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Landslide Monitoring For Wireless Sensor Network Using NSGA-II Algorithm

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Abstract

Landslides are triggered by rain duration, amount of rain and violence factors that must be known. Wireless sensor networks (WSN) located in Remote Sensing-based on landslide early warning systems which have great importance for landslide prediction. WSN is used in various applications. They are capable of collecting data with low-energy from a specific area and low-cost nodes are used in their networks. Localization is one of the important issue for these networks. In this study, an optimum WSN design is proposed for real-time landslide monitoring systems. The location of sensors used in real-time landslide monitoring systems are detected with GPS (Global positioning system) and localization techniques. For the transmission of sensed alerts, other sensors must be clustered. Additionally, the network structure via routing methods must be determined. The simulation studies are performed via MATLAB. The Multi-Objective NSGA-II (Non Dominated Sorting Genetic Algorithm-II) algorithm was used for efficient routing and optimal cluster head selection. With this proposed method, both clustering and determination of the optimal cluster head selection was carried out. This issue is a part of NP-hard combinatorial problems category. Simulation results show that this study provides an improvement for network life and energy efficiency.

Keywords: *wireless sensor networks, localization, multi-objective optimization algorithms, remote sensing, landslide prediction*

1. INTRODUCTION

Wireless Sensor Networks (WSN) remain on the agenda from military environments to living spaces to health due to their communication capabilities without being connected in short distances, their small sizes, low cost and low power consumption. WSN operates with a battery and therefore its life span is restricted in terms of energy. Good positioning algorithms and routing protocols may increase the life of WSN [1]. Landslide is considered a serious geological hazard. Landslide gives rise to crucial loss of life and property on a global scale. For that reason, there have been significant researches on the technologies for landslide monitoring and developing algorithms [2, 3].

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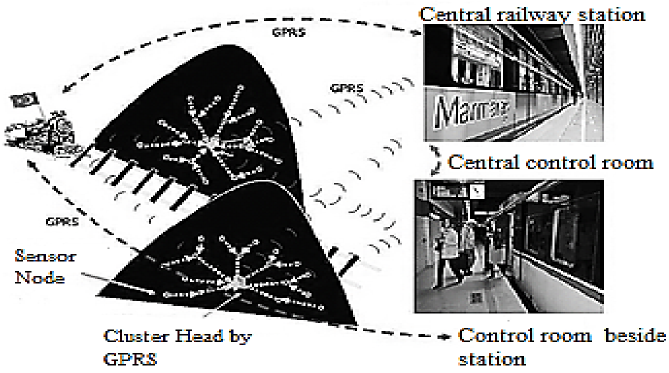

Fig. 1. Sensor Network based landslide forecast system

The article[4] suggests WSN for landslide forecast. As basic schematic is shown in the Figure 1, long range communication is carried out through GPRS (General Packet Radio Service) and short term communication is through WSN. Figure 1 shows early warning notification to the Base Station Main Control Room. Control Room is near a station and it is for the driver. Following are the topics with respect to the WSN based landslide forecast: Positioning, routing, fault tolerance, robustness and decision-making are some of them. The data of Sensor nodes, which are placed in a typical application such as landslide forecast will be considerably related. Therefore, collecting such data will be efficient for Local Decision communication and for making local decisions. This article focuses on distributed positioning and routing methods. Especially, two distributed clustering and routing protocols are proposed.

The first one is the new protocol called Clustering and Multiple Hop Protocol and is introduced for the first time[5]. The second one is the application for Lighthouse Vector Routing [6] of the Hybrid Energy-Efficient Distributed clustering algorithms[7]. Clustering and multiple hop protocol use the distributed clustering structure and decision for selection of dynamic cluster head is taken by basing on the local information of the individual nodes group. When we compare the delivery of individual data to the base station, clustering of a group of sensor nodes and dynamic head selection, we can say that individual nodes are there to deliver the abstract of the collected data and it is an energy-efficient approach. Clustering and Multiple Hop Protocol enable positioning and energy-efficient routing by using the Multiple Hop method.

Lighthouse Vector management is a Point-to-Point routing protocol and uses its connection features to create neighbor and positioning and done by some familiar landmarks. Routing is carried out to minimize the Distance Vector between the source and target. TEEN (Threshold-sensitive Energy Efficient sensor Network Protocol) [8]is the extension of event-based LEACH (low energy adaptive clustering hierarchy)[9] and thresholds are assigned to the sensor nodes. The nodes will notify the respective heads in the event of excess of data threshold sensor.

TEEN is suitable for landslide forecast, because there may be different rock types and thresholds. Energy will be considerably saved if nodes only send the data exceeding the threshold rather than continuously delivering them. Landslide forecast is a slow process and it does not exceed the data threshold, therefore energy will be saved. In this article, event based LEACH protocol is introduced within CAMP and BVR and the results of LEACH and proposed NSGA-II (non-dominated sorting genetic algorithm II) have been compared. According to the results, LEACH protocol is left behind the proposed protocol in terms of network life and energy distribution. The design of positioning and routing is carried out independently in the traditional approach. In this article, multiple purpose meta-intuitive network structure has been designed and metrics positioning has been affected by the algorithm. Therefore, energy efficiency of the real time network has increased.

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2. METHODS

A binary problem type has been considered in based on Server Location Problem [10] logic to identify the problem. Generally speaking, there is no reference to the location for the solution of server location problem, but only try to get the result by opening and closing the potential locations. Therefore, clustering [11] and selection of location of cluster head will be examined for the Wireless Sensor Network Design in the scope of the Service Location Problem. The server is a service unit and cluster head may represent it in WSN field.

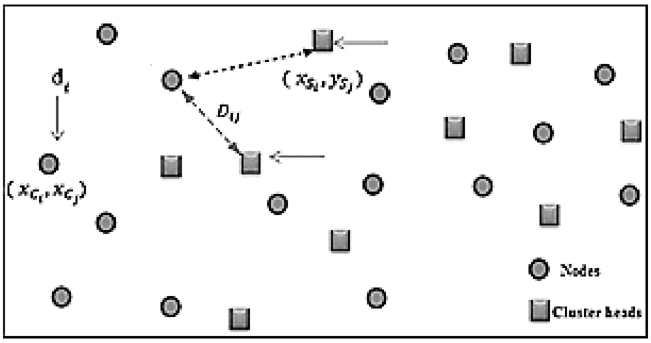

Fig. 2. The schema of the defined problem

In Figure 2, normal nodes are shown as circle and cluster head nodes are shown as square. The nodes are shown with i and number of demand per cluster head for each nodes are shown as d_i the objective is to transmit the demands of the nodes to the cluster heads as soon as possible and deliver the data package right away. The nodes, of which number of demand is d_i more, have more importance and they are given priority. Location is another feature of the nodes to be considered. The location of the nodes (x_{ci}, y_{ci}) is shown with the Cluster head coordinates (x_{sj}, y_{sj}). In this phase, the definition of the Norm in math [12] is used and nodes are connected to the nearest cluster head by calculating the distances. As it is shown in Figure 3, it is the distance between the i node and j node. The followings are the unknown variables in the objective function:

- $F_j = 0$ ⟹Cluster head node is closed
- $F_j = 1$ ⟹Cluster head node is open

For that reason, the defined problem is considered as the binary problem. While each node finds the nearest cluster head, it calculates the D_{ij} according to the City Scaled Distance and find the nearest open cluster head from the nodes that is D_i^{min} in the following.

$$D_i^{min} = \mathrm{Min}\left\{D_{ij} \,\middle|\, Fj = 1\right\} \quad (1)$$

$$D_i^{min} = \frac{D_{ij}}{Fj} \quad (2)$$

The above statement is more suitable because it is F_j or 0 or if 1 is 0 statement will be ∞ and not calculated. In other words, if a Cluster head is considered closed, it means that it is in ∞ location in terms of Custer head distance. It minimizes with the D_i^{min} distances of the number of the demand of the nodes in the first Objective that is the first term in the objective function. Furthermore, it will be minimized by considering the start-up costs or holding energy by the nodes in the second term. The distance of the nodes with a much higher demand carries more importance for us. The objective function is defined as in the equation 3 in the following.

$$\text{Min Z} = \sum_{\text{i}=1}^{\text{n}} di.D_i^{Min} + \sum_j Fj.Cj \tag{3}$$

- d_i = The number of the demand sent per Cluster by the Nodes
- D_i^{Min} = The distance of the nearest Cluster head among the Nodes
- Fj = 0 (Open) or 1 (Closed)
- C_j= Holding open or start-up cost of the nodes

This study has used the Wireless Sensor Networks, one of the Remote Sensing [13] technologies. Smart Environmental Monitoring [14] is a wide place to examine. Therefore, we start by basing the two dimensional Problem such as Landslide. Figure 2 shows the schema of locating the sensors in the test field to have a better visuality. MATLAB is used for simulation of the test field scenario. The number of the nodes is taken as 40 and the number of the cluster heads is taken as 20 in the simulation. 20 refers to the highest number of the cluster head which will probably occur. 20 cluster heads refer to location coordinate which has set up potential.

These coordinates are randomly distributed on 100*100 squares. That is to say that 20 x or y coordinates are produced for the cluster heads and similarly 40 x and y coordinates are randomly produced between 0 and 100 for other nodes. The demands (d_i) are produced and stored in a string in the size of nodes between 5-50 for each node randomly. A structure has been defined in the name of model in the MATLAB environment and values are kept within the model. After the model variable has been created, then it comes to generate a solution on a random basis. A function has been defined to randomly select which cluster head is open and which one is closed. The duty of the function is to generate random solutions and 20 random values (0, 1) in the dimension of 1*20 have been produced. Each solution is called chromosome. By this way, a chromosome has been created insomuch as the number of the population (n_{pop}) according to the binary-GA. $F_{n_{pop}}$= [0 0 0 1 1 1 1 1 1 1 1 0 1 0 0 1 1 0 1 1] After the Model and Random Solutions have been generated, they are sent to the assessment procedure named Cost Function in the equation 7.

While the start-up costs of the cluster heads, maximum value of the number of the demand between 5-50 is taken ($d_i = 50$). What is more, the longest distance between the node and cluster head is square diameter that is to say $100\sqrt{2} \cong 141$ for problem area is 100*100 and $141x50$ is considered the maximum cost of a node. Therefore, the maximum cost of a node is 7050. Furthermore, average cost of a node is 3525. By this way it is assumed that 3525*40 =141000 is the cost of all nodes. For the number of the cluster is 20, 141000/20 = 7050, all start-up cost of the cluster heads will be taken a little more than 7050 and stored in sequence randomly produced between 8000-12000 in a 20 randomly cost tolerated way to use in the program.

Radio Communication Model by Heinzelman et al [15] has been used to calculate the startup costs of cluster heads within a more realistic model. As it is explained in[16] a radio model has been used here. This study runs with iterative logic such as LEACH [15] protocol. By this way, the problem will be minimized by adding new real calculations to such costs, calculated before. This program has been run as followings for an iteration with radio communication model: N node number: The start-up costs of the 40 c nodes have been generated between 8000-12000 on a random basis in the iteration of the program. By this way, the consumed energy of the radio communication model has been added to the c matrix. This matrix changes every time.

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Table 1. Quantitative parameter values of the radio communication model

Description	symbol	values
Consumed energy to transmit for short distance	ϵ_S	10pJ/bit/m^2
Consumed energy to transmit for long distances	ϵ_I	0.0013pJ/bit/m^4
Electronic circuit consumed energy	E_S	50 nJ/bit
Consumed energy for beam forming	E_{BF}	5 nJ/bit

Objective function is defined in statement 4:

$$\mathrm{Min}\ \mathrm{Z} = \sum_{\mathrm{i}=1}^{\mathrm{n}} \mathrm{d_i}.\mathrm{D_i^{min}} + \sum_{j} \mathrm{F_j}.\mathrm{Energji_j} \tag{4}$$

The number of the cluster head is 20 in the problem description and it changes between 8000 and 12000 approximately. The energy matrix of the nodes has been given in the objective function in 4, in consideration of the radio communication model and therefore, algorithm has been run by considering the worst case scenario. Generally, simulation is applied in the worst conditions. In this study, algorithm has reached the solution with a good convergence to the Pareto of the problem although energy costs change continuously. Bar graph of the energy changes continuously with the increase of iteration and as the time passes by.

3. PROPOSED NSGA-II ALGORITHM

In this section, Non-dominated Sorting Genetic Algorithm (NSGA-II) will be addressed. NSGA-II has been put forward and developed by Kalyanmoy Deb [17] et al. NSGA-II is the most famous multiple purpose evolutionary optimization algorithm. The number of articles written based on this algorithm is more than others and the idea it uses is so prevalent. Algorithms such as Ant Colony, Bee colony, Particle swarm optimization and Differential Evolution have multiple purpose versions and operate by using NSGA-II ideas. As a result, each single purpose algorithm can turn into a multiple purpose algorithm by using NSGA-II. Solution layer is exclusive to NSGA-II technique, which is the estimation method of Pareto. The book of Dr. Carlos. Coello Coello [17] is far-reaching in this matter.

This book addresses the difference between the normal genetic algorithm and multipurpose genetic algorithm, which is the sequence technique of the answers. The new population selection is the difference between the normal genetic algorithm and multipurpose genetic algorithm. Non-order ability is the issue here. Furthermore, single dimension sequencing operator is not usable. Therefore, a new multi-phase operator is defined. This operator sequences by basing on the Quality of the answers and takes the second criterion as the Order if quality factor is not a determinant. For example: The point may not be a determinant in some cases in team eliminations in the football matches and in such case the number of the goal is used as a secondary criterion.

Kalyanmoy Deb [17] emphasizes that NSGA-II algorithm is Elitist [18].For that reason, he uses Merge & Sort & Truncate [18] scenario. Sorting turns into two phased proceeding. Rank is defined to rank the answers. If rank is not determinant, crowding distance [18] is defined and steps in as a secondary criterion. Crowding distance has been added to the NSGA-II algorithm then. Fitness sharing has been used rather than crowding distance in the first version of NSGA-I. There is a criterion in the ordering of the minimum cost values in the normal genetic algorithms that is to say that cost of the answers is ordered from big to small in a one-dimensional array and single line sequence and the smallest one is selected. However, there may be two or three criteria and such criteria may differ according to the number of the objective of the problem. These criteria are Quality and Order. Book author of (evolutionary algorithms for solving multi-objective problems)[18], Carlos. Coello Coello and Emoo repository web page [19]are the suitable and comprehensive resources to research for the multi objective field. Basing all we have said, we will examine and solve the problem of cluster head location in the wireless sensor networks with NSGA-II algorithm. Defined problem is multipurpose problem, which has two (z_1 andz_2) objective functions. The problem has been solved with genetic algorithm, single purpose weighted sum [20] and decomposition method [20] and different answers have been obtained with different w_1 and w_2 settings from the Pareto.

The method used in [20] approximately estimated the Pareto linearly. To sum up, we can say that there are disadvantages to develop the topic. Binary genetic algorithm used in the first section of [20] and Weighted Sum method cannot discover the concave sections of Pareto. Furthermore, each time Pareto runs, it only finds a point as an answer. The algorithm has to run with different settings or w to find all points. The results are not certain, time-consuming and approximate answers. Each individual [11] from the population in the classic genetic algorithm has compounds in the name of position and cost. But NSGA-II is not restricted with them. The best chromosome or optimum solution is obtained at last after going through Selection proceedings, crossover, and mutation, sorting and cutting-off in the iterative cycle of the algorithm. This study has been programmed in the file name NonDominatedSorting. m which is non-dominated sorting genetic algorithm in MATLAB.

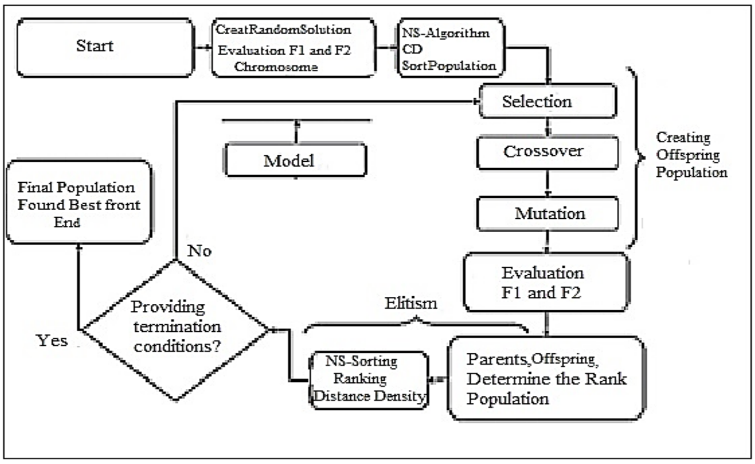

Figure 3. Problem and NSGA-II algorithm flow diagram

According to the report when the program in MATLAB is run, the intended outcome is carried out as shown in [20] in non-dominated sorting answers list. If we truncate from any part of the list, we can be sure that they are the best answers. This is compatible with elitism. As it is shown in the Figure 3, cross over, mutation, merge have been applied in this phase and then sorting and truncate proceedings are applied on them specifically. However, sorting has to be done after every truncate proceeding, because Rank and CD (Crowding Distance) are relative features and individuals of the population can still positively or negatively affect each other. There are 50 solutions for the best Pareto front and the best one, CD of which is the highest, is selected as [1 0 0 0 1 1 0 0 0 0 0 0 1 1 1 0 0 0 0 1] => CD = Inf. The clustering of the selected answer has been drawn and shown in Figure 4. In addition [17] emphasizes that the best solution found in a front is the one with the highest CD.

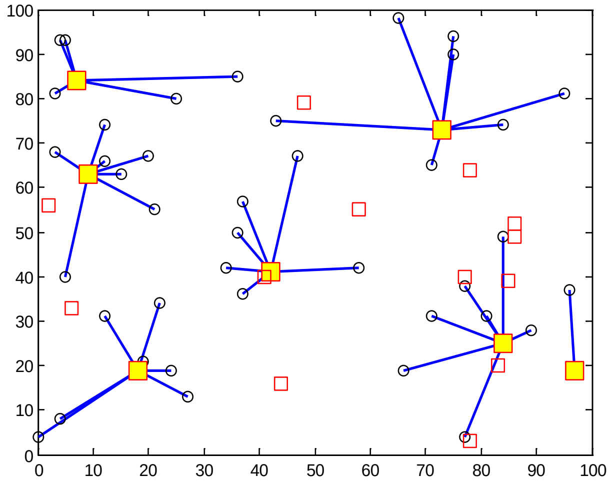

Figure 4. Pareto-front optimum answer

CONCLUSION

In this study, a multi-objective optimization algorithm NSGA-II has been used. Both the distance of the nodes and number of the demands have been minimized. Moreover, start-up costs of the cluster heads are taken to the optimum level with clustering. When NSGA-II algorithm runs with 50 population number and 100 iterations to solve the problem, run-time is reported as 74.647890 seconds. When it runs with 200 iterations and 100 populations, run-time is calculated as 432.21012 seconds. As the number of the population of the NSGA-II algorithm increases, the speed performance considerably decreases. Furthermore, processing load increases depending on them. Therefore, algorithm is used effectively and simply point of programming. Generally, the objective of this study is to find the non-dominated answers or Pareto of the defined problem. As a result, landslide monitoring system is a real time network and the number of the cluster head should be minimized depending on the start-up costs. Therefore, start-up cost has been optimized with the solution of this problem and the number of the used GPS has been decreased and life of the network has been extended.

REFERENCES

[1] Akyildiz, I. F., Su, W., Sankarasubramaniam, Y., & Cayirci, E. (2002). A survey on sensor networks. Communications magazine, IEEE, vol. 40, no. 8, p. 102-114.

[2] Ohlmacher, G. C., & Davis, J. C. (2003). Using multiple logistic regression and GIS technology to predict landslide hazard in northeast Kansas, USA. Engineering Geology, vol. 69, no. 3, p. 331-343.

[3] Wang, H., Xu, W., & Xu, R. (2005). Slope stability evaluation using back propagation neural networks. Engineering Geology, vol. 80, no. 3, p. 302-315.

[4] SMR. Hashemi, A. Broumandnia, "A New Method for Image Resizing Algorithm via Object Detection." International Journal of Mechatronics, Electrical and Computer Technology, Vol 5, Issue 16 2015

[5] Sheth, A., Tejaswi, K., Mehta, P., Parekh, C., Bansal, R., Merchant, S., Toyama, K. (2005). Senslide: a sensor network based landslide prediction system. Paper presented at the Proceedings of the 3rd international conference on embedded networked sensor systems, November 02 - 04, 2005.

[6] Singh, S. P., & Sharma, S. (2015). A survey on cluster based routing protocols in wireless sensor networks. Procedia Computer Science, vol. 45, p. 687-695.

[7] Fonseca, R., Ratnasamy, S., Zhao, J., Ee, C. T., Culler, D., Shenker, S., & Stoica, I. (2005). Beacon vector routing: Scalable point-to-point routing in wireless sensornets. Paper presented at the Proceedings of the 2nd conference on Symposium on Networked Systems Design & Implementation-vol. 2, p. 329-342.

[8] SMR. Hashemi " A Survey of Visual Attention Models" Ciência e Natura, v. 37 Part 2 2015, p. 297−306 ISSN impressa: 0100-8307 ISSN on-line: 2179-460X

[9] Younis, O., & Fahmy, S. (2004). Distributed clustering in ad-hoc sensor networks: A hybrid, energy-efficient approach. Paper presented at the INFOCOM 2004. Twenty-third Annual Joint Conference of the IEEE Computer and Communications Societies, vol. 3, no. 4, p. 366-379.

[10] Manjeshwar, A., & Agrawal, D. P. (2001). TEEN: a routing protocol for enhanced efficiency in wireless sensor networks. Paper presented at the null.

[11] Heinzelman, W. B., Chandrakasan, A. P., & Balakrishnan, H. (2002). An application-specific protocol architecture for wireless microsensor networks. Wireless Communications, IEEE Transactions on, vol. 1, no. 4, p. 660-670.

[12] Mohammad, N. (2010). Using genetic algorithms for the single allocation hub location problem. (Masters), Brock University, Kanada.

[13] SMR. Hashemi, M. Zangian, M. Shakeri, and M. Faridpoor, "Survey Article about Image Fuzzy Processing Algorithms." The Journal of Mathematics and Computer Science, Vol 13, Issue 1 2014 , pp 26-40

[14] Engelbrecht, A. P. (2007). Computational intelligence: an introduction, 2th ed. Publisher: Wiley & Sons Ltd 628p. ISBN 978-0-470-03561-0.

[15] Deza, M. M., & Deza, E. (2009). Encyclopedia of distances, 1th ed. Wiesbaden: Springer-Verlag Berlin Heidelberg 590 p. (In German). ISBN 978-3-642-00234-2.

[16] Schowengerdt, R. A. (2006). Remote sensing: models and methods for image processing: Academic press.

[17] Stribling, J. B., & Davie, S. R. (2005). Design of an environmental monitoring program for the Lake Allatoona/Upper Etowah River watershed. Georgia Institute of Technology Institute of Ecology, The University of Georgia, April 25-27. 2005.

[18] SMR. Hashemi, S. Mohammadalipour and A. Broumandnia, " Evaluation and classification new algorithms in Image Resizing.", International Journal of Mechatronics, Electrical and Computer Technology Vol. 5(18) Special Issue, Dec. 2015, PP. 2649-2654, ISSN: 2305-0543

[19] Heinzelman, W. R., Chandrakasan, A., & Balakrishnan, H. (2000). Energy-efficient communication protocol for wireless microsensor networks. Paper presented at the System sciences, 2000. Proceedings of the 33rd annual Hawaii international conference on, Jan 4-7. 2000.

[20] Hussain, S., & Matin, A. W. (2005). Energy efficient hierarchical cluster-based routing for wireless sensor networks. Jodrey School of Computer Science Acadia University Wolfville, Nova Scotia, Canada, Technical Report, 1-33.

[21] Coello, C. A. C. C. (2001). A short tutorial on evolutionary multiobjective optimization. Paper presented at the Evolutionary Multi-Criterion Optimization: Springer Berlin Heidelberg p. 21-40.

[22] Coello, C. C., Lamont, G. B., & Van Veldhuizen, D. A. (2007). Evolutionary algorithms for solving multi-objective problems: Springer Science & Business Media, 2th ed. Publisher: Springer US 800 p. (In US). ISBN 978-0-387-36797-2.

[23] Dr Carlos Coello's Home page. Retrieved from http://delta.cs.cinvestav.mx/~ccoello/

[24] Faryad, V. (2014). Multipurpose NSGA-II, and the optimal cluster head in a wireless sensor network optimization algorithms MOPSO site selection and clustering. (Masters), Karadeniz Technical University, Turkey.