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Optimizing the Coordinates Position for Optimal Placement of ZigBee for Power Monitoring From Remote Location

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Abstract

Monitoring of power and its proper management plays an essential role in today's world scenario. But this becomes a difficult task when the target area is a remote location. Long distance monitoring of any remotely located plant and managing of transmission and distribution of power efficiently and cost effectively is the main concern that has been focused upon in this paper. Various technologies are available for this purpose but selecting out the best is again a challenging job. In this paper we have proposed an algorithm which compares three of the technologies that is Bluetooth, ZigBee and Wibree, and selects the best combination in respect of cost, speed, power consumption and range for the purpose mentioned above. The data transfer network discussed here includes collection of data from remote locations and transmission through these technologies to a centrally located ZigBee which is further sent to a console through GSM.

Keywords: ZigBee, Bluetooth, Wibree, WSN, Monitoring, EA (Evolutionary Algorithm).

Introduction

As much technological growth the cities have witnessed, so much has the remote villages been neglected. These areas have hardly had any industrialization or development as a whole. One of the main reasons is topological constraints. Many areas are still deprived of power either completely or frequently. Setting up of plants in these locations is a really difficult as well as risky task. Even if some projects have been initiated, but their proper maintenance and monitoring could not be ensured due to unavailability of proper set up and trained workforce at such locations. This brings in the role of wireless sensor networks which can be employed to monitor plants in remote locations even from a distance. Various technologies are available for wireless networking but deciding the best out of them for use in remote locations is necessary. There are pro's and con's to each technology in respect of power consumption, battery life, cost, range, hardware requirement, data transfer rate and efficiency etc.

Yuanlong Liu and Reza Sahandi discussed ZigBee-based Wireless Personal Area Networks for utilization in healthcare, particularly for remote patient monitoring [1]. The research paper by Ramanathan P. and Pradip Manjrekar P. presents a Wireless Sensor Network for monitoring a patient's physiological conditions constantly [2]. Monitoring the condition of transmission line was discussed by Yang Yang, Guangzhong Xie, Xiangdong Xu and Yadong Jiang published using GPRS technology to ensure normal transmission of signals even over long distance [3]. In the paper by N. Javaid, A. Sharif, A. Mahmood, S. Ahmed, U. Qasim and Z. A. Khan, different hardware techniques for power monitoring, power management, remote power controlling at home and transmission side and the suitability of ZigBee have been discussed [4]. Soyoung Hwang and Donghui Yu discussed ZigBee based remote controlling and monitoring system [5]. The paper by Mrs. R. V. Chimankare and Mrs. Prof. Vidya Gogate proposes a cascaded ZigBee approach to monitor more than one room/block/floor from a remote distance and achieve control over switching without line of sight at a very low power [6].

In the paper by G. V. Satyanarayana and S. D. Mazaruddin, it is proposed to design, develop and implement a WSN connected to a central node using ZigBee, which in turn is connected to CMS through GPRS or GSM technologies for monitoring of distribution of water to agricultural fields [7]. Wibree technology was studied by Mr. Devang G. Chavda, Mr. Gaurav N Mehta, Mr. Jimish K. Desai, Mr. Nitin K. Nakum, Miss Ashita A Brahmwarin their paper [8].

A study of various Wireless Networks was done by Kanika Sharma, Neha Dhir comparing WPANs, WLANs, WWANs and WMANs evaluating their main standards and behavior, including the transmission methods and device types [9].
Most of the research that has been done in this field has mainly concentrated on a particular type of technology. The scope of optimizing has mostly remained ignorant. In this paper, we have proposed algorithm for optimizing the remote monitoring of plants. ZigBee, Bluetooth and Wibree have been compared using their significant parameters in Table 1.

Table 1: Feature Comparison of Bluetooth, Wibree and ZigBee

Table of Feature Comparison	**Bluetooth**	**Wibree**	**ZigBee**
Band	2.4GHz	2.4GHz	2.4GHz, 868MHz, 915MHz
Antenna/HW	Shared	Shared	Independent
Power	100mW	10mW	30mW
Target Battery Life	Days-Months	1-2 years	6months-2years
Range	10-30m	10m	10-75m
Data Rate	1-3Mbps	1Mbps	25-250Kbps
Component Cost	$3	Bluetooth+Wibree $3+20¢	$2
Network Topologies	Ad hoc, point to point, star	Ad hoc, point to point, star	Mesh, ad hoc, star
Security	128-bit encryption	128-bit encryption	128-bit encryption
Time to Wake and Transit	3s	TBA	15s

Problem Statement- In this paper, we have discussed about identifying coordinates for optimal placement of ZigBee module using Genetic Algorithm (GA) to achieve of Data Transfer from multiple remotely located areas considering having maximum rate of data transfer along with minimum losses of data and minimal cost of operation. Graphical representation of scenario is shown in figure 1.

Data is collected from three different locations which are way apart from each other in different directions. The data is to be sent to a GSM network through a centrally placed ZigBee. But this location is selected using genetic algorithm. ZigBee has a range of 2km so it can be placed anywhere in the circle of 2km radius with the GSM as the center. Now, the optimum point on the circumference of the circle would be that point which is gives shortest of the distances from all the 3 locations. This optimum point is selected using Genetic Algorithm.

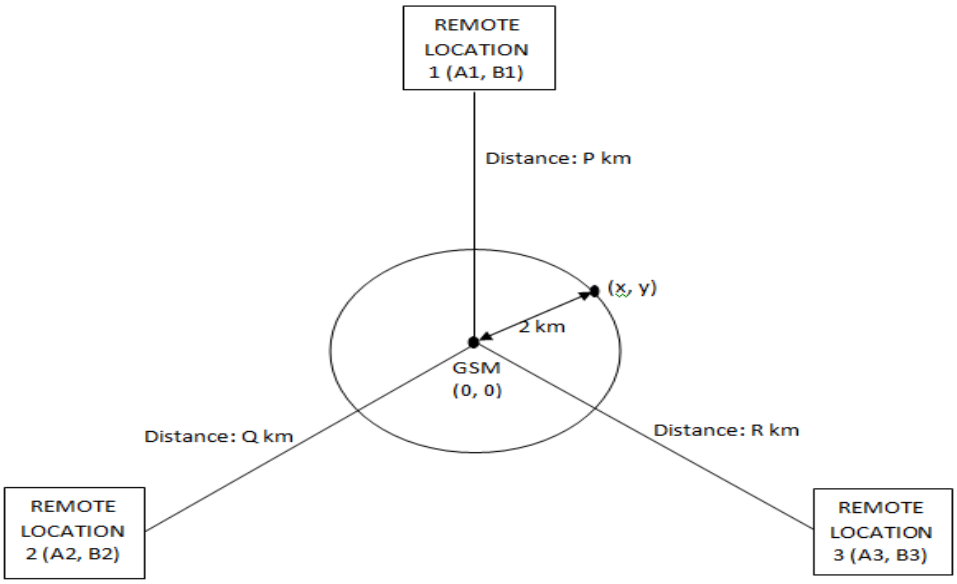

Figure 1: Basic Schematic of Data Transfer from Remotely Located Areas for Maximum Data Transfer with Minimum Data Loss and Minimum Cost.

Optimal Placement of ZigBee using Genetic Algorithm - In optimal placement of ZigBee, the coordinates on the circumference of the circle, which indicate the periphery of the GSM with ZigBee are the variables and the objective is to find the minimum distances from all the n locations to that coordinate. Figure illustrates the procedure of optimal placement of ZigBee using GA. The detailed description of the GA for ZigBee placement is as follows:

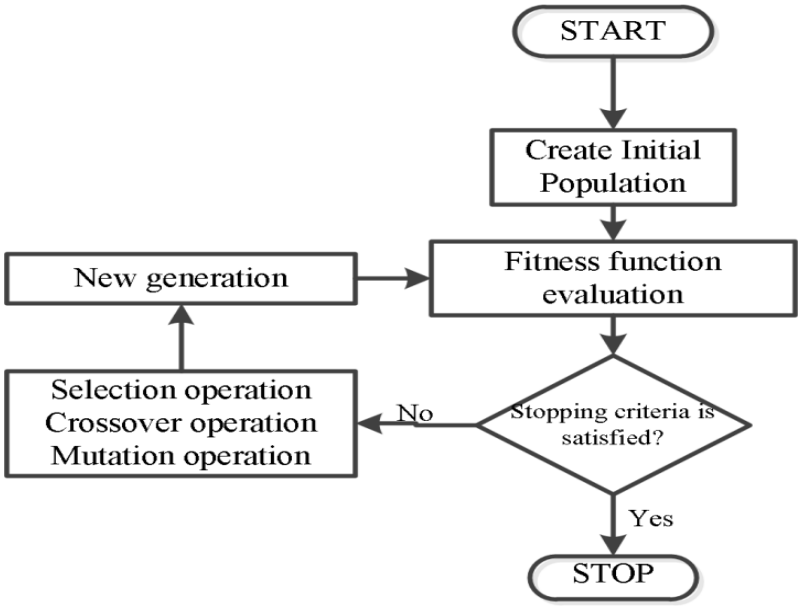

Figure 2: GA Flowchart

Step I Representation: The chromosomes X is represented as $X = \{x_1, x_2\}$, where x_1 is the longitude of the coordinate on the periphery of the GSM and x_2 is the latitude of the coordinate on the periphery of the GSM.

Step II Fitness definition: the objective function used in this work are:

$$F = \min\left(\sum_{j=1}^{n} \sqrt{(A_j - x)^2 + (B_j - y)^2}\right)$$

such that

$$-2 \le x \le 2;$$

$$-2 \le y \le 2;$$

$$x^2 + y^2 = r^2; \text{ where } r \text{ is the range of Zigbee and } n \text{ is the number of area}$$

Co-ordinates of Location1: (A1,B1)
Co-ordinates of Location2: (A2,B2)
Co-ordinates of Location3: (A3,B3)
Co-ordinates of GSM Network: (0,0)
Co-ordinates of centrally located ZigBee: (x,y)

Step III Population Initialization: In the proposed study, the initial population composed of hundred randomly created chromosomes. The population size is selected as a trade-off between the convergence time and population diversity.

Step IV Fitness Evaluation: The fitness value for each randomly generated chromosomes in step III is calculated using fitness function defined in step II.

Step V Creating New Population: Selection, crossover, and mutation are carried out to replace the current population by the newer population. The chromosomes with better fitness values are selected into the recombination pool using the roulette wheel. Genes between two parent chromosomes are exchanged to obtain new offspring to attempt to get better solutions, the probability of creating new chromosomes in each pair is set to 0.8. Mutation is performed to alter the binary code with a probability of 0.05.

Step VI Stopping Criteria: The process is repeated until from step IV to step V until the generation count reaches its limit.

The G.A generates a population size of 200 that is, it randomly selects 200 points on the circumference of the circle and then using the function cost selects out 10 minimum values. Now using these 10 values, it decides 200 more points in generation 2. This process is repeated up to the number of generations we use, for example, 100. That gives us the optimum point for the location of the central ZigBee.

Result and Discussion

As shown in figure 2, optimal placement of ZigBee using Genetic Algorithm (GA) is calculated by first creating initial population, then by calculating function evaluation untill stopping criteria is satisfied.

The input values taken into consideration for the calculations are shown in table 2. The calculated values of coordinates using Genetic Algorithm (GA) is shown in table 3. Figure 3 shows the optimal placement of ZigBee using Genetic Algorithm (GA).

Table 2: Input Parameters

Number of areas	**3**
coordinates of area 1 (A1 B1)	**(1 10)**
coordinates of area 2 (A2 B2)	**(-4 18)**
coordinates of area 3 (A3 B3)	**(-7 -20)**

Table 3: Calculated Coordinates using Genetic Algorithm (GA)

Optimal value of Co-ordinates to place ZigBee is	**(-0.5727, 1.9163)**

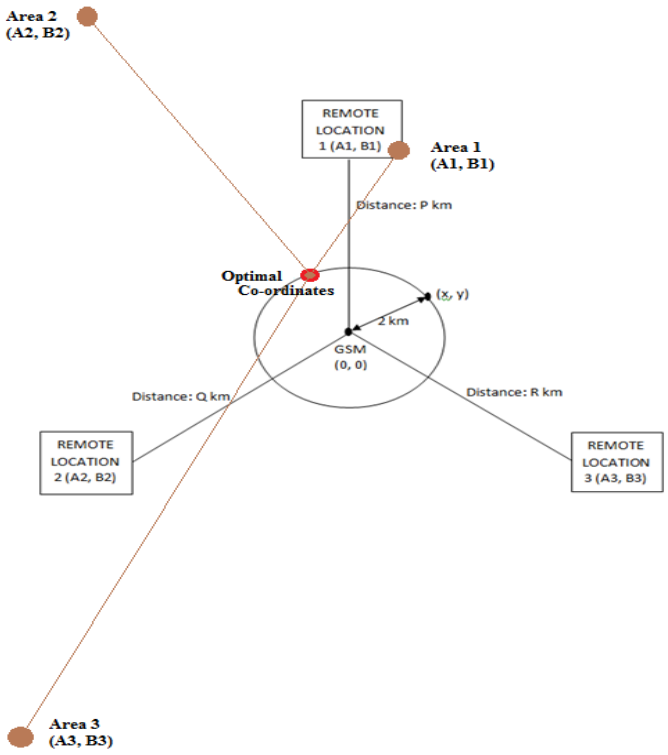

Figure 3: Optimal Placement of Zigbee using Genetic Algorithm (GA)

Conclusion

In this paper, we have optimized position of coordinates for their optimal placement in the 2D coordinate system but the similar calculations can be used to represent the latitude and longitude of any given area, where GSM area can be taken as the origin point.

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