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Coverage Optimization for WNSs using AI Technique

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ABSTRACT
Coverage in wireless sensors networks (WSNs) is one of the most active research topics in wireless networks.ThisPaper presented a new way to ensure getting the best coverage of the targets in the region of interest (RoI) in WSNs.The proposed approache used the artificial intelligence technique by considering the principle of columns generation (CG) to select the appropriate coordinates for the sensors to cover targets distributed in a specifc region.Simulationresults proved the effectiveness of the proposed approachefor obtaining the optimal distribution of the sensor nodes to cover all the targets in the RoI.

General Terms
Region of interest (RoI), Hill climbing, wireless sensors network, Random distributing, Optimal distributing, Artificial intelligence.

Keywords
WSN clustering hierarchy, Genetic algorithm, WSN lifetime, Power consumtption, Columns generation (CG), quality of service (QoS),Arifical intelligence (AI).

1. INTRODUCTION
Getting the best coverage in wireless sensors network considered one of the greatest challenges facing this type of networks, especially in the applications that required random distribution for these sensors as shown in Fig 1. Random distribution of sensors produce a gaps of uncovered areas in the region of interest.Sometimes the death of the sensor unit for any reason, such as the end of life time or the distortion of these units during the distribution process, causing deficiencies and gaps in coverage on the ROI.In both cases, the only solution is to find an alternative to theses sensors. Here the question that arises is what is the appropriate distribution that guarantees the best coverage for the uncovered regions,and what is the lowest number of sensors requiredto ensure the coverage of all the targets on the ROI?. To solve these questions, many studies and attempts were carried out to get the best possible coverage in different ways.This propoedapprocheaims to find the optimal solution to cover the area of interest with minimal number of sensor nodes.

2. MOTIVATIONS AND RELATED WORKS
A lot of studies and attempts was carried out in this field were aiming at getting the best coverage of events that occur in the region of interest. They proved good results, but they were not interested in whether that all targets in the ROI was covered or not. Some of these attempts were aimed at finding the best path (the shortest and the least cost path) from the ROI to be selected [1][2].Using the concept of the agent path, which is the path that the agent can use it to collectthe most possible active sensors in the ROI and other methods were condidered to optimized the coverage [3][4][5]. As mentioned earlier, these attempts proved their effectiveness and achive goodresuls with some tradeoff issues between the quality of service (QoS) requirements.The proposed approachefocused on how to cover the area of interest using the least possible number of sensors.The proposed approachecomes as a complement to all previous attempts.It aims to specify the optimal distribution of the sensors to cover all the targets in the ROI,specially in the applications requiring randomly distribution of sensors.

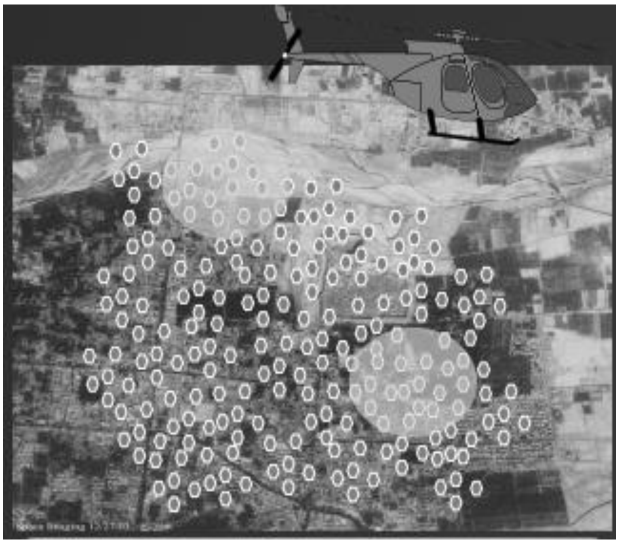

Fig1: The Random Deployment of Sensors

3. THE PROPOSED APPROACH
This proposedapproachassume a random distribution of sensor nodes on an environment with distributed targets. Then it evaluates the coverage obtained from this distribution in terms of the number of covered targets by the randomly distributed sensors.Covering the remaining targets is achived by redistributing a specified number of sensors using unicasting manner directed by the base station to the ROI gaps.Artificial intelligence techniques were considered to solve this issue with different waysachieving good results[5][6].The proposedapproach used genetic algorithms (GA) and the Hill climbing. Thegenetic algorithm generatea solution depends on the processes of the crossover and mutation of the possible solutions.Although that, the optimal solution achieved by this algorithm, it depends on random attempts to get these solution, which makes the optimal solution based on the principle of probabilities. That means that it can get optimal or bad results. Therefore, this propsedapproache used the genetic algorithm andthe hill climbing algorithm to work together using the principle of column generation (CG)[6][7].In this pproache, the genetic algorithm will find the appropriate distribution of sensors in the uncovered area, while the other apply the principle of its work in finding the greatest value of the generated solutions, which excludes the principle of probability that the genetic algorithm based on.

4. NODES DISTRIBUTION

Distributing sensor nodes, after determining the nwtork gaps, can be achived by different methods. It can be achived manually or by using an agent (robot) equipped with Global position system (GPS).Also it can be distributed using an agent such as aircraft, after providing this agent by GPS together with image processing technique.

Mobility pattern of each mobile entity is typically determined based on the network application and sensor node size. Based on mobility patterns, mobile unitscan be categorized into three types.The first type of these nodes is controllable mobile units such as mobile robots that the network planner can program them to meet the requirements. An example of this is a TagBot, which is designed by the Carnegie Mellon University. TagBot is an advanced robot that can communicate with sensor motes like MicaZ or Telos. It can move both forward and backward, and turn in any direction by a controlling program, which is resided in an Intel's board.

The second type is the uncontrollable and unpredictable mobile units, they move in a random fashion, such that the next movement cannot be predicted. For example, the movement of an animal or human, which carries a sensor, is generally considered in this category. For example, if the sensor is mounted on an elephant in Africa in finding its group behavior, the mobility of sensor is random as the elephant moves.

The third pattern of these units is uncontrollable but predictable mobile units. They are like bus or trainthat move according to a predefined schedule. Therefore, the movement of the sensor carried in the bus or train is usually not random and follows a predetermined path. However, the sensor itself cannot control them. For example, the movement path of a bus to collect sensor data may not be the best routine for WSN performance.

5. GENETIC AND HILL CLIMBING ALGORITHMS

AI algorithms are used to obtain an optimal solution for a specific problem using the principle of search and compare.The propsedused the genetic and Hill climbing. Genetic algorithm is the simulation process of mating between organisms of the same type.This technique considered many terms used in the organism genetics such as parents, generations, crossover, and mutation.Genetic algorithm aimsat finding the optimal solution based on AI algorithms by using the principle of search and compare.

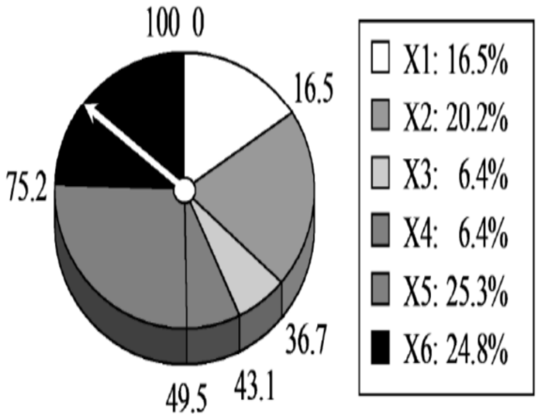

Fig 2: Roulette Wheel-style for Chromosome Selection

Darwin's hypothesis of evolution by retention the good features of the parents and inherit them to the children. So, the problem will converted to binary chromosomes, where each chromosome is a random solution to this problem, then this algorithm to study the fitness of this solution and apply principles of the crossover and mutation on this chromosome with others to get a new chromosome to represents a solution to the problem and examine the fitness of this solution by calculating what is known by fitness ratio , chromosomes are selected within the processes of crossover and mutation randomly depending on the roulette wheel principle (Fig 2) where the fitness ratio this chromosome represent appropriate space in the roulette wheel therefore chromosome with the most fitness ratio becomes most likely choosing within the crossover and mutation. In each stage, GA will generate the same number of the chromosome chosen for crossover and mutation but the new values may be better bad compared by the original values (parents), therefore if GA did not find the optimal solution, it will choose the last solution reached as an optimal solution (Fig 3).

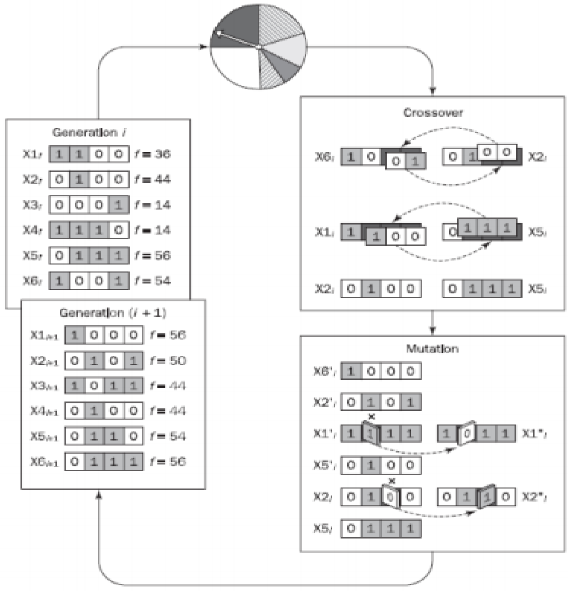

Fig 3: The Genetic Algorithm Cycle

The principle of the Hill climbing algorithm depends on choosing a random solution from a range of solutions and move to the another one and compare between them to choose the best one as a starting point to find a new solution and so on [8][9]. This helps to solve the problems of some algorithms that generate solutions close to the optimal solutions but this solution will not be selected as a solution to the problem because the search goal is to find the optimal solution itself.

6. CALCULATIONS

The application of the proposed approache will ask the user to enter the dimensions of the RoI, number of goals, sensing range ,andthe number of sensor nodes Fig 4.

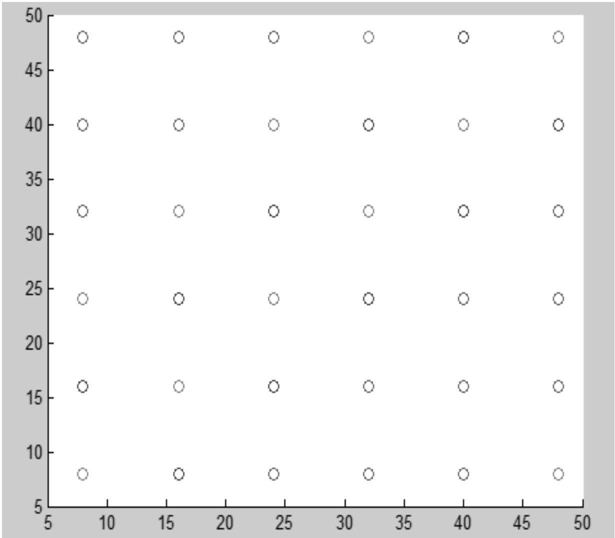

Fig4: The Distribution of the Targets on the ROI

Then, the application, randomly, distribute these sensors over the region of interest and calculated the percentage of the target coverage.This percentage is estimated by calculating the distance between the sensors center and all the targets on the RoI.If the distance is less than the radius of the sensor coverage range, the target will consider to be covered by this sensor.The covered targets will be addede to a matrix containing the goals that have been covered.In this case, the covered goals counter will be increased by one.If there are any target has been covered before, itwill not consider as a new covered target and the covered target counter will notincremented by one. Then the application will estimate the ratio of the covered targets to the total number of targets in the region of interest.

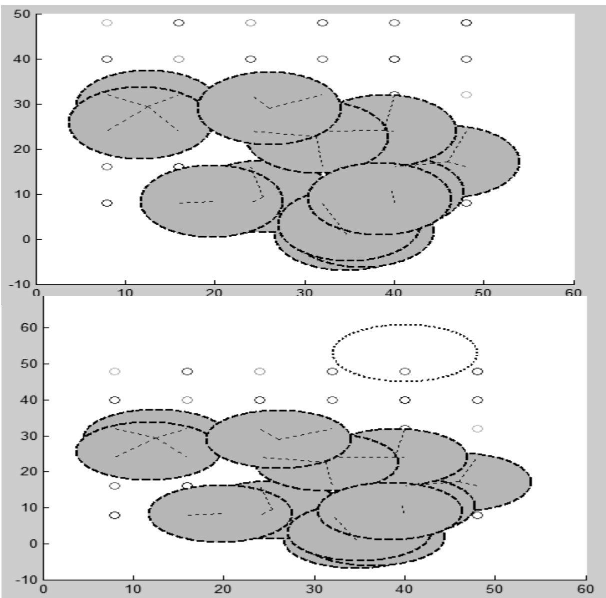

Fig 5: The First Implementation of GA

Genetic algorithm comes into play and requests to enter the number of generations, which can crossovered and mutated.Then it willstart generatingrandom coordinates, which represent the position of the mobile sensors that can cover the targets in the RoI that were not covered by the random distribution of the stationary nodes as shown in the white dashecircles in fig 5 & fig 6.

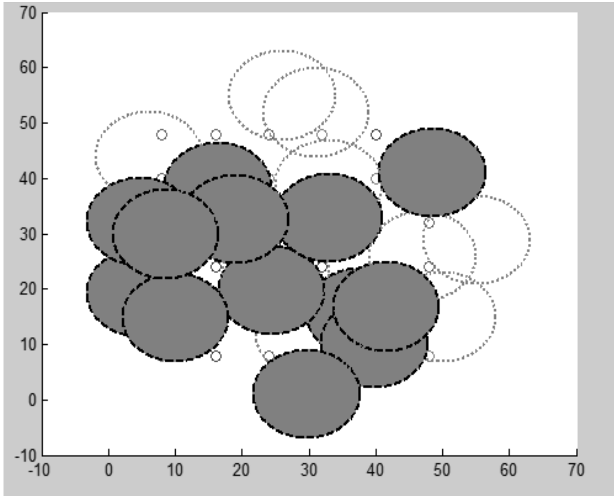

Fig6: The Second Implementation of GA

This process repeats it selfaccording to the number of generationsgenerations. In case of failure of this algorithm to achieve this goal, the hill climbing algorithm will start with random initial value and generate coordinates for the mobile sensors.The hill climbing algorithmcompare the coverage ratio with any value obtained by the genetic algorithm.

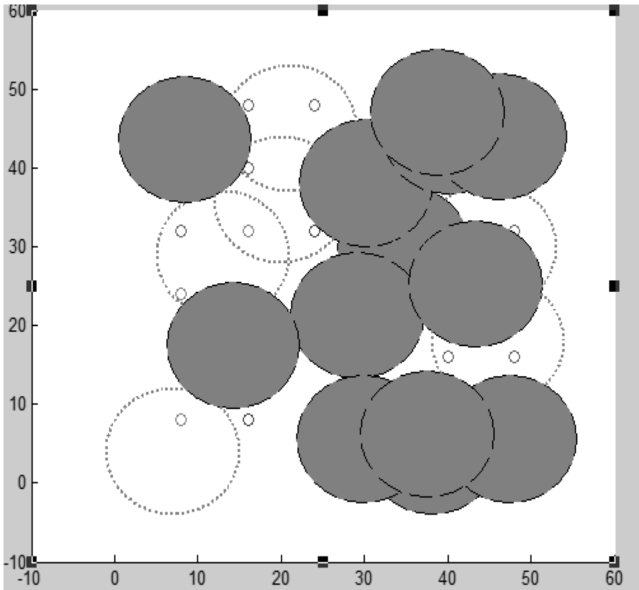

Fig 7: The Enhancement of Hill Climbing Algorithm over GA

In the case that the value obtained is less than the value obtained from genetic algorithm, GA results will be considered as the initial value for starting new search, either if this value higher than the value generated by the genetic algorithm, this value itself will be considered as a starting point for new search process Fig 7.

7. CONCLUTION

The simulation results show the effecincyof the prposed modelforachivingthe optimal distribution for the sensors to ensure the best coverage of the region of interest with the minimal possible number of sensor nnodes.The proposed apprache can be used to solve the distribution gaps issues with minimal number of sensor nodes. distribution gaps issues always happen as aresult of the random distribution of sensors or the death of theses units. So, this method guarantees the best distribution for the sensor nodes which can be applied with differents type of wirless network applications.

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