Vibration Analysis for IOT Enabled Predictive Maintenance

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ABSTRACT
Thispaperdiscusses a vibration analysis for IoT Enable Predictive maintenanceto the base station placement in a wireless sensor network (WSN) field. The WSN model have multi cluster approach has been investigated. The objective is to minimize the overall energy consumption in a WSN during the data transmission over nodes by figuring out the utilization of cluster head and overlapping head nodes.
We prove that the overall energy consumption is minimized at the centroid of the nodes and proposed point of the node as the compare of the minimum enclosing circle of the center of the nodes. We know thatmost of the nodes are close to the base station, whereas a few nodes are far from it. Therefore these far-off sensors nodes use more energy than nearer ones. We have used a centroid method for finding the cluster head node location and investigating how to find the base station location related data transmission to reduce energy consumption and hence to increase network lifetime.

Keywords:WSN,Vibration analysis for Iot Enable predictive maintenance.

1. INTRODUCTION

Wireless sensor network (WSN) is a densely deployed collection of a large number of self-Organizing wireless sensor nodes with limited energy resource, and usually a base station to collect and process the data from sensor nodes. A sensor node consumes energy for event sensing, coding, modulation, transmission, reception and aggregation of data. Data transmission has the highest share in total energy consumption.The required transmission power of a wireless radio is proportional to square or an even higher order exponent of distance in the presence of obstacles. Thus, the distance between transmitter andreceiver is the main metric for energy consumption in a WSN.
Base station location affects the lifetime of the sensor network as all the data are finally transmitted to the base station for processing and decision making for various applications. We can reduce transmission energy by reducing the distance between the sensor nodes and the base station. This can be achieved by placing the base station at an optimal location.We can reduce transmission energy by reducing the distancebetween the sensor nodes and the base station. This can be achieved by placing the base station at an optimal location. In the paperso far, many heuristic algorithms have been proposed to find sub-optimal solutionsof the optimum base station positioning in two-tiered WSN. Although these heuristics are shown to be effective, their algorithms depend on the topology and are based on structural metrics.WSN and micro-electronic devices have limited source of power and have commonly powered using batteries but for the application where the system is expected to operate for a very long period, and energy becomes a bottleneck. In sensor network, normally each sensor can relay traffic to other sensor using multi-hope routing algorithms until data reaches its destination.
mobile network is a collection of mobile nodes that are dynamically and arbitrarily located in such a manner that the interconnections between nodes are capable of changing on a continual basis. In order to facilitate communication within the network, a routing protocol is used to discover routes between nodes. The primary goal of such an ad hoc network routing protocol is correct and efficient route establishment between a pair of nodes so that messages may be delivered in a timely manner. Route construction should be done with a minimum of overhead and bandwidth consumption. This article examines routing protocols for ad hoc networks and evaluates these protocols based on a given set of parameters. The article provides an overview of eight different protocols by presenting their characteristics and functionality, and then provides a comparison and discussion of their respective merits and drawbacks [1]. A suite of algorithms for self-organization of wireless sensor networks in which there is a scalably large number of mainly static nodes with highly constrained energy resources. The protocols further support slow mobility by a subset of the nodes, energy-efficient routing, and formation of ad hoc sub networks for carrying out cooperative signal processing functions among a set of the nodes [2]. The problem of adjusting the transmit powers of nodes in a multi hop wireless network (also called an ad hoc network) to create a desired topology. We formulate it as a constrained optimization problem with two constraints - connectivity and bi connectivity, and one optimization objective - maximum power used. We present two centralized algorithms for use in static networks, and prove their optimality. For mobile networks, we present two distributed heuristics that adaptively adjust node transmit powers in response to topological changes and attempt to maintain a connected topology using minimum power. We analyze the throughput, delay, and power consumption of our algorithms using a prototype software implementation, an emulation of a power-controllable radio, and a detailed channel model. Our results show that the performance of multi hop wireless networks in practice can be substantially increased with topology control [3]. Thenetworking together hundreds or thousands of cheap Micro sensor nodes allows users to accurately monitor a remote environment by intelligently combining the data from the individual nodes. These networks

require robust wireless communication protocols that are energy efficient and provide low latency. In this paper, we develop and analyze low-energy adaptive clustering hierarchy(LEACH), a protocol architecture for micro sensor networks that combines the ideas of energy-efficient cluster-based routing and media access together with application-specific data aggregation to achieve good performance in terms of system lifetime, latency, and application-perceived quality. LEACH includes a new, distributed cluster formation technique that enables self-organization of large numbers of nodes, algorithms for adapting clusters and rotating cluster head positions to evenly distribute the energy load among all the nodes, and techniques to enable distributed signal processing to save communication resources. Our results show that LEACH can improve system lifetime by an order of magnitude compared with general-purpose multi hop approaches [4].

2. Related Work

we have established the set of metrics that will be used to evaluate the performance of the sensor network as a whole, we can attempt to link the system performance metrics down to the individual node characteristics that support them. The end goal is to understand how changes to the low-level system architecture impact application performance. Just as application metrics are often interrelated, we will see that an improvement in one node-level evaluation metric (e.g., range) often comes at the expense of another (e.g., power, flexibility, security, communication, computation, time synchronization and environmental data collection, security monitoring, and sensor node tracking). We believe that the majority of wireless sensor network deployments will fall into one of these class templates.

At the network level, the environmental data collection is characterized by having a large number of nodes continually sensing and transmitting data back to a set of base stations that store the data using traditional methods. These networks generally require very low data rates and extremely long lifetimes. In typical usage scenario, the nodes will be evenly distributed over an outdoor environment. This distance between adjacent nodes will be minimal yet the distance across the entire network will be significant. Environmental data collection typically use tree-based routing topologies where each routing tree is rooted at high-capability nodes that sink data. Data is periodically transmitted from child node to parent node up the tree-structure until it reaches the sink. With tree-based data collection each node is responsible for forwarding the data of all its descendants. Nodes with a large number of descendants transmit significantly more data than leaf nodes. These nodes can quickly become energy bottlenecks and Security monitoring networks are composed of nodes that are placed at fixed locations throughout an environment that continually monitor one or more sensors to detect an anomaly. A key difference between security monitoring and environmental monitoring is that security networks are not actually collecting any data. This has a significant impact on the optimal network architecture. Each node has to frequently check the status of its sensors but it only has to transmit a data report when there is a security violation. The immediate and reliable communication of alarm messages is the primary system requirement. These are "report by exception" networks.

Sensor networks is the tracking of a tagged object through a region of space monitored by a sensor network. There are many situations where one would like to track the location of valuable assets or personnel. Current inventory control systems attempt to track objects by recording the last checkpoint that an object passed through. However, with these systems it is not possible to determine the current location of an object. For example, UPS tracks every shipment by scanning it with a barcode whenever it passes through a routing center. The system breaks down when objects do not flow from checkpoint to checkpoint. In typical work environments it is impractical to expect objects to be continually passed through checkpoints.

And in a network designed to track vehicles that pass through it, the network may switch between being an alarm monitoring network and a data collection network. During the long periods of inactivity when no vehicles are present, the network will simply perform an alarm monitoring function. Each node will monitor its sensors waiting to detect a vehicle. Once an alarm event is detected, all or part of the network, will switch into a data collection network and periodically report sensor readings up to a base station that track the vehicles progress. Because of this multi-modal network behavior, it is important to develop a single architecture.

3. Methodology

The transmitter dissipates energy to run the transmitter radio electronics and the power amplifier, andthe receiver dissipates energy to run the receiver radio electronics. If the distance between the transmitter and the receiver is less than a threshold (d_0), the 'free space (fs) loss' model is used; otherwise, the 'multipath loss' model is used. Here, we are assuming that a suitable power controlmechanism exists to regulate transmit power depending on the distance to the receiver. In a transmission amplifier .we used path loss exponent, n= 2, for free space loss model and n = 4 for multi-path loss model. The consumed amplifier energy E_{amp}, of a sensor node is $E_{fs}.d^2$ or $E_{mp}.d^4$ depending on the distance d between node and base station.

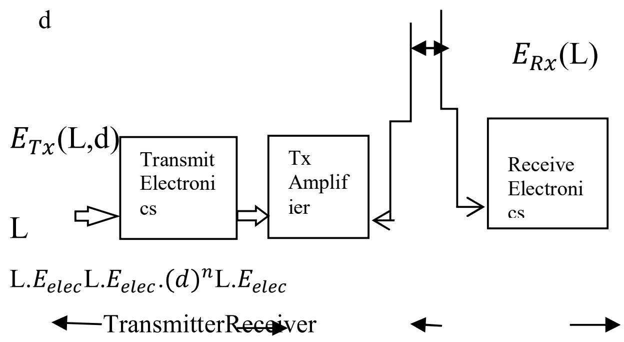

Fig.**Radio Model**

$E_{amp}=\begin{cases} E_{fs}.d^2 & d < d_0 \\ E_{mp}.d^4 & d \geq d_0 \end{cases}$…(1)

Here, threshold distance d0 for swapping amplification model is calculated by equating E_{amp}(fs) to E_{amp}(mp).

$E_{fs}.d^2 = E_{mp}.d^4 \quad = d_0=\sqrt{\frac{E_{fs}}{E_{mp}}}$….(2)

whereE_{fs} is free space loss constant measured in J/bit/m2 and $E_{mp}$is multi-path loss constant measured in J/bit/m4. If a node transmits L number of bits, the energy used in transmission will be

$E_{TX}(L,d) = E_{TX-ele}(L)+E_{amp}(L,d)$

$=\begin{cases} LE_{ele} + LE_{fs}.d^2 & d < d_0 \\ LE_{ele} + LE_{mp}.d^4 & d \geq d_0 \end{cases}$…(3)

To receive L message bits, the radio spend

$E_{RX}(L) = E_{RX-ele}(L)=LE_{elc}$…(4)

Here, E_{ele} is the energy, in J/bit in transmission and reception electronics. Most of the earlier work had considered only free space loss (n = 2) as the model of radio communication. We are not aware of any work that considers multi-path loss (n =4) in their radio model or multi-path radio models for analysing optimal base stationpositioning.

We have considered the same energy consumption model, which was used in LEACH [17].WSN topology is divided into clusters. Cluster heads are selected among all nodes in each round of data transmission. Each node chooses the nearest cluster head for forwarding packets to the base station. Cluster heads collect data from all the nodes inside the cluster, aggregate it and pass it to the base station.

Let there be n nodes uniformly distributed in an M × M area and k number of clusters in the topology. There will be on an average (n/k) nodes per cluster. Out of these, there will be one cluster head node and (n/k - 1) non-cluster head nodes. Energy consumption for a single frame (one round) of transmission of data for topology will be as follows.

The energy consumption E_{non-CH} for a single non-cluster head node only for transmission of L bits to cluster head is

E_{non-CH}=L.E_{elec}+LE_{fs}.d^2_{CH}….(5)

Following [18].

$d^2_{CH}=\frac{M^2}{2\Pi K}$…(6)

whereE_{CH} for a particular cluster head node is calculated as the sum of the energy consumed in reception of data from all non-cluster head nodes of that cluster and data aggregation and transmission of the aggregated data to the base station. It is important to mention here that each non-cluster head node transmits data of L bits, then the cluster head aggregates all these bits with its own L bits to form aggregated L bits of data for transmission to the base station.

$E_{CH} = \left(\frac{n}{k} - 1\right).\text{L}.E_{elec} + \frac{n}{k}.\text{L}E_{DA} + E_{TX}(L,d)$..(7)

where$E_{DA}$is energy used by the cluster head for data aggregation. Now the energy consumption in a cluster for one round of transmission is given by

$E_{cluster}$=E_{CH} + $(\frac{n}{k} - 1)E_{non-CH}$…..(8)

The energy consumption in the network for one round is the sum of the energy dissipated by all the clusters.

$E_{ROUND} = \sum_{j=1}^{k} E_{cluster(j)}$…..(9)

Case 1: When all the nodes in a sensor network are near the base station, such that there is free space loss for transmission from the nodes to the base station. Then, E_{ROUND} is given by

E_{ROUND}=L$(2n - k)$.E_{elec}+n .E_{DA}+(n-k). $E_{fs}.\frac{M^2}{2\Pi K}$+$E_{fs}\sum_{j=1}^{k} d_j^2$ …..(10)

wheredj is the distance between the cluster head and the base station. After (n/k) rounds, when every node has become a cluster head once, the total energy spent is given by

E_{total}= L$\frac{n}{k}$[$(2n - k)$.E_{elec}+n .E_{DA}+(n-k). $E_{fs}.\frac{M^2}{2\Pi K}$]+L. $E_{fs}\sum_{j=1}^{k} d_j^2$…….. (11)

Case 2: When the base station is far away from all the nodes,multi-path loss exists for transmission from nodes to base station. Then, E_{total} is given by

E_{total}=E_1+L. $E_{mp}\sum_{j=1}^{k} d_j^4$…(12)

Where

E_1= L$\frac{n}{k}$[$(2n - k)$.E_{elec}+n .E_{DA}+(n-k). $E_{fs}.\frac{M^2}{2\Pi K}$]….(13)

Case 3: When some nodes are near and some nodes are far away from the base station then,$E_{total}$is given by

E_{total}=E_1+L. $E_{fs}\sum_{i=1}^{p} d_i^2$ +L. $E_{mp}\sum_{j=1}^{q} d_j^4$….(14)

where node i and node j are from different sets, and here, p number of nodes are nearer to the base station and q number of nodes are farther from the base station (di < d0 ⇒ nearer nodes and dj≥ d0 ⇒ farther nodes). Since E_1 is same in all the three cases.

For Case 1, energy for transmitting data to base station in E_{bs} (n/k) rounds is

$$E_{bs}=L.E_{fs}\sum_{j=1}^{k} d_j^2 \ldots\ldots(15)$$

For Case 2,

$$E_{bs}=L.E_{mp}\sum_{j=1}^{k} d_j^4 \ldots\ldots(16)$$

For Case 3,

$$E_{bs}=L.E_{fs}\sum_{i=1}^{p} d_i^2 + L.E_{mp}\sum_{j=1}^{q} d_j^4 \ldots(17)$$

We need to find the optimal location for the base station, which minimize E_{bs}.

4. Result and Discussion

WSN model design using the MATLAB. Using this model we have determined the energy consume by sensors during the force of data transmission from WSN sensor to base station. We have analyzed three different scheme of determining the location of base station with respect to minimum energy expenditure of a sensor network. we have shown the surface plot obtained from %Ecp, %Emc, %Emp in the 2(a),4(a),5(a) using this surface plot we can visualise how does percentage energy Reduction varries with different configuration of WSN nodes and field area. In the surface plot the colour of the surface changes from red to blue shades where red shades represents high values, yellow represents medium values and blue represents low values.
In Fig. (a) we have shown %Ecp on the z-axis, nodes and area are on the x-axis and y-axis. As we can see that x-axis varrying from 0-200 and

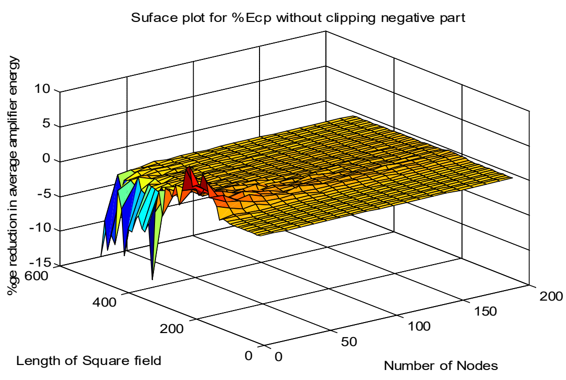

Fig. (a) Percentage reduction in average amplifier energy for the proposed point compared with centroid without clipping negative part

y-axisvarrying from 0-600 because we have changed nodes from 5-200 and area is chaged from 30- 500. The z-axis shows % Ecp having peak value of 6.07 at area=240 and node= 5(see Fig. (b)) hence it shows that there is 6.07% of less energy is consumed by the sensor nodes during the data transmission if we place our base station at our proposed point instead of centroid.

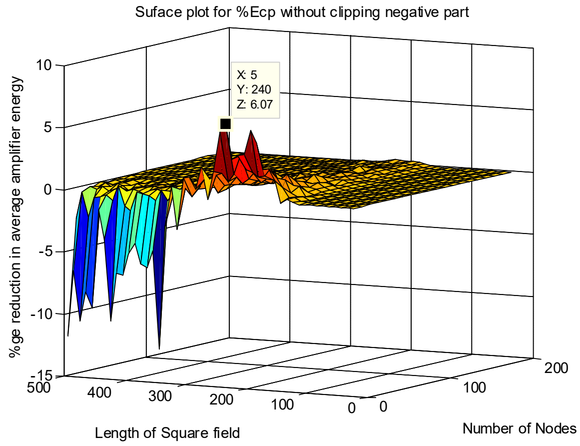

Fig. (b) side view of Percentage reduction in average amplifier energy for the proposed point compared with centroid without clipping negative part

Same figure is again shown in the top view in Figure 2(c). Here we have in circle the portion where %Ecp is significantly larger than the other cluster.for more clearty we have clipped the negative part to zero such that the surface plot becomes blue in the region
shaving Ec=Ep

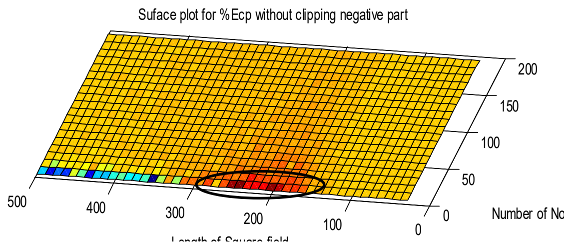

Fig. (c) top view of Percentage reduction in average Amplifier energy for the proposed point compared with centroid without clipping negative part.

This is shown in Fig.(a) having only those portion are shown where energy consumption by our proposed location is less than Ec

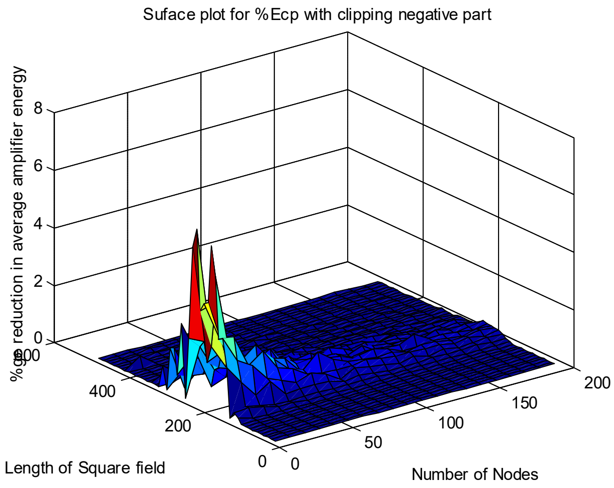

Fig.(d):- Percentage reduction in average amplifier energy for proposed point compared with centroid with clipping negative part

Fig.(d) is the side view of above figure it is also showing that there is maximum %Ecp is 6.07 at area=240 node=5. Now the portion which above the surface are representing the range of area field and number of nodes for which our proposed algorithm prove itself better than the base station location as centroid. For this purpose we have taken the top view %Ecp with negative part clip to zero.

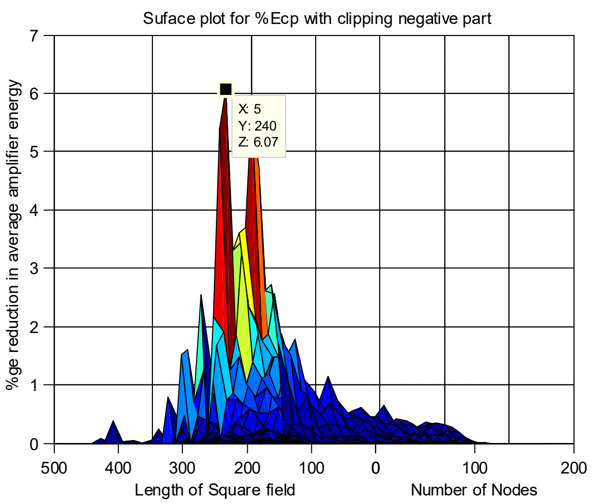

Fig. (e):- side view of Percentage reduction in average amplifier energy for proposed point compared with centroid with clipping negative part.

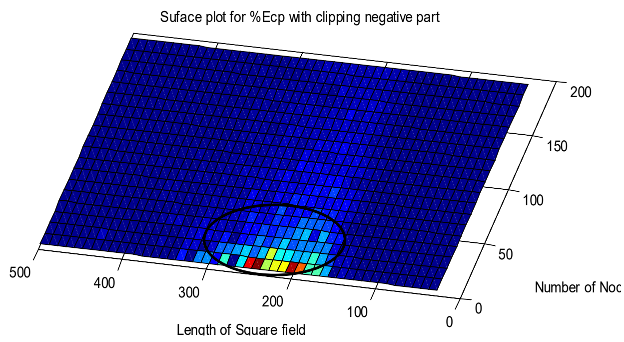

Fig. (f):- top view of Percentage reduction in average amplifier energy for proposed point compared with centroid with clipping negative part

In the Fig (f) we can see that a yellow line is drawn in the portion having %Ecp as positive in this region area varries from 100 to 350 meter and number of nodes are varring from 5 to 180. It represents that for area less than 100 the performance of both algorithm are same . However since our thresold distance is 80 for area of length 100 all the nodes will be at a distance less than d_0. So there will be no case of amlpifiaction loss there will be only the free path losses that is why for area less than 100 our proposed point and centroid point is similar. For large area above than 350 both algorithm are giving same performance. So we can say that our proposed base station location is good for area of field length less than 150 and for all combination of number of sensr nodes. We have also incircle the region where the surface value is significanly larger for %Ecp with black circle in figure 3(c). This region is under the range 150-300 meter field length with new nodes 5-50.

5. Conclusion

In this paper we have worked in finding optimum location of base station evaluation analysis with keeping constraints of minimum energy expenditure for providing maximum life time to the nodes of sensor network.
Many algorithm related to this work are analyzed and design in this work and it had been found that our proposed weighted centroid approach with considering minimum amplification losses is giving maximum reduction in percentage energy consumption .we have compared our result with a respect to approach of positioning base station using minimum enclosing circle and centroid of the cluster.
The results are first of all evaluated for the wireless sensor network having three nodes placed in triangle as a uniformly distributed sensor network. after this we investigated energy consumption minimized losses for different schemes with variation of area and number of nodes .for area we are considered field length of 30-500 meter and number of nodes 5-200.above 20 times we have run above algorithm for 48 ×20 combination of area and nodes and the average percentage reduction in energy consumption for each defined area and nodes evaluated for three

times.

In this way we found that proposed weighted centroid based approach is best for giving highest percent of reduction in energy consumption compare to centroid and minimum enclosing circle base positioning of base station .maximum percentage reduction approximately 4-6 % compare to percentage reduction when centroid is taken as position of base station.

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