ENERGY EFFICIENT HYBRID LEACH PROTOCOL FOR WIRELESS SENSOR NETWORKS

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ABSTRACT
The energy efficiency of sensor nodes is an important issue to handle in distributed wireless sensor network (WSN) for gathering massive information. In WSN, sensor node has drawbacks of limited energy and shorter lifetime. Therefore, efficient network routing protocol should be developed to minimize the energy dissipation while maximizing its coverage. In the proposed algorithm, the main focus is to efficiently utilized the energy while communicating to base station (BS). Since location of most BSs varies from nodes to nodes in sensing area, hence energy dissipation in sending data also varies. Low-energy adaptive clustering hierarchy (LEACH) protocol is no doubt a good alternative but its performance is not good always. A hybrid protocol is proposed, which optimizes the energy and enhancing the coverage of nodes. A hybrid LEACH protocol is a combination of bacteria foraging (BF) and particle swarm optimization (PSO). It enhances networks life time by making it energy efficient.

Keywords: Wireless sensor network (WSN); bacteria foraging (BF); Particle swarm optimization (PSO).

1. Introduction
The wireless sensor networks (WSNs) have sensing nodes (SNs) with limited power, memory and computational capabilities. The applications of WSNs include local monitoring, fire-detection and health care information. Mostly the usage of WNSs is in remote areas, where the replacement of dead nodes or recharging is near to impossible task. Energy efficiency of a WSN is an important issue. For enhancing the network lifetime, the clustering protocols mentioned in [1-6] can be used.

The SNs in a WSN can be combined in form of clusters. Each cluster is supervised by a leader named as cluster head (CH), and each CH transmits data from SNs to BS. The author in [1] suggested a clustering algorithm for WSN which is known as low energy adaptive clustering hierarchy (LEACH). CHs in LEACH protocol are selected on random basis and this selection of CHs is constantly rotated to distribute energy load along all node in the entire network. In LEACH protocol, to decrease the load of transmitted data, the CH compresses the received data and transmit an accumulated packet to BS [7-9].

LEACH-C [4] is a hierarchy based protocol in WSN. For the processing of LAECH-C some complementary method is needed and it has also found an optimal solution. LAECH-C protocol is further optimized using the bacteria foraging algorithm (BFA) for making clusters. In case, we employ the position of the particles (e.g., nodes) with respect to local best position and global position, then the LAECH-C provides the better results.

However, using BFA in combination with LEACH-C protocol, the iterative loops will be increased. During the proceed loops, global position is often used in bacterium tumbling mode for tracking the optimum global solution [5]. Thus the network lifetime is directly affected. But in the proposed hybrid algorithm (i.e., BF-PSO), we can optimize this issue. This hybrid algorithm is also effective method of
forming better clusters in a network [6]. Because of the proposed hybrid technique, the lifetime of nodes increases and decreases the transmission energy consumption. The main goal of the WSN is to transmit data continuously and to maximize the network coverage [10-15]. By increasing energy in different techniques, we can prevent connectivity of nodes. There are many challenges to construct an efficient routing protocol discussed below;

1) Limited energy dissipation: In a WSN, nodes use their limited supply of energy to transmit information. It is very important to conserve energy in form of communication as well as computation. The lifetime of sensor nodes depends on the battery capacity. The sensing network works on both ways: i) data sender and ii) data router [10-11]. Due to the failed battery, most significant changes in topologies could occur. The functioning of some sensor nodes can cause packets re-routing and network re-organization.

2) Node deployment: The node deployment in WSN affects the performance of routing protocol. The sensor is placed in pre-determined path and data is routed in the deterministic deployment but in random node deployment, an infrastructure of sensor nodes is created by scattering in deterministic ad hoc manner [12].

3) Node Heterogeneity: There are some application of WSN in which various types of sensor nodes are used. The data can be generated at different rates from different sensor. There can be different types of data operating models that a network can follow and it can also be subjected to different quality of service. The routing becomes more complex due to this kind of heterogeneous environment [11, 13].

4) Coverage: In WSN the coverage of nodes means either sensing coverage or communication coverage. In radio communication, the sensing coverage is less than the communication coverage is significantly larger. In practical application, the sensing of coverage means that how to detect an event or the information about the detection of an event. The interested network area could be known as dense if it is under full coverage [11-13].

5) Fault Tolerance: In heterogeneous network some nodes may dead or could not transmit because of limited power, bodily impairment, or bad weather condition. The aim is that under all scenarios, the performance of the network should not be affected. Under sever circumstances (failure of large number of node), the MAC and routing protocols should adjust the new link formation and provides better routes for data collection from BSs. In order to ensure this feature, we require active power and better signaling rate for the available links [14-16].

6) Scalability of sensor nodes: The numbers of SNs in a WSN network can be in form of hundreds or thousands, or more. It is a fact that each routing protocol is able to work with large number of sensor nodes. Some routing protocols have ability to response an event. It is seen frequently that the sensors are in a sleep mode until an event take place [10].

7) Quality of service: When a sensor node sense an event, then the data can be transmitted at that specific time. In most of the condition quality of sense data is not much important than the conserved energy and also the network coverage. To reduce the energy ingesting in the SNs, the network required to reduce the quality of results. To overcome this problem, we need to think about the energy conscious routing protocols [10].

Although LEACH-C protocol has been proved to provide good performance rather than LEACH, it has many drawbacks too i.e. random selection of CH by centralized method degrades LEACH-C performance and there are also many problems like energy consumption, it is not suitable for large area and not suitable for densely deployed network non-uniform distribution of CHs.

To overcome the specified problems, we propose a hybrid LEACH protocol that combines the BFA and PSO based routing. The energy consumption of the nodes during communication is minimized due to this optimization clustering technique. It will be also used interchangeably with respect to the network conditions that will result in enhancement of network’s lifetime and least power consumption.
The researchers in the recent years have got great interest in energy aware routing in wireless sensor networks. These RPs have two important considerations: i) energy efficiency and ii) data transmission with QoS [15,16]. A compromise between these two considerations is the main topic of interest for the research community.

The important issue raised by researchers [9-13] regarding the above mentioned protocols is the formation of clusters in such a way as to minimize the energy dissipation and optimized the delay constraint of the communication. The pivotal characteristics of distressing the cluster-formation and communication between the CHs, both are the main research areas in the future. Some spatial queries about the usage of distributed WSNs and the location-based RP is also an open issue, which should be explored as well.

In literature [6-12], many protocols assume the SNs and the sink to be stationary. But, there are some scenarios, i.e., for war environment in which the situation is different that the sink and SNs remain to be in continuous motion. For such scenarios, we need to be frequently updated about the position of the node (command and sensor) and circulate the information in the network. In doing so, we need lot of energy consumption, which is not required for efficient network. To overcome that problem, we need to develop a novel routing algorithms, which can handle all the above mentioned issues efficiently.

The proposed hybrid (BFPSO) algorithm significantly improves the energy efficiency, network coverage (lifetime), good time for stability and the more number of message packets can be transmitted to BS in a heavily deployed WSN.

- Due to BFA by minimizing the SNs, we maximize the coverage within the network and the SNs.
- We optimize the clusters by employing the Euclidean distance calculation.
- We choose such clusters which has central transceiver point selected from a group of SNs.
- We optimize position of SNs within each individual cluster.

2. Hybrid BFPSO Algorithm

In order to optimize the network life time and efficient utilization of energy we propose a hybrid algorithm based on principles of two optimization algorithms, PSO (Particle Swarm Optimization) and BFA (Bacteria Foraging Algorithm). This hybrid algorithm is used in LEACH-C, clustering based protocol to generate the optimal clusters. In LEACH-C the cluster head is selected and place at the local/ global best position obtained using PSO.

In hybrid algorithm model as BFA is used which contain bacterial population chemo taxis, swarming, reproduction, elimination, and dispersal are the main steps in this algorithm and PSO particle swarm optimization is also implemented simultaneously in the proposed algorithm. The process is driven by all steps of bacteria foraging algorithm but when chemotactic occur in that stage PSO will be proceed in which position and velocities of particles are assigned. The flowchart of the BFPSO is shown in Fig. 1.
Step 1: Using the above algorithm initialize the parameters and values shown in table 1.
Step 2: Initializing the loop
Step 3: Initializing reproduction loop

<table>
<thead>
<tr>
<th>Table 1. Parameter of proposed hybrid BFPSO algorithm</th>
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<tbody>
<tr>
<td>Parameters and initial values for simulation</td>
</tr>
<tr>
<td>( S )</td>
</tr>
<tr>
<td>( N_x )</td>
</tr>
<tr>
<td>( N_c )</td>
</tr>
<tr>
<td>( N_{re} )</td>
</tr>
<tr>
<td>( N_{el} )</td>
</tr>
<tr>
<td>( P_{el} )</td>
</tr>
<tr>
<td>( C(i) )</td>
</tr>
<tr>
<td>( (i, j, k, l) )</td>
</tr>
<tr>
<td>( W )</td>
</tr>
<tr>
<td>( V_i )</td>
</tr>
<tr>
<td>( C_1, C_2 )</td>
</tr>
<tr>
<td>( n_1, n_2 )</td>
</tr>
</tbody>
</table>

Step 4: Initializing of chemotaxis loop : \( j = j + 1 \)

a) For \( i = 1, 2, \ldots S \) take a chemotactic step for bacterium \( i \).

b) Generate a random vector \( \Delta (i) \in \mathbb{R}^p \) with each element

\[
\Delta_{el}(i), m = 1, 2, \ldots, p
\]

In this when evaluate the \( s_{b_{max}} \), for every bacterium and \( s_{b_{max}} \).

In next step, the velocity and position is updated.

Step 5: The replica for the agreed \( k \) and \( j \), for each \( i = 1, 2, \ldots S \), \( f_{b_{max}}^j = \frac{\sum_{i=1}^{S} J_i(j, i, k, l)}{S} \) define the fitness of bacterium. Observe bacteria and chemotactic parameters \( C(j) \) in order of rising cost (greater cost means lesser fitness). The \( s_{a} \) represent the values of bacteria which have highest cost of \( f_{b_{max}}^j \).

Step 6: Due to eradication and scattering each bacterium, the number of bacteria in the populace persist constant because if a bacterium is removed then there will be dispersion of one bacterium in random location, for \( i = 1, 2, \ldots S \) with probability \( P_{el} \).

Step 7: At the end of the process, if \( i < N_{el} \) then go to step 1; otherwise end. Where \( N_{el} \) denotes elimination and dispersal steps.

3. Simulation Setup

In simulation the performance will be compared between "total energy dissipation in nodes” and "number of alive node”.

First in beginning 100 WSN nodes were randomly distributed un a spatial
region of 50x50 network area. In LEACH 5% of nodes have been taken as cluster-heads and each node transmits 2000 bit in a round $E_{tx} = 50 \text{nJ/bit}$, $E_{rx} = 100 \text{nJ/bit}$ and $E_{amp} = 100 \text{nJ/bit}$. All parameters are represented in table.

![Radio model used for simulation.](image)

For transmission of $k$ bits message to a distance $d$, the radio model for our simulation is given in Fig. 2.

\[ E_{tx}(k,d) = E_{tx} - E_{rx}(k,d) + E_{tx-amp}(k,d) \]
\[ E_{rx}(k,d) = E_{rx} + E_{amp}(k,d) + E_{transmit} \]

where $E_{tx}(k,d)$ denotes dissipation energy over distance $d$, $E_{tx} - E_{rx}(k,d)$ is the transmitter’s components dissipated energy, $E_{tx-amp}(k,d)$ is amplifier electronics consumed energy and $E_{transmit}$ is the energy expended to drive the amplifier and transmitter circuitry.

### Table 2. Network Parameter for Simulation

<table>
<thead>
<tr>
<th>Simulation Parameters</th>
<th>Defined Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nodes</td>
<td>100</td>
</tr>
<tr>
<td>Zone size</td>
<td>50mx50m</td>
</tr>
<tr>
<td>Chosen CH</td>
<td>5%</td>
</tr>
<tr>
<td>Battery energy</td>
<td>0.5J</td>
</tr>
<tr>
<td>bits sent in one round from one node</td>
<td>2000 bits</td>
</tr>
<tr>
<td>Location of base station</td>
<td>[25, -100]</td>
</tr>
<tr>
<td>$E_{rx}$</td>
<td>50 nJ/bit</td>
</tr>
<tr>
<td>$E_{amp}$</td>
<td>100 nJ/bit</td>
</tr>
</tbody>
</table>

### 4. Results and Discussion

Figure 3 show the comparison of LEACH-C, BFA LEACH-C and BFAPSO LEACH-C in terms of coverage of the network and early energy. As it can be seen that the BFAPSO LEACH can form cluster quickly by consuming low energy using tumble and bacteria and results in enhanced network lifespan.
Figure 3 displays the performance in terms of total nodes active inline to the simulation run. From the beginning each scheme contains equal nodes but nodes of LEACH-C survived for less than 600 seconds where the nodes of BFA LEACH-C survived for less than 1300 seconds. However, the nodes remained alive for maximum time almost 1600 seconds only in BFPSO LEACH-C.

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5. Conclusion
In this paper, we present the simulation results obtained using the proposed algorithm. It is clearly seen from the simulation results that our proposed scheme BFPSO LEACH-C shows better performance compared to the classical schemes. The performance improvement is seen in terms of energy.
efficiency. Furthermore, it enhances the network life time and the expected coverage of the network as was expected.

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REFERENCES