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An Energy Saving Approach in Wireless Body Sensor Networks for Health Care Monitoring

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Abstract
Recent technological advances in sensors, low-power micro-electronics and miniaturization and wireless networking have enabled the design and proliferation of wireless body sensor networks capable of autonomously monitoring and controlling environments. One of the most promising problems existing in this network is efficient data transmission with optimized resource utilization. This paper handles the most influencing factor to obtain such efficiency with respect to energy consumption. Selection for optimized routing with the better load balancing is determined and the enhanced uniform clustering of the sensor nodes is performed using the K-Nearest Neighbor algorithm with the best possible route selection using the tree clustering technique. The result shows that the proposed method outperforms the existing approaches mentioned in this paper.

Keywords: Distance, Energy Consumption, Lifetime, Wireless Body Sensor Networks, Health Monitoring

Introduction
Wireless sensor network [10] is a popular area for research now days, due to vast potential usage of sensor networks in different areas. Classical approaches like Direct Transmission and Minimum Transmission Energy [11] do not guarantee well balanced distribution of the energy load among nodes of the sensor network. Using Direct Transmission (DT), sensor nodes transmit directly to the sink, as a result nodes that are far away from the sink would die first [12]. On the other hand, using Minimum Transmission Energy (MTE), data is routed over minimum-cost routes, where cost reflects the transmission power expended. Under MTE, nodes that are near the sink act as relays with higher probability than nodes that are far from the sink. Thus nodes near the sink tend to die fast. Under both DT and MTE, a part of the field will not be monitored for a significant part of the lifetime of the network, and as a result the sensing process of the field will be biased. This paper proposes a new technique on optimal energy utilization.

Related Works
LEACH protocol designed by [1] in 2000 it is one of the mostly used hierarchical routing algorithms in the sensor networks. The main plan of LEACH protocol is to divide the total wireless sensor network into many clusters. The Cluster Head (CH) node is randomly selected. But due its random nature there is a high chance of choosing low energy node as cluster head and it also suffers from uneven distribution of nodes while forming clusters these factors will greatly affect the energy consumption. In 2002 an improved version of Low-energy Adaptive Clustering Hierarchy (LEACH) was introduced by [2] in this rather than forming clusters, it is based on forming chains of sensor nodes. The distinction from LEACH is to employ or use multi hop transmission and choosing or selecting only one node to transmit to the sink or base station. But this method suffers from high energy loss due to sensor nodes die earlier they reach the destination and excessive delays caused by the one or single chain for distant nodes and a high probability for any node to become a bottleneck. G. Smaragdakis et al [3] projected Stable Election Protocol (SEP) protocol. This protocol is also a further modification to the LEACH protocol, in this cluster head selection is performed by weighted election probabilities of every node based on their specific energy. The shortcoming of SEP method is that the election of the cluster heads among the two type of nodes is not dynamic, which results that the nodes that are far away from the powerful nodes will die first. Hybrid Energy-Efficient Distributed clustering (HEED) [4] also extends the fundamental scheme of LEACH by using residual energy and node degree as a main parameter for cluster election to achieve power balancing. But Cluster heads, mainly which are near to the sink, might die earlier because they have very large workload. Xu et al. [5] have made a simple survey of clustering routing protocols, including only six typical clustering algorithms. The authors of the survey simply compared these clustering routing algorithms based on some performance parameters, including energy conservation, network lifetime, data aggregation, robustness, scalability, security, and etc.
Another simple survey on clustering routing algorithms was given by Joshi [6]. The authors of the survey briefly compared these clustering routing approached based on energy conservation and the network lifetime. An overview of Haneef and Deng [7] focuses on design challenges and comparative analysis of WSN clustering routing algorithms for improving the network lifetime. The authors of the overview analyzed

many challenging factors that influenced design of routing protocols in WSNs, and presented a simple classification of routing protocols. Besides, many efficient clustering based classical WSN routing protocols with comparative analysis were discussed in the overview. In [8, 9] a scheme is proposed to reduce the data transmission distances of the sensor nodes by using the uniform cluster structure concepts. To make an ideal cluster distribution, the distances between the sensor nodes are calculated, and the residual energy of each sensor node is accounted for when selecting the appropriate cluster head nodes.

This paper aims to develop a dynamic energy efficient protocol architecture with K-Nearest Neighbor (K-NN) based Uniform clustering and it finds the on the basis of the uniform cluster location, the data transmission distances between the sensor nodes can be reduced by employing an adaptive multi-hop approach. The energy consumption is condensed, and the lifetime is extended for the sensor nodes by balancing the network load among the clusters

Enhanced Energy-Saving Routing Architecture

This paper proposes an enhanced model of energy-saving routing architecture that has K-NN clustering algorithm to reduce the energy consumption and to prolong the network lifetime in wireless body sensor networks. The Proposed work aims at an adaptive multi-hop approach to providing less transmission power for each sensor node and a longer network lifetime for the wireless body sensor networks. This work adopts centralized and cluster-based techniques to create a cluster-tree routing structure for the sensor nodes based on our proposed Enhanced Saving energy clustering algorithm (ESECA) scheme. In the proposed scheme, for each round, it is assumed that the Base Station (BS) receives the information of the location and the residual energy for all the sensor nodes. When the residual energy of a sensor node is higher than the average residual energy of all the sensor nodes in its cluster, the sensor node becomes a candidate of the CH.

Architecture of ESECA

As Shown in the figure1 In this scheme, the operation includes two phases: setup and steady-state phases

Setup phase

During the set-up phase, the BS collects the position information and the energy level from all the sensor nodes in the networks. In accordance with the locations of the sensor nodes, the suitable initial Means of Points (MP) for the clusters can be obtained.

Goal: Create Cluster and find the CH node.

1) Find the center point of all the sensor nodes. Use center point to find the average distance from all the sensor nodes
2) Initial Means of points for each cluster is calculated using the center point and average distance.
3) The initial value k must be decided in the initial set-up phase, where optimum cluster k is calculated using leach-c method.
4) After the initial MPs are set, based on the locations of all of the sensor nodes, the BS creates some clusters. In this work K-NN algorithm is used to partition the n sensor nodes into k clusters, in which each sensor node belongs to the cluster that has the nearest MP.

- The minimal distances between the MPs and all the sensor nodes are calculated. Then, the sensor nodes are classified into the cluster according to the minimal distance.

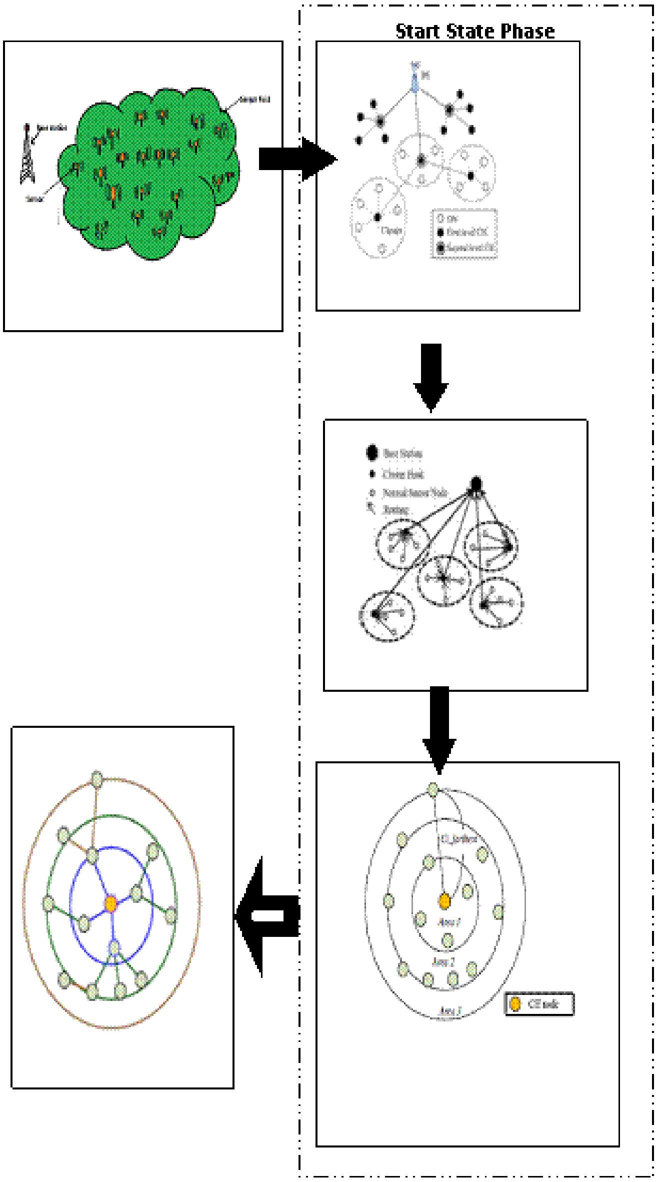

Figure 1: Architecture of ESECA

5) When the classification of all the nodes is completed, the new MP is created and as the MPs are changed, the sensor nodes are reclassified to obtain the minimum distances between the MPs and the sensor nodes for all the clusters.
6) Thus the final clusters are formed when each sensor node is fixed in the cluster. The CH is the sensor

node that is closest to the final MP, and the residual energy of the sensor node is higher than the average residual energy in each cluster.

7) Due to the user mobility in the wireless body sensor network systems, the clusters are re-created dynamically. To adapt to the mobile environments, the ESECA scheme is slightly modified for creating clusters using adaptive multi-hop approach to create the cluster-tree routing structure for the cluster member nodes. This architecture not only reduces the data transmission distance from each sensor node to the CH but also balances the network loading in the cluster. Hence, the transmission power of each sensor node is lowered, and the packet delays can be maintained at an acceptable level.

K-NN Clustering

A distance is assigned between all nodes in a network. Distance is defined as the Euclidean distance between two nodes is:

$$d = \sqrt{\sum_{i=0}^{i=n} (x_i - y_i)^2}$$

From these distances, a distance matrix is constructed between all possible pairings of nodes (x, y).

Each sensor nodes within the network has a class label in the set, C={c1,..., cn}.

The data points', k-closest neighbors (k being the number of neighbors) are then found by analyzing the distance matrix. The k-closest data points are then analyzed to determine which class label is the most common among the set. The most common class label is then assigned to the nodes being analyzed.

In the case where two or more class labels occurs an equal number of times for a specific node within the network, the KNN [13] test is run on K-1 (one less neighbor) of the node. This is a recursive process. If there is again a tie between classes, KNN is run on K-2. This continues in the instance of a tie until K=1. When K=1 there is only one class represented in the outcome and thus there can be no tie. These resulting class labels are used to classify each node in the network.

Cluster tree structuring

It is obvious that the transmission distance between two sensor nodes is shortened by using ECRA. The non-CH nodes play both the role of sensing the environment as well as receiving sensed data from other non-CH nodes, aggregating them and sending them to the CH node as a hop. This approach increases the energy consumption of those non-CH hop nodes.

This proposed approach increases the energy consumption of those non-CH hop nodes. However, the network loading is balanced in the cluster, and the energy consumption of the CH node is shared. Hence, the total energy consumption is reduced in the cluster, and the network lifetime is extended for the sensor nodes.

When the cluster routing structure is created, the BS broadcasts the cluster routing information to all of the sensor nodes. Hence, each sensor node has its own routing table and knows its task (e.g., CH or non-CH). Additionally, each sensor node knows the distances from any other sensor node in its cluster and thereby calculates the transmission power. In accordance with the number of sensor nodes within the cluster, the CH node creates a schedule based on Time Division Multiple Access (TDMA) to allocate the time for the cluster members.

- When the cluster architecture is created, the farthest and the nearest distances between the CH and the non-CH nodes are calculated for each cluster and also calculate the number of divided areas in each cluster.
- Thus the farthest non-CH nodes can connect to the CH via multi-hops
- The non-CH nodes are classified into the different areas in its cluster. For each cluster, the non-CH nodes directly connect to the CH in Area 1. On the other hand, a non-CH node in Area u + 1 connects to the non-CH node in Area u, where the distance between the two nodes is minimal.

Steady-state phase

1) Once the clusters are created and the TDMA schedule is fixed, data transmission can begin.
2) The non-CH nodes send sensing information (sensing data, position, and residual energy) to the CH node during their allocated transmission time.
3) When all of the information has been received, the CH node performs signal processing to compress the information into a single signal. Then, this signal is sent to the BS.
4) The amount of information is reduced because the data aggregation is performed at the CH or non-CH hop nodes.
5) This round is completed, and the next round begins with a set-up phase and a steady-state phase; this process is repeated.

During the iteration process

1) In the other rounds, during the set-up phase, the BS collects the position information and the energy level from all of the sensor nodes based on the previous round. According to the location and residual energy of the sensor nodes, the routing structure is created.
2) When the routing architecture is created, the BS broadcasts the CLU_ROU-IND to all of the sensor nodes.
3) During the steady-state phase, the non-CH nodes send sensing information (sensing data, position, and residual energy) to the CH node during their allocated transmission time. When all of the information has been received, the CH node performs signal processing to compress the information into a single signal (SEN_INF-RSP). Then, this signal is sent to the BS.
4) To avoid unnecessary node control message transmissions and control overhead of the BS, the clusters are re-created only when the CH sensor node does not receive all of the data from its non-CH

sensor nodes in a certain round. Thus, the calculation of overhead is only the CH selecting the most set-up phases.

Experimental Result

In this section, we evaluate the performance of our proposed SECA-M and ECRA by using a simulation model. We describe our simulation environment and illustrate the simulation results, and we compare our schemes with LEACH [10], LEACH-E [11], HEED [12], NCACM [13], LEACH-C [14], and PEGASIS [21]. In the simulation, the human-centered applications in wireless body sensor networks are accounted for. We assume that the sensor nodes are employed and equipped with the users in the outdoors, and the moving situation of each user is a random movement within a sensing area. To prove that our proposed scheme is promising, we design a visual interface simulator and implement several existing schemes for fair comparison.

The assumptions for our simulation environment are as follows:

- A BS is fixed and located far from the sensor nodes.
- The initial location of each user is randomly distributed in the sensing area.
- The speed of each user is uniformly distributed between 0 and 5 km/h.
- All of the sensor nodes can send data to the BS.
- All of the sensor nodes in the network are homogeneous and energy constrained.
- The non-CH nodes can monitor the environment and directly send data to the CH node, or through the non-CH hop nodes.
- The CH node can gather data, compress it, and forward it to the BS.
- The initial energy is the same for each sensor node.
- The energy of the sensor node cannot be recharged. The sensor node continues to sense and transfer data until its energy is depleted.
- All of the parameters used in our simulation are listed in Table 1

Table 1: Parameter Values used in this simulation

Parameter	Value
Electronic Energy	50 nJ /bit
Energy for data aggregation	5 nJ /bit/signal
Initial Energy of sensor node	2J
Communication Energy	10 pJ /bit/m^2
Communication Energy	0.0013 pJ /bit/m^4
Threshold value of distance	75m
Packet size	2000 bits
Sensing Area	100m x 100m, 200mx200m
Position of BS	(50, 175), (100, 350)
Number of Sensor Nodes	100, 200, 500 and 1000

The result was simulated for 100, 200, 500 and 1000 nodes. The performance of the proposed method was compared with LEACH, LEACH-C, SECA-M and ECRA.

Table 2: Average Total Network Energy Consumed for 100, 200, 500 and 1000 number of sensor nodes

Protocol	Sensor Nodes			
	100	200	500	1000
LEACH	77.3	79.1	82.3	84.7
LEACH-C	80.6	83.5	87.4	88.3
SECA-M	85.2	89.2	90.1	92.4
ECRA	89.8	90.3	92.6	94.2
ESECA	91.2	92.7	95.3	96.8

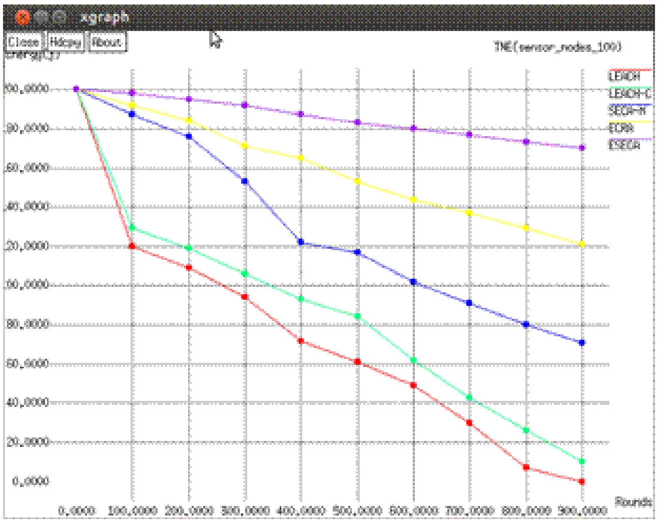

Figure 2: Total network energy (sensor nodes = 100)

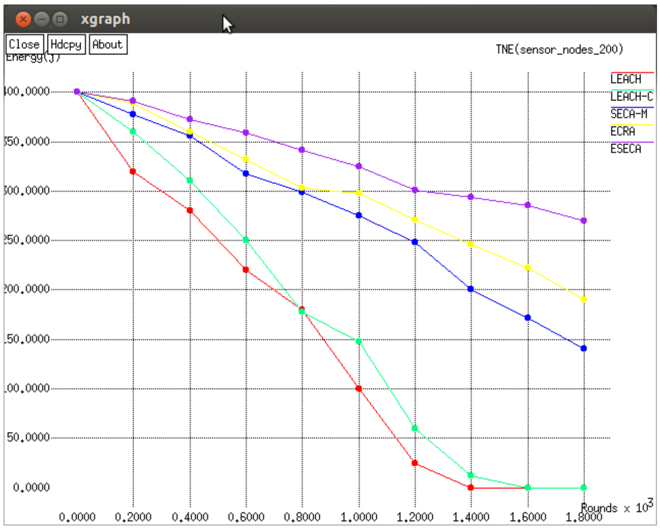

Figure 3: Total network energy (sensor nodes = 200)

The Figures 2 and 3 depicts the total network energy when the number of sensor nodes for 100 and 200 with the sensing area is 100 m × 100 m. Due to the increase in number of sensor nodes better cluster distribution approach takes place and which leads to the lower energy consumption. This proposed work improves the energy saving scheme by using kNN for cluster formation for both 100 and 200 number of sensors. According to the proposed feature it is intuitive that the proposed ESECA scheme results in a higher residual energy than the LEACH, LEACH-C, SECA-M and ECRA and schemes when the number of sensor nodes is increased in the same sensing area. The life time of the proposed scheme sensor node is maintained significantly better.

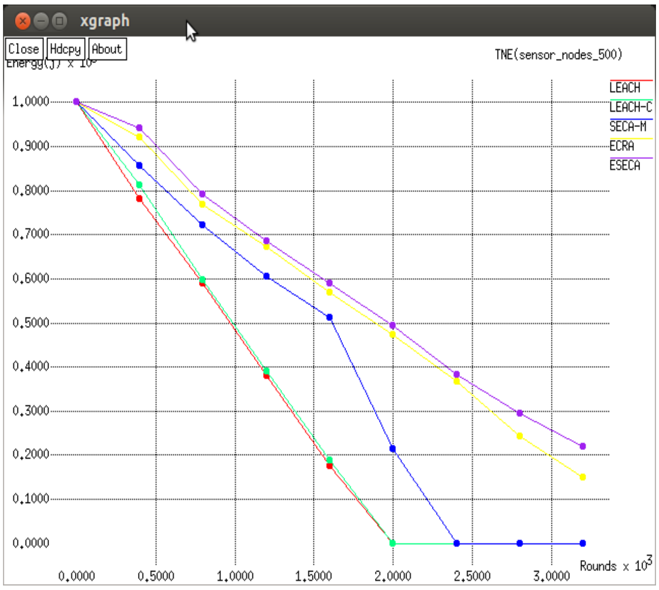

Figure 4: Total network energy (sensor nodes = 500)

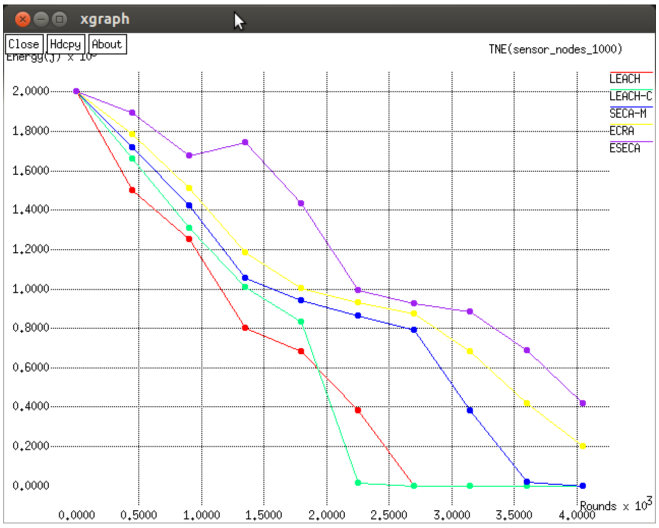

Figure 5: Total network energy (sensor nodes = 1000)

Moreover, this proposed work extend the sensing area to 200 m × 200 m in the simulation environment. Figures 4 and 5 show the total network energy when the number of sensor nodes are 500 and 1000, correspondingly. The cluster distributions in LEACH, LEACH-C, SECA-M are not uniform, and a few of the clusters have a very large number of sensor nodes in a large area. When the sensing area is extended transmission power to send data from non-CH to CH node was required at the same time there is a high chance of heavy traffic load, which results in considerable energy consumption for getting and aggregating the data from its non-CH nodes. Furthermore, LEACH and LEACH-C is unsuitable for a large-scale sensing area because some sensor nodes must transfer data through a longer distance. According to Figs. and, the graph point out that our proposed scheme reduces the energy consumption more significantly than the LEACH, LEACH-C, SECA-M and ECRA schemes

Conclusion

Major toughest issue still prevail in wireless body sensor network is energy consumption.
Simulation results indicate that the proposed algorithm achieves lower energy consumption and longer network lifetime in wireless body sensor networks. In the proposed scheme, a cluster-tree routing architecture for sensor nodes is created by using centralized and cluster based techniques. The proposed method utilizes K-NN to calculate the distances between the sensor nodes and account for the residual energy by selecting the appropriate CH nodes. The main reason is that the routing structure is improved by using KNN based clustering in the proposed scheme. The transmission distance between two nodes is reduced considerably. Hence, the transmission power is lowered. From the simulation results, it is clear that our proposed scheme not only achieves the appropriate performance level with respect to the energy consumption and network lifetime for the wireless body sensor networks but also is suitable for large-scale sensing and detecting environments.

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