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A Survey on Geographical Routing Protocols in Wireless Sensor Networks

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Abstract—To extend a network's life time and improve network performance, various routing, transmission, security protocols and techniques are being introduced. A network's life time is determined by the energy levels of the sensors and the performance is determined by the quality transfer of data. Features like energy, throughput, security and time describe the network performance. Routing protocols ensure network connectivity and transmission of data. In a WSN network with large number of sensor nodes, ensuring connectivity and transmission is challenging as many nodes leave the network due to their energy levels. Geographical routing protocols are used to locate the senor's and find optimal path for transmission of data with respect to time, energy, efficiency and security. The optimal path is selected using the location of the sensors. This paper surveys on literatures related to geographical routing protocols and discuss its performance in improving network life time, energy consumption, packet delivery rate and network performance.

Keywords—*WSN Network, Geographical routing protocol, network performance, optimal route, Locate sensors, energy optimization*

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I. INTRODUCTION

Wireless Sensor Network finds a wide range of application in monitoring, security and management. WSN are deployed in traffic monitoring, agriculture, healthcare, climate, industrial automation and military services. WSN are deployed to sense, collect and transmit the data from the environment. WSN are capable of collecting information of the environment and the information is used to implement suitable operations. For example, a sensor data is used to trigger water irrigation system based on the soil temperature data collected by the senor's. The WSN topology is designed in such a way that the data collected by the senor's are transmitted to the sink and from sink the data is sent to the base station. While sensors transmitting data to the sink, sensor nodes consume more energy and with fewer transmission, the energy levels of sensors are completely drained. The energy depletion in sensors limits the network life time and the performance which does not guarantee data transmission. To improve the network lifetime and performance, various transmission protocols are designed to utilize low energy levels by reducing the distance between sink and nodes, involving lower number of nodes.

Multi-hop transmission involves sensors that forward the data to the nearest nodes and finally to the base station. In such transmission there is a transmission delay and also, energy depletion in nodes leads to dead end. Dead end is the point where nodes do not have neighbors to forward the data in a transmission. The presence of dead ends in a network does not complete data transmission and the transmission fails. Addressing dead ends in a network is an important problem in WSN as it causes data loss. To mitigate data loss, routing protocols need to find the optimal path with nodes that have neighbors to complete the transmission. Identifying nodes with neighbors could cause energy depletion and transmission delays.

Transmission of data using multi-hop might fail to reach the static sink due to dead ends. To avoid dead end problems mobile sink is used to collect the data from sensor nodes. Mobile sink is a moving sink which collects data from nodes through its mobility. To collect data from sensors, mobile sink needs to visit the nodes and in large WSN networks, this cause transmission delays (Xu & Liang, 2011). While using mobile sink, there is a need to find the optimal path to cover all the nodes (Rao & Biswas, 2008). Low Energy Adaptive Clustering Hierarchy (LEACH), Mobile Ubiquitous Local area network Extensions (MULE), Power Efficient Gathering in Sensor Information Systems (PEGASIS) and Virtual grid architecture routing (VGA) are some of the protocols developed for efficient transmission. Energy-efficient mobile sink routing algorithm (EEMSRA) (Yuan & Zhang, 2011), competitive clustering algorithm (Wang et al., 2012) and geometric model (Akbar et al., 2017), cluster head based model (Wang et al., 2017) and different data gathering methods (Kaswan et al., 2017; Wen et al.,

2017; Zhong et al., 2018; Zayoud et al., 2018) are introduced to address energy efficiency, optimal path and transmission.

Geographical routing protocol use location details of the node to derive optimal path. Using the location information, nodes find the corresponding neighbors and forward the data packers to its next neighbor and reach sink. Protocols developed using geographic location suffers from dead ends and periodic update of node location which consumes more energy. Also single hop is more efficient than multi hop transmission in geographic routing. Several geographic based routing algorithms are developed addressing hop count, geographic boundary, route optimization, energy efficient, network life time and performance.

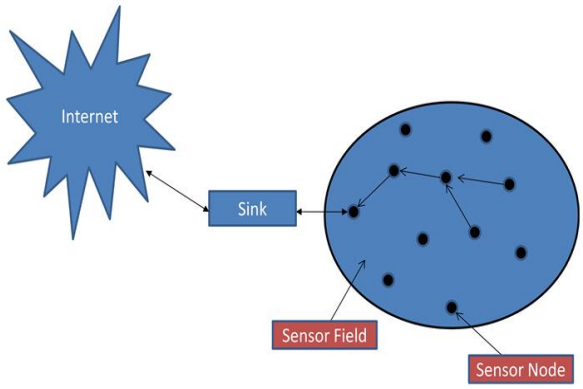

Fig 1 WSN Network

The following section discusses the recent literatures on geographical routing protocols and their performances in WSN. The last section concludes the paper.

II. LITREATURE REVIEW

(Hussein et al., 2022) proposed an efficient and intelligent routing protocol based on geography. The routing protocol is based on throughput and energy levels, where the shortest path to the sink is selected with respect to high throughput and high energy. The proposed routing algorithm reduces the delay and energy consumption increasing the network lifetime with low packet loss.

(Verma & Jain, 2022) proposed an efficient data collection method by sinks in WSN. The data aggregation in WSN is expensive when sinks are mobile and finding the nodes and collecting data from neighboring nodes has high time consumption. The proposed method identifies main visiting points in the network and allow sink to visit and collect the data from the neighboring nodes with low energy consumption. This method also improves the efficiency of data collection by minimizing the time delay.

(Redjimi et al., 2021) demonstrated a geographical routing protocol using neighborhood mechanism. The protocol aims to utilize the node position and directs the data packets to the sink with minimum energy consumption. The energy consumption is kept low when the routing path is optimized for shortest path. The shortest path is selected using information of the neighbors.

(Hameed, et al., 2020) proposed an energy efficient geographic routing protocol (EEG). Using mean square algorithm, the algorithm maintains single hop neighbor while routing. The proposed algorithm efficiently reduces energy consumption and network performance by decreasing dead ends. Estimation of mean square error on nodes improves the transmission path with higher energy nodes and closer to the destination node. The single neighbor node efficiently removes dead ends by choosing nodes that have optimal energy. The proposed routing algorithm improves network performance, Packet delivery rate and reduces energy consumption.

(Padmanaban & Muthukumarasamy, 2020) proposed EESCA-WR based on grid based technique to collect data. The proposed algorithm is energy efficient which use a clustering technique to select the grid leader. The grid leader collect data and forward to grid relay nodes. Grid leader and relay nodes are designed to reduce the distance between the nodes and to select the optimum path for transmission. The proposed routing protocol improves network life time, load balancing and reduces energy usage.

(Christopher & Jasper, 2020) proposed a routing protocol for privacy preservation and congestion mitigation using location based sensor nodes. The network topology is constructed using a virtual ring and a radial line. The nodes in the ring aggregates data and through nodes in radial, the data is forwarded to the mobile sink. The proposed routing protocol show high network life, energy efficient and reduces delay.

(Gbadouissa et al., 2020) proposed a clustering based on graph theory to improve energy optimization of sensor nodes in WSN. The proposed hyper graph clustering technique selects cluster head by the amount of energy consumed and the geographical position of the sensors. The details of the CH on energy levels, distance

and location are stored in a table and are update for every round of transmission. The simulation of HGC algorithm show low energy consumption.

(Jain et al., 2019) proposed a query driven routing protocol in WSN. Using a virtual wheel, angel based forwarding algorithm and packet forwarding technique the data is forwarded to the mobile sink. Initially the sink sends queries to the nodes and nodes forward the data to the sink. Since sink is mobile, the location of the sink has to be determined for each transmission. The proposed method eliminates the energy loss in finding sink location and improves energy efficiency with high data delivery rate and low delay time.

(Maurya et al., 2019) proposed a delay aware efficient routing protocol (DA-EERR) for heterogeneous environment. Mobile sink and heterogeneous network have high energy consumption, congestion, transmission loss and to overcome this, the proposed algorithm use restricted search space. Inside the search space, optimum path is selected with single hop neighbors and the data is transmitted to the sink. The proposed method show better results in reducing data loss, reducing energy consumption and avoid congestion.

(Almesaeed & Jedidi, 2020) proposed a routing protocol for mobile WSN and static sink. Capturing the location of nodes in the optimal path, the data is transmitted to the sink. The dynamic directional routing method uses a pie shaped region to establish a path to the base station. The locations of the nodes in the pie shaped region are selected using a search angle to find the next neighbor. The dynamic directional routing method improves network life time, PDR and optimal path.

(Yarinezhad, 2019) proposed a routing protocol for WSN with mobile sink. The mobility of the sink increases the energy consumption to locate the position of the mobile sink. Using a multi ring shaped region, the protocol address the sink location. Inside each ring, the data collector nodes are placed to aggregate the sensor data and through the collector nodes in each ring, the path to sink is constructed. The position of the sink is shared to its nearest neighbor from each ring and the data is sent to the mobile sink. The proposed algorithm show less energy consumption and better network performance.

(Hong et al., 2016) proposed a hybrid approach based on geographical routing. The hybrid beacon less approach is a reactive model where the forwarding nodes are selected based on two mechanisms. The hybrid model use contention channels to derive priority of the data packets. The forwarding agents are selected based on the distance to the sink. Using circle arcs around the sink the, the forwarding agents that are closer to the sink are used for transmission.

(Ghaderi et al., 2020) proposed geographic adaptive fidelity routing protocol with data gathering mechanism. Compressive data gathering method is used to collect information from the nodes and fuzzy logic is applied to select the forwarding agents. Initially the network is region is divided into hexagonal cells and the forwarding agents while transmitting data to the sink checks for two conditions. If the distance to the sink and the agent is lesser then the packet is forwarded directly to the sink otherwise the data is forwarded to the next neighbor. The proposed hybrid model show better results on network lifetime and energy consumption.

(Kumar & Kumar, 2019) proposed a location aware routing method for WSN (LARCMS). The routing is designed using tow mobile sinks. Initially the location aware nodes are selected from the normal nodes and two mobile sinks mobility is controlled in a style that when one reaches the end of the network, the second sink moves to the center of the network. This controlled movement of sinks allows location aware nodes to capture the location of the sinks that is closer. Sink with a shortest distance to the source node is selected to forward the message. The proposed method improves Network performance and transmission delays. Also using two mobile sinks avoid dead end problems.

(Wang et al., 2019) proposed an efficient routing protocol for WSN using mobile sink. The method uses clustering technique to find nodes with higher energy levels. The higher energy nodes are the cluster head which aggregate the data from its neighboring nodes. Initially the network is divided into number of sectors in which the nodes are assigned to each sector based on their location data. Sink select it relay cluster head close to it and other cluster head transmit data to the relay node. The advantage of the mobile sink is that it sends to cluster head sector it resides currently. The performance of the model shows better performance in terms of energy consumption and network life time.

(Lee et al., 2018) proposed a data dissemination method WSN with mobile sink in groups. The proposed method classifies the mobility of the sinks and use node locations to forward data. The data transfer is done using one hop movement using grid patterns of the network. Closed grid and open grid methods are studied to assess the performance of the network. The sink collects the data from the sensor nodes while it moves close to the nodes. The energy management is achieved thorough maintaining local data on each node in the local area. The performance of the model show low energy consumption and high delivery rate.

(Tabatabaei & Rigi, 2019) proposed a routing algorithm using clustering technique and mobile sink. The nodes position and energy levels are used to cluster in the proposed method. Generally, a node with maximum energy inside a cluster is selected as cluster head but in this work, the distance to sink is also estimated to define the cluster head. The node with shortest distance to the sink and with maximum energy is chosen as cluster head. Whenever a cluster head dies, the corresponding node with maximum energy is replaced. Once the data collection

is done, cluster head send message to sink to receive and the sink moves to the location where cluster head energy is low and collects the data in single or two hop counts. The proposed method show improved network performance and energy consumption.

(Mitra & Sharma, 2018) proposed a routing algorithm based on hierarchical routing scheme by optimizing path. The proposed model builds a grid structure and transfers data to the sink. The nodes in the network transfer data to the grid head and the grid head transmits the data to the sink. The path to the sink is built by minimum hop counts which achieved best routing of data and reduces energy consumption.

(Su & Zhao, 2018) proposed a clustering mechanism for routing in WSN to reduce the energy consumption. The network is split into clusters based on the density of the nodes with respect to location. The CH membership is made through energy levels and apply Fuzzy C-means algorithm, the cluster numbers are created. Using hop count neighbors the communication is established with the sink. Single hop communication is used nodes inside the cluster and multi hop communication is used to reach sink. The proposed method improves network life time and reduces energy consumption.

(Ghosh et al., 2017) proposed a geographical routing algorithm using Moore cure trajectory. The network is aligned into a grid structure and the sink moves in the said trajectory. The forwarding of data packets is achieved through sleep-awake pattern of the nodes. The routing of data packets through single hop count is achieved through the trajectory movement of the sink and further communication between sink and sensors are not required since sink knows the position of the sensors while moving. However the data transmission does not guarantee shortest path in this method. The proposed method improves network life time and low energy utilization.

(Tazeen & Sharma, 2017) introduced a grid based routing protocol with minimum of packets in the path. Based on the transmission range, a virtual grid is constructed for the nodes in the network. The grid head is selected based on the energy levels and the other grid members acknowledge. The energy management is achieved through switching the state of the head between awake and sleep. While a grid head is in sleep mode, other members with active state are filtered and chosen as grid head. The sink finds the grid head that is closer and satisfies minimum hop count and set as relay nodes. The relay grid nodes collectively form's a path to the sink and the data is transmitted to the sink with minimum hop count. The proposed method achieves energy efficiency of network.

(Soni & Mallick, 2017) proposed a fuzzy logic based geographical routing method. The proposed method use fuzzy logic based on GAF protocol using hexagonal grid structure. The network is converted into hexagonal grid and using fuzzy logic the amount of energy required for transmission is estimated and the nodes with high energy are selected. The transmission nodes are selected based on the geographical distance between the source and the sink. A weighting scheme is used to select the CH, node with highest weight becomes CH. Using the routing table, the status of energy levels and distance is updated. The proposed method improves energy efficiency and network life time.

(Wang et al, 2017) proposed a clustering based routing scheme with mobile sink. The proposed method is designed to improve the latency, life time and energy efficient. The initial energy of the sensors not considered instead the energy levels of the nodes after transmission is counted. Using PSO method, the sensors in the network are clustered. The cluster head is selected based on the energy levels and the distance to the sink. Sink visit cluster heads and collects the data. For every round of transmission, cluster heads are reassigned based on the energy levels and also at each transmission cluster head loses energy. The overall performance of the network improves with the virtual clustering using PSO in the proposed method.

(Deepa & Suguna, 2017) proposed a multipath QOS aware protocol for WSN. The proposed method use clustering technique to avoid dead end in the network. Using modified PSO algorithm, the sensor nodes are clustered. The multipath is constructed using SSAD method. The cluster heads are selected based on RSSI and the route is discovered which satisfies the QOS metrics constraining hop counts on the cluster head. Based on the distance to the sink and the cluster head, the data is transmitted. The proposed method show better results in terms of network performance, energy consumption and reliability.

(Abuarqoub et al., 2017) proposed an energy efficient management model to routing problems in WSN. The proposed work involves clustering technique to improve scalability and avoid more energy consumption. Using dynamic clustering technique, the mobile nodes are managed to form a path to sink in an energy efficient way. By clustering the sensors based on the service points. The energy expenditure is controlled. The proposed adaptive clustering technique improves network performance and energy consumption.

(Bhatia et al., 2016) proposed a routing scheme to improve the network life time. In the proposed work, the selection of CH is made through GA and the relay nodes are selected based on the distance function. The distance aware genetic algorithm (GADA) optimizes the energy levels by assigning a threshold for the energy levels as the fitness function. The fitness function improves the selection of CH based on the distance to the corresponding sensor nodes in the network and distance to the sink from CH. The performance study model improves network life time and low energy consumption.

(Das et al., 2015) proposed a coverage tree based routing algorithm for WSN. The proposed tree based routing scheme selects CH using minimum spanning tree and based on the distance of CH to the sink, the data is transmitted. However this model has two drawbacks, if there are more dead nodes then the packet forward fails and the density of the nodes cause distortion in paths selection through CH. The proposed method show better results compared to GPSR-PLAN and GPSR-PLAN-CLDP methods.

(Han & Lin, 2012) proposed a geographically routing protocol by creating network grid. The protocol largely relies on the geographical location of the sensor nodes. The large network is divided into smaller grids and the importance of distance and energy levels are update in the grid table. Based on the distance between the sink and the grids, a routing path is constructed satisfying one hop neighbor. Each grid with grid head creates a routing path. For every transmission, the starting grid is updated with respect to distance and energy levels. The data is finally sent to the sink. The proposed protocol improves network life time and packet delivery.

Table 1 Summary of Literatures discussed

Author	Year	Technique	Sink Type	Performances
Hussein et al.,	2022	SGFTEM	Static	Low energy consumption Sensor node lifetime Low packet loss
Verma & Jain	2022	Hamiltonian Cycle	Mobile	energy consumption lowers data collection time delay high throughput
Redjimi et al.	2021	Neighborhood mechanism	Static	Energy management Low packet loss Shortest path
Hameed, et al.,	2020	EEG-mean square error	Static	network performance, Packet delivery rate and reduces energy consumption
Padmanaban & Muthukumarasamy	2020	EESCA-WR-Clustering	Static	improves network life time, load balancing and reduces energy usage
Christopher & Jasper	2020	JDRP	Mobile	energy consumption, packet delivery delay and lifetime
Almesaeed & Jedidi	2020	Dynamic directional routing	Static	network life time, PDR and optimal path
Ghaderi et al.,	2020	geographic adaptive fidelity routing protocol	Static	network lifetime and energy consumption
Gbadouissa et al.,	2020	HGC algorithm	Static	Low energy consumption
Jain et al.,	2019	query driven routing protocol	Mobile	high data delivery rate and low delay time, energy efficient
Maurya et al.,	2019	DA-EERR	Mobile	reducing data loss, reducing energy consumption and avoid congestion
Yarinezhad	2019	Nested Routing algorithm-Virtual Ring	Mobile	less energy consumption and better network performance
Kumar & Kumar	2019	LARCMS	Mobile	improves Network performance and transmission delays, hot spot
Wang et al.,	2019	Clustering and sink mobility technology	Mobile	energy consumption and network life time
Tabatabaei & Rigi	2019	distributed clustering reliable routing protocol	Mobile	network performance and energy consumption
Lee et al.,	2018	active data dissemination protocol	Mobile	low energy consumption and high delivery rate
Mitra & Sharma	2018	virtual grid based hierarchical routing	Static	Optimal path and energy efficient
Su & Zhao	2018	Fuzzy C-means algorithm	Static	network life time and reduces energy consumption
Ghosh et al.,	2017	Moore cure trajectory	Mobile	network life time and low energy utilization
Tazeen & Sharma	2017	Mode-Switched Grid-based Routing (MSGR)	Mobile	energy efficient and load balancing
Soni & Mallick	2017	geographic adaptive fidelity (GAF) + fuzzy logic	Static	energy efficient and network life time
Wang et al,	2017	Clustering with PSO	Mobile	latency, life time and energy efficient
Deepa & Suguna	2017	multipath QOS aware	Static	network performance, energy consumption and reliability, dead end
Abuarqoub et al.,	2017	dynamic clustering technique	Static	network performance and energy consumption
Bhatia et al.,	2016	distance aware genetic algorithm (GADA)	Static	network life time and low energy consumption
Hong et al.,	2016	hybrid approach	Static	Optimal path and energy efficient
Das et al.,	2015	minimum spanning tree	Static	Optimal path
Han & Lin,	2012	geographically routing protocol - network grid	Static	network life time and packet delivery

III. CONCLUSION

The literature survey conducted on geographical routing protocols used in WSN show that location based routing plays an important role in improving network performance, reducing energy consumption, packet delivery ratio and hotspots. WSN are effectively employed for surveillance, health monitoring, traffic signaling, weather forecast, environment monitoring, industrial automation and location based services. The literature review conducted reveals that Geographical routing protocol are efficient in addressing problems related to network life time and energy optimization, removing delays, scalability, heterogeneous network and mobile network in WSN. Different clustering techniques, trajectory and routing mechanisms based on location show promising future to address the challenges in WSN.

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