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ENERGY EFFICIENT ROUTING PROTOCOL FOR INCREASING LIFETIME OF WIRELESS SENSOR NETWORK

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Abstract:
In the recent years, an efficient design of a Wireless Sensor Network has become important in the area of research. The major challenges in the design of Wireless Sensor Network is to improve the network lifetime. The main difficulty for sensor node is to survive in that monitoring area for the longer time that means there is a need to increase the lifetime of the sensor nodes by optimizing the energy and distance.
There are various existing routing protocols in which optimal routing can be achieved like Data-Centric, Hierarchical and Location-based routing protocols. In this paper, new power efficient routing protocol is being proposed that not only select the shortest path between the source node and sink node for data transmission but also maximizes the lifetime of the participating nodes by selecting the best path for sending the data packet across the network. The main objective of this research is to develop a faster algorithm to find the energy efficient route for Wireless Sensor Network. Simulation results shows that this strategy achieves long network lifetime when compared to the other standard protocols.

Keywords: *Wireless Sensor Network; Energy Efficient Routing Protocols; Energy Consumption; Network Lifetime.*

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1. Introduction

Wireless Sensor Network is mainly considered as one of the most important technologies in the past centuries. WSN basically consists of a large number of low-power, low-cost and multifaceted sensor nodes which can perform several tasks like sensing, processing, wireless communications and computation capabilities [1, 2]. The sensor nodes communicate with other node within their communication range via a wireless medium and collaborate to achieve a common task in the field of military surveillance, environmental monitoring, industrial process control and other commercial areas. The basic methodology behind WSN is that the capabilities

of each individual sensor node are limited, and the aggregated power of the entire network is sufficient for the required mission.

WSN consists of protocols and algorithm with self-organizing capabilities. Researchers have been designed a number of different routing protocols whose aim is to achieve the minimum delay in the transmission of data from source to the sink, reducing data redundancy, minimum energy consumption within the whole network and achieves maximum network lifetime.

2. Routing Protocols in Wireless Sensor Network

Routing Protocols in Wireless Sensor Networks plays an important role in the field of military, traffic monitoring, environmental monitoring and in many other commercials applications. The sensor nodes are constrained to limited resources itself, so our main focus is to design an effective and efficient routing protocol in order to increase the network lifetime for specific application environment. There are some aspects like energy efficiency, fault tolerance, scalability, power consumption, accuracy, QOS which need to keep in mind while designing the routing protocol in Wireless Sensor Networks.

Based on the underlying network structure as shown in figure 1, the routing protocols in WSNs are classified into three main category i.e. data-centric, hierarchical and location based Routing Protocols. The Data-Centric protocol are query-based and mainly depends on naming the desired data which helps in eliminating many redundant transmission. In Hierarchical approach, the main aim is at clustering the node so that the cluster heads (CH) can do some aggregation and reduction of data in order to save energy. Location-based protocols make use of the position information to transmit the data to the desired regions rather than the whole network. Location information is used to improves the performance of routing and provide new type of service.

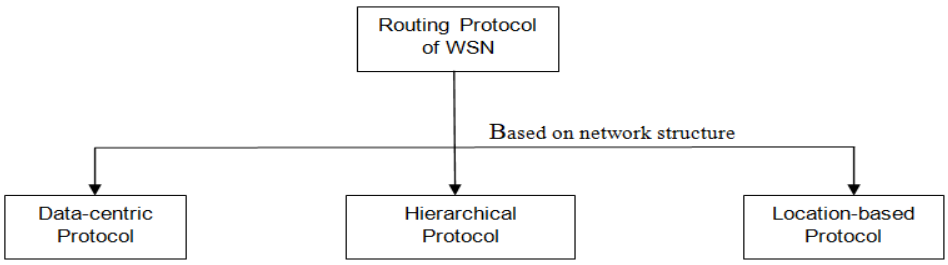


Figure 1: Routing Protocol of WSNs

2.1. Data-Centric Protocols

In the traditional address-centric protocol, it was not possible to assign the global identifiers to each and every node due to the large number of nodes available in the monitored area. So, this consideration has led to data-centric routing protocol where the source sensor node sends their data to the sink, and the intermediate sensor node can perform some form of data aggregation originating from multiple source sensors node and send the aggregated data towards the sink node. Since, this is very efficient in terms of energy consumption because of less transmission required from the source to the sink. In this section, we will review some of the data-centric routing protocols for WSNs.

1) **Flooding -** Flooding [5] is the most traditional routing in which each node receives the data packet and broadcasts it to all the neighboring nodes and this process continues until the packet arrives at the destination or the maximum number of hops for the packet is reached. Although flooding is very easy but it has several drawbacks like implosion, overlap and resource blindness problem.
2) **Gossiping -** In Gossiping [4] mechanism, the sensor node sends the data packet to randomly selected neighbor, which pick another random neighbor to forward the packet until the packet reached at the destination node. Gossiping avoids the problem of implosion by sending the information to a random neighbor instead of broadcasting. However, this cause delays in the transmission of data among the sensors nodes.
3) **SPIN (Sensor Protocols For Information Via. Negotiation) -** SPIN [5] is the first data-centric protocol which considers data negotiation between the nodes in order to eliminate the redundant data and save energy. ADV message allows a sensor to advertise a particular meta-data, REQ message request for the specific data and DATA message that carry the actual data as shown in Figure 3 from [5]. However, SPIN's data advertisement mechanism cannot guarantee the delivery of data.
4) **Gradient-Based Routing -** Gradient-based Routing [9] is the revised version of Directed Diffusion where the aim is to get the total minimum hop other than total shortest time. The main objective of this scheme is to obtain a balanced distribution of traffic in the network, thus increasing the network lifetime.

2.2. Hierarchical Protocols

In Hierarchical Routing, the clusters are formed and each cluster has a head node. These head nodes are the leaders of their respective clusters and has the responsibility to collect and aggregate data from their respective clusters and forward that aggregated data to the base stations. By this technique of aggregation of data, can reduce the energy consumption in the network which will increase the lifetime of the sensor network.

The main objective to develop this technique, is to reduce the network traffic from source to the sink sensor node. It gives better performance and consume less energy as compared to the Data-Centric Protocol.

1) **Leach (Low-Energy Adaptive Clustering Hierarchy) -** LEACH [10] is one of the most popular energy-efficient hierarchical routing algorithms for sensor networks. This protocol was proposed to reduce the power consumption. This is basically used when the node in the network fails or it's battery get stops working. The idea behind this protocol is to form the clusters of the sensor nodes which is based on the received signal strength and use local cluster heads rather than all sensor nodes. However, LEACH uses single-hop routing where each node can transmit directly to the cluster-head and the sink. Therefore, it is not applicable to networks deployed in large regions.
2) **Pegasis and Hierarchical Pegasis -** PEGASIS (Power-Efficient Gathering in Sensor Information Systems) is chain-based protocol that is an improvement of LEACH protocol. In order of forming multiple clusters, PEAGSIS construct a node chain where nodes are placed randomly in a monitoring area then each node communicates only with a close neighbor, and take turns and transmit data to the base station, thus reducing the

amount of energy spent per round [11]. However, each and every sensor node is aware of the status of its neighbor so it knows where to route that data. Such topology amendments can introduce significant overhead particularly for highly utilized networks.

3) **Teen -** Threshold sensitive Energy Efficient sensor Network protocol (TEEN) [12, 13] is a hierarchical protocol developed for the reactive networks. TEEN is similar to LEACH and based on hierarchical grouping which divides the sensor nodes twice for grouping cluster in order to detect the scene of sudden changes in the sensed attributes such as temperature. After forming the clusters, TEEN separates the Cluster Head into the second-level Cluster Head and uses Hard-threshold and Soft-threshold to identify the sudden changes. This protocol is not suited for applications where the user needs to get data on a regular basis.
4) **Apteen -** The Adaptive Threshold sensitive Energy Efficient sensor Network protocol (APTEEN) [14] is the improvement over TEEN which overcomes its shortcoming and aim at capturing the periodic data collections (LEACH) and by supporting periodic reports for time-critical events (TEEN). The main drawback of this algorithm is the overhead and complexity of forming clusters.

2.3. Location-Based Protocol

In Location-based Protocol, sensor nodes are addressed by means of their location. Location information is required to calculate the distance between two particular nodes on the basis of signal strength so that energy consumption can be estimated. It is also utilized in routing data in energy efficient way when addressing scheme for sensor network is not known. It is worth noting that there have been many location-based protocols in Ad Hoc networks and it makes great effects when we transplant those research achievements for wireless sensor networks in some ways.

1) **GAF (Geographic adaptive fidelity) -** Geographic adaptive fidelity (GAF) [17] is a energy-aware location-based routing algorithm which is proposed for mobile ad-hoc networks, but can also be used for WSNs due to energy consumption. The large numbers of sensor nodes are placed in observed area and only few nodes are selected to transmit data, while the other nodes sleep. In this way, GAF reduces the number of nodes needed to form a network and saves the battery of nodes.
2) **GEAR (Geographic and Energy-Aware Routing) -** GEAR is an energy-efficient routing protocol proposed for routing queries to the target regions in the sensor field. The aim behind this routing is to reduce the number of Interest in Directed Diffusion and add geographic information into interest packet by only considering a certain region instead of sending interest to the whole network by means of flooding. GEAR uses energy aware and geographically informed neighbor selection heuristics to route a packet towards the target region [19]. In this way, GEAR helps in balancing energy conservation and increase the network lifetime.
3) **MECN (Minimum Energy Communication Network) -** Minimum Energy Communication Network (MECN) [15] establish and maintains a minimum energy network for wireless sensor networks by having low power GPS. The main idea of MECN is to find a sub-network, which will have less number of nodes and require less

power for transmission between any two particular nodes. In MECN, it is assumed that every node can transmit to every other node, which is not possible every time.

4) **SMECN (Small Minimum Energy Communication Network) -** The Small Minimum Energy Communication Network (SMECN) [16] is an improvement to MECN. In SMECN, possible obstacles between any pair of nodes are considered. Simulation results shows that SMECN uses less energy than MECN and maintenance cost of the links is less. However, finding a sub-network with smaller number of edges introduces more overhead in the algorithm.

3. Proposed Algorithm

The requirements of proposed algorithm which is designed for environmental applications, are different in many aspects from those designed for military or health applications. However, routing protocols for all Wireless Sensor networks, regardless of the application, must try to maximize the network life time and minimize the overall energy consumption in the network. Network lifetime is a critical concern in the design of WSNs.

The proposed technique is an energy-aware routing technique which is best suited to find the energy efficient route for Wireless Sensor Network and the main focus of this algorithm is to increase the network lifetime of WSN by optimizing the energy and distance. The idea is to define many paths from source to sink and send through them the same sub packets. This implies that the traffic will increase significantly, at the same time it will increase the reliability of the network. The idea is to split the original data packet into sub packets through each path. This can offer at the end, even with the loss of sub packets, the reconstruction of the original message.

3.1. First Order Radio Model

We assume a simple model [23, 24] where the radio dissipates $E_{elec} = 50$ nJ/bit to run the transmitter or receiver circuitry and $\epsilon_{amp} = 100$ pJ/BIT/m^2 for the transmit amplifier to achieve an acceptable E_b/N_a as shown in Figure 2 and Table 1. These parameters are moreover better than the state-of-the-art in radio design. We also made other assumption like r^2 energy loss due to channel transmission.

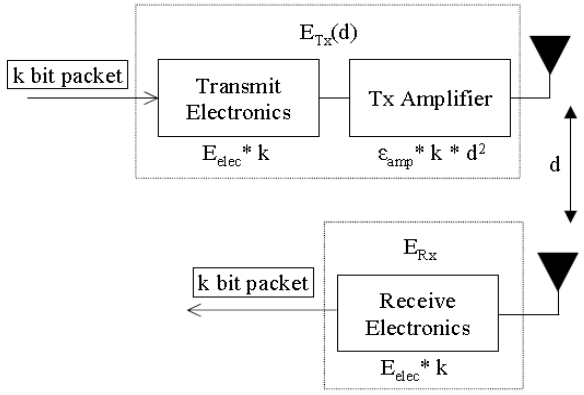


Figure 2: First Order Radio Model

Table 1: Radio characteristics

Operation	**Energy Dissipated**
Transmitter Electronics ($E_{Tx\ --\ elec}$) Receiver Electronics ($E_{Rx\ -\ elec}$) ($E_{Tx-elec} = E_{Rx-elec} = E_{elec}$)	50 nJ/bit
Transmit Amplifier (ϵ_{amp})	100 pJ/bit/m^2

However, the energy consumed while transmitting a k-bit message to its neighboring node:
$E_{Tx}(k,d) = E_{Tx-elec}(k) + E_{Tx-amp}(k,d)$

$$E_{Tx}(k,d) = E_{elec} * (k) + \epsilon_{amp} * k * d^2 \quad (1)$$

And the energy expands while receiving the k-bit message from the neighboring node:
$E_{Rx}(k) = E_{Rx-elec}(k)$
$$E_{Rx}(k) = E_{elec} * k \quad (2)$$

The above transmitting and receiving energy values are used in this algorithm.

ALGORITHM 1: Energy Efficient Routing Algorithm

```
1. function EnergyEfficient (Graph,Source)
2. create vertex set W
3. Initialize distance        // distance from node to node
4. Initialize energy          // initial energy of each node
5. for every vertex v in Graph
6.         distance[v] <- ∞
7.         previous[v] <- Undefined
8.         add v to W
9.  distance[source] <- 0
10. while W is not empty
11.          u <- vertex in W with min (α.distance[u]+β.1/Energy[u])
//α+β=1
12.        remove u from W
13. alt <- length(u , v)+ distance[u]
14. if alt is less than distance[v]
15.        distance[v]<-alt
16.        previous[v]<-u
17. return distance[],previous[]
```

4. Simulation and Analysis

The simulations are done under the MATLAB programming environment. Custom code is written to simulate the wireless sensor network. This paper shows the comparison of different energy efficient routing schemes for WSN with the proposed scheme.

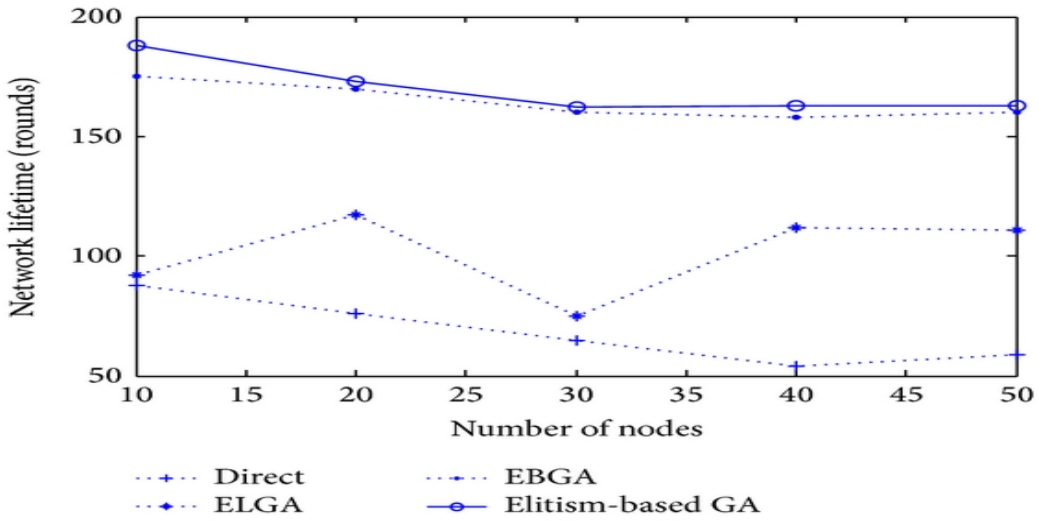
Table 2: Simulation Parameter

Parameter	**Values**
Area of simulation	100*100
Number of sensor nodes	50
Initial Energy	1 J
Packet size	4000bit
Simulation Time	50ms
Traffic Type	CBR

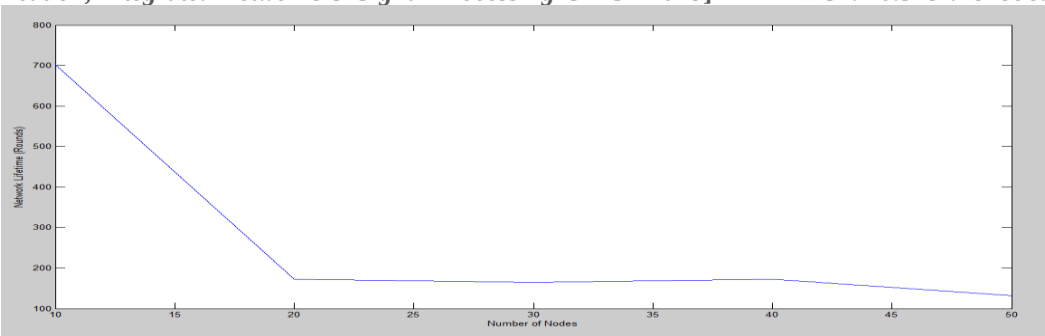
The existing routing protocol uses the techniques like Direct, ELGA, EBGA, and Elitism-based GA. ELGA, where the genetic algorithm is used to keep the least average energy consumption, EBGA (Eavesdropping-based Gossip Algorithm), where genetic algorithm is used in addition to keeping energy balance into consideration, and the Direct technique uses the direct communication between the node and the sink node.

Figure 3.(a) shows the comparison of different energy efficient routing schemes for WSNs: (i) direct transmission between sensor and the sink node, (ii) genetic algorithm based routing with least average energy consumption (ELGA) [22], (iii) genetic algorithm based routing with energy balance being taken into account (EBGA) [22], and (iv) Elitism based GA routing [24] which takes into account the distance between the nodes as well as balance the energy of the individual node.

Figure 3.(b) Shows the proposed algorithm with much more improvement in the network lifetime and better utilizes the network energy. There is 6% improvement in the network lifetime with the proposed scheme for 50 nodes. The average residual energy of the network using direct, ELGA, and EBGA method is 0.6972 J, 0.3791 J, and 0.0184 J [22]. The average energy of the network using the proposed algorithm is 0.1530 J which is 16.8478% improvement over the EBGA.



(a)Network lifetime versus number of nodes; comparison of different routing schemes



(b) Network lifetime versus number of nodes; proposed scheme

Figure 3: Comparison of the total Energy Consumption per round of the existing scheme and proposed algorithm

When compared with ELGA, EBGA, and Direct techniques simulation results show that the proposed algorithm better utilizes the network in terms of energy as well as the shortest distance which increases the network lifetime and consumes less energy. Hence, more data is delivered to the base station.

5. Conclusion

The results shows that the proposed routing algorithm is a very good concept for routing in WSNs. Compared with ELGA, EBGA, and Direct techniques simulation results show that our protocol can reduce the total energy consumption which improves the network lifetime hence more data is delivered to the base station.

The power efficient routing protocol is being proposed that not only select the shortest path between the source node and sink node for data transmission but also maximizes the lifetime of the participating nodes by selecting the best path for sending the data packet across the network.

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