Improved life expectancy of GADA-LEACH using particle swarm optimization in wireless sensor network

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Abstract: A wireless sensor network consists of low-cost micro sensing devices, largely deployed to collect data from the sensor nodes and route it to the base station. Each node in the network having low battery power can run up to few hours. Energy efficiency plays an important role in lifetime of the network which needs to be boosted timely. So a novel technique called Hybrid protocol is proposed by combining GADA-LEACH with PSO. In this technique a direct communication is established between sensor nodes and relay node escaping cluster head, if and only if, the distance between sensor nodes and cluster head is more than the distance between sensor node and relay node. It is implemented using MATLAB platform. The results clearly show that the novel technique outperforms than the available at the initial energy level of 0.002J/sensor node.

Keywords: Clustering, GADA-LEACH, Particle swarm optimization, Network lifetime.

1. Introduction

All the sensor devices has capability of sensing as well as communicating data which help it to sense the environment and collect data from the sensor nodes and then route the data to base station in the. WSNs are based on a huge quantity of low-cost, micro, low-power, and multiple functionality wireless sensor nodes. These sensor nodes are widely used in many applications and can communicate with small connectivity through a wireless system and work together to achieve average tasks like keeping the rack of military services or examination and process control in industries. The most important fact about WSN is each and every device is equally important to achieve the result collectively. Though there are numbers of applications of WSNs, but still such networks have various limitations like delay of packets, restricted supply of energy, low computing power, and bandwidth of the wireless sensor nodes. The amount of energy is consumed more on communication than to the computation. That's why various energy efficient and intelligent routing protocols should be developed to manage better energy utilization and congestion control. The routing protocols are categorised as data-centric, location-based and cluster-based hierarchical. In order to manage energy constraints cluster-based hierarchical method is preferred as compare to another method. This cluster-based hierarchical protocol organize the nodes in clusters, where in every cluster one node is elected as cluster head (CH) node and rest of the nodes become cluster member nodes(CM). Data aggregation is mainly used to aggregate and gather information in a most energy efficient way, so that network lifetime is increased by improving energy consumption. Energy dissipation can be reduced up to ten times when compared with other routing protocols. So, we proposed a hybrid protocol (GADA-LEACH/PSO). The main aim of the proposed protocol is the sensor nodes will be able to communicate directly with the relay node through which data will be sent to base station bypassing the communication with cluster head.

The rest of the paper consists as follows: Section 2 includes an overview of existing and related work of the proposed protocol. Section 3 presents the Algorithm of the protocol along with its data flow diagram, features and description whereas Section 4 represents the data flow diagram of proposed algorithm. Performance is evaluated in Section 5, various metrics are compared with existing protocol in terms of Packet transferred, packet send to BS, Packet send to CH and throughput is also covered. Finally, this paper is concluded in Section 6.

2. Related work

LEACH (Low-Energy Adaptive clustering Hierarchy) [4], a clustering-based protocol that uses the cluster-heads to evenly distribute the energy loads among the sensor in the network. The operation of LEACH includes two phases: setup phase and steady

phase. In setup phase, nodes will decide whether to become the cluster head or not and after selection of cluster head, the nodes will select its own cluster head and in the steady phase cluster head send the fused data from the cluster members to the base station. Simulation results has shown that LEACH reduces the communication energy by as much as 8x compared with direct transmission. DEEC (Distributed energy-efficient clustering scheme)[5] the cluster heads are elected by the probability of the ratio between the average energy of the network and the residual energy of each node. The simulation results has shown that the DEEC achieves more network lifetime and more effective messages than current important clustering protocols in wireless sensor network. GMCAR (Grid-based Multipath with Congestion Avoidance Routing protocol) is proposed for gridded sensor networks. This efficient QoS routing protocol is evolved to divide the sensor network field into grids. Inside of the every grid, one sensor nodes is elected as a master node which delivers the data generated by the node of that particular grid and also route the data to their neighbouring grids. In the routing table, routing entries are stored which defines the multiple diagonal paths that connect the master node to the sink. This novel technique is developed to remove the congestion from the network. DAlPaS (Dynamic Alternative Path Selection Scheme) [6] is a lightweight congestion control and avoidance scheme. It is a very simple technique to control congestion as it keeps minimal overhead. This scheme controls the resources instead of sending rate at the source. Co-OWDM [7] (Coherent orthogonal wavelength division multiplexing) is a highly efficient scheme. The effect of channel spacing on inter-channel crosstalk induces power penalty and on decision threshold Q-factor is studied. Also the effect of number of channels on Q- factor is also discussed. Results of this coherent detection are compared with direct detection technique. In this approach, Co-OWDM with QPSK technique, passive micro-optics based 90◦ optic is used for coherent detection. [8]] In this article two efficient scheduling algorithms; weighted fair queuing (WFQ) and weighted round robin (WRR) lined on token bucket and leaky bucket shaping algorithms. The presented algorithms are compared to weighted round robin (WRR) and the recently proposed bin sort fair queuing (BSFQ).

3. Proposed algorithm

Initially nodes are deployed randomly along with the parameters and respective co-ordinates of the sensor nodes and base station.

1. Threshold function $T_{(n)}$ is applied to the sensor nodes for the cluster head selection.

$$(T_{(n)} = \begin{cases} \frac{P}{1-P\left(r \bmod \frac{1}{P}\right)} & \text{if } n \in G \end{cases}$$

2. Each node choose value $V_{(n)}$ between 0 & 1.

If $V_{(n)} > T_{(n)}$ then

Node (i) becomes cluster head else cluster member.

3. Association of member nodes with cluster head (CH) is done by using Euclidian distance and each member node will be associated with the nearest CH.

$$d = \sqrt{(W_{(i)}.xd - W(CH).(xd)^2) + (W_{(i)}.yd - W(CH).(yd)^2)}$$

4. Communicate with cluster head and base station by using by introducing relay node.

5. Apply the PSO based technique to find the minimal path from cluster heads to base station if the distance between sensor node and relay node is more.

6. Using Roulette Wheel selection, the best individuals are chosen from the population.

7. Crossover and mutations functions are applied to find the efficient cluster heads.

8. Next evaluate the fitness and update initial population of new generation.

9. Check the dead node.

$$\text{Dead} = \text{ if } W_{(i)}.\text{Energy} < 0$$

If all nodes are dead then proceed with next step.

10. Finally return network lifetime.

4. Data flow diagram

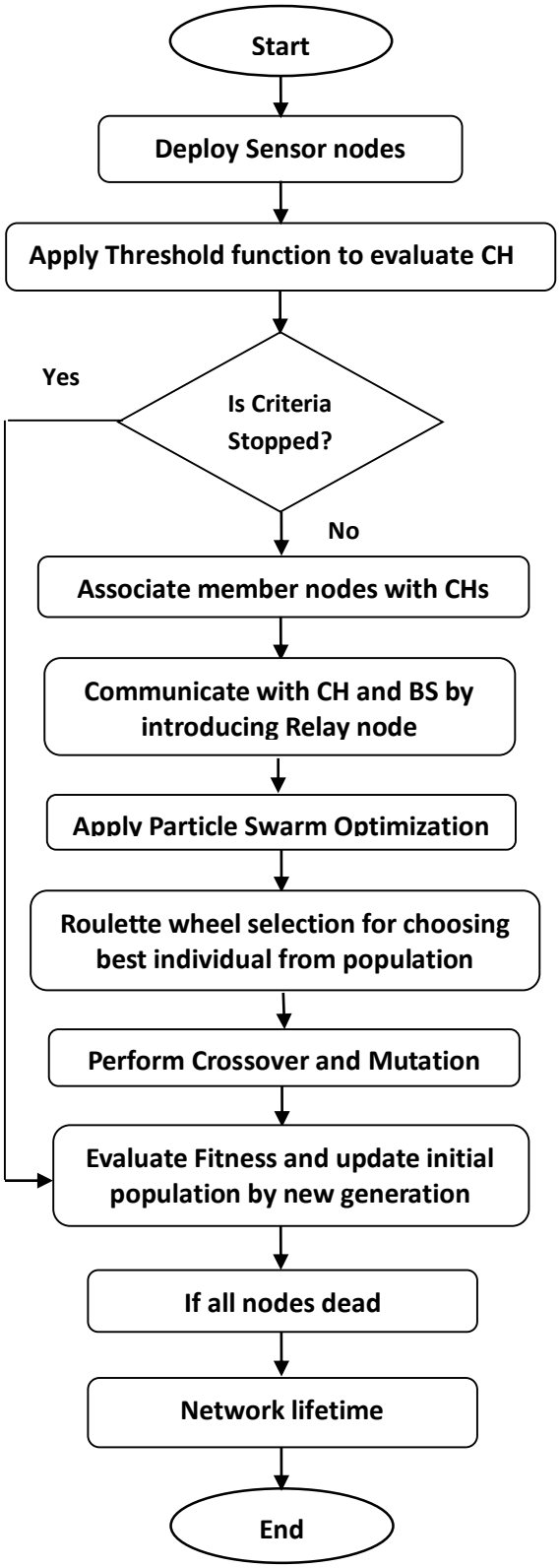

Fig. 1 Data flow diagram of proposed protocol

5. Performance Evaluation

To analyse the performance of proposed protocol, the simulation has performed on the basis of following parameters as shown below in the Table 1.

Simulation Parameters	Value
Routing protocol	GADA-PSO LEACH
Topology Size	100m *100m
Number of sensor nodes	100
Location of Base station	(100, 100)
Initial sensors energy	0.02 J
Network Energy	10 J
Electronic circuit energy	50 J/bit
Energy model of free space fading	10J/bit/m^2
Number of Rounds	1000
Packet Size	4000 Bits
Crossover rate	0.4
Primary population	100
Mutation rate	0.005

Table 1 Experimental Setup

The comparison of existing (GADA-LEACH) and proposed (Hybrid LEACH) technique is done by considering varying number of nodes and at Initial energy 0.02.

1. **Packet transfer rounds:** This metric indicates how data is routed and transferred by means of addressed packets to the base station. Below Fig. 2 shows the difference of packet transfer between existing and proposed technique.

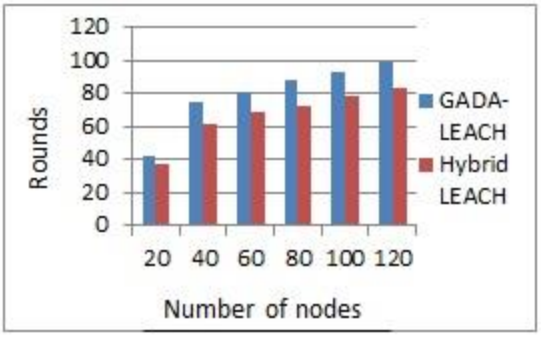

Fig. 2 Average of total number of packets transfer rounds

In table 2 we can see that proposed technique has better hold on transfer of packets than the existing protocol. When we took 20 nodes, In case of GADA-LEACH all the packets sent upto 42 rounds where as in Hybrid LEACH all packets sent at 38th round. So, it is clear that Hybrid LEACH performs better.

Output Metric	Rounds	
No. of Nodes	GADA-LEACH	Hybrid LEACH
20	42	38
40	75	62
60	81	69
80	88	72
100	93	78
120	99	83
140	106	97

Table 2 Analytical Comparison of Packet transfer rounds

2. **Packet sent to BS:** Fig. 3 Hybrid LEACH shows higher delivery of number of packets when compared with the GADA-LEACH. Data aggregation is also used .to reduce the communication cost.

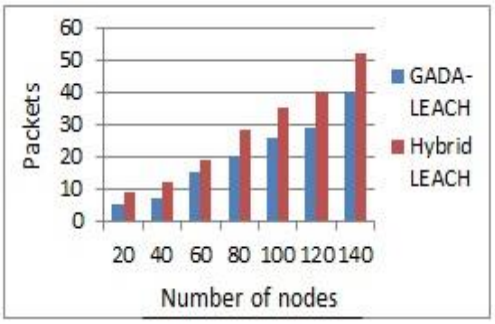

Fig. 3 Total amount of data delivered to BS

Output Metric	Packets	
No. of Nodes	GADA-LEACH	Hybrid LEACH
20	5	9
40	7	12
60	15	19
80	20	28
100	26	35
120	29	40
140	40	52

Table 3 Analytical Comparison of packet sent to BS

Table 3 Indicates that when we sent data using 40 numbers of nodes, then GADA-LEACH sent only 7 packets whereas Hybrid LEACH sent 12 packets which shows that proposed technique outperforms.

3. **Throughput:** Throughput defines the number of round at which the network stops i.e. the round at which all the nodes got dead. The whole lifetime depends upon the battery life of the sensor nodes. It is includes Stability period, half node dead and last node dead. On the basis of the proposed simulation we calculated results which are shown in the Fig. 4.

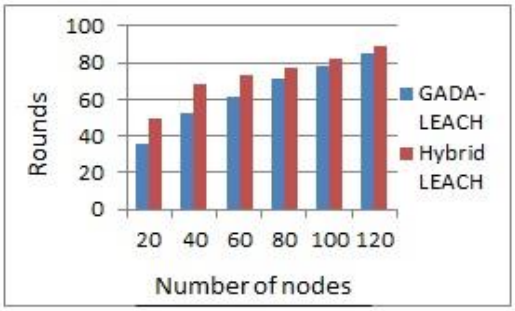

Fig. 4 Throughput of the network

Table 4 Shows that the life expectancy of the network increases very rapidly as the number of nodes are increased.

Output Metric	Throughput	
No. of Nodes	GADA-LEACH	Hybrid LEACH
20	36	49
40	52	68
60	61	73
80	71	77
100	78	82
120	85	89
140	80	97

Table 4 Analytical Comparison of network life

4. **Packet sent to CH:** This metric defines about the total number of packets delivered to the CH during each round. Fig. 5 depicts the better performance of our approach in terms of packet transmission to cluster head in comparison to existing.

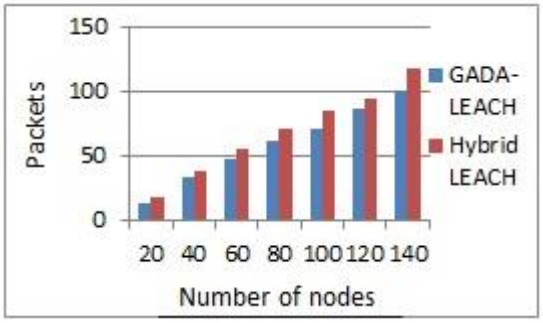

Fig. 5 Packets sent to CH

Henceforth, Table 5 Represents the overall result of comparative analysis of the simulated test cases demonstrates that the proposed technique is more competitive than the existing algorithm in terms of data delivery to CH.

Output Metric	Packets	
No. of Nodes	GADA-LEACH	Hybrid LEACH
20	13	17
40	33	38
60	47	55
80	62	71
100	70	84
120	86	94
140	101	118

Table 5 Analytical Comparison of packet sent to CH

6. Conclusion

The proposed Hybrid protocol assured that the bandwidth of the network is utilized efficiently and maintains the flow of data. Simulation results clearly shows that hybrid protocol works well in case of data transmission to base station, cluster head, total transfer of packets and this protocol works nearly 25% better than the existing GADA protocol. In near future, different parameters can be used to verify and analyse the results. The concept of sleep and awake node can also be used to find the best result and better performance.

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