Enhanced Energy Accuracy Based on Clustering

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Abstract: The paper mainly focuses on the methods for improving accuracy of energy prediction using piggybacking technique. Generally, the sensor nodes send their energy/location information to the Base Station (BS). BS then applies suitable clustering technique to group the nodes in clusters and declares the list of CGs and CMs. Afterwards, the CHs and CMs go through the steady state phase data transmission. The reclustering process is called iteratively at every round. The centralized clustering protocol suffers from the excess energy usage during location or energy information transmission to BS. It severely affects the network lifetime. In proposed scheme an energy usage estimation technique (LCEFCM), which employs the fuzzy C-means clustering for creating, clusters in the wireless sensor networks. In this scheme, energy estimation based centralization clustering protocol is used. LCEFCM reduces the energy consumption considerably compared to other clustering methods like simulated annealing and K-means clustering. It applies the dynamic clustering mechanism combined with balances clustering method. LCEFCM outperforms LEACHC, LEACHC Estimate (LCE) and LCWKM for various performance measuring factors like network lifetime, data received, alive nodes etc. a method is contributed to improve accuracy of energy prediction using piggybacking technique.

Index Terms - clustering, energy consumption, and piggybacking technique.

I. INTRODUCTION

In present days, the importance of wireless sensor networks plays a vital role in many application areas such as industries, agricultural monitoring, and environmental monitoring (earthquakes, animals, volcanoes etc...), and healthcare and particularly in underground communication etc. A Wireless sensor network is a collection of sensing devices that can communicate wirelessly [1]. Each device senses the input from other device and processes it and communicates to its neighboring nodes. Historically, WSN’s have been characterized as wireless networks consisting of numerous small, energy constrained, low cost, autonomous nodes that are distributed over an area for the purpose of monitoring and sensing [11] [2]. The ultimate goal of WSN’s is long lasting, flexible and reliable operation of nodes with respect to security and routing.

The sensor networks are already implemented in existing and potential applications from commercial agricultural and geology to security and navigation has limited capabilities for monitoring various underground conditions. Generally field conditions are the important deciding factor for agricultural production. Data acquisition method is one of the primary technical problems in field information research and realization in modern agricultural production, which can collect variable information of crop growth environment in many-sides, accurately, rapidly and effectively. It is also the key and decisive factor of the modern efficient agricultural production. Perception, processing, management decision-making and Information integration control of farmland information has become the focus in the field of contemporary international agricultural science and technology research. The wireless sensor network technology has been applied in agricultural information monitoring field, and it has achieved good scientific research achievements. In case of underground communication water as the medium (like in the sea etc.), the major challenging factors are strength of signal and distance of communication etc. The Electromagnetic waves can easily attenuate in the water, so that it’s not possible to transmit information to long distance [3].

A. Applications of WUSN:

WUSN’s have many application areas such as agriculture, infrastructure monitoring, earthquake monitoring, environmental monitoring, Border patrol and security monitoring, underwater communication in the seas etc... 

I. Environmental monitoring: Wireless underground sensor networks can be used to monitor the soil in conditions such as

- Monitor soil water and mineral content for irrigation
- Monitor soil conditions for sports field monitoring
- Monitor soil movement for landslide prediction
- Coal mine monitoring
- Monitor glacier movement
- Earthquake monitoring

II. Infrastructure monitoring: WUSN’s used to monitor the Underground infrastructure like pipes, wiring etc. also these WUSN’s are used for Monitoring underground components of bridges, dams etc.

III. Security – WUSN’s can have the ability to monitor the aboveground presence and movement of the people and objects with the use sensors like pressure, vibration, or sound. This may be useful for business and home security as well as for
military applications. On extend these WUSN’s can be used for border patrol by deploying wireless pressure sensors along length of the border could be used for the detection of intruder or an object and information will be transmitted to responsible authority[4].

II. LITERATURE REVIEW
There are so many innovations are developed for implementation of wireless sensor networks with respect to data aggregation, placement of sensor nodes at different places and the protocols used for simulation different parameters do WSN. Here some of the papers discussing some existing protocols and algorithms

Title: Energy-efficient communication protocol for wireless micro sensor networks

Description: Wireless distributed micro sensor systems will enable the reliable monitoring of a variety of environments for both civil and military applications. In this scheme, look at communication protocols, which can have significant impact on the overall energy dissipation of these networks. Based on our findings that the conventional protocols of direct transmission, minimum-transmission-energy, multi-hop routing, and static clustering may not be optimal for sensor networks, in propose LEACH (Low-Energy Adaptive Clustering Hierarchy), a clustering-based protocol that utilizes randomized rotation of local cluster based station (cluster-heads) to evenly distribute the energy load among the sensors in the network. LEACH uses localized coordination to enable scalability and robustness for dynamic networks, and incorporates data fusion into the routing protocol to reduce the amount of information that must be transmitted to the base station. Simulations show the LEACH can achieve as much as a factor of 8 reductions in energy dissipation compared with conventional routing protocols. In addition, LEACH is able to distribute energy dissipation evenly throughout the sensors, doubling the useful system lifetime for the networks are simulated.

Title: An experimental study of routing and data aggregation in sensor networks

Description: Several sensor network applications, such as environmental monitoring, require data aggregation to an observer. For this purpose, a data aggregation tree, rooted at the observer, is constructed in the network. Node clustering can be employed to further balance load among sensor nodes and prolong the network lifetime. In this scheme, design and implement a system, head, in which node clustering is integrated with multi hop routing for TinyOS. We consider simple data aggregation operators, such as AVG or MAX. We use a simple energy consumption model to keep track of the battery consumption of cluster heads and regular nodes. We perform experiments on a sensor network testbed to quantify the advantages of integrating hierarchical routing with data aggregation. Our results indicate that the network lifetime is prolonged by a factor of 2 to 4, and successful transmissions are almost doubled. Clustering plays a dominant role in delaying the first node death, while aggregation plays a dominant role in delaying the last node death.

I. Existing System: LEACH guarantees that the energy load is well distributed by dynamically created clusters elected as cluster heads with optimal probability. Cluster head nodes summarize the data received from members. Then, it sends that aggregated data to BS. The cluster-head role is assigned on rotational basis during every round so that energy expenditure of being cluster-head is uniformly spread across the network. LEACH suffers from several drawbacks like non-uniform clusters and no residual energy considerations. Due to this, it does not create clusters uniformly over the deployment region. Sometimes, it may create clusters concentrated in a particular area of the deployment region leaving nodes uncovered.

Limitations:
- It increases the energy consumption and reduces network lifetime.
- It reduces the data delivery ratio.

II. Proposed System: In centralized version of clustering protocols, generally, the sensor nodes send their energy/location information to the BS. BS then applies suitable clustering technique to group the nodes in clusters and declares the list of CHs and CMs. Afterwards, the CHs and CMs go through the steady state phase of data transmission. The reclustering process is called iteratively at every round. The centralized clustering protocol suffers from the excess energy usage during location or energy information transmission to BS. It severely affects the network lifetime if the base station is located far away from the deployment field. Various schemes have been proposed in the literature to reduce such transmissions to conserve the energy. In this scheme, energy estimation based centralized clustering protocol is used. In proposed scheme an energy usage estimation technique (LCEFCM) has been proposed which employs the Fuzzy C-Means clustering for creating clusters in the Wireless Sensor Networks. LCEFCM reduces the energy consumption considerably compared to other clustering methods like simulated annealing and K-Means clustering. It applies the dynamic clustering mechanism combined with balanced clustering method. LCEFCM outperforms LEACHC, LEACHC Estimate (LCE) and LCEK means for various performance measuring factors like network lifetime, data received, alive nodes etc.
The clustering process is done with FCM based clustering for the proposed approach to control the cluster size variation. Instead of estimating energy based on average observations, the CH and CM energy consumption is being estimated. During 10% of the time, energy information is directly received. Remaining 90% of the time, the energy usage of CH and CM is estimated as per the energy model based on radio propagation model. The actual energy received at every tenth round ensures that energy estimations are aligned with the actual residual energy of nodes and rectified accordingly.

**Advantages:**

1. It reduces the energy consumption and increase the network lifetime.
2. It increases the data delivery ratio.

**Energy Piggybacking with Data transmission:**

In proposed scheme, FCM based clustering approach with energy estimation is not accurate to calculate the actual energy of corresponding node at every round. So a Piggybacking technique is contributed that improves the accuracy at every round by attaching actual energy of corresponding node with data packets. The CMs send their data packets with actual energy of nodes to CHs and CHs send their aggregated data packets with actual energy of CMs and CH to Base Station. BS then applies suitable clustering technique to group the nodes in clusters and declares the list of CHs and CMs. Afterwards, the CHs and CMs go through the steady state phase of data transmission. The reclustering process is called iteratively at every round. So current cluster formation round get actual energy from nodes which is more accurate when compared to estimation energy usage technique.

**III. BLOCK DIAGRAM**

The above figure 1 shows the block diagram design flow with inputs are original energy levels of sensor nodes and outputs are performance evolution of different parameters like energy consumption, PDR and alive nodes ratio.

The clustering is done using Fuzzy C-Means clustering algorithm. The clusters are announced during the setup phase. During 10% of the time, energy information is directly received as per the strategy of Kim et al. Remaining 90% of the time, the energy usage of CH and CM is estimated as per the energy model based on radio propagation model. The actual energy received at every tenth round ensures that energy estimations are aligned with the actual residual energy of nodes and rectified accordingly. Algorithm summarizes the proposed FCM based clustering approach with energy estimation.

Algorithm for fuzzy c means clustering:

1: Initialize min. degree of membership, fuzziness coefficient, k
2: if Round % 3 = 1 then
3: Collect Energy Information from nodes
4: Apply FCM Clustering and Announce k Clusters
5: else
6: Predict CH and CM Energy Usage
7: Compute LD
8: if Ei Node<LDth then
9: Discard the Node, from repository
10: end if
11: Apply FCM Clustering and Announce k Clusters
12: end if

**Performance evolution:**

**Energy consumption:** Energy consumption is defined as the amount of energy consumed for the network operation and data transmission.

**Packet delivery ratio:** It is proportion of the total number of packets reached the destination to number of packets sent from the source.

% of PDR = (No. of packets successfully delivered to destination/ No. of packets from source)

**Alive node ratio:** The ratio between alive nodes and the total number of nodes is called alive node ratio.

Figure 1: Block diagram
IV. SIMULATION MODEL

Here listing out some of the requirements for implementing the clustering algorithm in network simulator software.

### Table 1: Software requirements

<table>
<thead>
<tr>
<th>Simulator</th>
<th>Network simulator2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Topology</td>
<td>Random</td>
</tr>
<tr>
<td>Interface</td>
<td>Phy/ WirelessPhy</td>
</tr>
<tr>
<td>Language</td>
<td>TCL, C++</td>
</tr>
<tr>
<td>MAC Type</td>
<td>802.11</td>
</tr>
<tr>
<td>Queue Type</td>
<td>Drop tail/Priority Queue</td>
</tr>
<tr>
<td>Queue length</td>
<td>100 Packets</td>
</tr>
<tr>
<td>Antenna type</td>
<td>Omni Antenna</td>
</tr>
<tr>
<td>Propagation type</td>
<td>Two ray ground</td>
</tr>
<tr>
<td>Routing Protocol</td>
<td>Ex: GPSR</td>
</tr>
<tr>
<td>Transport Agent</td>
<td>UDP/TCP</td>
</tr>
<tr>
<td>Application Agent</td>
<td>CBR</td>
</tr>
<tr>
<td>No. of nodes</td>
<td>Random</td>
</tr>
<tr>
<td>Simulation time</td>
<td>100 seconds</td>
</tr>
<tr>
<td>Transmission range</td>
<td>500 * 500</td>
</tr>
</tbody>
</table>

**A. GPSR:** Greedy Perimeter Stateless Routing, GPSR, is a responsive and efficient routing protocol for mobile, wireless networks. Unlike established routing algorithms before it, which use graph-theoretic notions of shortest paths and transitive reach ability to find routes, GPSR exploits the correspondence between geo graphic position and connectivity in a wireless network, by using the positions of nodes to make packet forwarding decisions. GPSR uses greedy forwarding to forward packets to nodes that are always progressively closer to the destination. In regions of the network where such a greedy path does not exist (i.e., the only path requires that one move temporarily farther away from the destination), GPSR recovers by forwarding in perimeter mode, in which a packet traverses successively closer faces of a planar sub graph of the full radio network connectivity graph, until reaching a node closer to the destination, where greedy forwarding resumes.

GPSR will allow the building of networks that cannot scale using prior routing algorithms for wired and wireless networks. Such classes of networks include:

- **Rooftop networks:** fixed, dense deployment of vast numbers of nodes.
- **Ad-hoc networks:** mobile, varying density, no fixed infrastructure.
- **Sensor networks:** mobile, potentially great density, vast numbers of nodes, impoverished per-node resources.
- **Vehicular networks:** mobile, non-power-constrained, widely varying density.

**Network Simulator2:** Network simulator ns-2 can be defined as a simulator that is written in two languages, C++ and OTcl (object-oriented tool command language), with the concept of object oriented. The topology of simulation is written with Tcl, and it has been linked with the modules of the simulator that are written in C++ through the use of OTcl linkages (the universal functioning could be represented in the figure below). The process of error debugging became more complicated with ns-2, and it is considered to be a drawback with the use of this simulator, since there is a combination of two languages with this simulation.

**Tool Command Language:** TCL is used for millions of people in the real world. It is a language with very simple syntaxes and it allows a very easy integration with other languages. Tcl was created by John Oosterhout.

The characteristics of this language are:

- It allows a fast development.
- It provides a graphic interface.
- It is compatible with many platforms.
- It is flexible for integration.
- It is free and easy to use

**AWK:** AWK is a command/tool available in all the Linux/Unix flavors to do text filtering, manipulation etc. This tool is mainly meant for processing text files and reporting. AWK can be treated as a programming language due to its capabilities such as Arithmetic operations, Binary operations, conditions, loops, functions etc. AWK is an interpreter language. This tool/programming language was developed in 1977 by Alfred V. Ado, Peter J. Weinberger, Brian W. Kernighan. AWK got its name from it’s creates family names.

V. SIMULATION RESULTS

A. Formation of nodes:

Figure2: formation of nodes
The above figure 2 shows the placement of 40 nodes in the scenario and base station is at node 0.

B. Data transmission from cluster member to CH

Figure 3: Data transmission from cluster to CH node

Figure 4: CH Election based on estimated energy

Computing likely to die threshold based on slot size, round duration, number of CMs and average energy. If energy of node is less than threshold means it is declared as dead nodes and status is 1. The Dead node is discarded from future data transmission. Otherwise node is includes in FCM Clustering.

Figure 5: Threshold calculation and dead nodes count

Figure 6: Energy Piggybacking
By piggy backing technique, the accuracy at every round will be improved by attaching actual energy of corresponding node with data packets. The CMs send their data packets with actual energy of nodes to CHs.

Figure 7: Energy consumption

X axis - Number of nodes
Y axis - Energy Consumption

When number of nodes is increased energy consumption is increased and enhancement achieves reduced energy consumption when compared to propose.

Figure 8: Control overhead

X axis - Number of nodes
Y axis - Control overhead

When number of nodes is increased control overhead is increased and enhancement achieves reduced control overhead when compared to proposed method.

V. CONCLUSIONS

Energy estimations using absolute measures, like average energy usage by CM or CH for limited number of rounds does not work when clustering process is not generating quality clusters. When the cluster size is controlled during clustering process, energy estimations can be more accurate. This would also depend on the radio propagation effects. The lifetime and data delivery observed for the LCEFCM approach is higher than LCE, LCEKM and LEACHC. As the energy usage estimations for LCEFCM are more accurately computed compared to LCE, the death of nodes are more precisely calculated. This has an indirect effect on clustering process, as likely to die nodes are avoided from becoming members. The energy estimation based strategies are more efficient when the base station is placed far from the area to be monitored. The assumptions about radio propagation models have significant impact on the accuracy of energy estimations based protocols. Proposed approach can be further analyzed with various realistic radio propagation models. The network topology also plays important role when multiple nodes are communicating in clustered groups and directly with the base station. In this scheme, the topologies considered are uniform random topologies. The proposed approach can be also compared as an extension against several realistic sensor network topologies. A method is contributed to improve accuracy of energy prediction using piggybacking technique.
REFERENCES