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Routing Protocol in Urban Vehicular Scenarios

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Abstract: Vehicular Ad Hoc Networks (VANET) is an emerging technology to achieve intelligent inter-vehicle communications, seamless internet connectivity resulting in improved road safety, essential alerts and accessing comforts and entertainments. But the key hindrance in operation of VANET comes from the high speed and uncertain mobility (unlike MANET) of the mobile nodes (vehicles) along the paths. This suggested that the design of efficient routing protocol demands up gradation of MANET architecture to accommodate the fast mobility of the VANET nodes in an efficient manner. Geographic routing has become a popular routing method in VANET because of its simplicity and low overhead. That's why Geographic stateless routing schemes such as GPSR, GpsrJ+ have been widely used to routing in VANET. However, due to the particular urban topology and the non-uniform distribution of cars, the greedy routing mode often fails and needs a recovery strategy such as GPSR's perimeter mode to deliver data successfully to the destination. This warranted various research challenges to design appropriate routing protocol. In this paper, we describe NewGpsr, a solution that further improves the packet delivery ratio of GPSR, GPCR and GpsrJ+ with minimal modification by predicting on which road segment node will forward packets to. NewGpsr differs from GPSR, GPCR, and GpsrJ+ as decisions about which road segment to turn does not need to be made by junction nodes. Consequently, GpsrJ+ reduces the hop count used in the perimeter mode by and also increases the throughput. It therefore allows geographic routing schemes to return to the greedy mode faster.

Keywords: Greedy Fording, GPSR, GPCR, NewGpsr, VANET.

I. INTRODUCTION

In recent years, the auto-mobile industry has made affordable vehicles for safe and pleasant travelling. Hundreds of millions of vehicles are running on the roads around the world. With the sharp increase of personal and sport utility vehicles in the recent years, driving has not stopped from being more challenging and dangerous. Roads are saturated, safety distance and reasonable speeds are hardly respected, and drivers often lack enough attention. Without a clear signal of improvement in the near future, leading car manufacturers decided to jointly work with national government agencies in order to develop solutions aimed at helping drivers on the roads by anticipating hazardous events or avoiding bad traffic areas and help to the derivers. One of the solution of wireless access called Wireless Access in Vehicular Environments [1]. The IEEE 1609 Family of Standards for Wireless Access in Vehicular Environments (WAVE) [2] completely address the latter issue, and provide a sufficient foundation regarding the organization of management functions and modes of operation of system devices to address the former. The WAVE standards define an architecture and a complementary, standardized set of services and interfaces that collectively enable secure vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) wireless communications. Together these standards provide the foundation for a broad range of applications in the transportation environment, including vehicle safety, automated tolling, enhanced navigation, traffic management and many others. When equipped with WAVE communication devices, cars and roadside units form a highly dynamic network called Vehicular Ad Hoc Network (VANET). While some safety scenarios mostly need point-to-point connectivity, it is expected from most of the scenarios developed for intelligent transportation systems (ITS) to benefit from a multi-hop connectivity. In adhoc networks (MANET) mainly deal with networks in which the topology changes are very slow. The solution developed for Mobile Ad Hoc Networks (MANET) such Distance Vector (DV), Link State (LS), and Path Vector routing algorithms is well established, but it is to be highly inappropriate for VANET due a specific mobility and higher velocity. VANET provides internet connectivity to vehicular nodes, so the user can download music, play games or send e-mails. High nodes mobility and unreliable channel conditions are the characteristics of VANET, which poses many challenging issues like data sharing, data dissemination and security issues. Minimum communication time with minimum consumption of network resources is the main requirement of routing protocol. Some routing protocol like DSR (Dynamic Source Routing) [3] and AODV (Ad-Hoc On-Demand Distance Vector) [4] which are developed for MANETs (Mobile Ad-Hoc Networks) are directly applied to VANETs. Due to high mobility of nodes where network can be dense or sparse such phenomenon is not suitable. In VANET finding and maintaining routes is a very challenging task due to the high mobility. In VANET a number of studies has been done [5][6][7][8][9] and the simulation result shows that because of the characteristics of dynamic information exchange, fast vehicle's movement and relative high speed of mobile nodes suffers from poor performances using the MANET protocols.

Then, Solution is the position based i.e. geographical routing schemes. Geographic routing [10] (also called georouting or position-based routing) is a routing principle that relies on geographic position information. It is mainly proposed for wireless networks and based on the idea that the source sends a message to the geographic location of the destination instead of using the network address. The idea of using position information for routing was first proposed in the 1980s in the area of packet radio networks and interconnection networks.

In this paper, we propose to new geographical routing protocol. The new schema remove unnecessary junction node awareness while keeping the efficient planarity of topological maps. The new schema which we call NewGpsr is a simple and intuitive scheme that does not need to be aware of junction nodes and predicts which road segment its neighboring junction node will take to forward the packet. In NewGpsr avoid wrong decisions and decision take using the neighbor‗s broadcast routing table. NewGpsr manages to increase packet delivery ratio of GPCR, GpsrJ+ further and reduce the number of hops compared to GPSR, GPCR and GpsrJ+.
The rest of this paper is organized as follows: Section II provides a short background on geographical routing protocol such as GPSR GPCR and GpsrJ+ and also provide recovery strategy. In Section III, we formally introduce the NewGpsr protocol and in Section IV, we provides simulation results. Finally, Section V describes other related work, while Section VI summarizes our contribution and presents future works

II. BACKGROUND

In this section, we provide a short description of the Greedy Perimeter Stateless Routing (GPSR) [11] algorithm, the Greedy Perimeter Coordinator Routing (GPCR) [12] algorithm and GpsrJ+ algorithm [13].

1) GPSR [11]

The Greedy Perimeter Stateless Routing (GPSR) algorithm belongs to the category of position-based routing. . The GPSR is in positions based routing and sub-category of GPSR is Non-DTN (Delay Tolerant Network). It is under the Non-DTN because, it is not uses the carry & forward strategy to overcome frequent disconnection of nodes in the network. It stores the packet & forwarding is done based on some metric of nodes neighbors. In Non-DTN, GPSR comes under the Beacon. Beacon means transmitting short hello message periodically. In GPSR node sending the beacon message contain its own position for exchange the own position it with neighboring nodes by sending beacon messages and obtain the position of the destination. The GPSR is working in two mode, one is Greedy Mode and Perimeter Mode.
The greedy mode intermediate node forwards a packet to an immediate neighbor which is geographically closer to the destination node. This approach is called greedy forwarding. For that matter, each node needs to be aware of its own position, the position of its neighbors as well as the position of the destination node. How positions are obtained or shared is outside the scope of this paper. We assume that each node is able to obtain its own position using GPS devices, exchange it with neighboring nodes by beacon messages and obtain the position of the destination node by a separate location service [14]. Greedy Perimeter Stateless Routing are particularly efficient on highly dynamic networks. Using geo-localization information, packets are greedily forwarded to the vehicle bringing the maximum progress towards the destination. As position-based routing schemes are based on local information only, and due to non-uniform distributions of nodes and high mobility of vehicles or to the existence of radio obstacles, it is possible that a packet reaches a local maximum with respect to the distance to the destination. The local maximum means, in some time, there might not be such a vehicle or nodes which is closest to the destination. At that time the greedy method is fail to forward the packet. Then recovery strategy is used to overcome this situations, called perimeter routing or Perimeter mode in GPSR, is used to find an appropriate next path. The packet will be forwarded backward with respect to its distance to the destination until it reaches a node whose distance to the destination is closer and greedy mode may be resumed. Many recovery algorithms have been developed including GPSR [11], Compass [15], Face-1 and Face-2 [16], or GOAFR+ [17]. GPSR recovers from a local maximum using a Perimeter mode, where the right-hand rule is used. The right-hand rule requires that all edges are planner graph i.e. no edges are crossing. In GPSR uses the planner graph. Relative Neighborhood Graph (RNG) [18] or Gabriel Graph (GG) [19] to get a planar network graph with no crossing edges in GPSR, while another approach suggests the use of spanning trees or convex hulls [20]. In this paper, no need for planarization by observing that we may extract a planar graph from an urban map at no extra cost. And also create our own city scenario.

2) GPCR[12]

Greedy Perimeter Coordinator Routing (GPCR) is a position-based routing protocol. The main idea of GPCR is to take advantage of the fact that streets and junctions form a natural planar graph, without using any global or external information such as a static street map. Greedy Perimeter Coordinator Routing algorithm is an enhancement of the GPSR protocol. GPCR consists of two parts: a restricted greedy forwarding procedure and a repair strategy which is based on the topology of real world streets and junctions and hence does not require a graph planarization algorithm. The GPSR is working in two mode,
i) Restricted Greedy Routing
ii)Recovery mode (Repair strategy)

The improved greedy routing strategy [11] is the Restricted Greedy Routing. Special form of greedy forwarding is used to forward a data packet towards the destination. In vanet the main problem is blockage of signals due to the obstacles i.e. building or any other data packets should be forwarded and routed along streets. In

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GPCR the major routing decision taken at junctions for forwarding the packet to street. Therefore packets should always be forwarded to a node on a junction rather than being forwarded across a junction. Then junction node decide which street packet move further. In greedy mode the packet id forwarded to the geographical closet to destination but sometimes it leads to the local maximum i.e. dead end. To avoid or minimize the local maxima the GPCR improve the greedy routing strategy. The junction nodes is called as coordinator node in GPCR. Despite of the improved greedy routing strategy the risk remains that a packet gets stuck in a local optimum. Hence a repair strategy is required. When GPCR is in recovery mode, packets are backtracked in a greedy fashion (i.e. bringing maximum progress) to a junction node in order to find an alternate solution to return to the greedy mode. At the junction node, the right-hand rule is used to find the next road segment to forward the packets. The major weak points or disadvantages of GPCR are three. First, junction nodes need to be determined and advertised. Second, recognizing a junction node, which is faulty in GPCR, is extremely crucial to avoid local maximums and consequent hop reduction. In that perspective, it would be better if the observation of a critical junction be made by nodes before the junction and find the route using neighbor's table. That is precisely what we propose to do in this paper with NewGpsr.

3) GpsrJ+[13]

GpsrJ+ is a position-based routing protocol. It is come under category Non-DTN and under Beacon. Like GPCR and unlike GPSR, the GpsrJ+ is come under the overlay. In the GpsrJ+ all nodes virtually connect nodes. The GpsrJ+ is the advance version of the GPCR protocol [13]. As like the GPSR and GPCR, the GpsrJ+ consists of two modes, yet using a special form of greedy forwarding. As obstacles (e.g., buildings) block radio signals, packets may only be greedily forwarded along road segments as close to the destination as possible. Accordingly, the major directional decisions are made at junctions. When packets reach a local maximum, a point at which there is no node closer to the destination, the node switches to GpsrJ+'s recovery mode. In the recovery mode, packets are greedily backtracked along the perimeter of roads. It is not necessary to backforward in small steps through plenaries links, first because the general direction of the right-hand rule always results in the opposite direction of where packets were going before recovery, and second because the objective is to come back as fast as possible to a junction. Unlike GPCR, where packets must be sent to a junction node since junction nodes coordinate the next forwarding direction, GpsrJ+ lets nodes that have junction nodes as their neighbors predict on which road segment its junction nodes would forward packets onto, and thus may safely overpass them if not needed. The prediction is based on the fact that the forwarding node knows all road segments on which its junction neighbors have neighbors. The GpsrJ+ uses the modified beacon [13]. GpsrJ+ further enhances GPCR by taking fewer hops to the destination, while keeping the same route traversal and the same high delivery ratio as GPCR over GPSR. Main disadvantage of GpsrJ+ is not appropriate for the delay sensitive applications.

III. NEW GPSR

For VANET design the efficient routing protocol is challenging task because of the highly dynamic topology. In VANET mostly used the Geographical based routing protocol because of the Geographical based routing protocol is very well suited for highly dynamic environments such as inter-vehicle communication and vehicle-to-RSU communication on highways. NewGpsr algorithm belongs to the category of position-based routing. The NewGpsr is in positions based routing and sub-category of NewGpsr is Non-DTN (Delay Tolerant Network). It is under the Non-DTN because, it is not uses the carry & forward strategy to overcome frequent disconnection of nodes in the network. It stores the packet & forwarding is done based on some metric of nodes neighbors. In Non-DTN, NewGpsr comes under the Beacon. Beacon means transmitting short hello message periodically. In GPSR node sending the beacon message contain its own position for exchange the own position it with neighboring nodes by sending beacon messages and obtain the position of the destination.

NewGpsr is a position-based routing protocol which consists of two modes, yet using an advance greedy forwarding. As obstacles (e.g., buildings) block radio signals, packets may only be greedily forwarded along road segments as close to the destination as possible. Accordingly, the major directional decisions are using the neighbor's broadcast routing table. When packets reach a local maximum (dead-end), a point at which there is no node closer to the destination, the node switches to NewGpsr recovery mode. The NewGpsr is working in two mode, i) Advance Greedy Mode and ii) Perimeter Mode (Repair Strategy).

A) Basic Assumptions

Before we describe NewGpsr formally, we make some assumptions. First, we assume a road segment to be an edge formed by two points, intersecting or not. For example, in Fig. 1, two edges that overlap each other form four segments with five points, one of which is an intersecting point. This assumption naturally gives us a planar graph out of a city map. Second, similar to [11], we assume that nodes on different road segments cannot detect one another because of radio obstacles. However, if one road segment is an extension, either horizontally or vertically, of another road segment, nodes may detect each other. Third, unlike the geo-routing protocol presented by [11], we assume the map of a city is given. We believe this is a reasonable assumption as more and more cars are equipped with an on-board navigation system. Consequently, each node knows its location and the road segment it is on. Each node also knows whether it is a junction node. Lastly, in the scope of this work, we assume that the city map is in the form of grids, that is, there are no turning or diagonal straight roads for the prediction to make sense.

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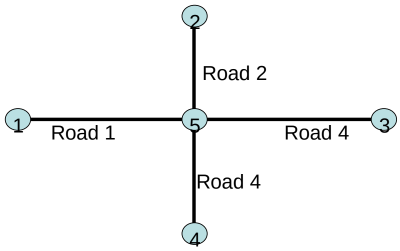

Fig.1 Five nodes with four road segments

When there are turning or diagonal straight roads, packets must go through junction nodes. Therefore, no prediction can take place at all. We argue that this assumption does not limit GpsrJ+ to grid scenarios which do happen frequently in cities, but rather complement GPCR when grid scenarios happen. We yet plan to extend GpsrJ+ to handle such configuration in future work.

B) Enhanced Beacon

In addition to node's position in the beacon, each node also broadcasts the road segments that its neighbors are on. Since each node is equipped with a navigation system, it is easy to extract the road segments on which its neighbors are, given their locations. In the neighbor list, each node therefore has its neighbor's location and the associated road segments on which its neighbor's neighbors are. The size of the enhanced beacon is bounded by the number of roads a junction node can have. In a grid network, this is at most four. In most of the city scenarios, this number is also trivially small. As GPCR also needs to transmit a flag bit per intersection node, the size of the enhanced beacon is only increased by 1 bit in Grid areas compared to GPCR.

C) NewGpsr's Algorithm

NewGpsr is a position-based routing protocol which consists of two modes, yet using an advance greedy forwarding. As obstacles (e.g., buildings) block radio signals, packets may only be greedily forwarded along road segments as close to the destination as possible and finding the direction. Accordingly, the major directional decisions are made using the neighbor's broadcast table. When packets reach a local maximum, a point at which there is no node closer to the destination, the node switches to NewGpsr recovery mode (i.e. Perimeter Mode). Bellow shows the algorithm of NewGpsr.

At source:
mode = greedy
Intermediate node:
if (mode == avdgreedy)
{
Advance greedy forwarding;
if (fail) mode = avdperimeter;
}
if (mode == avdperimeter) {
if (have left local maxima) mode = greedy;
}

The proposed method in NewGpsr Advance Greedy forwarding has the advantage of finding the direction of node using the neighbor's broadcast table so it reduces hop count. The greedy method used in the [11] [12], greedy forwarding to forward packets to nodes that are always progressively closer to the destination. In regions of the network where such a greedy path does not exist (i.e., the only path requires that one move temporarily farther away from the destination), and recovers by forwarding in perimeter mode, in which a packet traverses successively closer faces of a planar sub graph of the full radio network connectivity graph, until reaching a node closer to the destination, where greedy forwarding resumes. The proposed method has the advantage of finding the direction of node in the neighbor's broadcast table so it reduces hop count and result show in Section-IV also increase the Packet delivery ratio. Broadcasting is used to find the next road segments and nodes Sometimes it reaches local maximum at that the recovery mode will occur. The node is in local maximum occurs due to dead end and obstacles means it switches to perimeter mode (or recovery mode) and the node will broadcast again so it takes more time and hop counts. The proposed method has the advantage of finding the direction of node in the neighbor's broadcast table so it reduces hop count, that is whenever the broadcast message sends to the node, the node will analyze the source and destination address and then it analyze the shortest path after that it forwards the packet. If the TTL (Time To Live) of packets expires before reaching destination means the coordinator node will re-broadcast the message to the node in proposed method i.e. NewGpsr. In previous, if no nodes available to forward packets through destination means the current node will have packets and it forwards to some node towards destination. In this situation there is more time loss.

IV. PERFORMANCE EVALUATION

In this section, we evaluate NewGpsr by comparing it with GPSR, GPCR and GpsrJ+. Our objective is to show that NewGpsr improved recovery strategy brings significant results compared to the benchmark GPSR, GPCR and also to GpsrJ+, yet without the cost of computing and maintaining junction nodes. First we describe our experimental setup and then provide simulation results.

A. Experimental Setup

We based our simulations on NS-2 simulator version ns-2.34 with 50 nodes up to 100 nodes, with a 10-node increment. We use IEEE 802.11g DCF as the MAC with a transmission rate of 2Mbps and transmission range of 371m. The default transmission range yields on average 3 to 5 neighbors for non-junction nodes and 3 to 9 neighbors for junction nodes for node density between 50 and 100. These settings well guarantee a fully connected network. The mobility traces were generated by SUMO[22] and TraNS[22]. SUMO is an open source, highly portable, microscopic and continuous road traffic simulation package designed to handle large road networks SUMO's

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functionalities are decomposed into macro- and micro-mobility features of a vehicular environment to produce realistic urban mobility traces. The macro-mobility part is composed of motion constraints and a traffic generator, while the micro-mobility part controls cars' acceleration and deceleration in order to keep a safe inter-distance and avoid accidents and overlapping. TraNS (Traffic and Network Simulation Environment) is a GUI tool that integrates traffic and network simulators (SUMO and ns2) to generate realistic simulations of Vehicular Ad hoc networks (VANETs). TraNS allows the information exchanged in a VANET to influence the vehicle behavior in the mobility model. For example, when a vehicle broadcasts information reporting an accident, some of the neighboring vehicles may slow down. In this paper we are using the SUMO-0.10.0 and TraNs-1.0. The urban topology employed in this paper is a user defined of 1100m by 1100m as illustrated in Fig. 1. All intersections are controlled by stop signs and all road segments contain speed limitations.

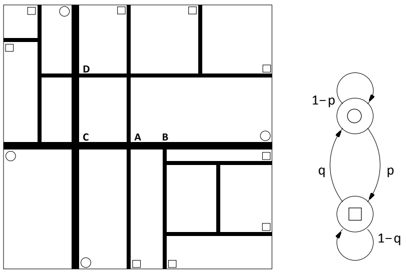

Fig 1.City section map and activity chain

Unless specified differently, all roads have a single lane, and a speed maximum speed limit of 15 m/s (54 km/h), except for the roads represented with thicker lines, which allow a maximum speed of 20 m/s (72 km/h). Vehicles travel between entry/exit points at borders, identified with circles and squares, crossing the city section according to the fastest path to their destination. The trips generation scheme is activity-based and the relative transition probability matrix describes a simple activity chain depicted in Fig. 9. As also shown in Fig. 9, the states denote the class of the selected destination: a round for the entry/exit points of high-speed roads, a square for the entry/exit points of normal-speed roads. The paths between entry/exit points are computed based on a speed-based shortest path cost function. Finally, the micro-mobility is controlled by the IDM-IM, an extension to the Intelligent Driver Model (IDM) considering intersections.

A radio propagation model [21], also known as the Radio Wave Propagation Model or the Radio Frequency Propagation Model, is an empirical mathematical formulation for the characterization of radio wave propagation as a function of frequency, distance and other conditions. A single model is usually developed to predict the behavior of propagation for all similar links under similar constraints. Created with the goal of formalizing the way radio waves are propagated from one place to another, such models typically predict the path loss along a link or the effective coverage area of a transmitter.

In this paper we are using the Two Ray Propagation model. The two-ray ground reflection model considers both the direct path and a ground reflection path. It is shown [21] that this model gives more accurate prediction at a long distance than the free space model. The received power at distance *d* is predicted by,

$$p_r(d) = \frac{P_t G_t G_r h_t^2 h_r^2}{d^4 L}$$

Where Pt is the transmitted signal power, Gt and Gr are the antenna gains of the transmitter and the receiver respectively. L is the system loss and ht and hr are the heights of the transmitter and receiver antennas respectively. We collected mobility traces of 50, 60, 70, 80, 90 and 100 nodes, each of them considered at steady state. For each node density, there were 10 simulation runs with different sets of 10 random source-destination pairs that used CBR for data traffic generation. In the next section, we show performance evaluation metrics of the delivery ratio and hop count.

B. Experiment Results

We evaluate GPSR, GPCR, GpsrJ+ and NewGpsr using metrics: packet delivery success rate, Hope count, Throughput, routing protocol overhead.

i) Packet Delivery Success Rate

The packet delivery success rate is show in Figure-2. Figure-2 shows how many application packets NewGpsr delivers successfully for varying values of B, the beaconing interval, as a function of pause time. The same figure for GPSR, GPCR, and GpsrJ+ are included for comparison. Packet delivery success rate means Packet delivery ratio.

Packet delivery ratio (PDR): the ratio of the number of delivered data packet to the destination. This illustrates the level of delivered data to the destination. Delivery failure to a truly disconnected destination does not represent failure of a routing algorithm. Packet delivery ratio is calculated as follow

$$PDR = \frac{\sum Number\ of\ packet\ receive}{\sum Number\ of\ packet\ send}$$

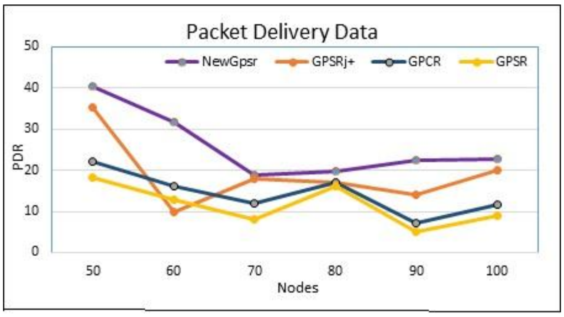

Fig: 2 Packet Delivery Ratio

ii) Hope Count

Figure-2 shows the packet delivery ratio (PDR) between GPSR, GPCR, GpsrJ+ and NewGpsr. Clearly, taking aggressive hops in the recovery mode along the perimeter improves the PDR. Hope count refers to the intermediate

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nodes through which data must pass between source and destination show in figure-3. A higher number of hops implies an increased probability of channel contention; therefore, there is a higher probability that a packet gets dropped along the way.

The total hop count of NewGpsr is still lower than that of GPSR, GPCR and GpsrJ+. At node 100 for example, the hop count of GpsrJ+ (16.93) is twice as high as that of NewGpsr (8.20). In summary, the inefficiency of node planarization strategies in urban vehicular scenarios to forward packets in perimeter mode not only affects the delivery ratio, it also impacts the hop count and network resources as packets stay longer in the network before being dropped. The data are presented y-axis is in total hopes count and x-axis number of nodes.

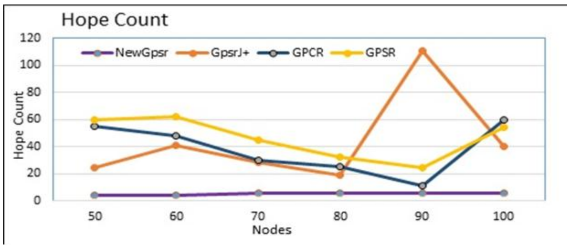

Fig: 3 Hope Count

iii) Normalized Routing Protocol overhead

Figure-4 shows the normalized routing protocol overhead (NV), measured in total number of routing protocol packets sent network-wide during the entire simulation. Normalized Routing Load (or Normalized Routing Overhead) is defined as the total number of routing packet transmitted per data packet.It is calculated by dividing the total number of routing packets sent (includes forwarded routing packets as well) by the total number of data packets received.

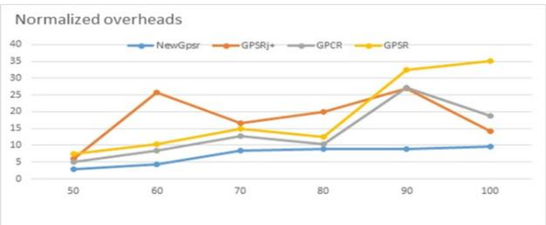

Fig: 4 Normalized Overheads

iv) Throughput

Throughput refers to how much data can be transferred from one location to another in a given amount of time.

$$Throughput = \frac{\sum Total\ no.\ bits\ send\ from\ source\ to\ destination}{\sum GivenTime}$$

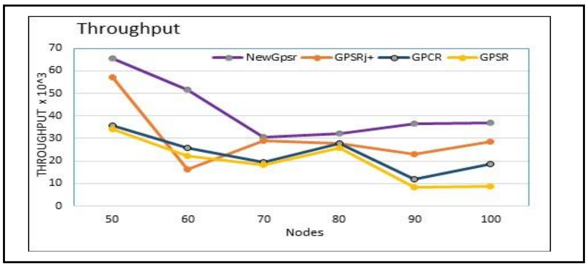

Fig: 5 Throughput

V. CONCLUSION

In this paper, we have introduced geographical routing protocol NewGpsr as an intuitive predictive scheme that improves the recovery strategy of geographic forwarding algorithms. Unlike GPSR, it does not require an expensive planarization strategy and makes more efficient routing decisions at road junctions. Unlike GPCR and GpsrJ+, NewGpsr only forwards packets to nodes in road segments, if and only if the forwarding decision changes with respect to the general forwarding direction of the recovery mode; otherwise, packets are allowed to progress across the intersection with the maximum progress, saving the protocol many hops. We have shown that NewGpsr improves GpsrJ+, GPCR and GPSR in packet delivery ratio, and improves the hop count and also reduce the overhead of network.

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