E-HORM Energy Hole Removing Mechanism in WSNs

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Motivation

- Energy efficiency is the main issue in WSNs
- Due to uneven energy consumption energy holes are created
- Sensor nodes deplete more energy due to energy holes
- Our work is to remove energy holes to balance energy consumption
Energy Holes

- Sensor nodes in targeted area consume more energy due to dense deployment
- Unbalance energy utilization is main reason for the creation of energy holes
- Random deployment of nodes is another reason
- More nodes due to dense deployment will increase the hardware cost
- After energy hole problem, no data will be transmitted to sink
- In routing schemes for optimal path, intermediate node depletes more energy which expands the area of energy hole
Network Life and Energy Holes

- Due to energy holes problem nodes deplete energy more quickly
- Greater data load near the sink, nodes deplete their energy more quickly and leading to the death of the network.
- This phenomenon reduces the network lifetime
- How to avoid the energy hole becomes a vital research now a days
Energy Holes Removing Techniques

1. Nonuniform node deployment
2. Sensor redistribution
3. E-HORM Energy Efficient Hole Removing Mechanism
   i. Place the sensor nodes in different densities according to their distances
   ii. Mobile sensor is used to reallocate the sensor node to fully cover the targeted area
E-HORM Propose Scheme

- E-HORM scheme has three major phases
- Initializing phase, Threshold calculating phase, Cluster formation and Sleep/Awake scheduling phase
- We first calculate the threshold energy of maximum distant node
- Each node determines its energy level before data transmission
- If energy level of any node is less than threshold energy, it moves toward sleep mode
- When number of sleep nodes $n > 10$, the first sleep node turn into active mode
E-HORM Energy Hole Removing Mechanism in WSNs

E-HORM Flow Chart

Start

Calculate Maximum distance node

Calculate threshold energy

S(i).E>E_th

No

Selection of cluster head

Divide into clusters

TDMA schedule creation by CH

Local data aggregation by CH

Data transmission by CH to BS

Compute energy consumption of every node

Life time over?

Output

If Sleep>10

Put that Node into sleep mode

Yes

Output

Figure: 1
## Simulation Parameters

### Table: 1

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$X_m$</td>
<td>Distance at x-axes</td>
<td>100 meter</td>
</tr>
<tr>
<td>$Y_m$</td>
<td>Distance at y-axes</td>
<td>100 meter</td>
</tr>
<tr>
<td>$N$</td>
<td>Total number of nodes</td>
<td>100 Nodes</td>
</tr>
<tr>
<td>$E_0$</td>
<td>Total energy of network</td>
<td>0.5 J</td>
</tr>
<tr>
<td>$P$</td>
<td>Probability of cluster head</td>
<td>0.1</td>
</tr>
<tr>
<td>$E_{RX}$</td>
<td>Energy dissipation: receiving</td>
<td>$0.0013/pj/bit/m^4$</td>
</tr>
<tr>
<td>$E_{fs}$</td>
<td>Energy dissipation: free space model</td>
<td>$10/pj/bit/m^2$</td>
</tr>
<tr>
<td>$E_{amp}$</td>
<td>Energy dissipation: power amplifier</td>
<td>$100/pj/bit/m^2$</td>
</tr>
<tr>
<td>$E_{ele}$</td>
<td>Energy dissipation: electronics</td>
<td>$50nj/bit$</td>
</tr>
<tr>
<td>$E_{TX}$</td>
<td>Energy dissipation: transmission</td>
<td>$50/nj/bit$</td>
</tr>
<tr>
<td>$E_{DA}$</td>
<td>Energy dissipation: aggregation</td>
<td>$5/nj/bit$</td>
</tr>
<tr>
<td>$d_0$</td>
<td>Reference distance</td>
<td>87 meter</td>
</tr>
<tr>
<td>$n$</td>
<td>Number of sleep nodes</td>
<td>10 Nodes</td>
</tr>
</tbody>
</table>
We determine the energy level of each node according to their distance from sink

- **Case 1**
  - $E_0 > E_{th}$: When remaining energy is greater than the threshold energy, the node is in active mode

- **Case 2**
  - $E_0 < E_{th}$: When remaining energy is less than the threshold energy, the node turns into sleep mode
E-HORM Formulation

- Cluster head forward both the data generated by itself and its members
- **CH** Receive the following data
  
  \[
  (D_1 + D_2 + D_3 + \ldots + D_N)
  \]

- **CH** Forward the following data
  
  \[
  (D_{CH} + D_1 + D_2 + D_3 + \ldots + D_N)
  \]
E-HORM Energy Consumption

- When the distance between N and CH is $d < d_0$. The energy consumption

$$ E_N^{CH} = D_N^{CH}(E_{ele}) + D_N^{CH}(E_{fs})(d^2) $$  

- When the distance between N to CH is $d > d_0$

$$ E_N^{CH} = D_N^{CH}(E_{ele}) + D_N^{CH}(E_{amp})(d^4) $$

- Energy consumed by CH to transmit data to the S when distance between them is $d < d_0$

$$ E_{CH}^S = D_{CH}^S(E_{ele}) + E_{DA} + D_{CH}^S(E_{fs})(d^2) $$
When distance CH and S is $d > d_0$

$$E_{CH}^S = D_{CH}^S(E_{ele}) + E_{DA}D_C H^S(E_{amp})(d^4)$$  \hspace{1cm} (4)$$

$$E_{Total\_CH} = E_{CH} + E_N$$ \hspace{1cm} (5)$$

$$E_{Average\_CH} = \frac{E_{Total\_CH}}{N}$$ \hspace{1cm} (6)$$

Energy saving for normal node

$$E_{Save\_N} = E_{elec} + E_{TX} + E_{amp}$$ \hspace{1cm} (7)$$

Energy saving for CH is

$$E_{Save\_CH} = E_{ele} + E_{DA} + E_{TX} + E_{RX} + E_{amp}$$ \hspace{1cm} (8)$$
Simulation Results iLEACH

![Graphs showing the number of dead nodes and packets to BS over the number of rounds for iLEACH and LEACH](image)

**Figure: 2**

(a) No of dead nodes (b) Packets to BS
We implement sleep and awake mechanism to avoid energy holes.

In LEACH the probability of coverage holes are greater than iLEACH due to randomly deployment of sensor nodes.

Sleep awake scheduling reduces the interference caused by closely deployed sensor nodes.

Stability period and network lifetime of iLEACH is greater then LEACH.
Simulation Results iTEEN

Figure: 3
(a) No of dead nodes (b) Packets to BS
■ TEEN is homogeneous routing protocol
■ All nodes have the same energy level
■ Low energy nodes move towards sleep mode for some rounds to save energy
■ Node deplete balance energy to prolong stability period and network lifetime
Simulation Results iSEP

Figure: 4

(a) No of dead nodes (b) Packets to BS
- SEP and DEEC are heterogeneous routing protocol having normal and advance sensor nodes
- Advance nodes have more energy than normal nodes
- The death ratio of normal nodes is greater than advance nodes
- Ratio of normal nodes in sleep mode is greater than advance nodes due to less energy
- Sensor nodes consume balance energy and enhance the network lifetime
Simulation Results iDEEC

(a) No of dead nodes (b) Packets to BS

Figure : 5
DEEC is multilevel heterogeneous routing protocol

- All nodes have the different energy level
- The death ratio of less energy nodes is greater than other nodes
- Sleep and awake mechanism turns the less energy nodes into sleep mode to enhance the network lifetime
Conclusion

- Main focus is on energy hole problem
- Random deployment causes the creation of energy holes
- Energy hole problem is mitigated by using sleep and awake process
- My scheme outperforms in terms of energy efficiency and network lifetime
Thank you!