(Thesis Final Presentation)

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Publication

Outline

- Summary
- Related Work/ Past Work
- Motivation
- Radio Model
- Proposed Schemes
- Simulation Results
- Applications
- Conclusion
Summary

- Wireless sensors are limited energy devices
- Reduce the energy consumption
- Lifetime and scalability need to be increased
- Energy efficient protocol should be designed
- Proposed Schemes (H-DEEC and MH-DEEC) aims at fulfilling all these requirements
Related Work/ History

- Deployment Scenarios (Planned, Random, Fixed and Dynamic)
- Position of BS
- Communication Standards for WSNs (Bluetooth, WiFi, ZigBee and DASH7)
- Heterogeneous Routing Schemes (SEP and DEEC)
- Clustering Schemes (LEACH, SEP and DEEC)
- Multi Hoping/Chain Forming Approaches (PEGASIS, EEPB, IEEPB)
Related Work/ History…

- Deployment Scenario
  - Planned Deployment
  - Random Deployment
  - Fixed Deployment
  - Dynamic or Mobile
Related Work/ History…

- **Communication Standards**
  - **ZigBee** (IEEE 802.15.4, Low Powered, @ 2.4GHz, 250KB/s)
  - **Wi-Fi** (IEEE 802.11, High Powered, @ 2.5GHz, 54MB/s)
  - **DASH7** (ISO 18000-7, Low Powered, @ 433MHz, 200KB/s)
Journey of WSNs in Routing Layer

- Classical Routing Schemes
  - Direct Transmission (DT)
  - Minimum Transmission Energy (MTE)
- Clustering Schemes

(i) Random Deployment  (ii) MTE  (iii) DT
Journey of WSNs in Routing Layer…

- Clustering Schemes
  - LEACH (Homogeneous, Periodical selection of Cluster Heads)
  - SEP (2-level Heterogeneity, Periodical Selection of Cluster Heads)
  - DEEC (Multi-level Heterogeneity, Energy aware clustering)
Journey of WSNs in Routing Layer…

- LEACH (Homogeneous, Periodical selection of Cluster Heads)

(i) At time $t=0$

(ii) At time $t+\alpha$
Journey of WSNs in Routing Layer…

- **SEP** (2-level Heterogeneity, Periodical Selection of Cluster Heads)
Journey of WSNs in Routing Layer...

- DEEC (Multi-level Heterogeneity, Energy aware clustering)
Journey of WSNs in Routing Layer...

Chain Based Routing Schemes

- **PEGASIS** (Greedy Approach Based Algorithm)
- **EEPB** (Distance and Energy Based Leader Selection)
- **IEEPB** (Weighting Factor Introduced, Multi Edged, Avoiding Long Links)
Journey of WSNs in Routing Layer...

EEPB (Distance and Energy Based Leader Selection)
Related Work/ History…

IEEPB (Weighting Factor Based Leader Selection)
Motivation

• Similar Approaches for different application doesn’t work
• A technique has to be proposed which can perform better in real time scenario as well.
• Drawbacks of certain classical approaches like
  – LEACH (Clustering scenario, un-balance energy utilization)
  – SEP (Limited energy levels)
  – DEEC (Direct communication of Clusterheads)
  – All above technique are not applicable if shape of networks changes.
  – PEGASIS (Data Packet has to transverse from too many Hops )
  – EEPB (Long Link Problem)
  – Base Station Position dependent Scenarios.
Radio Model

- Energy consumed by a sensor is directly proportional to
  - Transmission distance \((d)\)
  - Packet size \((L)\)
### Radio Model

Energy dissipated by Transmitter and Receiver circuitry

<table>
<thead>
<tr>
<th>Operation</th>
<th>Energy Dissipated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transmitter Electronics ($E_{Tx-elec}$)</td>
<td>50 nJ/bit</td>
</tr>
<tr>
<td>Receiver Electronics ($E_{Rx-elec}$)</td>
<td></td>
</tr>
<tr>
<td>($E_{Tx-elec} = E_{Rx-elec} = E_{elec}$)</td>
<td></td>
</tr>
<tr>
<td>Transmit Amplifier ($e_{amp}$)</td>
<td>100 pJ/bit/m$^2$</td>
</tr>
</tbody>
</table>

Energy for Tx amplifier to achieve an acceptable $E_b/N_0$
Proposed Schemes

- (Hybrid DEEC) H-DEEC
- (Multi-edged chained Hybrid DEEC) MH-DEEC
H-DEEC
H-DEEC

- Random Deployment
- Heterogeneous Network \([E_0, E_0(1+a_{max})]\)
- Network is divided into two parts
  - Normal Nodes
  - Beta Nodes

Hybrid = Clustering + Chain forming
H-DEEC

• Our proposed scheme divided into different phases
  – Initializing the Network
    • Distance from BS will be broadcasted by BS.
  – Chain forming
  – Clustering
  – Data Transmission Phases
H-DEEC (Clustering)

- For Balancing the energy consumption DEEC is used for clustering.
- Cluster Heads will be elected on the base of residual energy (Nodes with higher energy will be more probable to elect as a Cluster Head of respective cluster)

\[ p_i = \frac{p_{opt} N (1 + a) E_i(r)}{(N + \sum_{i=1}^{N} a_i) \bar{E}(r)} \]

where

- \( p_i \) is the probability of a node to be clusterhead
- \( p_{opt} \) is the optimum probability of selection of cluster heads
- \( E_i(r) \) is residual energy of the node.
- \( N \) is the total number of nodes
- \( r \) is the current round
- \( a_i \) is the additional energy factor
- \( G \) is the set of nodes eligible for becoming a Cluster Head

\[ T(s_i) = \begin{cases} \frac{p_i}{1 - p_i(r \mod \frac{1}{p_i})} & \text{if } s_i \in G \\ 0 & \text{otherwise} \end{cases} \]
H-DEEC(Chain Forming)

• Beta Nodes will do multi-hopping and the sequence of Hops is elected on the basis of Greedy approach (PEGASIS).
• Leader is selected on the basis of distance of beta node to the base stations.
• Long Link Problem
MH-DEEC

![Diagram of network with 100m x 100m grid, indicating different node types: Normal Node, Beta Nodes, Cluster Head, Leader Node.](image-url)
MH-DEEC(Chain Forming)

• Chain forming Scenario is modified
• Nodes position will be broadcasted by the BS when network will be initiated.
• Leader is selected on the base of weight of every beta node
MH-DEEC(Chain Forming)

- **Leader Selection Phase**

  \[ E_p = \frac{E_{init\_b}}{E_{i\_b}(r)} \]

  where \( E_{init\_b} \) is the initial energy of beta nodes and \( E_{i\_b}(r) \) is the residual energy of beta node.

  \[ D_{toBS} = \frac{d_{toBS}^4}{d_{avg}^4} \]

  where \( d_{toBS} \) is the distance of beta node from BS and \( d_{avg} \) is the average distance of beta nodes from BS.

  Weighting factor is calculated as:

  \[ W_i = w_1 E_p + w_2 D_{toBS} \]

  Where

  \[ w_1 + w_2 = 1 \]
MH-DEEC(Clustering)

- Same as done in DEEC
- On the basis of initial and residual energy
Simulation Results
## Simulation Parameter

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Network size</td>
<td>100m × 100m</td>
</tr>
<tr>
<td>Number of nodes</td>
<td>100</td>
</tr>
<tr>
<td>BS position</td>
<td>(30m,150m)</td>
</tr>
<tr>
<td>Packet size</td>
<td>4000 bits</td>
</tr>
<tr>
<td>$P_{opt}$</td>
<td>0.1</td>
</tr>
<tr>
<td>$E_0$</td>
<td>0.5 J</td>
</tr>
<tr>
<td>$E_{elec}$</td>
<td>5 nJ/bit</td>
</tr>
<tr>
<td>Distance threshold ($d_0$)</td>
<td>70m</td>
</tr>
<tr>
<td>$\epsilon_{amp}$</td>
<td>10pJ/bit/m$^2$</td>
</tr>
<tr>
<td>$\epsilon_{fs}$</td>
<td>0.0013pJ/bit/m$^4$</td>
</tr>
<tr>
<td>Simulation Tool</td>
<td>Matlab</td>
</tr>
<tr>
<td>Communication Standard</td>
<td>ZigBee (assumption)</td>
</tr>
</tbody>
</table>
Stability Graph

Number of Alive nodes vs Number of Rounds for different algorithms:
- MH-DEEC
- H-DEEC
- DEEC
- SEP
Stability Graph

• Stability time is greater than all other classical approaches which will avoid coverage holes
• Shows the efficient and balanced utilization of energy.
• Network lifetime is greater than DEEC and SEP
• Stability Graph Comparison (approx.)

<table>
<thead>
<tr>
<th>Protocols</th>
<th>SEP</th>
<th>DEEC</th>
</tr>
</thead>
<tbody>
<tr>
<td>H-DEEC</td>
<td>38%</td>
<td>35%</td>
</tr>
<tr>
<td>MH-DEEC</td>
<td>61%</td>
<td>60%</td>
</tr>
</tbody>
</table>
Throughput Graph
Throughput Graph Comparison

<table>
<thead>
<tr>
<th>Protocols</th>
<th>SEP</th>
<th>DEEC</th>
</tr>
</thead>
<tbody>
<tr>
<td>H-DEEC</td>
<td>93%</td>
<td>57%</td>
</tr>
<tr>
<td>MH-DEEC</td>
<td>90%</td>
<td>45%</td>
</tr>
</tbody>
</table>
Applications

- Battle Fields Monitoring
- Borders Monitoring
- Crops Monitoring
- Forest Fire Monitoring
- Underground Networks for soil monitoring
- Linear Networks
- Underground Mine Monitoring
- Linear Network Application
- Body Area Network

Centre for Advanced Studies in Telecommunication (CAST), CIIT, Islamabad
Future Work

- Working on Practical Sensor Nodes
- Application for the underground mine sensor Network
- Publication to be submitted in ICC 2014
- Wizzi motes
Conclusion

- Efficient energy utilization is a serious issue in WSNs and H-DEEC and MH-DEEC are energy efficient.
- Both protocol achieving greater stability time and throughput.
- Balanced and Efficient energy utilization
Tools

- Matlab® → For simulations
- Latex → For writing the manuscript and paper
- Inkscape → For figure formatting
- Microsoft Visio → For drawing the diagrams
Questions???