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SOECS: Scheduling based Optimal Energy Clustering Scheme for WSN

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Abstract: Balancing the energy consumption and location accuracy is one of the critical tasks in WSN. Energy consumption of sensor nodes is measured in terms of route discovery, packet forwarding and data transmission. In this research work, it is proposed that scheduling based Optimal Energy Clustering Scheme (SOECS) to attain the maximum location accuracy and energy efficiency during route maintenance. It consists of three phases. In first phase, the node deployment is done using Gaussian distribution function to route the packets effectively. In second phase, Cluster heads are chosen and energy is estimated for optimal cluster heads. In third phase, TDMA scheduling algorithm is introduced to improve the energy efficiency using stable routes and scheduling table. The work is evaluated using network simulation tool. The proposed scheme produces high performance than existing schemes.

Keywords: *Gaussian random distribution function, node deployment, energy efficiency, network lifetime, location accuracy and TDMA scheduling.*

1. Introduction

In past few decades, Wireless Sensor Networks (WSN) plays a vital role in wireless network and growth of WSN rises rapidly. The wider detection range and flexibility was provided effectively due to radio waves and sensor nodes. The real time environment changes are detected by sensor nodes [1]. The data gathering process is done by the sensor nodes and data aggregation is implemented to save the energy. Energy efficiency is the major issue in WSN and the consumption of energy can be measured based on various applications [2].

2. Previous Work

The distributed optimization issue for the energy of wireless sensor network. The nodes or the players completed the iterative solution to increase the energy utilization rate. Meanwhile the energy of WSN was improved with the new revenue model. Individual constraints were converted into players to provide better energy [3].

An energy efficient chain cluster based intelligent routing algorithm to extend the network lifetime [4]. The load distribution was enhanced with routing algorithm to improve network performance and energy efficiency. The Power Energy Gathering in Sensor Information Systems protocol and Ant Colony Optimization were integrated together to find the optimal chain in order to reduce the data redundancy , distance between intermediate nodes and delay of data transmission through longer length links.

The cluster head selection method was adopted to reduce the energy wastage on packet transmission during data communication [5]. The time division multiple access schedule was adopted to optimize the energy consumption. The progression of cluster head movement, energy conservation and packets transmission to the base station were monitored with LEACH protocol. In initial phase of the algorithm, stable cluster head was chosen to route the packets effectively.

Enhanced set of optimization rule with LEACH routing protocol to improve energy efficiency [6]. The concept of Particle Swarm Optimization algorithm was adopted to provide optimized clusters. The major inputs were the fitness functions, set of rules and residual energy estimation. The special CH was chosen based on average cluster energy, replacement of CH with least value of fitness function and hub density distribution.

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The power efficient gathering in sensing information systems to extend the network lifetime [7]. The optimal chain based protocol was implemented to improve the network lifetime. Nearest intermediate node was communicated with each node to select a head based on data collection from the intermediate nodes and selection report was sent to base station. The bandwidth requirement and energy consumption was reduced and to strengthen the network lifetime.

The selective hop communication to improve the network lifetime [8]. The cooperative based communication was attained based on energy efficiency. The hop devices were chosen for co-operative transmission. Cooperative transmission was adopted to increase the network lifetime by extending energy efficiency. The distributed medium access control was presented with optimization technique to choose hop device to reduce energy per bit transmission.
efficiency.

Energy clustering based on self-organizing map (ECSOM) to improve the network lifetime [9]. It was based on two criterias i.e. energy level and spatial coordinates. Due to that, the longevity and coverage were improved.

The energy efficient clustering protocol based on decision making algorithm to increase the energy level of sensor nodes in the cluster [10]. The maximum number of high energy nodes was used to choose the cluster head and self-mapping was used to attract low and high energy nodes. The intermediate nodes were not required to create clusters based on energy value, intermediate nodes, node density and distance to destination node.

An joint utility optimization technique for maintaining power control, routing and scheduling in an efficient way [11]. It was done with the deployment of Lyapunov optimization technique and perturbation technique. The trade-off between network utility and backlog was maintained with dynamic systems. The energy was not only exchanged but also harvested between nodes. The network stability was maintained based on Lyapunov drift where queue size is low. The explicit estimation of energy was determined based on queue backlog bounds in multi-hop sensor networks.

An energy efficient routing approach for sensor networks [12-13]. The design of the protocols aimed to meet the requirements of scalability issues. Scalability was provided using hierarchical architecture to improve the network lifetime. The energy consumption of sensor nodes was maintained in multi-hop communication within a cluster region to achieve data aggregation. The number of transmitted messages was reduced to destination node. The cluster properties such as cluster size, number of cluster size and cluster communication inside and outside the zone. The chosen CH can be adopted as stationery or dynamic based on coverage area[14-15].

The proposed SOECS is organized into five sections. Section 1 deals with overview of WSN and need for energy efficiency. Section 2 surveys the various methods and protocols relevant to proposed approach. Section 3 discusses the proposed approach that contains node deployment, optimal energy estimation of cluster head and routing methods. Section 4 deals with simulation results and last section concludes the proposed work.

3. Optimal Energy Clustering Scheme

In this research work, optimal cluster heads are chosen based on remaining energy, distance to sink node and node capacity to increase the network lifetime. In previous work, it is concluded that balancing energy consumption and location accuracy is the biggest task in the sensor network. In this section, nodes are deployed according to Gaussian distribution and the energy consumption for transmission of packets and clusters. Cluster head is chosen based on residual energy, distance to destination node and node capacity. Scheduling algorithm is adopted to save the energy during packet transmission.

Node deployment

In WSN, the protection routing and statistics transmission gets tormented by the deployment of sensor nodes. Nodes positioned nearly the vacation spot node will transmit or get hold of the packets speedy whilst eating quicker strength. The strength hollow problem can also additionally have an effect on the community performance. 3-d elliptical ordinary distribution approach is followed to outline the state of affairs of cluster head, cluster participants, and anchor nodes. way to the effect on strength and community lifetime with the aid of using the best deviation, the ordinary distribution is able to stability the strength and community life. all through this phase, nodes are deployed to discover the locations nearly the centroid. The geographical place and strength have been diagnosed with the aid of using the sensor node with sector ID. Each cluster participant song the sensing sector continuously.

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Energy estimation of Cluster through threshold value

If the sign is robust, it is going to be immediately communicated to the CH. Each cluster of participants has identical strength at the beginning phase.

At the top, a few nodes can also additionally lose their strength way to excessive mobility or losing strength on non-stop retransmission of packets.

$$E_{CH} = mE_{amp}M_k / C_k + mE_{DA}M_k / C_k + m\varepsilon_n d_{toCH}^4$$

Where

E_{amp} is the electronic and amplified energy that counts on packet filtering, modulation and signal spreading.

E_{DA} is the energy spent during data aggregation.

d_{toCH} is the distance between cluster member and cluster head. The energy spent in the non-cluster heads for transferring the packets to the cluster head is estimated as,

$$E_{SN} = mE_{amp} + m\varepsilon_r d_{toCH}^2$$

The distance is between cluster to non-cluster head and it is calculated as,

$$d_{toCH}^2 = \frac{N_k^2}{2\pi C_k}$$

The total energy spent by a cluster in the single frame is estimated as,

$$E_c = E_{CH} + E_{SN}M_k / C_k$$

The amount of power spent is reduced in the proposed scheme while enhancing the selection method based on threshold to select stable and optimized CHs.
The illustration of cluster head election through threshold value is given in Figure 1.

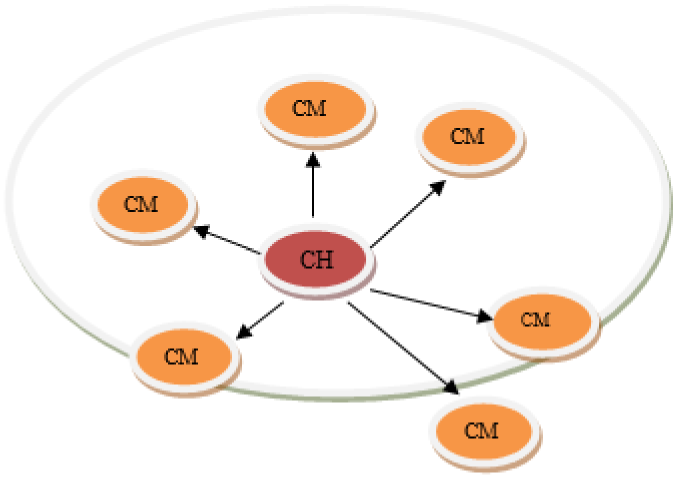

Figure 1. Optimal Cluster head election

Before route transmission process, the cluster head will be nominated to enhance the energy level and network lifetime.

Scheduling algorithm

The energy gap between the cluster members is reduced by adopting the scheduling algorithm. Each cluster member sends its sensed data to CH within its allocated slot time during steady state condition. Here it is divided into frames, CH receives the data from all cluster members in each round. Network lifetime is estimated based on the number of cluster members and rounds. The scheduling algorithm is illustrated below.

Step 1: Based on number of requests, the sensor nodes are allocated to Cluster heads.

Step 2: CH broadcasts message to all nodes which are attached to remaining cluster heads and obtain the capacity of cluster.

Step 3: The TDMA schedule duration is implemented based on the capacity of cluster.

Step 4: Data is transmitted by all nodes to CH according to TDMA schedule. Small clusters go to sleep mode after sending all information to CH.

Algorithm:

1. Start
2. Group the nodes.
3. Create cluster group.
4. If residual energy of sensor node is high
5. {
6. Choose it as Cluster Head.
7. else
8. Retransmission begins.
9. }
10. Adopt the schedule.
11. Increased Residual energy and network lifetime.
12. End

At the end, the network lifetime is improved without degrading the performance of network.

SOECS Packet format

CH I. D	TTL	Residual Energy	TDMA	FCS
2	1	3	2	3

Figure 2. Packet format

Figure 2 illustrates the packet format. In this packet format, CH id occupies 2 bytes and time to live decides the lifetime of sensor nodes that occupies 1 byte. The residual energy of node is occupied in the fourth field. TDMA initiates the scheduling that occupies 2 bytes and last field is Frame check Sequence for error correction.

4. Simulation Setup

For simulation, the proposed scheme is evaluated with network simulation tool (NS 2.34). The coding language used here is C++ and Tool command language. The following metrics are used for analysing the performance of SOECS.

1. Network lifetime
2. Packet arrival rate
3. Computation Overhead

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4. Energy consumption rate
5. Packet delay

Table 1. Simulator settings for SOECS

Sensor nodes	100
Coverage area	1000 x 1000 sq.m
Simulation time	60msecs
Node mobility model	RWP
Traffic	Possion
MAC	IEEE 802.15.4
Packet rate	5 pkts/sec

The performance of SOECS is evaluated with ESO-LEACH and PEGASIS.

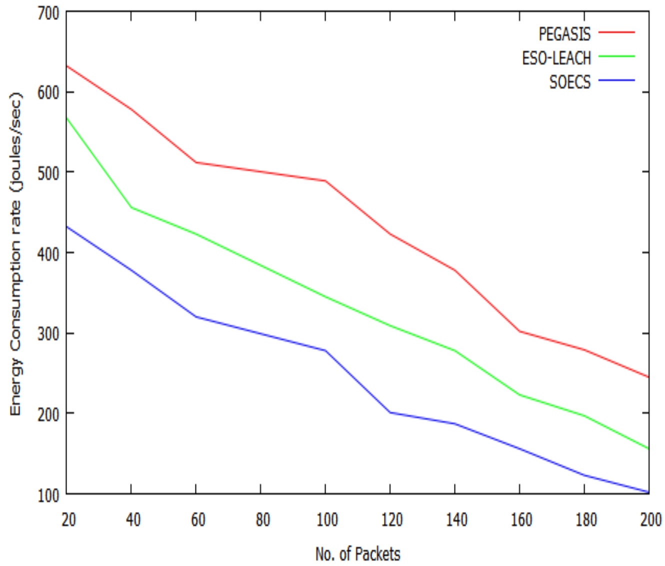

Figure 3. Energy consumption rate Vs No. of packets

Figure 3 shows the energy consumption rate while varying the number of packets from 20 to 200. The proposed scheme achieves less energy consumption than existing schemes due to the energy estimation of cluster head and non-cluster head.

Figure 4 shows the illustration of computation overhead while varying number of links from 20 to 100. From the results, it is seen that SOECS achieves less overhead than ESO-LEACH and PEGASIS.

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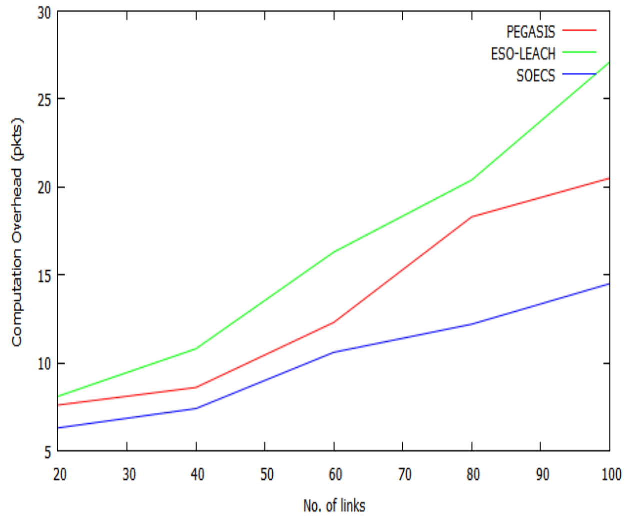

Figure 4. Computation Overhead Vs No. of links

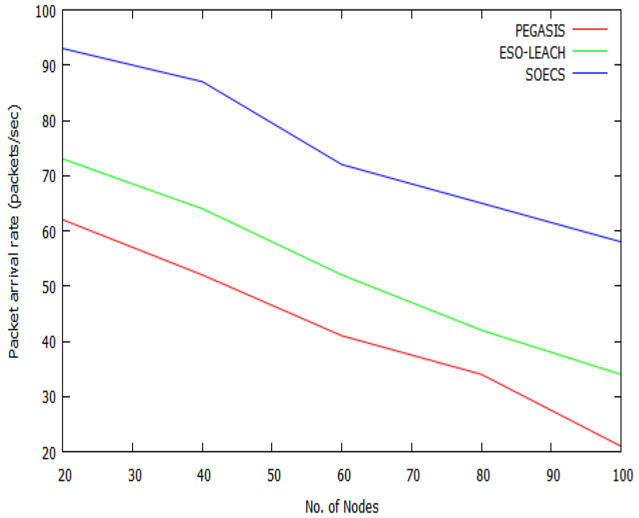

Figure 5. Packet arrival rate Vs No. of Nodes

Figure 5 illustrates the performance of SOECS in terms of packet arrival rate. The number of nodes is varied as 10, 20… 100. Due to the deployment of TDMA schedule, packet arrival rate of SOECS is higher than existing schemes.

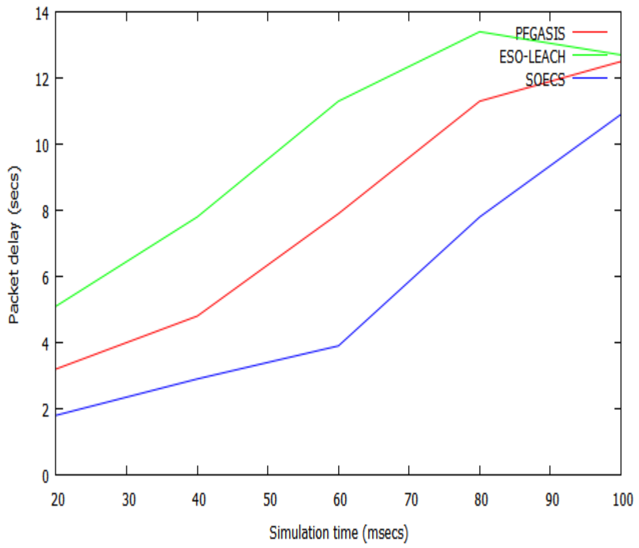

Figure 6. Packet delay Vs Simulation time

Figure 6 illustrates the performance of packet delay for proposed and existing schemes. Delay of SOECS is low due to the implementation of TDMA Schedule and cluster head election phase.

Figure 7 illustrates the network lifetime comparison. The SOECS achieves more network lifetime than existing schemes due to the adaptation of node deployment.

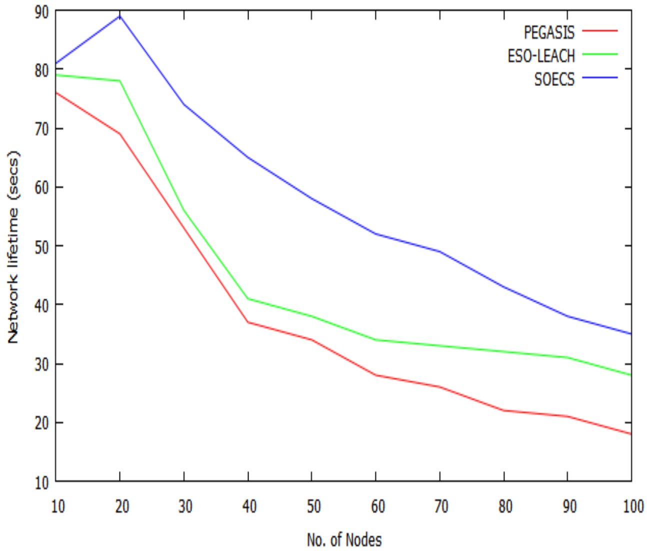

Figure 7. Network lifetime Vs No. of nodes

5. Conclusion

Location accuracy and energy efficiency are the important criteria in WSN. In this research, scheduling based optimal energy clustering scheme is proposed to balance the localization issue and energy efficiency. During node deployment phase, the location of nodes is identified by the cluster heads where the Gaussian distribution is used for performance analysis. The energy estimation of optimal cluster head is done with the help of link efficiency and channel capacity. From the results, SOECS produces better performance in terms of packet delay, packet arrival rate, network lifetime, energy consumption rate and Computation overhead.

The table 2 shows the simulation performance analysis with various existing protocols.

Table 2. Performance Analysis

Parameters	PFGASIS	ESO-LEACH	SOECS
Average Delay	9-11	7-10	3-8
Overhead	17-20	15-18	12-16
PDR	53-58	72-77	88-93
EFficiency	65-70	57-62	80-85
Energy Consumption	110-130	90-120	85-100
Packet Loss	25-30	22-28	19-23

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