Base Station Placement Strategy In Various WSN Systems

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Abstract: We are mainly focusing on the issues related to the base station placement in a wireless sensor network (WSN) field. The WSN model have multi clusters 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 minimised at the centroid of the nodes and proposed point of the node as the compare of the minimum enclosing circle of the centre of the nodes. We know that most 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: Base Station, Localization, Leach, and WSN.

1. Introduction:

Wireless sensor network (WSN) is a densely deployed collection of a large number of self-organising 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 and receiver 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 distance between the sensor nodes and the base station. This can be achieved by placing the base station at an optimal location. In the literature so far, many heuristic algorithms have been proposed to find sub-optimal solutions of 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.

Wireless sensor nodes are micro-electronic devices and have a very limited source of power. They are commonly powered using batteries, but for applications where the system is expected to operate for a long period, energy becomes a bottleneck. In sensor networks, normally each sensor can relay traffic to other sensors using multi-hop routing algorithms until this data reaches its destination.

2. System Evaluation Metrics

Now that we have established the set of application scenarios that we are addressing, we explore the evaluation metrics that will be used to evaluate a wireless sensor network. To do this we keep in mind the high-level objectives of the network deployment, the intended usage of the network, and the key advantages of wireless sensor networks over existing technologies. The key evaluation metrics for wireless sensor networks are lifetime, coverage, cost and ease of deployment, response time, temporal accuracy, security, and effective sample rate. Their importance is discussed below

One result is that many of these evaluation metrics are interrelated. Often it may be necessary to decrease performance in one metric, such as sample rate, in order to increase another, such as lifetime. Taken together, this set of metrics form a multidimensional space that can be used to describe the capabilities of a wireless sensor network. The capabilities of a platform are represented by a volume in this multidimensional space that contains all of the valid operating points. In turn, a specific application deployment is represented by a single point. A system platform can successfully perform the application if and only if the application requirements point lies inside the capability hyperspace.

3. Radio Model

We need a radio model to estimate energy consumption in the process of base station location optimisation. We have considered the same radio model as used by [18].

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(mp) 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[18].

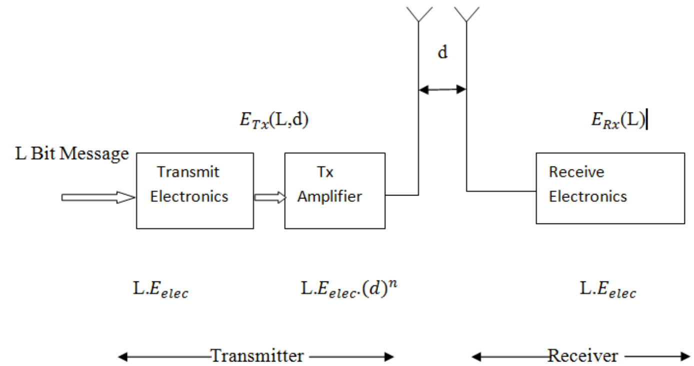

Fig. 1 : Radio Model

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

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

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

(2)

where E_{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

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

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 station positioning.

4. Optimal Location Of Base Station Analysis With An Example

Let us consider a homogeneous network in which the position of the nodes are known and these three nodes which are placed at positions (0, 150), (0, 0) and (150, 150) in a 150× 150 square metre area. We have assumed the values of E_{mp} = 1.3 × 10^{-15} J/bit/m^4 as multi-path loss constant and E_{fs} = 10^{-11} J/bit/m^2 as free space loss constant.

Step 1:-define the x and y co-ordinates of three nodes

x=[0, 0 ,150]

y=[150, 0, 150]

n=3(number of nodes)

Step 2:- $d_0 = \sqrt{\frac{E_{fs}}{E_{mp}}}$ = 87.7058

Step 3:-calculate the cetroid of three points and these are C_x and C_y from equation 18 and 19 and the location is shown in figure 3.

C_x=50

C_y=100

Step 4:-calculate the distances from the centroid

dc = [70.7107 111.8034 111.8034]

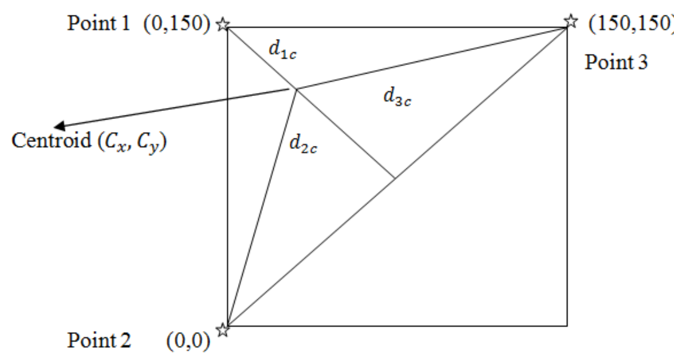

Fig. 2: Energy expenditure from the centroid

Step 5:- Now we calculate the average amplifier energy consumption in J/bit node for three nodes at the centroid with the help of equation (2).

Ec=(Efs*(dc(1)^2)+Emp*(dc(2)^4)+Emp*(dc(3)^4))/n

E_c= 1.5208× 10^{-7}

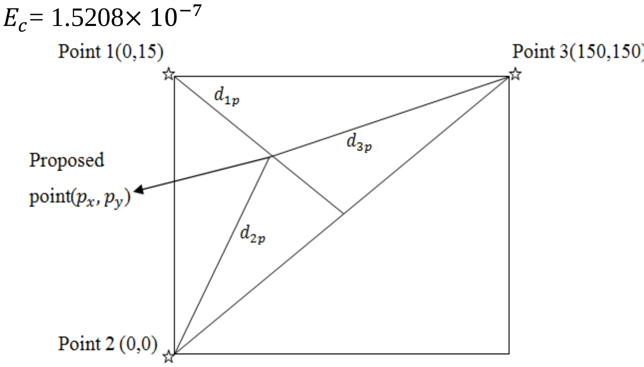

Fig. 3: Energy expenditure from the proposed point

Step 6:- calculate the proposed point with the help of weight from equation 21. We take weight w as 1 for the nodes which are less thand_0 distance and $\frac{d_{ic}^2}{d_0^2}$for the other nodes which are at equal or higher distance than d_0. The points $p_x$and p_y are calculated from the equation 23 and 24 and the location is shown in figure 4.

p_x =57.3529
p_y =92.6470
Step 7:- calculate the distances from the proposed point
d_p = [81.1093 108.9626 108.9626]
Step 8:- Now we calculate the average amplifier energy consumption in J/bit node for three nodes at the proposed point with the help of equation

Ep=(Efs*(dp(1)^2)+Emp*(dp(2)^4)+Emp*(dp(3)^4))/n

$$E_p = 1.4410 \times 10^{-7}$$

Step 9:- We also calculate the amplifier energy by considering the centre of a minimum enclosing circle as the base station location. The points at the minimum enclosing circle is m_x and m_y and the location is shown in figure 5.

$$m_x = 75$$
$$m_y = 75$$

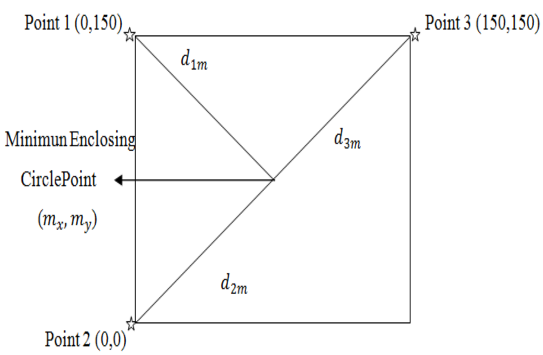

Fig. 4: Energy expenditure from the centre of the minimum enclosing circle

Step 10:- calculate the distances from the centre of the minimum enclosing circle

$$d_m = [106.0660 \ ,106.0660, \quad 106.0660]$$

Step 11:- The average amplifier energy consumption $E_m$in J/bit-node for three nodes at the minimum enclosing circle.

Em=(Emp*(dm(1)^4)+Emp*(dm(2)^4)+Emp*(dm(3)^4))/n

$$E_m = 1.6453 \times 10^{-7}$$

5. Result and Discussion:

In this section we have described above 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 analysed three different scheme of determining the location of base station with respect to minimum energy expenditure of a sensors network.

5.1 Design Of WSN Model:-

We have design WSN model having large number of wireless sensor nodes with limited energy resources model having a base station that can collect and process the data obtained from sensor nodes. For this purpose an algorithm using MATLAB 10 software. In this algorithm we have generated randomly distributed sensor node in a given field having square area M×M meter square. The number of nodes are varied from 5 to 200 nodes for a given area .We have also considered field area of different dimensions having length of square area 30 to 500 meters. Every time we have increment of 10 and nodes are increment of 10 also. In this way we have generated about 48×20 random distributed WSN cluster with different areas and different number of nodes. Let we have N sensor nodes randomly distributed in a rectangular field at a location(Px, Py) where ;
Px=X1,X2,X3................Xn
Py=Y1,Y2,Y3................Yn
After that we have calculated the location of centroid for given randomly distributed wireless sensor nodes.
Figure 5 (a), (b), (c) and (d) are shown below where x and y axis represents the length of square field and stars shown the location of wireless sensor and a circle shown the location of centroid.
Figure 5(a) shows the cluster of nodes (blue stars), centroid (mageta diamond) and proposed position of base station (red circle) for area field of length=120 and number of nodes=175 in this Figure. Here area is small hence centroid and proposed position are approximately same with centroid and proposed base station location.

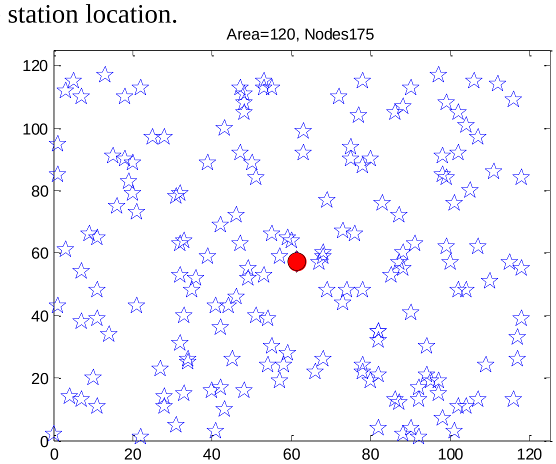

Fig. 5a: WSN sensor node cluster for area =120 and node=175

Similarly Figure 5(b),(c) ,(d) shows the randomly picked WSN cluster field map for different areas and nodes. In these figures we can see that our proposed base station location and centroid location are different.

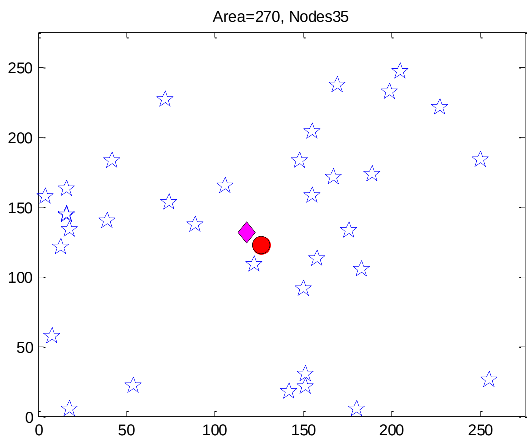

Fig. 5(b): WSN sensor node cluster for area =270 and node=35

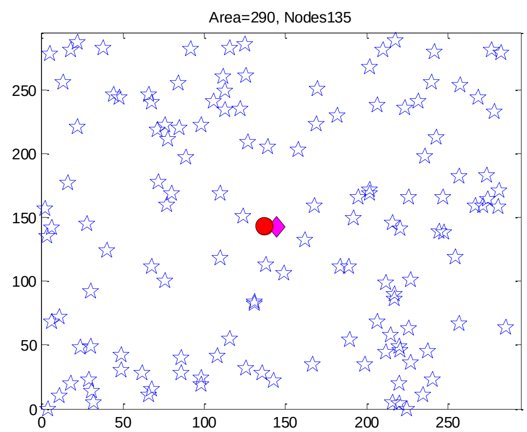

Fig. 5(c): WSN sensor node cluster for area =290 and node=135

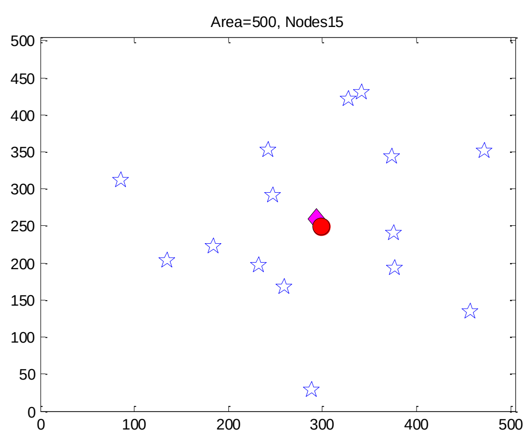

Fig. 5(d): WSN sensor node cluster for area =500 and node=15

We also compared percentage energy reduction for considering centroid and minimum enclosing circle and the surface plot is shown in Figure 6 where z-axis shows percentage energy reduction, x-axis and y-axis shows the number of nodes and area. Figure 7 shows the plot %Emp with respect to area and number of nodes. In both the plots all the surface are below zero, if Ec or Ep is greater than Em that is why %Emc or %Emp will always result in negative value shown so we can conclude that both base station location points either centroid or proposed location gives lower energy consumption compare to minimum enclosing circle for all the combination of area and number of nodes

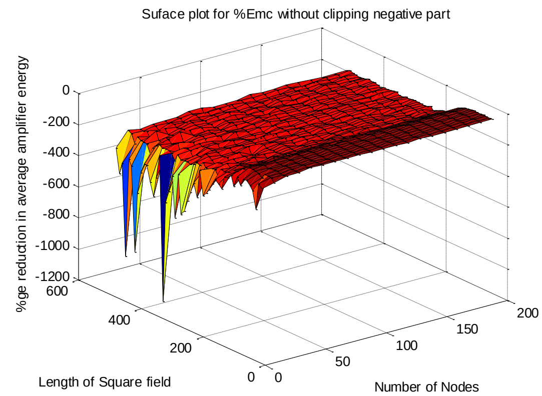

Fig. 6: Percentage reduction in average amplifier energy for the centroid compared with minimum enclosing circle without clipping negative parts

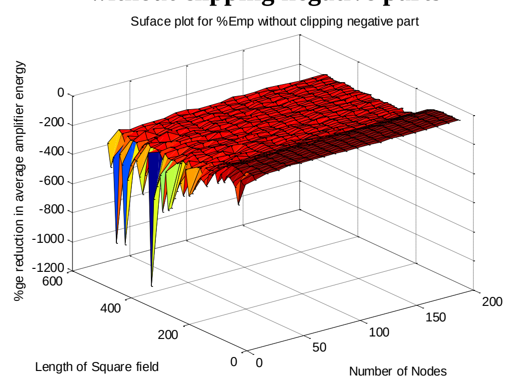

Fig. 7: Percentage reduction in average amplifier energy for proposed points compared with minimum enclosing circle without clipping negative parts

6. 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. It has been observe that number of nodes are increases, this node ratio decreases and as we increases the area this node ratio again decreases , and it has been found that if we take number of nodes above than 75 for area above than 210 meter length , we can get node ratio less than one. this shows that number of nodes suffering from multi-path loss decrease from area 210 meter but same observation for area length of 240 meter in the case of centroid .in this way we can reduced the multi-path losses for area 210 meter for the case the proposed schemes but for centroid same result are found from a slightly higher area.

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