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Optimal Location of Base Station in a Wireless Sensor Network Using Gravity Location Model

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Abstract—
Base station location has a major impact on the network's lifetime performance for a wireless sensor network. Due to energy constraints in individual sensor nodes, extending the lifetime is an essential objective in Wireless Sensor Networks (WSNs). Energy efficiency is a critical issue in designing the sensor networks as the nodes have limited battery power. An important characteristic for wireless sensor networks is so-called network lifetime performance, which is highly dependent upon the physical topology of the network. This is because energy expenditure at a node, to transmit data from one node another not only depends on the data bit rate but also on the physical distance between the nodes. Consequently, it is important to understand the impact of location related issues on the network lifetime performance and to optimize the topology during network deployment stage. This work considers the importance of base station placement problem for a given sensor networks such that network lifetime can be maximized. Specifically, the gravity location model is considered to identify the optimal location of the new base station, increase the life time of the sensor networks has been proposed.

***Keywords:* Wireless Sensor network, Base station, Lifetime, Optimization, Energy, Gravity Location**

I. INTRODUCTION

A wireless sensor network (WSN) consists of spatially distributed autonomous sensors to monitor physical or environmental conditions, such as temperature, sound, pressure, etc. and to cooperatively pass their data through the network to a main location. The more modern networks are bi-directional, also enabling control of sensor activity. The development of wireless sensor networks was motivated by military applications such as battlefield surveillance; today such networks are used in many industrial and consumer applications, such as industrial process monitoring and control, machine health monitoring, and so on.

The WSN is built of nodes – from a few to several hundred, where each node is connected to one (or sometimes several) sensors. Each such sensor network node has typically several parts: a radio transceiver with an internal antenna or connection to an external antenna, a microcontroller, an electronic circuit for interfacing with the sensors and an energy source, usually a battery or an embedded form of energy harvesting. A sensor node might vary in size, depending on the functions. The cost of sensor nodes is similarly variable, depending on the complexity of the individual sensor nodes. Size and cost constraints on sensor nodes result in corresponding constraints on resources such as energy, memory, computation.

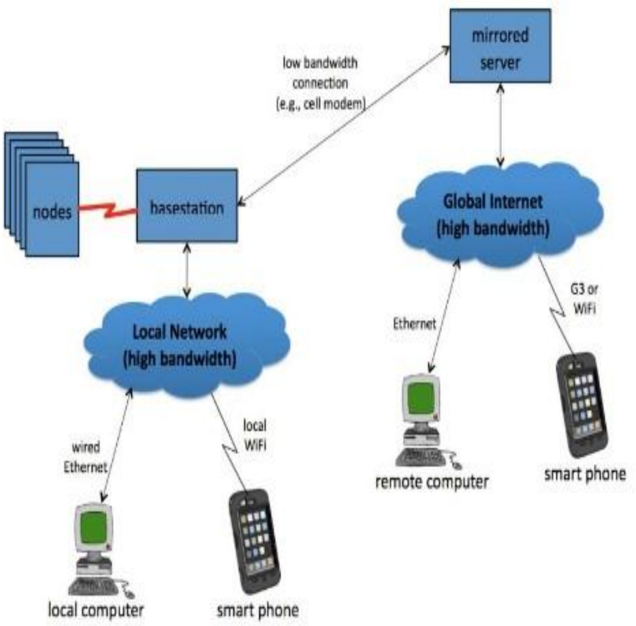

Fig 1.1 Wireless Sensor Network

An important performance metric for wireless sensor networks is the so-called network lifetime, which is highly dependent upon the physical topology of the network. This is because energy expenditure at a node to transmit data to another node not only depends on the data bit rate, but also on the physical distance between these two nodes. Consequently, it is important to understand the impact of location related issues on network lifetime performance and to optimize topology during network deployment stage. This article considers the important base station placement problem for a given sensor networks such that network lifetime can be maximized. Specifically, we consider the following problem. Given a sensor network with each node I producing sensing data at a rate of r , where should we place the base station in this sensor network such that all the data can be forwarded to the base station (via multihop and multipath if necessary) such that the network lifetime is maximized

The Section III and IV provide the related work and the problem statement. The Section V provides the data collection, which are obtained from a steel manufacturing company. Followed by the Gravity location model. It deals with the location of the optimum point using gravity location algorithm. Section VII provides the simulation of the algorithm and finding the new optimum location among the spreaded sensor nodes.

II. Literature Review

The following are the relevant literature pertaining to the process placing base station in an optimized location. Yi Shi et al [1] this paper deals with the approximation algorithm that can guarantee optimal network lifetime performance for base station placement problem. Dionisis Kandris et al [2] author explained most power dissipation occurs during communication, thus routing protocols in wireless sensor networks (WSNs) mainly aim at power conservation. A routing protocol should be scalable, so that its effectiveness does not degrade as the network size increases. Konstantinos Kalpakis et al [3] discussed the maximum lifetime data gathering problem. Ming Yu et al [4-5] addressed how to dynamically organize these sensors into wireless communication network and effectively route the information among sensors to a remote collection station. Hossam Hassanein et al [6] proposed Reliable Energy Aware Routing (REAR), which is a distributed, on-demand, reactive routing protocol that is intended to provide a reliable transmission environment for data packet delivery. An energy-aware QoS routing protocol for sensor networks which can also run efficiently with best-effort traffic [7-8]. The problem involving clustering of wireless sensor nodes and and coverage area is given in [9-11].

III. Related Work

In the existing Base station locations, the sensor network lifetime is short due to higher energy consumption. Higher energy consumption is due to the non-optimized location of base station. Non optimized location increases the distance between the sensor nodes to the base station, so it will not transfer the data directly to the base station. Each node transfer the data to the neighbor node and finally it reaches the base station. Due to transferring of the data to the neighbor node increases the data rate step by step and also the number of sensor nodes increases the optimal location of base station to become complex. So the problem is to find out the optimal location of the base station for sensor nodes and an optimal path for each sensor nodes so that the data can be transferred efficiently with degrading the lifetime of the sensors.

IV. PROBLEM DESCRIPTION

In the existing Base station locations, the sensor network lifetime is short due to higher energy consumption. Higher energy consumption is due to the non-optimized location of base station. Non optimized location increases the distance between the sensor nodes to the base station, so it will not transfer the data directly to the base station. Each node transfer the data to the neighbor node and finally it reaches the base station. Due to transferring of the data to the neighbor node increases the data rate step by step and also the number of sensor nodes increases the optimal location of base station to become complex. So the problem is to find out the optimal location of the base station for sensor nodes and an optimal path for each sensor nodes.the main objective is to find optimal base station location to reduce energy consumption and to maximize the network's lifetime in wireless sensor networks.

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V. Data Collection

The following data is collected from a steel manufacturing industry.

Table 5. 1: Data collection

S.NO	LOCATION X	Y	DATA RATE(Kbps)	ENERGY(J)
1	8.5	1.3	1	1600
2	3.1	0.6	9	4300
3	6.5	5.6	3	3100
4	6.3	7.4	9	4700
5	9.1	4.8	1	1900
6	2.6	3.5	8	1500
7	4.2	7.3	3	1000
8	9.3	1.5	7	1500
9	6.3	9.6	6	1100
10	0.3	2.7	1	3500
11	6.7	4	6	2300
12	2.1	1.6	7	4300
13	8.6	9.6	1	900
14	5.6	0.9	9	2700
15	8.8	5.1	3	1100
16	8	9.2	8	1700
17	8.7	3.8	1	1500
18	7.1	1.2	8	5000
19	3.8	9	2	1800
20	4.4	3.4	9	2000

Table 5.1 shows the different locations of 20 senor nodes in the area of 100m x100m, corresponding average data transmission of each node to base station and the energy taken for transmitting each node to base station is tabulated. According to this data the optimal base station has been located.

VI. GRAVITY LOCATION MODEL

Gravity location model is one of the supply chain management techniques using for locating the ware house optimally. The same technique is used for locating the base station optimally. Data rate and energy is the main factor influencing the location the base station. Here the main problem is 20 sensor nodes are placed randomly in the sensible area 100m x 100m, all nodes having the different load and different energy level. So this project locates the base station optimally to all nodes. The gravity location model is very useful method to find out the optimal location. In supply chain, cost and load (how much quantity is transferred) are considered, to locate the ware house. Here the energy and data rate is considered to locate the base station optimally.

Gravity models are used to find locations that minimize the energy of transmitting sensed data from sensor node to the base station. Gravity models assume that both sensor nodes and the base station can be located as grid points on the plane. All distances are calculated as the geometric distance between two points on a plane. Gravity location model is used to find the optimal location of base station and the total energy spent for transmitting data to base station. Location, data rate (load) and energy is the input data for the gravity location model.

The obtained data are plotted and the location of the sensornodes is shown in the figure 6.1.

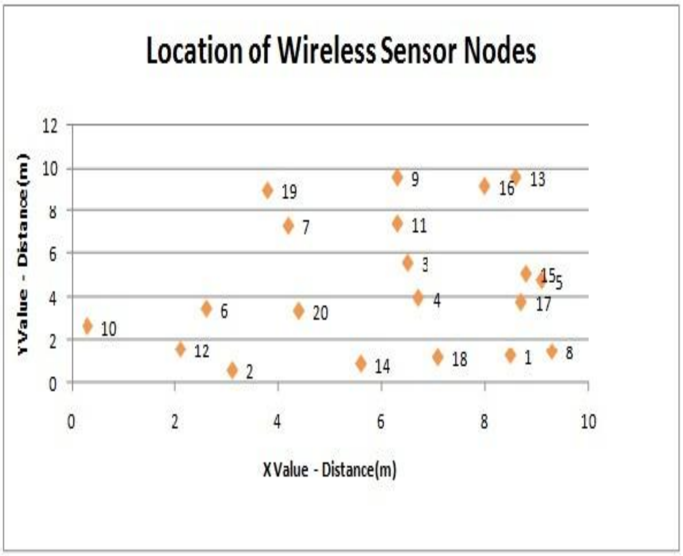

Fig 6.1 Location of the sensor nodes.

VII OPTIMAL LOCATION OF BASE STATION

The placement of the base station should be optimized among the dispersed location of the wireless sensor nodes. The optimum location can be obtained by using the gravity location model. Using the gravity location model, the base station location can be identified and also the total energyalso can be calculated.

7.1 Formulae used for Calculating the Total Energy

Total energy spends for transmitting data from sensor node to base station

$$E_j = \sum_{n=1}^{k} d_n D_n F_n$$ --------- (1)

E_J -Total energy spends for transmitting data

F_n - Energy of transmitting one bit for one meter between the sensor nodes to base station n

D_n - Load (data) to be transmitted between sensor nodes to base station

x_n , y_n - Coordinate location of either a sensor node or base station

If (x, y) is the location selected for the sensor node, the distance d_n facility at location (x, y)

$$d_n = \sqrt{(x - x_n)2 + (y - y_n)2}$$ ---------- (2)

In this method, the optimal location of base station is obtained by evaluating the above formulae and substituting the collected data.

7.2 The Gravity Location Algorithm

The location that minimizes the total energy E_j is obtained by iterating through the following three steps where (x,y)is the location of the base station to begin each iteration,

1.For each sensor node or base station n, evaluate using the formula d_n

2.Obtain a new location (x', y') for the base station.

$$x' = \frac{\sum_{n=1}^{k} \frac{Dn\,Fn\,Xn}{dn}}{\sum_{n=1}^{k} \frac{DnFn}{dn}}$$ ……………………….(3)

$$y' = \frac{\sum_{n=1}^{k} \frac{Dn\,Fn\,Xn}{dn}}{\sum_{n=1}^{k} \frac{DnFn}{dn}}$$ ………………………….(4)

3.If the new location (x', y') is almost the same as (x, y) stop. Otherwise, set (x, y)= (x',y')and go to 1st step.

The gravity location algorithm helps in finding the optimum location of base station. The algorithm can be validated and the collected data can be processed using the algorithm to find the best location of the base station placement.

Table 7.1 Data with Euclidean distance

S.NO	LOCATION X	Y	DATA RATE (Kbps)	ENERGY (J)	EUCLIDEAN DISTANCE dn (m)
1	8.5	1.3	1	1600	4.75
2	3.1	0.6	9	4300	3.90
3	6.5	5.6	3	3100	2.30
4	6.3	7.4	9	4700	3.61
5	9.1	4.8	1	1900	4.44
6	2.6	3.5	8	1500	2.21
7	4.2	7.3	3	1000	8.42
8	9.3	1.5	7	1500	5.30
9	6.3	9.6	6	1100	5.67
10	0.3	2.7	1	3500	4.64
11	6.7	4	6	2300	2.00
12	2.1	1.6	7	4300	3.65
13	8.6	9.6	1	900	6.69
14	5.6	0.9	9	2700	3.37
15	8.8	5.1	3	1100	4.20
16	8	9.2	8	1700	6.02
17	8.7	3.8	1	1500	4.01
18	7.1	1.2	8	5000	3.80
19	3.8	9	2	1800	4.93
20	4.4	3.4	9	2000	0.81

X value for base station location x =5.4

Y value for base station location y = 5.8

Total energy consumption = 1014214.882J

The total energy consumed is cal culated using the equation (1). The Euclidean distance is calculated using (2).
There are 20 nodes placed in 100m x100m, each node is placed according to its x, y co ordinates value. Optimal base station is placed between the 20 nodes as shown in fig 7.1. (5.4, 5.8) represents the optimal location of base station. Newly located base station is the optimum location from each node. The nodes are plotted along with the position of the new base station.

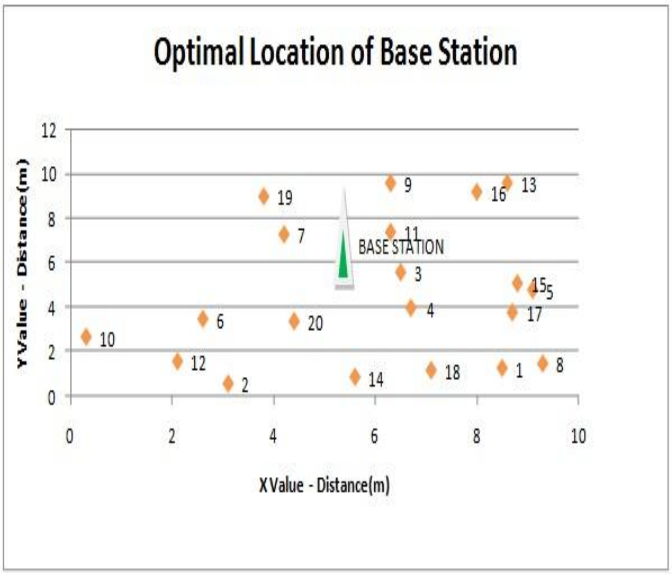

Fig 7.1 Optimal location of base station

.VIII CONCLUSION

The Optimum location of the base station is very much important constraint that the network life time can be maximized. By using the gravity location model, for the available twenty sensor nodes, the optimum location for the base station which minimizes the energy spend on the sensor node to transmit the data is located. The lifetime of the network can further be increased by optimization techniques.

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