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A Comprehensive Review of Geographic Routing Protocols in Wireless Sensor Network

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Abstract: To analyses the impact of high mobility, dynamic topologies, scalability and routing due to the more dynamic changes in network. To enhance mobile Ad-hoc network (MANET) self-organization capabilities by geographical routing algorithm during mobility. In this paper, a survey has been carried out on geographic routing protocols, such as hybrid routing, Greedy Routing, face-2 Algorithm, Perimeter Routing, quasi random deployment (QRD) techniques and time of arrival (TOA). An optimized multipath routing in wireless sensor network (WSN), energy utilization, detection of anonymous routing, node mobility prediction, data packet distribution strategies in WSN is analyzed. Geographic routing offers previous data packet information such as physical locations, packet elimination dependencies, storage capacity of topology, Associate costs and also identifies the dynamic behavior of nodes with respect to packets frequencies.

Keywords: Wireless sensor networks (WSN); Quasi random deployment (QRD); Geographic routing protocol (GRP); Time of arrival (TOA); Mobile Ad-hoc network (MANET); Dynamic topology; Position based routing

1. Introduction

Wireless Networks grew to 1700 million in 2010 as a result of technological advancements and competition among mobile operators, and this increase is expected to continue. This trend is expected to accelerate, reaching in 2015, more than 2500 million was spent. Wireless networks are grouped into two categories:

- Wireless networks with infrastructure.
- Wireless networks without infrastructure.

We can find the fixed infrastructure in infrastructure wireless networks, mobile nodes usually have a characteristic feature of transferring the data from one base station to another, each and every base station will have its own entry point and the communication happens between two base stations through the access points. The scattering sensor nodes can collect data and send it back to the sink. As shown in Figure 1, the sink can communicate with the task manager node via the internet or satellite [1, 2].

A MANET is a kind of wireless network in which each mobile device can communicate with the others apart from the need of any infrastructure. Each and every node in a MANET act as a router, which means that each individual node is utilized for transferring both data and routing. MANET node has been equipped with a variety of radioactive devices with insecure transmission and reception capabilities as well as the ability to operate on numerous asymmetric frequency bands linkages, resulting in heterogeneity in radio capabilities for data transmission. The routing strategy to be employed is one of the major concerns for the ad-hoc routing protocols, dynamic network structure, Mobile nodes are nodes that travel from one base station to the next, which is either unicast or multicast routing, and mobile node speed [3, 4].

The typical mobile Ad-hoc network is demonstrated in Figure 2. Different routing protocols are used to avoid routing difficulties in dynamic topologies. Proactive Routing, Reactive Routing, and Hybrid Routing are three different types of MANET routing. The path for sending data is already known in proactive routing, thus if a node is required to transmit the data, the node is already aware of how to transfer the data. Each node keeps track of its routing table in real time. The source and destination addresses are recorded in the routing table. DSDV, WRP, and other Proactive Routing Protocols are examples. The drawback of these routing is that because of the unused path, it consumes more bandwidth network's available in case of changes in the topology. Reactive kind of routing is used to get around the demerits of proactive routing. Route is only constructed in in case of reactive routing when the node wishes to communicate the data. As a result, the information has been delivered only when the user wishes to communicate their data resulting in a routing overhead and low traffic. AODV, TORA, and other reactive routing protocols are examples. The key benefits of routing which include proactive and reactive are low overhead, low power consumption, and low bandwidth requirements [5-7]. Because of routes in a MANET which are only constructed when needed, drawback of adopting reactive routing occurs that is there will be a delay between packets when transferred. Due to the dynamic architecture of MANETs with node mobility, new routes will be formed, resulting in increased overall network load. If the direction of destination changes, the packets enrooted to the destination may be lost. As a result, hybrid routing is employed to avoid the difficulties which is caused due to the routing of proactive and reactive. The combination of proactive and reactive routing is commonly known as "hybrid routing". Here the path has been established with the help of Proactive Routing and also routing has been performed using reactive routing, hence it is referred as a hybrid type of routing. The efficiency of the network and scalability has been improved with the utilization of hybrid routing. The different routing protocols of MANETs are explained in Figure 3.

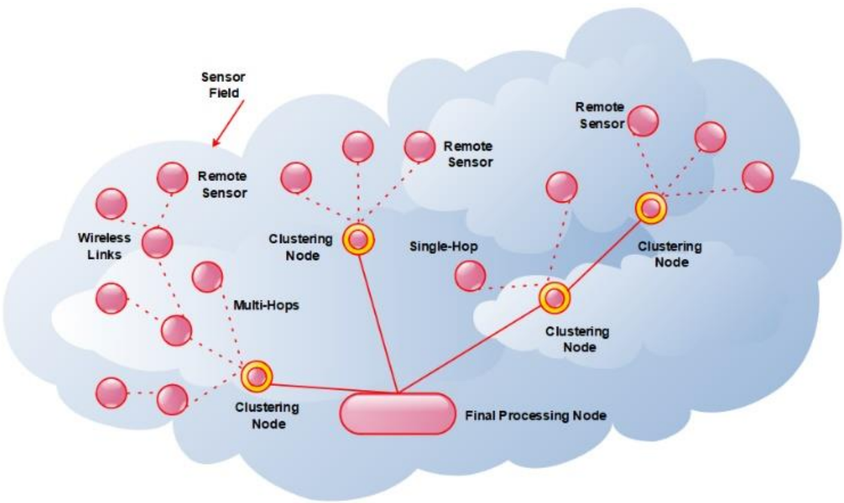

Figure 1. Fundamental structure of wireless sensor network arrangement

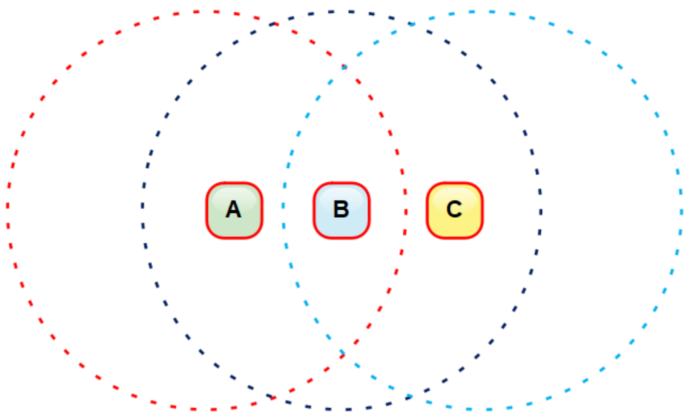

Figure 2. Block diagram of MANET

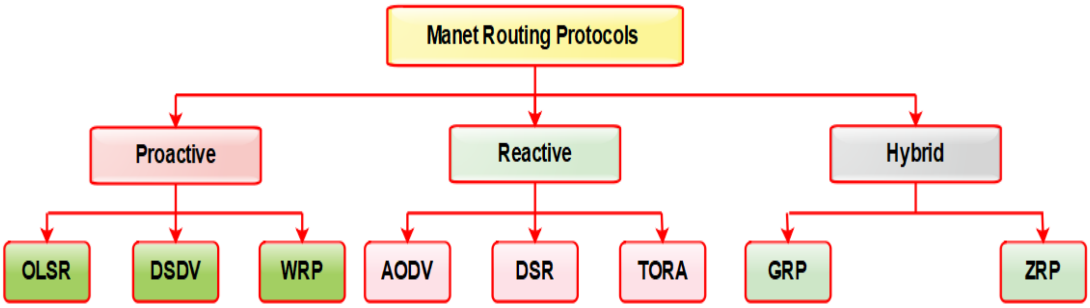

Figure 3. Routing protocols in MANET

In this section we are focusing on the hybrid routing and its protocols like GRP. The protocols of hybrid routing include proactive and reactive routing, but some of them also use the GPS (Global Positioning System) idea to transfer data. To send information in a GPS system, the transmitter must first detect the exact position of the receiver and then send the information after detecting the location. In order to utilize the GPS methodology, each node must be equipped with a GPS receiver capable of detecting the node's position in the global start organizing system.

2. Literature Review

Most of the researches has been carried out in the areas of routing of MANETs and routing of Geographic, MANET network.

Method of greedy network in MANET using geographical routing protocol has been investigated by Deshmukh et al. [8]. These methods are normally carried with the basis of Greedy forwarding technique through which the data has been forwarded to nearest target nodes and a neighboring node are chosen with the help of various greedy forwarding techniques. The suggested routing protocol that is Ad-hoc On-Demand Distance Vector (AODV) has been designed for usage by ad hoc mobile network nodes. Some of the features of these nodes are low network use, low processor and memory overhead it calculates the unicast routes to destinations within ad hoc network. It avoids difficulties involved in the conventional distance vector protocols by using destination sequence numbers to assure loop freedom at all the time.

Li [9] used packet level simulations to assess multiple routing methods for mobile, wireless, ad-hoc networks. The protocol suite contained ad-hoc routing protocols as well as more standard protocols such as link status and distance vector, which are utilized in dynamic networks. For a given traffic and mobility model, performance was measured in terms of the fraction of packets delivered, end-to-end delay, and routing burden. According to the authors, the next generation of on-demand routing protocols employs lower routing loads lower routing. On the other hand, traditional link state and distance vector protocols gives the better packet delivery and delay performance in general.

The IEEE 802.11 WLAN MAC - & PHY Specifications [10] standard focuses on creating a medium access control (MAC) and physical layer (PHY) definition for wireless communication in a local area for fixed, portable, and moving stations. The goal of this standard was to offer wireless access to automatic machinery, equipment, or stations that needed to be deployed quickly. These devices might be portable or hand-held, or placed on moving vehicles in a small area. These standards also provide the regulatory authorities with a way in order to regulate the access of one or more frequency band for communication of local region. This revision includes clarifications and technical adjustments to IEEE Std.802.11 for wireless local area networks (WLANS) as well as improvements in the current medium access control (MAC) and operations of physical layer (PHY). WiMAX (Worldwide Interoperability for Microwave Access) is a technology that bridges the gap between fixed and mobile access and provides the same subscriber experience for both fixed and mobile users.

Koulali et al. [11]. The first edition of WiMAX based on IEEE 802.16 and was optimized for access of fixed and nomadic. IEEE 802.16e, which is also known as Mobile WiMAX, was later extended to provide portability and mobility. Routing in Mobile WiMAX networks is a difficult problem because of frequent topology changes caused by node mobility. The authors examined and compared the performance of four ad-hoc routing protocols (AODV, DSR, OLSR, and ZRP) in a Mobile WiMAX environment, assuming that each subscriber station has routing capabilities within its own network. The ZRP and AODV protocols performed better than DSR and OLSR, according to the results. Various methods of mobile Ad-hoc networks deployment might widely vary with properties which have a significant impact over the behavior of various routing protocols established for this network.

According to Lin and Kuo [12]. It was critical for the developer to study the variation of probable quantitative behavior, problems, capacities, and deployment issues which supports their applications immediately before deploying them in such situations. The existing analytical model describes the behavior of MANETS, but they are limited to simple statistical models that represent either node mobility or link connectivity separately without taking into the account of interplay between the two or more major aspects of MANETs.

Shashi Raj et al. [13] studied several faces of routing algorithms, face routing strategies as well as greedy routing algorithms in MANET's. According to the authors, geographic routing methods are mainly based on the greedy forwarding technique in which data is forwarded to the nearest target node, but it can be damaged, lost or cancelled if there is no foreigner node nearby. The authors also suggested better strategies for recovering from this state, concluding that the most prevalent technique for recovering from the void state is face routing algorithm that utilizes planner graph.

Raval and Shah [14] examined the Adhoc networks (IHLR) of location-based routing, which combines the advantages of topology based and position-based routing algorithms to address the issues of reactive routing protocol. When compared to hybrid routing protocol, protocols of reactive routing will have more routing overhead. In comparison to reactive routing systems, the IHLR protocol had the shortest network delay and the highest throughput.

Raj et al. [15] examined the roles, functions, benefits, and limits of routing protocol and spatial routing protocol utilizing the GPS in MANET. According to the author, MANET is a constantly varying network topology in which consumption of energy rises as mobility rises, making it more difficult to attain high energy efficiency. The authors created an Energy Saving Geographic Routing Protocol (ESGRP) which uses GPS to get an effective routing with low energy cost. Huang et al. [16] examined DSR, TORA, and AODV, among other reactive routing protocols in MANET. Using several performance metrics such as Packet Delivery Ratio, End to End latency, and average throughput. The authors examined the above mentioned three protocols and also determined that AODV is best suitable protocol as compared to the other two protocols because of its low network traffic load than the other two protocols.

The hybrid routing protocol against reactive routing systems such as DSR and AODV has been compared by Pavithra and Babu [17]. The authors concluded that hybrid routing systems require less network latency and have a higher PDR than reactive routing strategies, and that hybrid routing protocols have a higher average throughput than reactive routing protocols with the help of the simulation tool OPNET modeler 14.5. Şen et al. [18] compares the complete end to end delay and network load, retransmission attempts and throughput of MANET routing protocols like AODV, GRP, OLSR and DSR. When compares to other protocol, the authors found that AODV and DSR performed better. With the comparison of other protocols, AODV and DSR have a higher throughput and a smaller delay. Yarinezhad and Azizi [19] investigated the performance of multiple geographic routing in high mobility protocols using performance measurements and the pros and demerits of these protocols were listed using these performance criteria. The numerous parameters involved in designing and choosing a routing protocol were discussed by the authors. Mahendra et al. [20] utilized real-time applications such as VoIP to compare the two reactive routing systems, AODV and DSR, on a MANET network. Using different QoS parameters, the author compared these two protocols. The authors concluded AODV protocol as a best suitable protocol for the routing of reactive protocol since it has the shortest delay and gives the better performance in dense populations of nodes. The Geo-cast routing protocols were explained by Pavithra and Babu [21] and their unique features like scalability, complexity of message, robustness and memory needs. The author suggested a temporary routing algorithm which is scheduled for Geo-cast routing in which routings of location-based employs both flooding and non-flooding network routing methods. The author finally concludes as in location-based flooding routing, the network maintains a multicast tree by employing two methods.

Thazeen et al. [22] compares the various kinds of geographic routing protocols like routing of location aided and routing of energy aware geographic on performance metrics that is end to end delay, utilization of energy with the help of the simulation tool NS2, pascket delivery ratio. When the topology varies dynamically and mobility is high, the authors determined that geographic routing provides a higher packet delivery ratio, better energy consumption, and longer network life than other protocols.

3. Factors Influence the Design of Wireless Sensor Networks

There is no fixed infrastructure in infrastructure-less or Ad-hoc networks. In this form of configuration, each node serves as both a router and a network host. MANET is a wireless network which does not have any infrastructure. Multi-hop routing, in mobile ad hoc networks, static network infrastructure is employed to offer network connectivity [2].

- Consequently, several factors exist that significantly influence the design of WSNs.
- This chapter describes the major factors including the hardware constraints, fault tolerance, scalability,

production costs, sensor network topology, transmission media; and power consumption.

- Hardware constraints: Processors, memory sizes, and other factors are all constrained.
- Fault tolerance: It is the ability to keep WSN operational without any sensor node failures.
- Scalability: The number of nodes in a sensor network ranges from a few hundred to the order of thousands and even an extreme value of millions.
- Production costs: Because the sensor network is made up of a large number of sensor nodes, the cost of each node determines the network's overall cost.
- Sensor network topology: Mobile or fixed nodes are possible. Any topology will require handling because the node density is high, sometimes as high as 20 nodes/m^3m^3.
- Operating environment: Typically, sensor nodes are deployed unattended.
- Transmission media: In a multi-hop sensor network, a wireless medium is deployed to connect the communicating nodes. These connections are made using radio, infrared, or optical media. To enable global operation, the medium should be chosen so that it is available worldwide.
- Power consumption: Power consumption is divided into three parts; sensing power, communication power, processing power.

4. Review of Location-Based Geographic Routing Protocols

The cooperative localization was described by Tarantilis et al. [23]. In the domain of wireless sensor networks, measurement-based models such as Angle of Arrival (AOA), Time of arrival (TOA), and received signal strength (RSS) are described. The Cramer-Rao bound (CRB) on location estimation precision can be calculated using these models. Researchers can use it to choose measuring methods and assess localization techniques. For geographical routing algorithms, sensor position information is particularly useful. Sometimes the data that needs to be detected is the place itself. The authors proposed an alternate strategy involving the use of pricey and energy-intensive global positioning systems (GPS). They advocated that a minimal number of sensors, called reference nodes, be chosen. GPS devices are used to obtain the coordinates of these reference nodes, and the remaining on unknown location nodes can obtain their coordinates on their own. Positioning mechanisms similar to those used in cellular mobile stations (MS) and wireless local area networks (WLAN) could be employed here. Animal tracking is the finest application they've presented so far. Low transmission powers from animal tags are enabled by using multi hop location data across the sensor network. Logistics is another attractive application. The high cost is reduced by deploying sensor nodes in an office building and making these sensors wireless. The automatic location of these sensors adds to the automation.

Menaga et al. [24] highlights about different routing protocols and simulation techniques for determining the ideal routing protocol. AODV and DSDV are investigated, with DSDV emerging as the best option for this simulation Network Simulator. According to the report, determining the ideal simulator is entirely dependent on the research goal.

Yang [25] demonstrate how AODV can be used in wireless sensor networks. This work is motivated by the requirement for a basic implementation of a routing protocol for a small system. Sensor networks are made up of small objects with a sensor or actuator, a tiny microprocessor, a communication device, and a power source. The fundamental benefit of such a system is that it does not require any kind of operation system.

The optimization challenges of the AODV Routing Protocol are discussed by Meijerink et al. [26]. A backup table is created if the node movement speed is less than the threshold value. The average delay throughput and routing load are reduced with this strategy. It also increases the network's capacity. Traditional AODV does not take into account the network's present load. Congestion occurs as a result of this. Based on node mobility, AODV has been improved. To determine whether or not to join a backup routing table, a threshold value V is used. It lowers the network's flooding RREQ.

Lima et al. [27] compares the protocols AODV, DSR, and DSDV. Various sensor network scenarios are employed. As a performance matrix, packet delivery ratio, throughput, end-to-end delay, and normalized routing load are employed. The findings reveal that DSDV performs better in dense networks or networks with stringent time constraints. Smaller networks benefit from DSR. AODV is preferred in networks with high throughputs and low loss environments.

5. Geographic Routing Protocol (GRP) - Analysis & Discussions

Geographic Routing Protocol (GRP) and methods of geographic were discussed in the previous section. For information sharing, the protocol of GRP routing employs the method of geographic routing [28]. To overcome the restrictions of topology-based routing, position-based or geographic routing is utilized. Because packets are delivered to their destination with consideration to their position, it provides superior performance in dynamic topologies. Each node finds its own position, and multiple positioning systems, including as GPS and GPRS, are utilized to determine the position of the network node. Geographic routing protocols does not require to build up and balance the connections when they use the concept of position-based routing. The nodes in hybrid routing does not require to store routing tables or keep them up to date in order to transmit data. It just finds the target node's location in the network and sends the data from the beginning point to the destination [29-31]. This protocol uses the target's site information and one-hop neighbors to transmit data. Greedy Forwarding and Face-2 Routing Perimeter are the two types of common forward algorithms used in the hybrid routing to communicate data as shown in Figure 4.

The sender is capable of knowing the estimated location in the receiving node of Greedy forwarding mechanism. The message is passed to the receiving node's nearest neighbor. The positioning technique, i.e., GPS, collects the message [32-34]. The data is received in between the node, which is two faced in a direction of the receiver nodes. This cycle is repeated until the data reaches the reception node. Each and every node in the network will have its own table in which it keeps track of its own location. The most difficult aspect of greedy forwarding is determining which accurate neighbor node to deliver data to. Different routing algorithms are employed in the selection of the neighbor node. In greedy forwarding, several routing algorithms are used, which are described in the parameters of space, development and direction towards recipient node. Most Forwarded Within R (MFR), Nearest with Forwarded Progress (NFP), and Compass Routing are three alternative routing algorithms used in greedy routing. A node can choose from the many ways to determine which neighbor node the packet should be routed to. Figure 4 illustrates these approaches.

Figure 5 shows the sender can use a variety of ways to send data from a source to target with S donating the source node and D donating the target node. The overall maximum range of S is shown by the rounded area with r. The primary aim is to transfer data from S to node that is nearest to D. From the provided example, this node might be node C, which is nearest to the target node within the coverage region of a node D. This method is called as Most Forwarded Within R (MFR), and it aims to reduce the number of hops used to transfer data from S to D. MFR is usually employed in situations where the packet will not modify the strength of signal for the communication among S and D. A third technique, namely nearest with Forwarded Progress is adopted in which the packet adjusts or adapts its signal intensity (NFP). The communication is sent to the sender's closest neighbor who lives nearest to the destination in NFP. That node is A in the example given. When all nodes use the NFP approach, there is a significant reduction in packet collisions during transmission [35, 36]. Compass Routing is a routing in which the sender node chooses the neighbor nearest to the straight line among Source and Destination, is another greedy forwarding strategy. The compass routing node in the figure is node B. This routing approach is designed to reduce the distance between the packet's source and destination. When the packet arrives at a node where the greedy forwarding routing technique fails to find a neighbor node that is close to the destination, the second way of hybrid routing, Face-2 routing is utilized to determine the destination address. Figure 6 depicts the greedy routing problem.

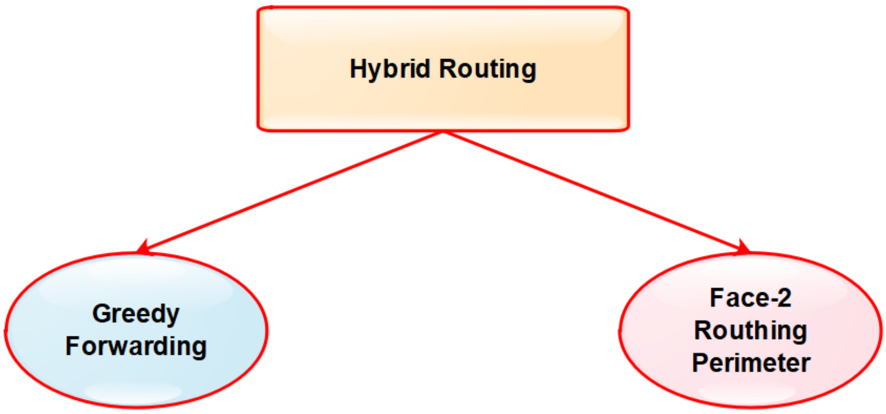

Figure 4. Types of hybrid routing

The radius of the distance between S and D is shown by the half circle around D, and the range of the S is shown by the circle around S. We can see from the diagram that S and D do not have a direct connection, hence greedy forwarding fails here. The Perimeter Method, also known as the Face-2 Algorithm, is used to escape the limitations of greedy forwarding systems. If any of the nodes cannot locate the forward way, the packet is then forwarded to a node with the least amount of backward outcome. However, the problem of looping packets occurs with this method, which does not arise while forwarding packets to their destination with good outcome [37-39]. The face-2 approach is based on the traversal of the planner graph, which eliminates the requirement for a node to store any extra or inadequate data. When the packet comes closer to the destination, it enters the greedy forwarding mode, after which it enters the improvement mode.

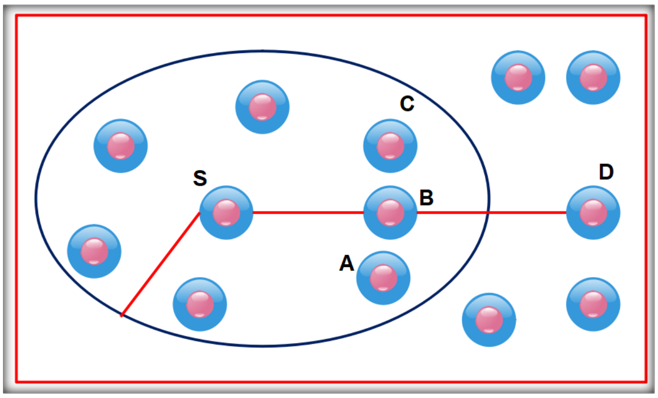

Figure 5. Strategies of greedy routing

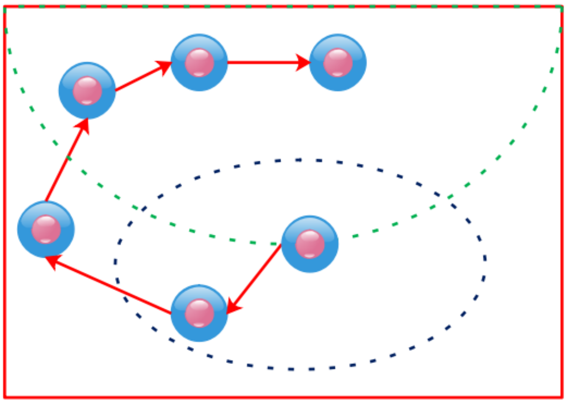

Figure 6. Failure of greedy routing

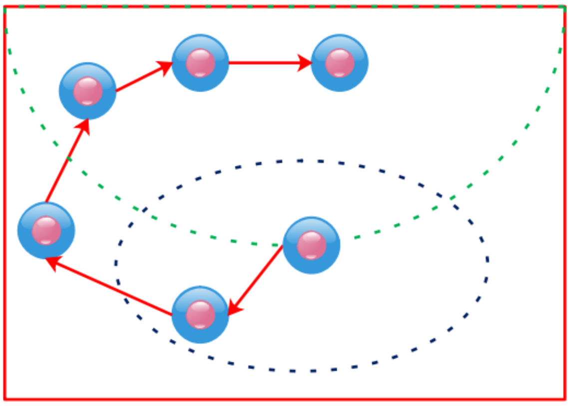

Figure 7. Traversal of planner graph

The traversal of the planner graph is shown in Figure 7. Graphs having no intersecting perimeters are known as planner graphs. The data is transported to an ad hoc network, in which the nodes are arranged in vertices and the perimeter exists in between the two vertices if they are close enough to transfer directly with each other. The packet is advanced down the Centre of the face by applying the rule of right-hand and the packet on the next hop had been carried out by counter clockwise from the perimeter on which it arrived in the planner graph traversal. The perimeter through which a packet must be transported is intersected by the line which is drawn between the source S and the destination D [40, 41]. If this intersection is close to where you want to go, you'll come across the other one.

Authors have carried out VANET efficiency analysis with respect to end-to-end communication, packet delivery ratio and throughput using various methods. The results are estimated and tabulated in Tables 1, 2 and 3 respectively. Figure 8 shows the various methods of end-to-end delay in WSN with respect to the vehicle (node) velocity of 40Km/h [42-46]. Figure 9 shows the comparison analysis of various techniques of PDR with respect to the vehicle velocity 40Km/h and Figure 10 shows the throughput analysis of various techniques with respect to the number of nodes.

Table 1. Comparison analysis of various methods on End-to-End delay with respect to 40Km/h

Time (s), Speed = 40Km/h	End-to-End Delay (s) QAGR	UVAR	ARPRL	AODV	GPSR
30	2.4	0.48	3.1	4.6	0.3
60	1	0.399	2.8	4.2	0.4
90	0.48	0.48	1.8	4.1	0.3
120	0.4	0.4	0.4	4.3	0.4
150	0.4	0.4	0.4	4.3	0.3

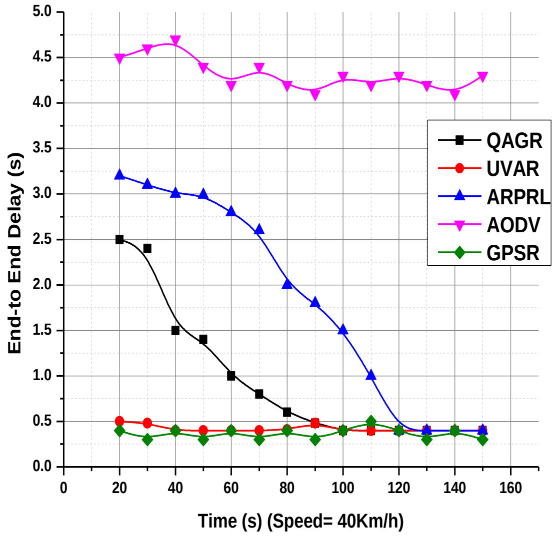

Figure 8. Comparison analysis end to end delay in wireless sensor network

Table 2. Comparison analysis of various methods on Packet delivery ratio (PDR) with respect to 40Km/h

Time (s), Speed = 40Km/h	Packet delivery ratio (PDR) QAGR	UVAR	ARPRL	AODV	GPSR
30	0.86	0.84	0.42	0.41	0.31
60	0.9	0.8	0.5	0.42	0.31
90	0.9	0.89	0.55	0.42	0.31
120	0.91	0.84	0.61	0.43	0.32
150	0.9	0.839	0.62	0.43	0.31

Table 3. Comparison analysis of various techniques throughput with respect to number of nodes

Number of nodes	Throughput (%) ExOR	TCOR	EEOR	ERTO
40	0.18	0.25	0.265	0.32
60	0.17	0.254	0.268	0.354
80	0.16	0.259	0.27	0.38
100	0.15	0.262	0.273	0.39
120	0.146	0.267	0.275	0.4

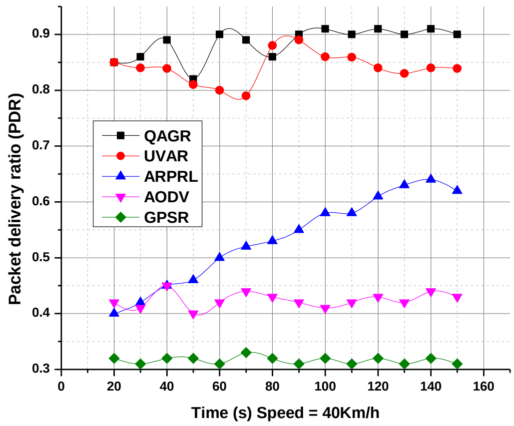

Figure 9. Comparison analysis packet delivery ratio (PDR) in wireless sensor network

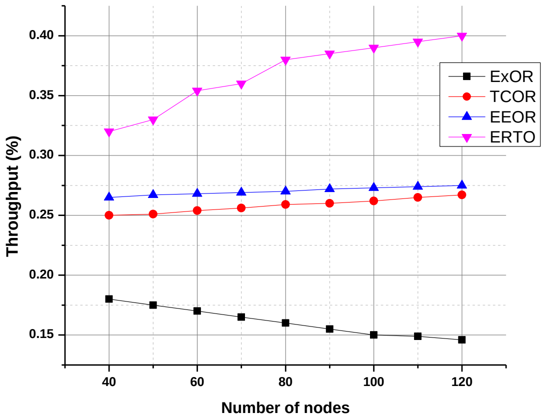

Figure 10. Comparison analysis throughput of various methods in wireless sensor network

6. Conclusion

In this paper, a survey has been carried out on the geographic routing protocols (GRP) in wireless sensor network. A comparison analysis has been done on various parameters of GRP on the basis of node position, storage capacity of topology and many more standard criteria. In this paper the routing maintenance table has also been discussed, it has been created on the basis of GRP schemes such as greedy forwarding and Face-2 routing strategies. In analysis on various schemes and topological networks organization, a conclusion has been obtained on the routing strategies. It is very helpful to select better neighbor nodes for multipath communication and also for planning of graph transversal.

Data Availability

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

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Conflicts of Interest

The authors declare that they have no conflicts of interest.

References

[1] A. Srivastava, D. Kumar, and S. C. Gupta, “Geographic and reactive routing protocols for MANET,” In 2013 European Modelling Symposium, Manchester, UK, November 20-22, 2013, IEEE, pp. 590-594. https://doi.org/10.1109/EMS.2013.98.

[2] Q. Li, "Link quality aware geographical routing in hybrid cognitive radio mesh networks," In 21st IEEE International Conference on Network Protocols, (ICNP), Goettingen, Germany, October 07-10, 2013, IEEE, pp. 1-3. https://dx.doi.org/10.1109/ICNP.2013.6733650.

[3] A. Arshad, Z. M. Hanapi, S. K. Subramaniam, and R. Latip, "Performance evaluation of the geographic routing protocols scalability," In 2019 International Conference on Information Networking, (ICOIN), Kuala Lumpur, Malaysia, January 09-11, 2019, IEEE, pp. 396-398. https://dx.doi.org/10.1109/ICOIN.2019.8718178.

[4] H. Kaur and Meenakshi, "Analysis of VANET geographic routing protocols on real city map," In 2nd IEEE International Conference on Recent Trends in Electronics, Information & Communication Technology, (RTEICT), Bangalore, India, May 19-20, 2017, IEEE, pp. 895-899. https://dx.doi.org/10.1109/RTEICT.2017.8256727.

[5] G. C. Şerban, A. D. Dumitru, A. Marinescu, C. Dobre, and V. Cristea, "Routing protocol for urban mobile networks based on geographical location," In Proceedings of the 2010 IEEE 6th International Conference on Intelligent Computer Communication and Processing, Cluj-Napoca, Romania, August 26-28, 2010, IEEE, pp. 479-482. https://dx.doi.org/10.1109/ICCP.2010.5606394.

[6] A. Revathi and N. Malathy, "VAGR — Void aware in geographic routing for wireless sensor networks," In 2016 10th International Conference on Intelligent Systems and Control, (ISCO), Coimbatore, India, January 07-08, 2016, IEEE, pp. 1-6. https://dx.doi.org/10.1109/ISCO.2016.7727095.

[7] S. Mallikarjunaswamy, N. Sharmila, D. Maheshkumar, M. Komala, and H. N. Mahendra, “Implementation of an effective hybrid model for islanded microgrid energy management,” *Indian J. Sci. Technol*., vol. 13, no. 27, pp. 2733-2746, 2020. https://dx.doi.org/10.17485/ijst/v13i27.982.

[8] A. R. Deshmukh, S. A. Dhawale, and S. S. Dorle, "Analysis of cluster based routing protocol (CBRP) for vehicular Adhoc network (VANet) in real geographic scenario," In 2020 IEEE International Conference on Electronics, Computing and Communication Technologies, (CONECCT), Bangalore, India, July 02-04, 2020, IEEE, pp. 1-5. https://dx.doi.org/10.1109/CONECCT50063.2020.9198669.

[9] Z. Y. Li, "Geographic routing protocol and simulation," In 2009 Second International Workshop on Computer Science and Engineering, Qingdao, China, October 28-30, 2009, IEEE, pp. 404-407. https://dx.doi.org/10.1109/WCSE.2009.840.

[10] Y. L. Guo, Q. P. Wang, H. Huang, W. Tan, and G. X. Zhang, "The research and design of routing protocols of wireless sensor network in coal mine data acquisition," In 2007 International Conference on Information Acquisition, Seogwipo, South Korea, July 08-11, 2007, IEEE, pp. 25-28. https://dx.doi.org/10.1109/ICIA.2007.4295690.

[11] M. A. Koulali, A. Kobbane, M. Elkoutbi, and M. Azizi, "A QoS-geographic and energy aware routing protocol for Wireless Sensor Networks," In 2010 5th International Symposium on I/V Communications and Mobile Network, Rabat, Morocco, September 30 - October 02, 2010, IEEE, pp. 1-4. https://dx.doi.org/10.1109/ISVC.2010.5656191.

[12] J. L. Lin and G. S. Kuo, "A novel location-fault-tolerant geographic routing scheme for wireless Ad Hoc networks," In 2006 IEEE 63rd Vehicular Technology Conference, Melbourne, VIC, Australia, May 07-10, 2006, IEEE, pp. 1092-1096. https://dx.doi.org/10.1109/VETECS.2006.1683003.

[13] K. Shashi Raj, G. K. Siddesh, S. Mallikarjunaswamy, and K. Vivek Raj, “Interference resilient stochastic prediction based dynamic resource allocation model for cognitive MANETs,” *Indian J. Sci. Technol*., vol. 13, no. 41, pp. 4332-4350, 2020. https://doi.org/10.17485/IJST/v13i41.687.

[14] T. J. Raval and J. S. Shah, "Network density based analysis of Geographic Routing Protocol for random mobility of nodes in MANET," In 2011 International Conference on Emerging Trends in Networks and Computer Communications, (ETNCC), Udaipur, India, April 22-24, 2011, IEEE, pp. 282-286. https://dx.doi.org/10.1109/ETNCC.2011.6255905.

[15] E. G. D. P. Raj, S. SelvaKumar, and J. R. Lekha, "LBRP: Geographic routing protocols for MANETs," In 2011 International Conference on Recent Trends in Information Technology, (ICRTIT), Chennai, India, June 03-05, 2011, IEEE, pp. 318-323. https://dx.doi.org/10.1109/ICRTIT.2011.5972470.

[16] H. J. Huang, H. Yin, G. Y. Min, J. B. Zhang, Y. L. Wu, and X. Zhang, "Energy-aware dual-path geographic routing to bypass routing holes in wireless sensor networks," *IEEE T. Mobile Comput.*, vol. 17, no. 6, pp. 1339-1352, 2017. https://dx.doi.org/10.1109/TMC.2017.2771424.

[17] G. S. Pavithra and N. V. Babu, “Energy efficient hierarchical clustering using HACOPSO in wireless sensor networks,” *Int J. Innov Technol. Exploring Eng*., vol. 8, no. 12, pp. 5219-5225, 2019. https://doi.org/10.35940/ijitee.l2789.1081219.

[18] S. S. Şen, M. Cicioğlu, and A. Çalhan, "IoT-based GPS assisted surveillance system with inter-WBAN geographic routing for pandemic situations," *J. Biomed. Inform.*, vol. 116, Article ID: 103731, 2021. https://doi.org/10.1016/j.jbi.2021.103731.
[19] R. Yarinezhad and S. Azizi, "An energy-efficient routing protocol for the Internet of Things networks based on geographical location and link quality," Computer Networks, vol. 193, pp. 1-13, 2011. https://doi.org/10.1016/j.comnet.2021.108116.
[20] H. N. Mahendra, S. Mallikarjunaswamy, V. Rekha, V. Puspalatha, and N. Sharmila, "Performance analysis of different classifier for remote sensing application," *Int J. Eng. Adv. Technol.*, vol. 9, pp. 7153-7158, 2019. http://dx.doi.org/10.35940/ijeat.A1879.109119.
[21] G. S. Pavithra and N. V. Babu, "An optimal energy utilization of cluster routing protocol for wireless sensor network in restricted area," *Indian J. Sci. Technol.*, vol. 14, no. 22, pp. 1813-1828, 2021. https://doi.org/10.17485/IJST/v14i22.671.
[22] S. Thazeen, S. Mallikarjunaswamy, G. K. Siddesh, and N. Sharmila, "Conventional and subspace algorithms for mobile source detection and radiation formation," *Traitement du Signal*, vol. 38, no. 1, pp. 135-145, 2021. https://doi.org/10.18280/ts.380114.
[23] C. D. Tarantilis, D. Diakoulaki, and C. T. Kiranoudis, "Combination of geographical information system and efficient routing algorithms for real life distribution operations," *EUR. J. Oper. Res.*, vol. 152, no. 2, pp. 437-453, 2004. https://doi.org/10.1016/S0377-2217(03)00035-3.
[24] S. Menaga, J. Paruvathavardhini, S. Pragaspathy, R. Dhanapal, and D. Jebakumar Immanuel, "An efficient biometric based authenticated geographic opportunistic routing for IoT applications using secure wireless sensor network," *Mater. Today, Proc.*, pp. 1-8, 2021. https://doi.org/10.1016/j.matpr.2021.01.241.
[25] J. J. Yang, "An ellipse-guided routing algorithm in wireless sensor networks," *Digit. Commun. Netw.*, vol. 8, no. 5, pp. 770-777, 2021. https://doi.org/10.1016/j.dcan.2021.08.005.
[26] B. Meijerink, M. Baratchi, and G. Heijenk, "Design & analysis of a distributed routing algorithm towards Internet-wide geocast," *Comput. Commun.*, vol. 146, pp. 201-218, 2019. https://doi.org/10.1016/j.comcom.2019.07.025.
[27] M. M. Lima, H. A. B. F. Oliveira, D. L. Guidoni, and A. A. F. Loureiro, "Geographic routing and hole bypass using long range sinks for wireless sensor networks," *Ad Hoc Netw.*, vol. 67, pp. 1-10, 2017. https://doi.org/10.1016/j.adhoc.2017.08.010.
[28] S. Chaitra, V. Rekha, G. K. Siddesh, M. Komala, and N. Sharmila, "A comprehensive review of parallel concatenation of LDPC code techniques," *Indian J. Sci. Technol.*, vol. 14, no. 5, pp. 432-444, 2021. https://doi.org/10.17485/IJST/v13i20.459.
[29] S. Du, J. J. Hou, S. J. Song, Y. F. Song, and Y. X. Zhu, "A geographical hierarchy greedy routing strategy for vehicular big data communications over millimeter wave," *Phys. Commun.*, vol. 40, pp. 1-9, 2020. https://doi.org/10.1016/j.phycom.2020.101065.
[30] X. Pang, M. Liu, Z. C. Li, B. Gao, and X. B. Guo, "Geographic position based hopless opportunistic routing for UAV networks," *Ad Hoc Netw.*, vol. 120, pp. 1-14, 2021. https://doi.org/10.1016/j.adhoc.2021.102560.
[31] R. Shivaji, K. R. Nataraj, S. Mallikarjunaswamy, and K. R. Rekha, "Design and implementation of reconfigurable DCT based adaptive PST techniques in OFDM communication system using interleaver encoder," *Indian J. Sci. Technol.*, vol. 13, no. 29, pp. 3008-3020, 2020. https://doi.org/10.17485/IJST/v13i29.976.
[32] M. L. Umashankar, S. Mallikarjunaswamy, and M. V. Ramakrishna, "Design of high speed reconfigurable distributed life time efficient routing algorithm in wireless sensor network," *J. Comput. Theor. Nanos.*, vol. 17, no. 9-10, pp. 3860-3866, 2020. https://dx.doi.org/10.1166/jctn.2020.8975.
[33] M. L. Umashankar, M. V. Ramakrishna, and S. Mallikarjunaswamy, "Design of high speed reconfigurable deployment intelligent genetic algorithm in maximum coverage wireless sensor network," In 2019 International Conference on Data Science and Communication, (IconDSC), Bangalore, India, March 01-02, 2019, IEEE. https://doi.org/10.1109/IconDSC.2019.8816930.
[34] P. Satish, M. Srikantaswamy, and N. Ramaswamy, "A comprehensive review of blind deconvolution techniques for image deblurring," *Traitement du Signal*, vol. 37, no. 3, pp. 527-539, 2020. https://dx.doi.org/10.18280/ts.370321.
[35] T. A. Madhu, M. Komala, V. Rekha, S. Mallikarjunaswamy, N. Sharmila, and S. Pooja, "Design of fuzzy logic controlled hybrid model for the control of voltage and frequency in microgrid," *Indian J. Sci. Technol.*, vol. 13, no. 35, pp. 3612-3629, 2020. https://doi.org/10.17485/IJST/v13i35.1510.
[36] H. N. Mahendra, S. Mallikarjunaswamy, G. K. Siddesh, M. Komala, and N. Sharmila, "Evolution of real-time onboard processing and classification of remotely sensed data," *Indian J. Sci. Technol.*, vol. 13, no. 20, pp. 2010-2020, 2020. https://doi.org/10.17485/IJST/v13i20.459.
[37] S. Mallikarjunaswamy, K. R. Nataraj, P. Balachandra, and N. Sharmila, "Design of high speed reconfigurable coprocessor for interleaver and de-interleaver operations," *J. Imp. F.*, vol. 6, no. 1, pp. 30-38, 2015.

[38] F. Z. Bousbaa, C. A. Kerrache, Z. Mahi, and A. El Karim Tahari, “GeoUAVs: A new geocast routing protocol for fleet of UAVs,” *Comput. Commun*., vol. 149, pp. 259-269, 2020. https://doi.org/10.1016/j.comcom.2019.10.026.
[39] M. Won, W. Zhang, C. A. Chen, and R. Stoleru, “GROLL: Geographic routing for low power and lossy IoT networks,” *Internet of Things*, vol. 9, pp. 1-31, 2020. https://doi.org/10.1016/j.iot.2019.100152.
[40] T. Darwish, K. A. Bakar, and A. Hashim, “Green geographical routing in vehicular ad hoc networks: Advances and challenges,” *Comput. Electr. Eng*., vol. 64, pp. 436-449, 2017. https://doi.org/10.1016/j.compeleceng.2016.09.030.
[41] K. Shafiee and V. C. M. Leung, “Connectivity-aware minimum-delay geographic routing with vehicle tracking in VANETs,” *Ad Hoc Netw*., vol. 9, no. 2, pp. 131-141, 2011. https://doi.org/10.1016/j.adhoc.2010.06.003.
[42] M. Boulaiche and L. Bouallouche-Medjkoune, “HSecGR: Highly secure geographic routing,” *J. Netw. Comput. Appl*., vol. 80, pp. 189-199, 2017. https://doi.org/10.1016/j.jnca.2016.12.028.
[43] P. M. B. Muddumadappa, S. D. K. Anjanappa, and M. Srikantaswamy, "An efficient reconfigurable cryptographic model for dynamic and secure unstructured data sharing in multi-cloud storage server," *J. Intell Syst. Control.*, vol. 1, no. 1, pp. 68-78, 2022. https://doi.org/10.56578/jisc010107.
[44] S. Thazeen, S. Mallikarjunaswamy, and M. N. Saqhib, "Septennial adaptive beamforming algorithm," In 2022 International Conference on Smart Information Systems and Technologies, (SIST), Nur-Sultan, Kazakhstan, April 28-30, 2022, IEEE, pp. 1-4, 2022. https://doi.org/10.1109/SIST54437.2022.9945753.
[45] S. Thazeen, M. S, M. N. Saqhib, and N. Sharmila, "DOA method with reduced bias and side lobe suppression," In 2022 International Conference on Communication, Computing and Internet of Things, (IC3IoT), Chennai, India, March 10-11, 2022, IEEE, pp. 1-6. https://doi.org/10.1109/IC3IOT53935.2022.9767996.
[46] H. N. Mahendra, S. Mallikarjunaswamy, C. B. Nooli, M. Hrishikesh, N. Kruthik, and H. M. Vakkalanka, "Cloud based centralized smart cart and contactless billing system," In 2022 7th International Conference on Communication and Electronics Systems, (ICCES), Coimbatore, India, June 22-24, 2022, IEEE, pp. 820-826. https://doi.org/10.1109/ICCES54183.2022.9835856.