EEVR: Improving Energy Efficiency in Wireless Sensor Networks Using Void Routing Algorithm

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Abstract

Wireless Sensor Networks (WSNs) have recently gained popularity owing to developments in ICT and electronics. A network of sensor nodes (SN) or motes carefully deployed in a specific area detects any continually changing physical phenomena. These petite SNs gather and evaluate data before sending it to a base station or sink via radio frequency (RF). The small size of these sensors enables easy integration into any device or setting. Greedy Forwarding (GF) is a lightweight and effective routing technique for WSNs frequently used in data monitoring. The network lifespan reduces the likelihood of encountering a routing vacuum without adding complexity to the protocol; the ideal method is to search for the optimum commutation radius, which puts the network in the best condition. This research proposes Greedy Routing-based Energy Efficient in WSN using void routing algorithm (EEVR) to attain the maximum energy efficiency during routing maintenance. EEVR method increases the lifetime of WSNs. The proposed EEVR is simulated using the NS2 Simulation tool with SN and deployment region. Performance measures for the EEVR include network energy, packet delivery ratio, network energy consumption, throughput, and communication overhead.

Keywords: WSN, EEVR, Greedy Routing, Void routing algorithm, Energy Efficient

Introduction

A Wireless Sensor Network (WSN) comprises multiple SNs that collect data and transmit it to a Base Station (BS). The energy constraint on SNs is regarded as one of the most difficult difficulties in WSNs since it reduces the network's lifespan. Numerous energy-efficiency-based solutions have been created to address the issue of energy scarcity [1].

Due to the scarcity of available resources in WSNs, the efficient design of localized routing protocols [2] becomes critical. How to ensure packet delivery is a critical challenge for localized routing algorithms. Greedy Forwarding (GF) is a well-known protocol [4] widely believed to be a better method with reduced routing overheads. However, the GF algorithm's avoid issue [8] will fail to ensure the delivery of data packets. As discussed and suggested in [9], numerous localized routing methods use planar graphs to tackle the void issue. Nonetheless, planar graphs have substantial drawbacks due to eliminating crucial communication linkages [10]. The two primary problems in WSNs are optimizing energy performance and increasing network longevity. WSNs are composed of many SNs, which have been built lately for various purposes. The volume, velocity, and diversity of data provided by the many SNs in densely dispersed WSNs are all large [11-15].

Geographic routing relies on location information rather than global topological information, which results in a highly basic and scalable routing technique. The source and intermediary node utilize location information to determine the nearest next-hop node. Consequently, packets are eagerly forwarded to reduce their distance to the destination until they reach it. This straightforward position-based routing technique is referred to as greedy routing (GR) [16-19].

Nodes in a greedy embedding [20] are assigned specific coordinates to assure delivery through GR. It was first shown that greedy embeddings exist for certain graphs. It was subsequently shown for graphs with arbitrarily coupled edges [21], [22]. The network's spanning tree is extracted with these approaches, and the hop distances are preserved. There is a lack of attention paid to the robustness of the coordinates in the state-of-the-art literature in geographic routing research [23-25]. As a result of topological dynamics, a change in the network's geometric coordinates may be problematic for other tiers of the network stack that utilize coordinates as addresses. An address resolution service, for example, may play a significant role in the maintenance of coordinates. This might be expensive and could jeopardize the quality of application services [26, 27].

The proposed routing method tackles three major issues in WSNs simultaneously: energy optimization, packet selection, and depletion of shortest pathways. Generally, the shortest route is used for packet transfer. Nonetheless, this technique results in a few nodes using their energy while the others are scarcely utilized, decreasing the WSN's coverage area and adversely compromising its performance and longevity.

The remainder of the sections is as follows. Section I provides an overview. Section II contains a review of the literature. The system model is discussed in Section III. Section IV contains simulations and an assessment of the outcomes. Finally, Section V brings this effort to a conclusion.

Background Study

Alabdali, A. M. et al. [1] The suggested scheme reduces and balances the energy consumption of the CHs, increases the lifetime of the network, and reduces waste. As part of the initial component of the framework, n-level clustering is introduced for CH clustering, which reduces energy consumption. The network's lifespan is extended as a result. Energy balancers were also employed in the second section, resulting in zero variance in the CHs' remaining energy and a decreased energy loss. Bojan, S., & Nikola, Z. [3] offer an evolutionary approach for minimizing transmission energy in WSNs. The authors demonstrated via 650,000 tests that energy efficiency may be accomplished with great accuracy, a little amount of memory space, or even a tiny number of computations when the evolutionary algorithm is adapted for the platform and aim at hand.

The writers discover that Devika, Nayak, M. et al. [5] WSNs are widely dispersed. The fuzzy c-mean and kmean clustering approaches provide superior results compared to the EM and K-CONID clustering techniques. As a result, fuzzy clustering algorithms perform better than conventional clustering methods. They are utilizing a Fuzzy clustering technique to reduce energy use significantly.

Escalante, L. D. S. [6] presented an energy-efficient GR method based on swarm intelligence for prolonging the lifespan of a WSN. The basic concept is to consider fewer hop numbers and choose nodes with lower pheromone concentration as next-hops to prevent certain nodes from exhausting their energy prematurely due to excessive usage of short routes, hence balancing global energy consumption.

Gu, Y. et al. [7] This study investigates and analyses the clustering issue for WSNs, and presents an energy-efficient hierarchical algorithm. Each layer of the network is uniformly split into clusters. Na, J et al. [13] The authors present Yet Another Greedy Routing (YAGR), a unique GR technique that builds on the concepts of potential-based gradient routing. The simulation findings show that YAGR is an appealing GR method that maintains the simplicity of original GR while outperforming GPSR in routing performance.

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Samarasinghe, K. et al. [15] The authors suggest Greedy Zone Routing (GZR), a novel routing technique for ad-hoc wireless networks that places a premium on resilience and scalability. The design premise relies on greedy geographic routing rather than on individual node routing at an abstract level.

Shivaji, S. S., & Patil, A. B. [17] developed and implemented an energy-efficient intrusion detection system (EEIDS). In EEIDS, the Bayesian technique is used to forecast the energy consumption of SNs.

Xin, Y. et al. [22] present a dynamic cluster-based routing protocol based on the greedy algorithm (GDCRP) that extends the life of the whole WSN. GDCRP employs dynamic clustering to determine the cluster head and rotate the cluster head based on the link between the life cycle of WSN and the energy of nodes.

Zhihui, H. [25] Because WSNs have limited capacity for node computation and restricted node power, energy efficiency and algorithm simplicity must be addressed while building WSN routing algorithms. Ant colony optimization features a perfect distribution, a high capacity for global optimization, and a simple method that is straightforward to implement as a heuristic search algorithm.

Description of the Problem

The nearby node, closer to the sink node, performs data forwarding duties frequently; its energy will eventually deplete. Consequently, the node without energy will route via the forward region's routing cavity, reducing the overall network's performance.

System Methodologies

A variety of unrealistic design assumptions hampers the implementation of most geographic routing algorithms. The EEVR method to designing minimizes the energy during the data transmission in wsn. The proposed architecture is as follows.

The block diagram of the proposed EEVR model is seen in Figure 1. EEVR was created to increase routing efficiency by increasing the number of SNs. To improve routing efficiency, and efficient EEVR model is constructed. Enhanced GR utilizes a local search technique to determine the GF of surrounding nodes. The routing method is created with the routing overhead and the energy consumption of SN in mind. As a result, the proposed architecture dramatically decreases routing time and increases network coverage.

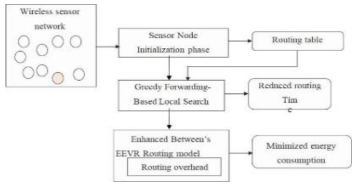

Figure 1: EEVR Block Diagram

Greedy Forwarding (GF)

Greedy Forwarding forwards packets to the closest neighbor node to local search. A local perspective is taken into account when each message is transmitted from the source to the neighbor node, and the one that results in the shortest routing time to the destination is used. In the suggested EEVR paradigm for WSN, greedy Forwarding is used. Thus, it discovers a path between the source and sinks nodes. Following that, the optimal SN transmits the data packet to a nearby node that is not only nearest to the target node but also has a sufficiently reliable end-to-end link.

To create the nearest function, suppose that an 'SN_j' contains neighbor nodes' $N_1, N_2, ..., N_n$' and a destination node 'D' that sends packet 'P_i.' Assume that the packet contains information a patient's blood pressure. Then, the nearest function is provided below to calculate the node's proximity to the target node.

$$CF = M(dis1, dis2, .. disn) \quad (1)$$

From eq(1), 'dis_i' symbolizes the distance between the two neighboring nodes (i.e., the new object detected and their neighboring node, respectively). The distance 'dis_j' is evaluated as given below.

$$dis_i, = \sqrt{(i1 - j1)^2 + (i2 - j2)^2} \quad (2)$$

Followed by the closest function obtained, the reliability value is measured based on the proportion of the SN's successful transmissions.

Algorithm 3.1 Searching Algorithm

Input: Packet $p_1, p_2, \ldots p_n$; SensorNode SN_j, Neighbor nodes $N_1, N_2, \ldots N_n$, Threshold t Output: Decide upon the optimal neighbor node

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1. Begin
2. For each Sensor Node SN_j
3. For each Packet P_i
4. For each neighbor N_i of SN_j
5. Measure closeness function using eq1
6. Measure Reliability factor SN using function eq2
7. If R(SN_j>t
8. proceed with the SN identified
9. Else
10. Go to 6
11. End if
12. End for
13. End for
14. End for
15. End for

The preceding algorithm 3.1 illustrates a local search algorithm based on greedy Forwarding, categorizing surrounding nodes nearest to the destination nodes and analyzing the SNs' dependability. This algorithm's primary goal is to find the closest node to the destination node using local information when an SN transmits a packet (such as air pressure values).

The reliability of the SN is calculated after computing the proximity factor. The level of reliability achieved is measured using the threshold value. The SN is considered the most reliable and closest node if the reliability rating exceeds the threshold value. Otherwise, the SN is not trustworthy, and the process continues until a reliable node is identified. Thus, the local search algorithm combined with local information shortens the routing time.

Algorithm 3.2 Enhanced Greedy Routing Algorithm **Input:** Packet P_i=P_1, P_2,…P_n, $path_1$, $path_2$….$path_n$ **Output:** Optimized Route

1: Begin
2: For each packet pi
3: Average routing overhead
4: Energy consumed for routing stage 5: End for
6: End

As seen in algorithm 3.2, the Enhanced GR algorithm determines the average routing overhead between all pairs of vertices by limiting the length of the routing overhead. In the modified GR method, calculate the average routing overhead and the remaining energy spent by SN in the network instead of evaluating the shortest route. In this manner, more coverage is achieved via the Enhanced GR model.

Proposed Eerv Algorithm

This section discusses the EERV algorithm that has been suggested. This eliminated empty areas by choosing the forwarder node with the highest residual energy and several nodes of varying depths. Additionally, it considers the holding time computation when discarding the same packets. Avoiding empty zones requires ranking nodes according to their depth, leftover energy, and holding duration. It calculates the two-hop depth difference using a weighting factor, i.e., the depth difference (Di) between the sender S and its one-hop recipient, send i, and the next-hop difference (D_{i}_nf) between the one-hop receiver i and its next-hop neighbor j.

$$Di = (ds - di) \qquad (3)$$

$$Di\_nf = (di - \min(di)) \qquad (4)$$

Here eq 3, 4 is worn to prioritize Di, Di_nf. Its assessment ranges from 0 to 1. The highest delay in wireless signals is denoted as d_s.

Void Node

Each ordinary node starts a void detection timer and waits for a message packet from a neighbour node with a lower depth than its own before initiating the data transfer process. The packet contains the neighbour node's ID, location, and current status. It is possible for a normal node to continue to route messages even if it receives a message packet from a neighbour node that is lower in depth than its own. Alternately, if the node is not inhabited, the network connection between it and the empty zone is broken. Tf of the void discovery timer is

$$T_f = T_{tra} + T_{pro} + \sum_{k=1}^{x} \frac{d(n,nk+1)}{v} \text{--------} \; (5)$$

where $Ttra$ and $Tpro$ are the broadcast moment and dispensation moment of the communication packet, correspondingly, $d(nk{,}nk{+}1)$ is the range among the k^{th} node and

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the $(k+1)^{th}$ node, v is the speed of the wireless signal, and $\sum^{x}$ of the holdup variations for the primary node to the x^{th} node. $(n,k+1)$ represents the computation.

Estimation of Holding Time

A packet of data is being prepared by Node S after it has detected its surroundings and taken appropriate action. Within the transmission range tr, this packet should be forwarded to node k. As a result, the information packet is rejected if $D_i > D_s$ is found at node k. The forwarder nodes' set FNs must be examined if the depth is less than the depth of the sender node S. It estimates the holding time if it has more than one forwarder node. If all adjacent nodes have a greater depth than the sender, the packet is discarded. The chosen forwarder nodule's holding time must be short relative to all neighbor nodes, with the largest residual energy and a huge deepness dissimilarity.

E2RV compute the holding time with the following formula:

$$Where\ H = e^{i} * \left(1 - \frac{d}{tr^{s}}\right) + \left(1 - \max\left(d_{FNs}\right)\right) \text{-----(6)}$$

Because the value of ei is smaller for node k, which has a bigger normalized deepness variation inconsistency, this node is chosen as the next forwarder node. Thus, the EERV's subsequent forwarder nodes will have a huge amount of leftover energy, a big depth difference, and a shallower depth than the source node.

Algorithm 3.3: Greedy Void Routing Algorithm

Input: Receiver node may *i* receives the sensed data container $\{S_{id}, d_s, E_{max}, E_{min}, tr_S, data\}$

Output: Onward the packet to a two-hop neighbor

1. Initialize packet queue
2. Initialize receiver node-set as N_{si}.
3. FN_{LS} is the next forwarder node list.
4. Timerdata is the regulator for the data packet received.
5. If (data ≥ queue), then
6. Add data to the queue
7. If (Timerdata == OFF) then

Node n receives the data packet. $\{d_s, E_{max}, E_{min}, tr_S\} \leq data$

8. If($i \in R_i$) then
9. If (FN_{LS} !=0)then
10. Calculate residual energy E_i
11. Calculate depth variance
12. Calculate stabling time
13. Set Timerdata= timer
14. Call Start Timerdata
15. End if
16. End if
17. End if
18. Remove data from the queue
19. End

In the Greedy void routing method, the source node's holding time must know all the nodes' distance and residual energy. All neighbor nodes will regularly relay this information to the SNs via message.

Results and Discussion

NS2 simulations are used to demonstrate and evaluate the performance of EEVR. There are 103 nodes in a square area uniformly spaced and immobile throughout the simulation. Nodes may create more data if the sink node visits these areas and captures them. They gather the packets since they don't have to go very far to get to the region's local drains. Packages may be delivered inexpensively by sink nodes to save costs and energy consumption. Packets clash with avoid holes in sparse WSNs more often, increasing the likelihood of a packet being lost as it makes its way to the surface sink.

It is much less of the problem when a sink node collects data from high-traffic areas of the network since it does so by traversing these areas. PDR rises due to multiple successful deliveries made possible by this strategy. Packets are more likely to arrive on time when the data rate increases. This results in reduced collision probabilities and an increase in the success rate of packets. However, due to the limited bandwidth available for acoustic transmission, the linear relationship between PDR and data rate is no longer valid for ever-increasing data rates. After a certain point, PDR cannot be increased anymore.

Performance Metrics

The network's security, energy efficiency, and dependability are evaluated using the following criteria.

- One way to measure the success in detecting malicious nodes is to compare how many of those nodes were accurately detected versus injected.
- A node's energy consumption while transmitting data is called "consumption."
- The packet delivery ratio (PDR) measures how many data packets are successfully received for every total number of packets sent.

Simulation Results

We simulate our proposed protocol in NS2 Simulator. We compare our EEVR Model with the Co-Operative Multiple-Input Multiple-Output Spatial Modulation (CMIMO-SM), Time Division Multiple Access (TDMA) method, and Greedy Knapsack Based Energy Efficient Routing Algorithm (GKEERA). The Network area size is 1300 x 2250 m.

Table 1: Simulation Parameters

Parameters	Value
Simulation Time	900(s)
Number of Nodes	0 to 102
Data Rate	1Mbps
Routing Protocol	DSR
Bandwidth	2 Mb
Simulation Area	1300 x 2250 m
Transmission Range	250m
Threshold	100dbm
MAC	802.11
Power monitor threshold	120dbm

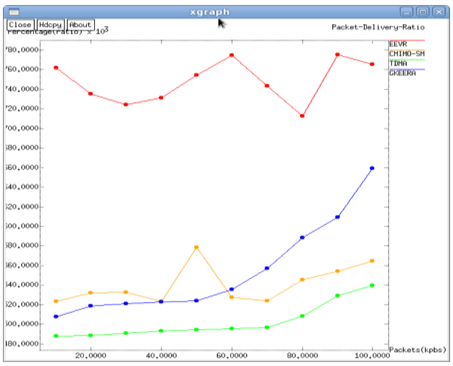

Figure 2 Packet delivery ratio

Figure 2 represents the PDR comparison chart. The EEVR method energy consumption is very less. The CMIMO-SM, TDMA, and GKEERA methods are high energy consumption of active nodes. The X-axis represents the size of the packet, and the Y-axis represents the Delivery ratio.

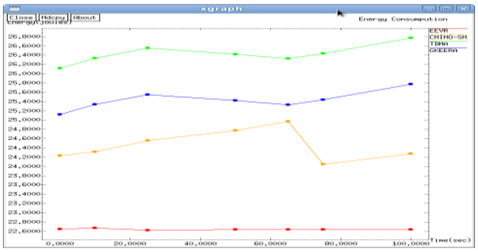

Figure 3: Energy consumption Comparison Chart

Figure 3 illustrates the time synchronization with energy consumption. The EEVR method energy consumption is very less. The CMIMO-SM, TDMA, and GKEERA methods are high energy consumption of active nodes. The X-axis represents the time in seconds, and the Y-axis represents the energy level.

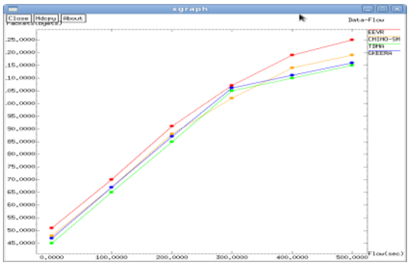

Figure 4: Data-Flow

Figure 4 illustrates the data flow level by packet transmission: the CMIMO-SM, TDMA, and GKEERA methods used as low data flow levels. The EEVR method has a high data flow level by comparing the existing methods. The X-axis represents the data flow in seconds, and the Y- axis represents the packets.

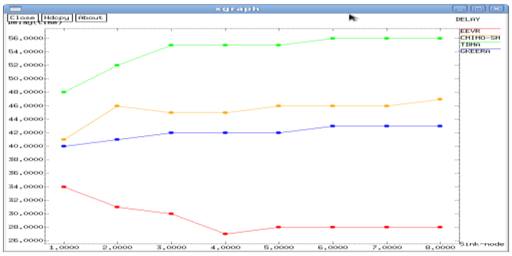

Figure 5: Transmission Delay

Figure 5 illustrates the data transmission delay. The CMIMO-SM, TDMA, and GKEERA methods are used for a high transmission delay. The EEVR method has less delay in transmission. The X-axis represents the sink node, and the Y-axis represents the delay in time.

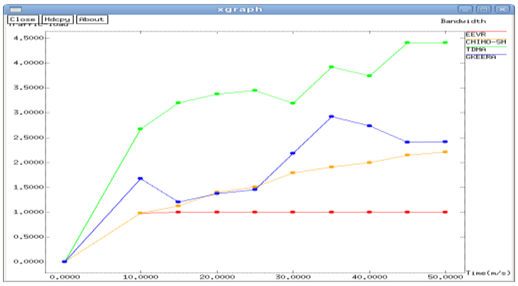

Figure 6: Bandwidth

Figure 6 illustrates the routing with bandwidth frequency: the CMIMO-SM, TDMA, and GKEERA methods used high bandwidth frequency levels. The EEVR method has less usage in bandwidth. The X-axis represents the average energy, and the Y-axis represents the bandwidth frequency.

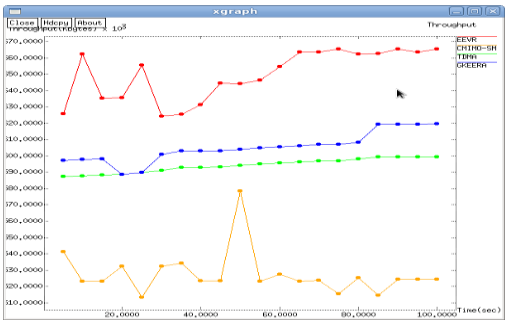

Figure 7: Throughput Comparison Chart

Figure 7 illustrates the routing with throughput. The accuracy of EEVR is increasing the message communication. It shows the throughput comparison; the EEVR has a better throughput than CMIMO-SM, TDMA, and GKEERA methods. In X-axis represents the time, and Y-axis represents the throughput levels.

Conclusions

In this study, the EEVR approach is proposed to be energy efficient in WSN and shows how relaying packets across intermediate nodes may overcome the drawback of unreliable transmission. By successfully avoiding vacant zones and enhancing transmission reliability in regions where ambient noise and direct discarding are prevalent, EEVR (Energy Efficient and Void routing) was proposed to decrease packet loss. Local information collected from GR is used to create the adjacency graph, form continuous clusters by limiting the likelihood of hidden nodes in each cluster using a low-cost heuristic technique, and eventually identify the ideal forwarding set. To ensure that no space is missed, EEVR allows packets to be routed in any direction, unlike other protocols in the literature that only allow packets to be routed toward the surface. It is clear that EEVR significantly decreases packet loss, energy consumption, and latency in sparse to crowded environments, as shown by our simulated results.

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