Hindawi
Complexity
Volume 2020, Article ID 4870162, 10 pages
https://doi.org/10.1155/2020/4870162

Research Article

Greedy Intersection-Mode Routing Strategy Protocol for Vehicular Networks

Marwan Mahmoud [1] and Mahmoud Ahmad Al-Khasawneh [2]

[1] *King Abdulaziz University, Jeddah, Saudi Arabia*
[2] *Faculty of Computer & Information Technology, Al-Madinah International University, Kuala Lumpur, Malaysia*

Correspondence should be addressed to Mahmoud Ahmad Al-Khasawneh; mahmoud@outlook.my

Received 22 July 2020; Revised 27 October 2020; Accepted 21 November 2020; Published 12 December 2020

Academic Editor: Atif Khan

The advantages of vehicular ad hoc networks (VANETs) have been acknowledged, particularly during the last decade. Furthermore, VANET-related issues have been addressed by different researchers. Forwarding information professionally in a VANET is considered a challenging task precisely at the intersections where forwarding the information turns out to be extremely problematic. To elucidate this problem, many researchers have established routing protocols. The improved greedy perimeter stateless routing protocol (IGPSR) has been suggested, in the direction of employing greedy-mode proceeding traditional transportation's streets as well as to employ intersection-method at the joints. In view of greedy mode, the selection of the following stage is as in GPSR. By contrast, in the mode at an intersection, we would expect the vehicle guidelines to govern the following stage. The recreated consequences expose the algorithm, which is anticipated to undeniably demonstrate its competency.

1. Introduction

Currently, with the growth of network technologies, driving tasks have turned out to be more puzzling when using innovative knowledge to identify road conditions, making it more essential to generate data from vehicle transmissions. An ad hoc system is a type of wireless network system that can change data between cars and create a vehicular ad hoc network (VANET) [1–4]. Although various protocols have been recommended to organize transport networks between vehicles [4], a supplementary investigation is still needed to cultivate a competent routing protocol that can reduce or decrease the hop count in the spread of data and to dodge a wrong track under several circumstances such as at intersections. The confidentiality of VANET routing protocols can be classified as follows: first, geographical routing protocols [5–13] that appoint the benefits of GPS obtain the vehicle spots where a message should be forwarded to reach the endpoint. The second category is topology-based routing protocols [14–17], which differ from the first category of protocols that use link data occurring in the network to accomplish packet advancement. The last category is cluster-based routing protocols [18, 19] in which a set of nodes are used to formulate clusters, and each cluster head shows the furthermost significant part in the choice of how the message is forwarded.

The proposed routing protocol can be classified under the first category of geographical routing protocols and proceeds with the benefits of GPS hence making messages to be forwarded at nodes.

2. Background and Related Studies

A general idea of a supplementary routing protocol is presented in this section. We briefly describe three GPSR algorithms, considering the greedy perimeter coordinator routing (GPCR) algorithm and GpsrJ+. The GPSR algorithm [5], which is considered a position-based routing algorithm, at a midway node forwards a container to a direct nearest place that is nearer to the target of the node. This is known as greedy forwarding. To deal with this issue, every single node must be alerted to its location when surrounded along with the location identified as the last stop node. This study considers the manner in which locations are acquired or collected independently from their opportunity. Our assumption states that every node can acquire its particular location by employing a GPS device, interchange the information among the nearest nodes through what is known as beacon messages, and gain a better spot of the objective or target node through another location service [20].

From the arrangements of position-based routing, which are constructed using confined local facts, in addition to being attributable to noneven circulations of nodes or the presence of radio complications, it is conceivable to think that the packet extents a surrounding supreme through reverence toward the expanse near the target. It can be stated that a node cannot discover a prospective advancement, which is nearer to the target than to the node (Figure 1). To guarantee outflow from this local maximum, there is a mode known as a recovery mode is castoff to frontward a packet to a node that is closer to the target than the node where the packet copes with the local maximum. The packet will be advanced backward with reverence to its space to the target until it extents a node whose distance to the target is nearer and then the resumption of greedy mode will be considered. Thus, the packet is regressively advanced towards its space to reach the node nearest the target, and the resumption of greedy mode will be assumed.

Numerous recovery algorithms have been established, including GPSR, Face-1, Face-2 [21], and GOAFR+ [22]. GPSR achieves progress at the beginning of a local supreme by using the perimeter mode and applying the rule of right-hand (Figure 2). These rule conditions while placing node x at the start are applied in recovery mode, and the furthering hop is a serial node that is counterclockwise with the fundamental second edge molded through x and the target D. Subsequently, the hop is succeeded serially counterclockwise toward the other edge designed through y and the preceding situation of node x (see [23] for more details).

Aimed at understandable details, the rule of the right-hand involves the total noncrossing edges. The GPSR recommends each relative neighborhood graph (RNG) [24] or a Gabriel graph (GG) [25] changing the planar chart of the system without any intersection edges, despite the fact that additional methods advocate the usage of crossing trees or curved hulls [26]. The preservation of the chart planar by every node requires substantial work. Although every node is a prerequisite to preserve the chart of the planar at all stages, the mentioned material can be castoff through nodes fronting the local smallest occurrence. Based on this observation, a planar diagram aimed at the mode of recovery is retained, which creates recovery modes that are fuller than stateless.

Our approach happens to ease what is necessary for planarization by discerning than possibly excerpting a graph of the planar commencing an urban diagram on no further price. Furthermore, to carry out the rule of the right-hand rule matching, the $\theta 1$ angle is between the x-axis and the edge, and the state of the preceding node (also a reliant target and what if first or remains happening inside the greedy perimeter mode) in addition to the $\theta 2$ angle among the x-axis besides the edge molded through the existing node and its surroundings. It is decided on the lowest angle $\theta 2$ effective intersection node, with GPCR coming across a local maximum with conviction (in Figure 3, case 1). Furthermore, once a packet does not face an earnest intersection (in Figure 3, the target node is D2), steering to an intersection node is a nonproductive approach of an overpass and the intersection toward transporting the relay in extreme space could have been chosen (in Figure 3, case 2). Considering this, this will be great if the surveillance of a grave intersection can be completed by nodes in advance to the intersection. This is exactly what we recommend herein, and GpsrJ+ is considered [8].

It is considered that GpsrJ+ would be a location establishing the steering protocol that contains the two methods that until now were considered an exceptional arrangement of a greedy advancement. For example, impediments (e.g., buildings) prevent radio signals, and the packets can remain strongly promoted across the road sections in place of a nearby target. Consequently, the main maneuvering choices are prepared at the intersection. When a packet is extended to a local extreme, there is no node that moves quickly toward the target, where the node modifications occur according to the mode recovery of the GpsrJ+. Considering the recovery mode, packets are greedily backpedaled sideways the border of roads. It is not essential to back frontward in minor stages over and done with planarized links, leading because the wide-ranging direction of the right-hand method continuously outcomes in the reverse direction of where packets were going in advance of recovery, and following because the target is to the response as quick as imaginable to an intersection. Unlike with GPCR, where packets essentially to be directed to an intersection node meanwhile intersection nodes organize the next advancing track, GpsrJ + lets nodes that have intersection nodes as their surroundings to calculate on which road segment and what is its intersection nodes, which would be frontward packets onto, and consequently, may be without harm crossing them if not needed. The expectation is founded using the fact that the furthering node recognizes all road's sections on which its intersection surroundings have neighbors. The road sections, on which neighbor nodes are, are pulled out from the urban plot by the neighbor's location. To end with, nodes combine these statistics in the adjusted beacon and show it to the advancing node that transports out of the expectation.

Bearing in mind that the consequential following stage is on a street section that bonds the same of x or y coordinate matching the advancing node's intersection, the advancing node will only go forward to the containers to such an afterward stage and possibly will keep one stage. Nevertheless, if the consequential stage is on a street section that is not a part of the similar coordinates of x and y that matches

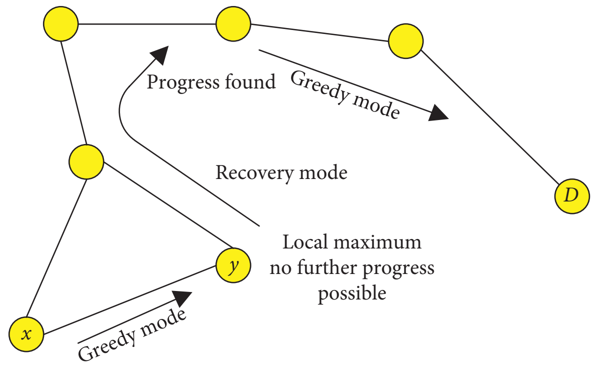

Figure 1: GPSR with local maximum.

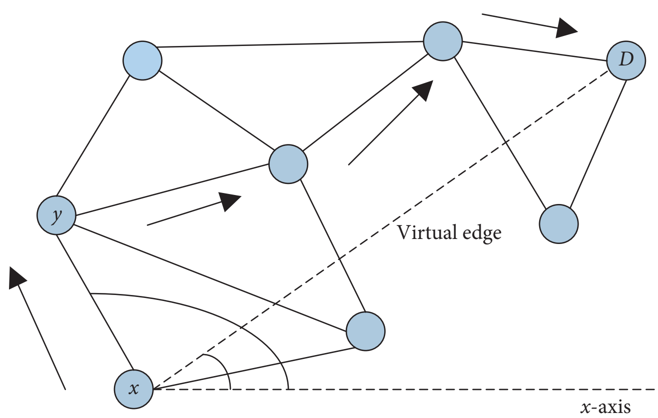

Figure 2: Routing by the right-hand rule.

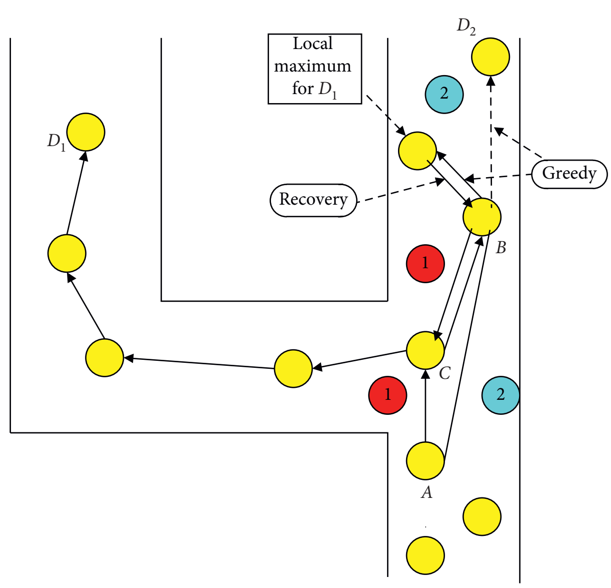

Figure 3: Routing with GPCR.

the advancing node's surrounding intersection, the advancing node's following stage essentially will certainly be its intersection neighbor. In conclusion, we can state that GpsrJ+ improves the GPCR by claiming fewer stages to the target, although protecting the identical route and a similar large transfer ratio as GPCR over GPSR.

3. Proposed Method

The proposed method aims to solve the forwarding problem at intersections.

The following is the pseudocode for the proposed routing Algorithm 1:

3.1. System Model. The estimation algorithm is a better-quality algorithm constructed on a GPSR routing protocol and some associated augmentations of a GPSR, such as GPCR and GpsrJ+, through various conventions, as clarified in the following:

(1) This algorithm thinks using the ad hoc mode of VANET, where every single vehicle can forward packets in ad hoc mode, as an alternative to the method of its infrastructure.

(2) Because GPSR maintains a geographic position-based routing rule, it is estimated that every vehicle has a GPS to acquire its specific position. A vehicle lacking geographic information system (GIS) statistics is uniquely starved of supplementary numerical diagrams.

(3) Each automobile distinguishes its own private matches. The foundation automobile packets its own position based on the ideal communication and thus the adjacent automobiles forward packets toward the location allowing ideal messaging.

(4) During an ideal stationary intermission, at every single-automobile exchange, the statistics of the adjacent automobiles are brought up to date regarding the surrounding list table by the ideal messages. At this time, the adjacent automobiles determine the one-stage surroundings.

(5) Uniquely, although the GPSR procedure is inadequate for forwarding packets in greedy mode, automobiles forward packets through perimeter mode. Meanwhile, the application of the right-hand method of the perimeter mode capacity advances toward the circle, where the relative neighboring graph (RNG) and Gabriel's graph (GG) are ordinarily anticipated in the direction of eradicating the opportunity of the circle. By contrast, considering an urban situation, this type of obstacle hardly occurs as vehicles are divided by loops and roads are infrequently present. Consequently, we proceeded using this system in our algorithm to diminish the timing of the scheming and the development difficulty.

(6) It is expected that the signals will be prevented by obstacles or houses because problems result from the signal to be attenuated and reduce the quality of the communication.

A schematic of a city area is specified in Figure 4. The spotted loop indicates the collection of the transmission data of the automobile. Automobile S (source) in the lower left is the foundation node. Automobile C (coordinator) in the middle is the coordinator of the intersection node. Automobile *D* (destination) in the upper left is the target.

3.2. Improved GPSR Protocol (IGPSR)

3.2.1. Route Establishment. This method sends beacon messages through source node routes, which can be recognized and implemented. The source node (*s*) originally transmits the message to the nearby neighbor nodes by greedy or intersection mode at the exact point of the intersection. In standing routing approaches, if the node is in a local extreme attributable to an end and has difficulties in switching to perimeter mode, the node will transmit again using additional time and hop counts. Each packet has an incomplete TTL because routing the packets within the TTL is considered significant. If there are no existing nodes to the frontward packets through the target, the existing node that has packets will forward it to the selected node in the direction of the target. At this location, more time loss will occur.

3.2.2. Route Discovery Process. This process deals with the existing routing protocol. The route detection method begins as soon as the source node drives packets to where the destination node is available. Primarily, the source generates a propagation message, and the header of the propagation messages contains the source, target node statement, and TTL added to the data packets. The source node will transmit the message to the neighbor node, and afterward, it analyzes this process, which is the direct route to subsequently scope the target packet, which will forward to the next node. It is assumed that there is a node intersection and that its meaning is forwarded by an additional mode.

At this time, the projected technique has the benefit of the direction of a node in the neighbor's transmission board; consequently, it diminishes the hop count. Propagation is castoff to catch the following road sections and nodes. Occasionally, it scopes a local extreme under the circumstance in which recovery mode will take place. The propagation may have overcrowding-associated difficulties because of the propagation of the packet to each neighbor node. This type of complication is diminished owing to the investigation and node routes. This is considered during every occasion where the propagation message is directed to the node, and the node will examine both the source and statement of the target and at that point the direct route subsequently to forward the packet is evaluated. It is important to know that if the TTL of the packets terminates in advance of reaching the target, it means that the coordinator node will repropagate the message again to the node (Algorithm 2).

3.2.3. Route Reply. Assuming the time at which the target node acquires the propagated message, it directs the comeback response message to the starting point by generating a reply message. Every time the reply message goes through the intersection or neighbor node, after which the routing tables will remain repeatedly informed.

Accordingly, we can acquire the next material in which the packets are guided by these nodes. It is known that the header of the reply message contains the statement of the source, the statement of the target, and the direct path.

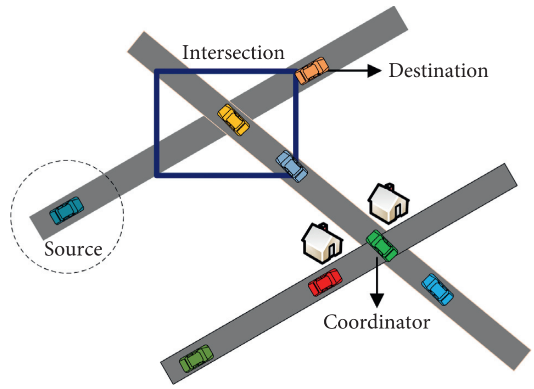

Figure 4: City scenario.

(1) nS node creates pkt (nS, nD, nDLoc (x, y), and TTL),
(2) broadcast to neighbor nodes
(3) forwarding pkt by greedy mode
(4) if (nd = = n max) then
(5) find intersection mode
(6) Else
(7) find next mode to transfer
(8) end if
(9) find direction of travel node in intersection broadcast table
(10) forwarding pkt by intersection mode
(11) if (ni = = nd) then
(12) Send RRP (nS, nD, and Rbest) return
(13) else
(14) if (rd = = straight road) then
(15) forwarding pkt by greedy mode

Algorithm 1: IGPSR.

3.2.4. Route Maintenance. The description of all nodes has been given, and we will update their routing table repeatedly owing to the high speed of the carriers, which may be cut off as carriers of high-speed vehicles. Therefore, preserving the routing is vital, and it keeps information in the table influenced by the source and movement targets. The central entity is the route that will be filled in every stage on every occasion a neighbor node transfers further than a variety, and it sustains the progression.

3.2.5. Greedy Mode. Positioning the greedy mode is based on routing in which the node in front of the packets is along the path sections to the neighbor node, which is close to the target node. It considered having many guiding intersections to forward the packets if it is a large network, and if any local extreme occurs, it switches to recovery mode.

The anticipated routing protocol of the greedy intersection mode routing strategy (GIRS), which states that this mode is castoff to choose the subsequent hop, picks out the vehicle node near the target. By bearing in mind the situation of vehicles within the transmission range, the vehicle next to the target is indicated as the following hop. It will take on the succeeding hops, and correspondingly, such a parameter is inadequate. It also embraces the space between two vehicles and the route of a node established on these parameters, and the position of the vehicle the packet will advance to in the succeeding hop. For this determination, every node requires a respectable awareness of its neighbor nodes as well as the target node and its personal status. Based on this perception, we accept that every node will recognize its and other nodes through a GPS device and will replace the material by a propagation message.

Bearing in mind the GPSR greedy mode, considering the nonuniform suppliers of the nodes, it is imaginable to grasp the local extreme at that stage, and it changes to perimeter mode when the packets are backtracked.

3.2.6. Intersection Mode. Previously, we stated that each vehicle will adjudicate or anticipate whether it is the coordinator based on the propagated messages. As a result, at any time, the vehicle will propagate the signal, which acts as a coordinator. At that point, the vehicle node changes to the

```
nS node creates pkt (nS, nD, nDLoc (x, y), and IDs TTL)
broadcast to neighbor nodes
if (ni = = nD) then
forwarding pkt to the shortest path of destination
else
broadcast message to the neighbor nodes
end if
if (RBP reaches nd) then
send reply response to the source node
else
broadcast message to the neighbor to reach destination
end if
if (TTL Expires) then
re-broadcast message to the neighbor to reach the destination
Send RRP (nS, nD, loc (x, y) IDS TTL) Return
save hop count
forward RPT to source node
else
broadcast message
end if
evaluate the best route based on routing protocol
else
forward RBP to the neighbor node
end if
```

Algorithm 2: Route discovery and route reply based on IGPSR.

mode of the intersection to discover the route of the neighbor vehicle.

Momentarily, considering the corresponding state in Figure 5, the source car S fluctuates in intersection mode and discovers the route of the neighboring vehicles. At this point, under these circumstances, car *J* transports into the left side of the road as the source node will prevent the packet from going to the target vehicle. The home vehicle investigates whether the route of the neighboring vehicles is headed to its target or not. If the route is not headed toward its target node at that time, the source will not direct its packets to the vehicle, taking in its place the source that will send packets to various other neighbor nodes, as shown in Figure 5. At any time, the circumstances occurred similarly. The nodes will alternate into a predictive mode. This is the part that we used for the enhanced method, as in the remaining classification, which is excluded from this article. It aids in transporting the packets to its target while such a position occurs.

3.2.7. Recovery Mode. By using this mode to avoid vehicles that have trouble with local maximum, at whatever time the local maximum trouble formerly occurs, the nodes will alternate into the mode of recovery allowing the problem to be resolved. The recovery mode was previously explained, and its anticipated structure itself is briefly considered. Furthermore, it accomplishes the assignment where the GPSRJ+ recovery mode is carried out. In recovery mode, it attempts to diminish the redundant hop count and traveling node. The foremost progression is to forward the statistics to the target over and the intersection mode.

4. Performance Evaluation

The imitation situation is the Manhattan grid, as shown in Figure 6, which is a part of various connections and is in the size of 500 m × 500 m. VanetMobiSim is a castoff used to produce suggestion files for NS-2. This suggestion file is castoff with a changed vehicle node configuration, and the output is transformed into input files for the program of the nodes in an NS-2 simulator.

Considering the wireless configuration setup, the circulated coordination function is supplementary with IEEE 802.11 and participates in the MAC layer. The research is shown for numerous vehicle node actions with an unlikely node density. Approximately, 75 vehicles are handed down for condensed systems and 50 vehicles for medium networks are used. In conclusion, sparse networks use 25 vehicles. The parameters and their assessment used for recreation are listed in Table 1.

Figure 7 shows the alteration among the three routing overhead procedures. The *x*-axis in the figure indicates the number of vehicles or carriers. Here, we adopt a single vehicle to simulate the consequences. This clarifies that, when the number of vehicles is amplified, the overhead values of the offered method decrease. Routing upward in the intelligence of packets is recurrently drifted with an erroneous retransmission. Practically, 50% of the routing overhead is reduced in the anticipated routing process GIRS equated with the other routing protocols (GPSR, GPCR, and GPSRJ+).

Consequently, the commencement of this packet supply ratio is augmented, and Figure 8 elucidates the research conducted for numerous packets and recurrent simulations. At this time, we use the *x*-axis as the number of vehicles to

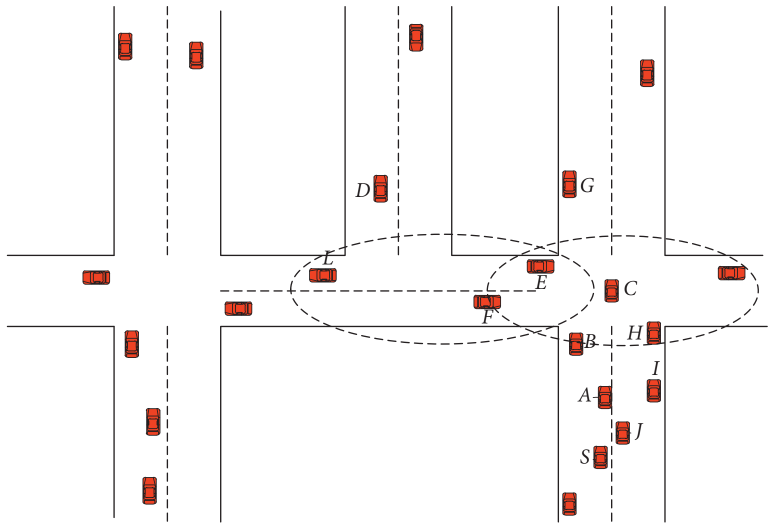

Figure 5: GIRS.

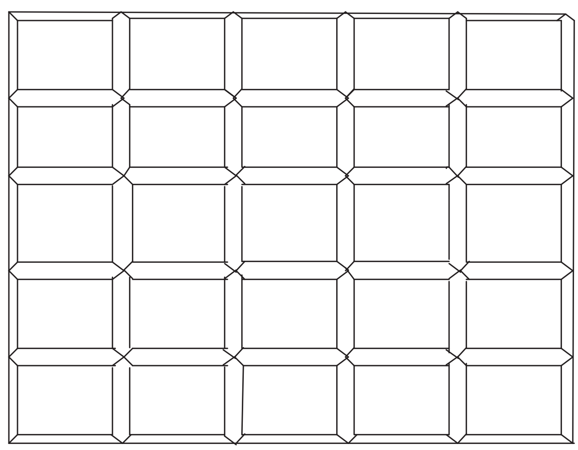

Figure 6: Manhattan grid.

Table 1: Parameters.

Parameters	Value
Simulation dimensions	700 m × 760 m
Simulation area	526060.5 m
Number of vehicles	25-50-75-100
Number of CBR sources	1–12
CBR rate	0.5 6 pkts/s
CBR packet size	1024bytes
Transmission range	200 m
Simulation time	250 s
MAC protocol	802.11 with DCF
Obstacles	Without
Data packet size	550 bytes approx.

determine the consequences. This clarifies that, when the number of vehicles is amplified, the packet delivery ratio will be clearly amplified. It undoubtedly positions the delivery of the packets and is nearly 30% finer than GPSRJ+, 50% finer than GPCR, and 85% finer than GPSR. The anticipated algorithm was more beneficial than GpsrJ+.

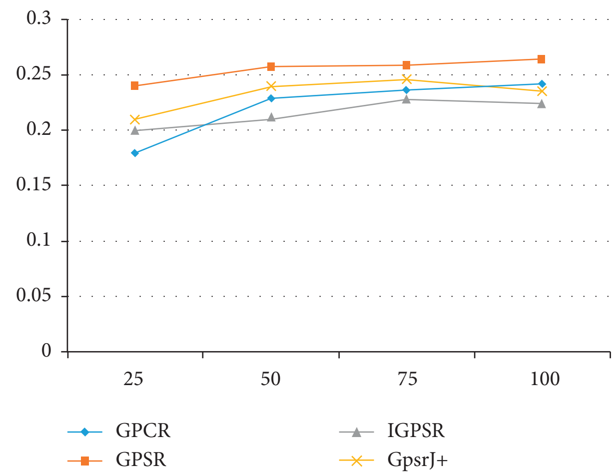

Figure 7: Routing overhead.

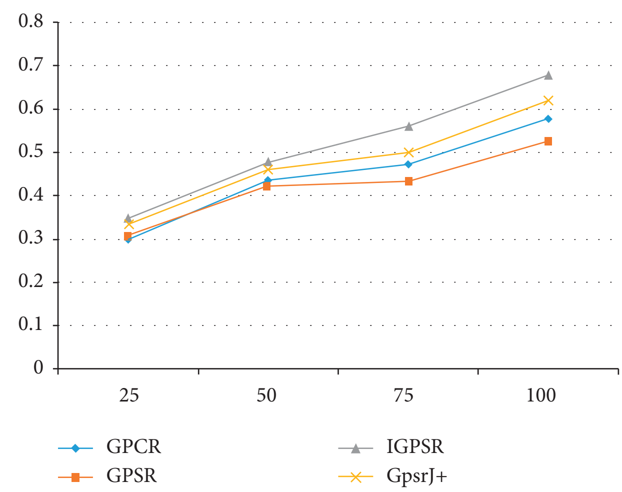

Figure 8: Packet delivery ratio.

Figure 9 clarifies the research outcome for the quantity as compared with GPSR, GPCR, and GpsrJ+. For all recreations, we spent the exact x-axis, and every time the vehicle density grew, the quantity will rose, and we will have the amount of carriers to forward the data. This also gives the outcome of the suggested algorithm with increased quantity, and thus the suggested algorithm is effective in real time. An exploration of the result shows that the quantity has improved by above 80% compared to GPSR and 30% higher than GPSRJ+, and 40% of the quantity was amplified when equated to GPCR. The quantity of unlike vehicle nodes is highly amplified because we use a direction-finding strategy.

Figure 10 clarifies the research results for end-to-end delay as with GPSR, GPCR, and GpsrJ+. A delay in the intelligence with the time taken to transport the packets is because of troubles or reduced vehicles. Compared to the GPR delay of packets, it has been reduced by nearly 60%, and when equated to the GPCR delay time, it decreased by 10%. This contrast outcome indicates that the delay of data packets is reduced in the anticipated technique, and thus

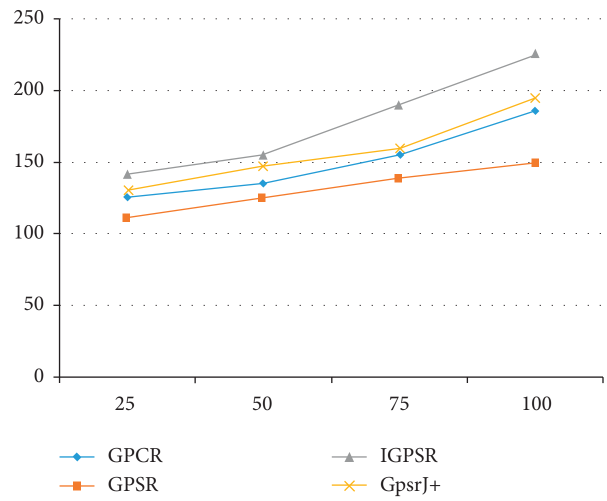

Figure 9: Throughput.

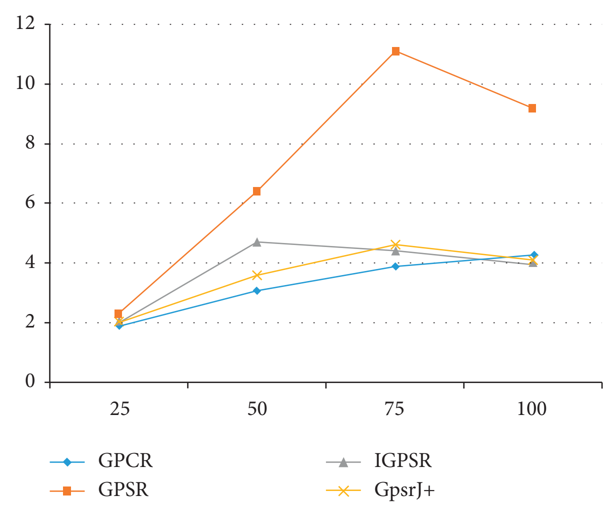

Figure 10: End-to-end delay.

statistical packets have been transported effectively and professionally.

5. Conclusions

Our approach here is to progress toward not only GPSR but also the geographic position-based routing protocol. However, similarly, the algorithm can be adjusted to outfit the urban situations in VANET. The replication outcome exposes the fact that the consumption of the direction is to control the following stage and moves to the predictive mode exactly at the connections. To certainly progress toward the routine, this is a suggested algorithm and raises the packet delivery ratio. In relation to the strong steering, the stability of the proposed algorithm is noticeably enhanced compared to that of GPSR, GPCR, and Gpsrj+. The future objective is toward challenging the flexibility of the proposed algorithm to dissimilar situations and attempt to apply the protocol of the geographical position-based steering that outfits the change in consequences. In accumulation, we challenge the difficulties in answering the confined supreme trouble and adjusting the recovery strategy.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Acknowledgments

This project was funded by the Deanship of Scientific Research (DSR) at King Abdulaziz University, Jeddah, under (grant no. J: 167-156-1440). The authors, therefore, acknowledge with thanks to the DSR for technical and financial support.

References

[1] K. C. Lee, U. Lee, and M. Gerla, "Survey of routing protocols in vehicular ad hoc networks," *in Advances in Vehicular ad-hoc Networks: Developments and Challenges*, pp. 149–170, 2010, IGI Global, Harrisburg, PA, USA, https://www.igi-global.com/chapter/advances-vehicular-hoc-networks/43169.

[2] A. Ullah, X. Yao, S. Shaheen, and H. Ning, "Advances in position based routing towards ITS enabled FoG-oriented VANET-A survey," *IEEE Transactions on Intelligent Transportation Systems*, 2019.

[3] I. Wahid, A. A. Ikram, M. Ahmad, S. Ali, and A. Ali, "State of the art routing protocols in VANETs: a review," *Procedia Computer Science*, vol. 130, pp. 689–694, 2018.

[4] S. M. Hanshi, T. C. Wan, M. M. Kadhum, and A. A. Bin-Salem, "Review of geographic forwarding strategies for inter-vehicular communications from mobility and environment perspectives," *Vehicular Communications*, 2018.

[5] B. Karp and H. T. GP. S. R. Kung, "Greedy perimeter stateless routing for wireless networks in," in *MobiCom '00: Proceedings of the 6th Annual International Conference on Mobile Computing and Networking*, pp. 243–254, August 2000, https://dl.acm.org/doi/abs/10.1145/345910.345953?casa_token=YC1ebSuNBlUAAAAA%3AeVIPoAWoxDgD_WFa3vG1Z2q-o_skJpwSWV1XOrPBRVRSh7SgGYh4GWRm8u5DzkpyU7nmwdrAXmY.

[6] C. Lochert, M. Mauve, H. Fubler, and H. Hartenstein, "Geographic routing in city scenarios," *ACM SIGMOBILE Mobile Computing and Communications Review*, vol. 9, no. 1, pp. 69–72, 2005.

[7] J. Zhao and G. Cao, "VADD: vehicle-assisted data delivery in vehicular ad hoc networks," in *Proceedings of the INFOCOM 2006. 25th IEEE International Conference on Computer Communications*, no. 3, pp. 1910–1922, April 2006, https://ieeexplore.ieee.org/abstract/document/4356982?casa_token=SMXktIWH7J4AAAAA:J2BkUwkwU689emYAJediUuM5rIl6WTtxZedMHrQWuBu2uE53b_wQVGacJGU5ODgvRy9s1uC6E30.

[8] K. Lee, J. Haerri, U. Lee, and M. Gerla, "Enhanced perimeter routing for geographic forwarding protocols in urban vehicular scenarios," *IEEE Globecom Workshops*, pp. 1–10, IEEE, 2007.

[9] V. Naumov and T. Gross, "Connectivity-Aware Routing (CAR) in vehicular ad-hoc networks," in *Proceedings of the INFOCOM 2007. 26th IEEE International Conference on Computer Communications*, pp. 1919–1927, May 2007.

[10] K. Lee, M. Le, J. Harri, and M. Gerla, "LOUVRE: Landmark Overlays for Urban Vehicular Routing Environments," in *Proceedings of the Vehicular Technology Conference, 2008. VTC 2008-Fall*, pp. 1–5, Alberta, Canada, September 2008.

[11] S. Schnaufer and W. Effelsberg, "Position-based Unicast Routing for City Scenarios World of Wireless, Mobile and Multimedia Networks," in *Proceedings of the WoWMoM 2008. International Symposium on a world of wireless, mobile and multimedia networks*, pp. 1–8, Newport beach, CA, USA, September 2008.

[12] M. Jerbi, S.-M. Senouci, T. Rasheed, and Y. Ghamri-Doudane, "Towards efficient geographic routing in urban vehicular networks," *IEEE Transactions on Vehicular Technology*, vol. 58, no. 9, pp. 5048–5059, 2009.

[13] K. C. Lee, P.-C. Cheng, and M. Gerla, "GeoCross: a geographic routing protocol in the presence of loops in urban scenarios," *Ad Hoc Networks*, vol. 8, no. 5, pp. 474–488, 2010.

[14] C. Perkins and E. Royer, "Ad-hoc on-demand distance vector routing mobile computing systems and applications," in *Proceedings of the 1999. Proceedings. WMCSA '99. Second IEEE Workshop on, Mobile Computing Systems and Applications*, pp. 90–100, New Orleans, LA, USA, February 1999.

[15] V. Naumov, R. Baumann, and T. Gross, "An evaluation of inter-vehicle ad hoc networks based on realistic vehicular traces," *ACM*, in *MobiHoc '06: Proceedings of the 7th ACM International Symposium on Mobile Ad Hoc Networking and Computing*, pp. 108–119, Florence, Italy, May 2006.

[16] A. Paier, J. Karedal, N. Czink et al., "First results from car-to-car and car-to-infrastructure radio channel measurements at 5.2GHZ personal," in *Proceedings of the IEEE 18th International Symposium on Indoor and Mobile Radio Communications,. PIMRC 2007*, pp. 1–5, Athens, Greece, September 2007.

[17] J. Nzouonta, N. Rajgure, G. Guiling Wang, and C. Borcea, "VANET routing on city roads using real-time vehicular traffic information," *IEEE Transactions on Vehicular Technology*, vol. 58, no. 7, pp. 3609–3626, 2009.

[18] J. Blum, A. Eskandarian, and L. Hoffman, "Mobility management in IVC networks intelligent vehicles symposium," *in Proceedings of the IEEE IV2003 Intelligent Vehicles Symposium, IEEE*, pp. 150–155, 2003, https://ieeexplore.ieee.org/abstract/document/1212900.

[19] R. A. Santos, A. Edwards, R. M. Edwards, and N. L. Seed, "Performance evaluation of routing protocols in vehicular ad-hoc networks," *International Journal of Ad Hoc and Ubiquitous Computing*, vol. 1, no. 1/2, pp. 80–91, 2005.

[20] Y. Seok, J. Park, and Y. Choi, "Multi-rate aware routing protocol for mobile ad hoc networks," in *Proceedings of IEEE Vehicular Technology Conference (VTC 2003)*, vol. 3, pp. 1749–1752, April 2003.

[21] L. Liu, Z. Wang, and W.-K. Jehng, "A geographic source routing protocol for traffic sensing in urban environment," in *Proceedings of the IEEE International Conference on Automation Science and Engineering, (CASE 2008)*, pp. 347–352, Washington, DC, USA, August 2008.

[22] D.-H. Kown, W.-J. Kim, and Y.-J. Suh, "Performance comparisons of two on-demand ad hoc routing protocols in dynamic rate shifting WLANs," in *Proceedings of IEEE International Conference on Communications. (ICC 2003)*, vol. 1, pp. 512–516, Alaska, USA, May 2003.

[23] J. Tian, I. Stepanov, and K. Rothermel, "Spatial aware geographic forwarding for mobile Ad Hoc networks," Technical Report, University of Stuttgart, Stuttgart, Germany, 2002.

[24] B. Awerbuch, D. Holmer, and H. Rubens, "High throughput route selection in multi-rate ad hoc wireless networks," in *Proceedings of the IFIP Working Conference on Wireless On-Demand Network Systems*, pp. 253–270, January 2004, https://link.springer.com/chapter/10.1007/978-3-540-24614-5_19.

[25] S. Zhao, Z. Wu, A. Acharya, and D. Raychaudhuri, "PARMA:a PHY/MAC aware routing metric for ad-hoc wireless networks with multi-rate radios," in *Proceedings of Sixth IEEE International Symposium on a World of Wireless Mobile and Multimedia Networks (WoWMoM 2005)*, pp. 286–292, June 2005, https://ieeexplore.ieee.org/abstract/document/1443512?casa_token=buJLgnW0GykAAAAA:7XgQ6Q0uSjkAZlxqZB3W0uxly59S1QM2PtzWL7i9CWTR424yVvPkJcsWWIkXMkTO9ivAykoIBz8.

[26] C. Lochert, H. Hartenstein, J. Tian, H. Fussler, D. Hermann, and M. Mauve, "A routing strategy for vehicular ad hoc networks in city environments," *IEEE Intelligent Vehicles Symposium (IVS 2003)*, pp. 156–161, 2003.