffer size	512
Interface Queue Length	50

Figure 3 shows the Packet Delivery Ratio (PDR) for GPSR protocol when the speed of the nodes is 20m/s. From the graph we can analyze that the PDR of GPSR increases with the number of nodes in the network. With increasing number of nodes there would be more number of intermediate nodes and thus leading to efficient forwarding of data packets by GPSR protocol.

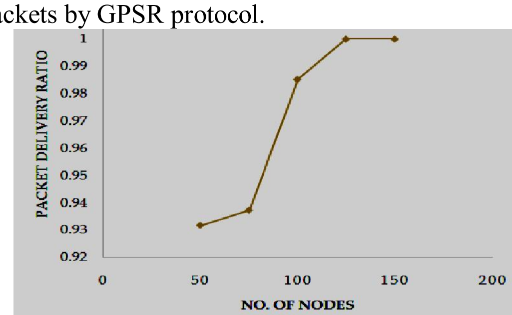

Figure 3.Packet Delivery Ratio Vs Number of nodes (Speed= 20m/s, Beacon interval=0.1s)

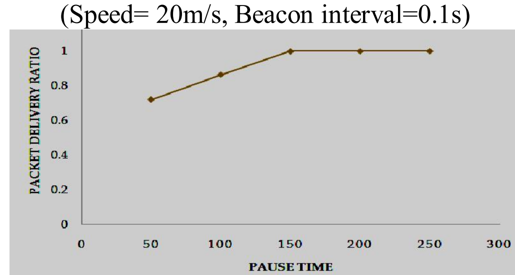

Figure 4.Packet Delivery Ratio Vs Pause Time (Speed=20m/s)

Figure 4 gives the Packet Delivery Ratio of the network using GPSR protocol with varying pause time. As the pause time increases, mobility of nodes decreases and thus the PDR increases. Figure 5 gives the Throughput of the network with GPSR protocol with varying number of nodes .As the number of nodes increases forwarding becomes more efficient in GPSR and therefore the Throughput of the network increases.

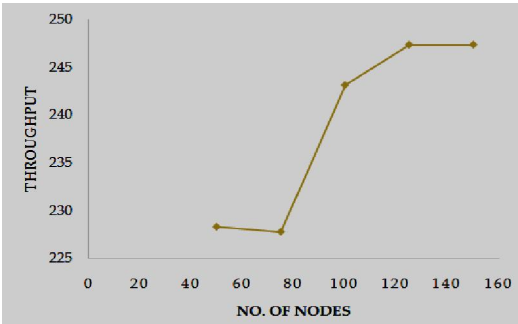

Figure 5.Throughput Vs Number of nodes

Figure 6 shows the Traffic Overhead in the network generated by GPSR protocol. As there are many messages and beacons transmitted the Traffic Overhead increases with the number of nodes.. Figure 7 shows the Packet Drop Ratio of the network using GPSR protocol. We can analyze that the packet drop decreases with increase in number of nodes in the network .As the number of nodes increases in the network, there would be more intermediate nodes and the packet forwarding would become more efficient.

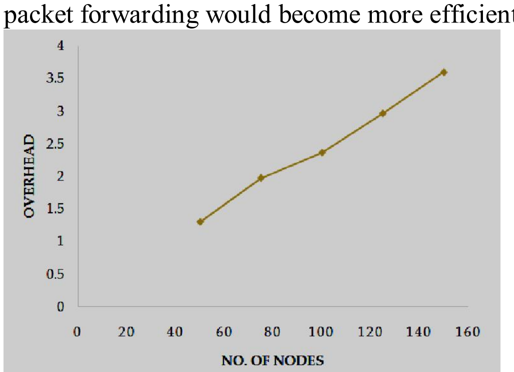

Figure 6.Traffic Overhead Vs Number of nodes

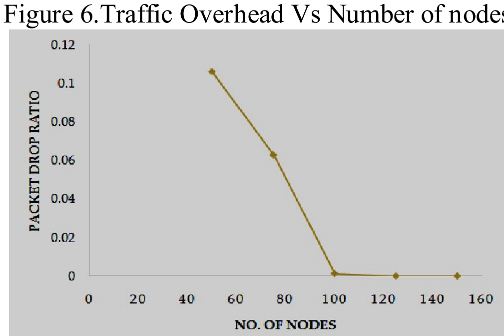

Figure 7.Packet Drop Ratio Vs Number of nodes

Figure 8 shows the performance comparison of GPSR protocol with the traditional protocols. The performance metric used for comparison is Packet Delivery Ratio. From the graph we can analyze that the Packet Delivery Ratio of GPSR increases with increase in number of nodes. As the network becomes more scalable, GPSR has a packet delivery ratio much higher than the traditional protocols like AODV, DSDV and DSR. The performance of traditional protocols remains the same or degrades as the number of nodes in the network increases. This comparison helps us to understand the advantages of geographic routing protocols over the traditional topology based protocols.

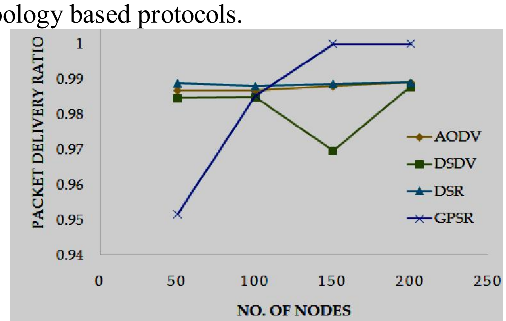

Figure 8.Comparison of Packet Deliver Ratio of GPSR with traditional protocols

4. Conclusion

In this research paper we analyzed the behavior and performance of Greedy Perimeter Stateless Routing Protocol in highly mobile ad hoc networks. Initially we studied the working of the GPSR protocol in detail including greedy and perimeter modes of forwarding. Using simulations we analyzed the performance of GPSR with the help of some performance metrics. We saw that the Packet Delivery Ratio and Throughput of the network using GPSR protocol increases with increase in number of nodes and the packet drop decreases with increase in number of nodes. This analysis showed that GPSR protocols supports scalability and its performance increases with increase in number of nodes in the network. Finally we compared the performance of GPSR with traditional topology based protocols DSDV, AODV and DSR using Packet Deliver Ratio as the performance metric and found out that the performance of GPSR compared to all other protocols went much higher with the increase in number of nodes in the network.

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5/22/2013