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Optimization approach in Greedy Perimeter Stateless Routing

Jitender Kumar
M.Tech (ECE)
Swami Parmanand Engineering College,
Mohali, Lalru, Punjab, India

Er. Shalley Raina
HOD, ECE
Swami Parmanand Engineering College
Mohali, Lalru, Punjab, India

Abstract— Greedy perimeter stateless routing (GPSR), a scalable routing protocol for wireless sensor networks (WSNs) that use the randomized positioning of routers in different configurations and algorithms are used to make packet delivery decisions through nodes. It consists of greedy forwarding decisions through router"s present to next state neighboring position composed of data information in the adaptive network topology for optimization. In this protocol, when a packet is near to its zone where greedy forwarding is impossible, then with the help of algorithm, it recovers its route by routing around the perimeter of the region. As the number of destinations increases this protocol scales better in per-router state than shortest-path and ad-hoc routing protocols. Because of scalable topology property in GPSR, it uses local topology (e.g. star, ring) to find out new and correct routes quickly as per demand. In this paper, we describe the GPSR protocol and optimization of mobile wireless networks to compare its performance based on changes in topology. Our simulation elaborates GPSR"s scalability on densely deployed wireless networks based on route adaptability.

Keywords— GPSR, WSN, Scalability

I. INTRODUCTION

In wireless networks because of entirely dense connected wireless stations, data gathering information may require multiple hoping, because of availability of finite radio ranges. Although community of networking has observed, demonstrated, implemented a number of routing schemes for ad hoc networks [1], [2]. The use of distance vector (DV), link state (LS) and path vector algorithms [3], [4] are used for scalable topology in wireless networks for efficient routing related to a given application. DV and LS algorithms are used for continuous distribution of data dissemination through topological changes. DV‟s Bellman-Ford approach makes this global data information transitively; in this each router includes its distance from all network destinations in each of its periodic beacons after a particular interval of time. LS‟s Digkstra algorithm directly gives information of the change in any link‟s status to every router in the network. Small inaccuracies found in both DV and LS can cause routing loops or disconnection [5]. When the topology is in constant flux, as under mobility, LS generates torrents of link status change messages, and DV either suffers from out-of-date state or generates torrents of triggered updates. As the number of destinations increases hierarchy plays a very vital role to scale the routing parameters. Without hierarchy, it is difficult to scale internet routing approach. The hierarchy is based on rarely changing administration with topological boundaries. So it is not easily approachable for freely moving ad hoc wireless networks, to have scalable topology characteristic.

Another approach related to scalable topology is Caching. Dynamic Source Routing (DSR) [6], Ad-hoc on demand distance vector routing (AODV) [7] and Zone routing protocol (ZRP) [8] all constantly inform about the current topology information in an on-demand scenario as recommended by their packet forwarding load, and to cache it accurately. If the topology becomes out-of-date then current topological updates are required. The main task of caching is to reduce overloading of packets in two ways:-

a. Without requirements; any topological change does not acceptable.
b. Decrease the number of hops between the routes.

We propose the efficient use of area under geography to get scalability in this wireless routing protocol known as Greedy Perimeter Stateless Routing. Scalability enhances the numbers of nodes and mobility rate.

The factors under scalability are:-

a. Numbers of packets send. b. Success delivery ratio.
c. Memory storage at each node.

1.1 Types of Networks

a. Ad hoc Networks: These are infrastructure-less networks having no centralized control. They have no dependency on pre-occupied infrastructure. These decentralized type networks have a wide scope in applications like post-disaster rescue operations, military operations, medical facilities, business decision etc [9], [10].

b. Sensor Networks: These are networks embedded with transducers to measure different physical parameters like temperature, humidity, speed, vibration intensity, sound intensity, illumination intensity, chemical concentration, pollutant levels, wind direction, pressure [11].

c. Rooftop networks: It is basically used in roof top areas for telecommunications in a densely deployed metropolitan area with respect to the line of sight phenomenon. It also provides conventional infrastructure in case of disaster. It has significant impact on scaling regarding self configuration without any need of trusted authority [12].

Table 1. Comparison between Traditional versus Conventional

Traditional versus Conventional routing protocols		
Parameters	Traditional	Conventional
Basis of routing	Proactive-type	Core-node cluster based
Routing mechanism	Uni-cast	Broad cast
Forwarding strategy	Single-hop	Multi-hop
Routing type	Flat	Hierarchical
Storage complexity	O(N)	O(2N)
QoS support	No	Yes
Uniformity	Uniform	Non-uniform
Protocol type	Distance-vector	Link state
Scalability	No	Yes
Overhead control	High	Reduced
Networks	Small	Dense
Multiple route support	No	Yes

1.2 Data Forwarding

In GPSR, routers are assumed to be stateless for propagation of topology information where each node need only is required to know its neighbor‟s positions. The usefulness of routing is attained through self-describing nature of positions of nodes. By knowing the position of a packet‟s destination and positions of the candidate next hops are sufficient to make correct decisions regarding routing forwarding. The wireless routers have complete information about their own positions through GPS services in outdoors, inertial sensors on vehicles, range finding using radar and ultrasonic chirps. The IEEE 802.11 wireless network MAC [13], [14] sends link based acknowledgements for uni-cast packets, with the bidirectional links in an 802.11.

II. ALGORITHMS

GPSR algorithm consists of two methods to forward the packets:

a. Greedy forwarding: It is used in an on-demand basis which is used wherever possible.

b. Perimeter forwarding: It is used in the regions where data forwarding through greedy perimeter is not possible.

2.1 Greedy Forwarding

In greedy forwarding, packets are identified by their originator with their own particular destinations. A forwarding node has task to be a locally optimal, greedy in choosing the next hop of the corresponding packet. If a given node knows the specified radio range of its neighbors then it will be easy to locate the next route destination. This process will be in repetitive mode until the destination reached [15].

2.2 Example

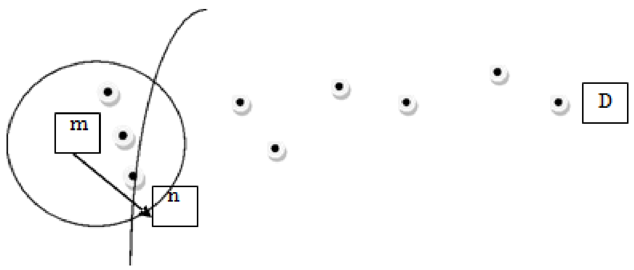

Figure 1. Greedy Forwarding Mechanism

In this example, m receives a packet destined for D. Radio range of m is denoted by the dotted circle about m, and an arc with radius equal to the distance between n and D is shown here. M forwards the data packet to n, as the distance between n and D is less than that between D and any of m‟s another neighbors. This forwarding greedy process repeats, until the data packet reaches D.

2.3 Forwarding process

In this process under GPSR, a beaconing algorithm is used for all nodes in combination with their neighbor‟s positions. The beacon consists of MAC addressing about its own identifier with IP address and position. An encoding scheme is applied as two four-byte floating point quantities, for individually m and n coordinate values. The timing limitation for each beacon depends upon 50% of the interval between beacons with uniform distribution as [0:5B; 1:5B]. Upon not receiving a beacon from its neighbor for more than timeout interval T, then GPSR router give assurance about the failing or lack of routing and delete this packet permanently from the table.

The main advantage of GPSR is to have only the information about neighbor‟s node and because of that overhead is reduced with the condition that number of neighbors of a corresponding node should be less than total number of nodes in the network. But no change of routing is acceptable without the knowledge of topology change. To minimize the beaconing cost, there is a copy of all packets through piggybacking by GPSR within a radio range based on an applicable application. Beacon contains twelve bytes per packet. Beacon timer is reset after every data sent entry. So in this way, this optimization minimizes the beacon traffic in regions of the network forwarding data packets actively. In addition to this, one beacon interval does not congest the simulated wireless networks.

2.4 Drawback:

The power of GPSR come with one drawback of choosing route during more than one neighbor‟s nodes approach near to source node.

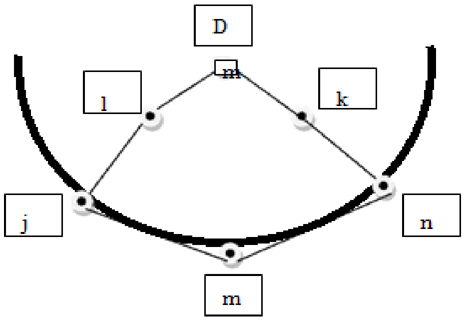

Figure 2. Greedy forwarding failure

This drawback is shown in Fig 2 as near to the source node m there are two neighbor nodes i and n to reach to the destination node D. As the distance between D and m is less than the distance between D-I and D-n. Node m is a local maximum in its proximity to D. So some other mechanism needed to be used to forward packets in this kind of situation.

2.5 To resolve drawback through RHR (right hand rule)

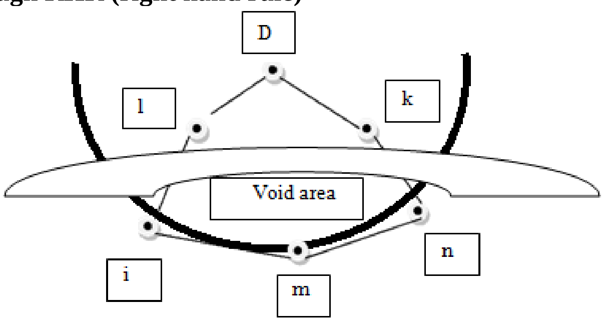

Figure 3. Node m‟s void area with respect to destination D

The area without nodes is known as void. The packet moves from node m to the destination D beyond the edge of the void.

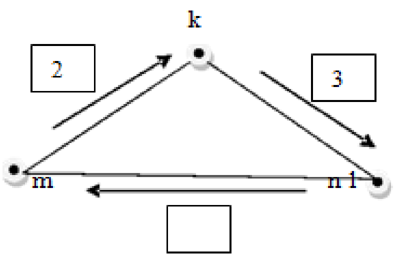

Figure 4. RHR (counter clock wise direction)

In the right-hand-rule the route mechanism obeys the counter clock wise direction outside the boundary of a void. The direction of propagation of packets is in the sequence of counter clock wise direction of 1-2-3 with respect to the nodes location of n-m-k. The edges formation of rotation in right hand rule is known as Perimeter of the Void. This RHR is work on no-crossing of edges with respect to each other. If crossing possibility occurs then there is a provision to remove the respective crossing edge through partition the network with appropriate geometric considerations.

2.6 Graphical Approach

Under the graphical approach the no-crossing demand of routing in GPSR is deal with the planar graphs. The graphs in which no two edges are crossing are known as planarized graphs. Graph is a composition of nodes with specified radio range, where all radios have identical, circular range r; and each node is treated as vertex with edge formation (m:n) exists between nodes m and n. The condition under radio range „r" is d(m, n) <= r.

2.6.1 Types of Graphs

a. Relative neighborhood graph (RNG)
b. Gabrial Graph (GG)

a . Relative neighborhood graph (RNG):

Removing edges from the graph does not mean to disconnect the graph, but to partition the network.

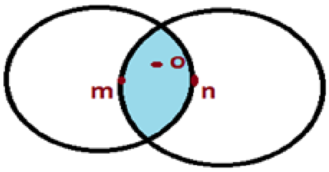

Figure 5. The RNG (Relative neughborhood graph) 2.6.2

RNG Algorithm:

An edge (m:n) exsists between vertices m and n with the distance between them d(m:n), is less than or equal to the distance between every other vertex o and being of m and n farther from o. In equational form:-

m, n : d(m:n) <= [d (m:o); d(n:o)]

The shaded region is the intersection area of two networks shown in Fig 5.

for all n € N do; where N is the total number of neighbors for all o € N do

if o==n then continue

else if d(m:n) > max [d(m:o);d(n:o)] then eliminate edge (m:n)

break end if end for end

b. Gabrial Graph (GG):

In this graph the mid-point of edge m-n is to be determined.

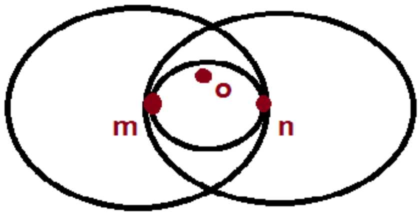

Figure 6. The GG (Gabrial graph)

An edge (m, n) exists between vertices m and n if no other vertex „o" present within the circle whose is diameter equals to the diameter of present edge (m, n).

In equatorial form:

u, v: $d^2(m, n) < [d^2 (m, o) + d^2 (n, o)]$

2.6.2 GG Algorithm:

M= mid- point of mn for all m € N do

for all o € N do if n == o then continue

else if

d(M, o) < d(M, m) then eliminate

edge (m, n) break

end if end for end for

Removing edged in the GG cannot disconnect a connected graph unit, as same as in RNG. The time taken by the algorithms RNG and GG at each node is O (deg2), where deg is the node"s degree in the complete radio graph. The RNG is a subset of GG. GG can work under smaller as shown in shaded region with less complexity as compared to RNG.

III. GPSR IMPLEMENTATION

GPSR has vigorously implementation on IEEE 802.11 network,

To make GPSR vigorous on a mobile IEEE 802.11 network, we made the considerable choices adopted are:

3.1 Queue Interfacing: In IEEE interface the packets are sent by queue after getting link level acknowledgements from the receiver. In addition to this if retransmit retry failure, there is a traverse of queue of packets and removal of all packets related to the failed transmission. Then there is a procedure to re-forwarding of packets in next hoop.

3.2 MAC-failure: Failure exists in 802.11 MAC layer when packets exceeds its maximum number of retransmission limitation. It happens under out of range radio range. It gives the information to the protocol about expiration of the neighbor"s time exceed interval.

3.3 Efficient use of Network interface: It considers the availability of packets with the beaconing interval within specified radio range in the network. The list is updated continuously with the present traffic load related to their neighborhood.

3.4 Planarized graphs: RNG and GG graph theory is used to get current information of positioning of nodes information. The loss of packets is distinguished by beacon interval. MAC is used to indicate failure packet transmission. The need is to update planarized graphs depends upon present load consideration.

IV. IMPLEMENTATION

To attain the design goals for GPSR, the algorithm is specified for a number of mobile network topologies. Topological scalability and mobility are main considerations to be adopted in this scenario.

4.1 Simulation Environment

The ns-2.34 wireless simulation tool is used to simulate nodes stirring in an unobstructed environment. Node chooses the destination in a uniform plane in random motion in the given simulated region. The main focus of nodes is to attain the destination with the chosen velocity and a pause time is acceptable before the repetition cycle repeats.

4.2 Program variables selected by user

o Nodes radio range o Algorithms
o Random movement range o Network size
o Network density o Beacon periods
o Type of Network (GPSR, Greedy)

4.3 Simulation parameters:

In the simulation, the network is for 30, 50, 100 nodes with 802.11 radios, with the nominal 150-meter range. The nodes are placed uniformly in a rectangular region at random motion. All nodes have velocity of 15 m/s. The pause times during simulation are 0, 5, 10, 15, 20 seconds as shown in Fig 7. The CBR is calculated at 30 bit rate traffic load. Each CBR traffic rate is 3 Kbps and uses 64-byte packets to be sent.

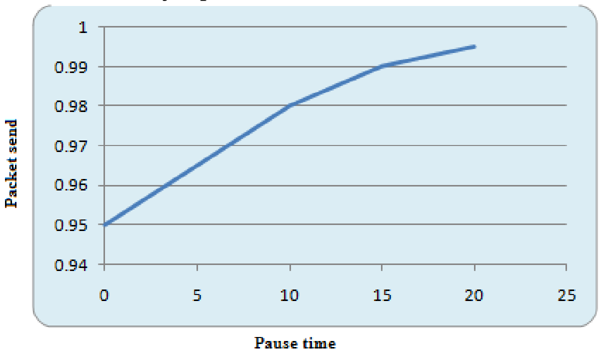

Figure 7. Packet ratio send

4.3.1 Algorithms comparison: The mobile network performance depends upon the transmission range of packets related to a particular algorithm. Under the greedy forwarding the algorithm that can be used by the user are DSDV, TORA. The GPSR capability to send packets under the transmission range is more than RNG and Greedy with the successful rate of transmission of packets with lee retransmissions.

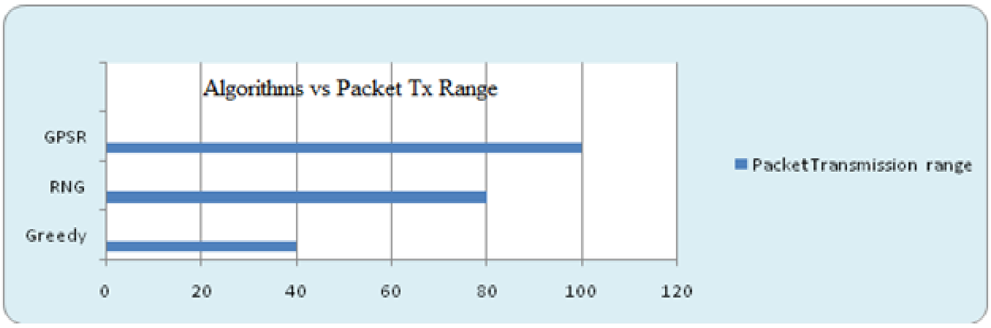

Figure 8. Algorithmic comparison

4.3.2 Topological Comparison on GPSR: The GPSR protocol depends upon the scalable topology consideration. Fig 9 shows the differences between Static Ring, Star, Ring and Static star with respect to the packets transmission range. Static ring is the most scalable topology under transmission with the less loss rate packets.

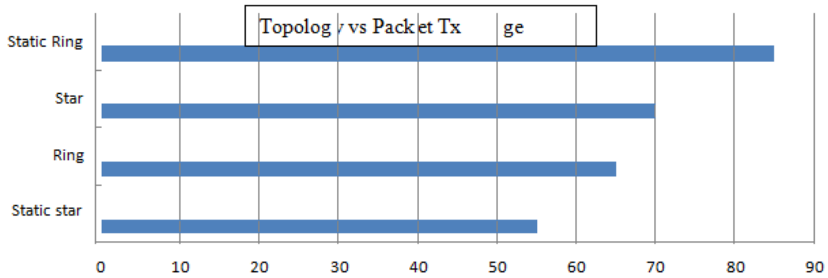

Figure 9. Topological Comparison

4.3.3 Fig. 10 shows the comparison among algorithms GPSR and Greedy in terms of percentage of packets send with respect to the number of nodes. The GPSR is based on adaptive scalable topology mechanism. So its rate of transmission of data packets is efficient than other Greedy algorithms. The packet"s drop rate is also minimal in case of GPSR algorithm. So the effective optimization of routing protocol through dynamic topology based on application aspect is adopted.

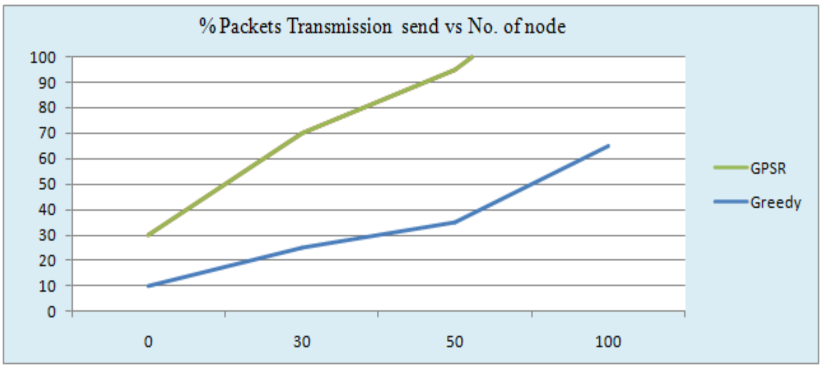

Figure. 10 Comparison among GPSR and Greedy

V. FUTURE PROPOSAL

GPSR protocol itself decouples participation during route finding as a forwarder from participation in the location data base entries. Only nodes that have information about the further traffic destinations need to send location updates. In a dense network, it is easy to configure only a small subset of sensor nodes to take measurements from source to destination, by flooding some few configurable packets through the network. On the other hand, the rest of the network can provide a robust transmit network to reach the destination without generating any information about traffic to and from the location data base due to traffic overhead. So for far end destinations with traffic overhead it is necessary that queries and data update on routing be geographically addressed.

VI. CONCLUSION

This paper presented Greedy Perimeter Stateless Routing (GPSR), a routing algorithm that uses optimization through scalable topology based on traffic demand. GPSR efficiently delivers 97% of data packets successfully. It is in competition with other Greedy algorithms like DSR, TORA, AODV including all pause timings with different topological configurations, and give good results than other Greedy algorithms on comparable parameters like percentage of data packets sent, scalability. GPSR gives routing protocol independent of the length of the routes and generates packets with high mobility. Other Greedy algorithms have chances to fail during caching overloading. To scale the routing through geographic addressing in addition to the scalable topology is the powerful lever to the optimization of routing in GPSR.

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