

Improving Coverage Deployment for Dynamic Nodes using Genetic Algorithm in Wireless Sensor Networks

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Abstract

Wireless Sensor Network is a group of sensor nodes aimed to monitor various environmental conditions at the field locations. Eventually the sensed data is sent to a processing center. Each sensor node consists of a different number of sensors for sensing different parameters in the field area. The sensor nodes are usually equipped with a pair of limited alkaline battery. Achieving maximum coverage deployment is a major problem in wireless sensor networks. In the Existing system, by using the Random Deployment some nodes may get overlapping this will cause unbalanced structure. By using maximum coverage sensor deployment problem, the Coverage achieved only for static nodes. In the proposed system, a Genetic Algorithm is used to deploy Sensor Nodes for the Maximum coverage within the area, where the sensors are of different types. In this work, first analyze the total coverage area the WSN, identify the types of Sensor nodes and Coverage sensing distance, and calculate the coverage sensing distance for the combination of all sensor types based on radius of each node. Improving the deployment of Dynamic nodes for achieving maximum coverage deployment by using Genetic Algorithm. As a result, we were implemented this work in Java. This will show the best performance in coverage and network lifetime.

Keywords: Coverage Deployment, Genetic Algorithm (GA), Wireless Sensor Networks (WSN)

1. Introduction

Wireless Sensor Network is a challenging technology in real world applications. In recent years clustering techniques were implemented based on LEACH protocol. Instead of transmitting sensed information to the destination, a Specific node takes the responsibility for message transmission. The major constraints in wireless networks are energy, Routing, clustering, coverage deployment.

Extracting genetic algorithm in WSN is to improve the energy dissipation among the sensor nodes and reduces the overall energy performance. At times nodes, which are

located in a long distance could not able to communicate with the cluster lead due to larger transmission range. To overcome this problem multi hop routing techniques was developed.

Another serious issue in wireless sensor networks is about coverage deployment. Achieving maximum coverage improves the quality of service as well efficient transmission rate. Coverage in wireless sensor networks characterized as area coverage, target coverage and point coverage. We mainly concentrated on area coverage. Coverage in the sense determined by placement of nodes efficiently. The placed nodes should cover maximum area in a sensing region.

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Coverage becomes a critical issue, when huge amount of nodes is placed. To overcome this problem Genetic Algorithm is elaborated in wireless sensor networks. Only the selected nodes get deployed in a sensing area which covers the every place in the field location. In our paper, we have proposed gap cluster is to improve the performance of coverage deployment in wireless sensor networks.

2. Literature Survey

In ¹ studied about the efficiency of target coverage. In these initially nodes are placed randomly and then qualified nodes are selected. Only the selected nodes in the field location for coverage. This will increase the energy consumption. In ² discussed about the problem in unbalanced placement of nodes. Unbalanced node placement problems, minimizes through the Maximal independent set, head selection and multi hop communication.

In ³ introduced the Link aware Clustering Mechanism (LDAM); clustering mechanism concentrates on efficient cluster head and gateway selection. In ⁴ discussed comparisons between Cluster Based Multipath Dynamic Routing (CBDR) and EQSR. The CBDR protocol provides the better energy efficiency based on routing. Here, the term multipath routing in the sense aggregation of information between the nodes, finally a single node transmits the aggregated data to the base station. In ⁵ concentrated on reducing the network lifetime and prevention of hotspot problem based on clustering technique.

In ⁶ introduced the pure Genetic Algorithm (GA) for achieving the maximum coverage deployment for static nodes. In ⁷ GA with hierarchical clustering improves the energy dissemination among the nodes. Sensing range in wireless sensor networks is classified as target (point) coverage, area coverage, path coverage. In ⁸ discussed about the of genetic algorithm and objectives of that. Genetic Algorithm produces many possible solutions for a single problem. Also introduced many techniques for genetic operators.

Processing power and energy resources are limited by make use of Hierarchical Clustering Routing techniques (HCR); the nodes are characterized into three layers (level1, level 2, level 3). Level 1 cluster aggregates the data from both level 2 and level 3 clusters in order to improve the transmission rate ⁹. Low energy adaptive clustering hierarchy has further most used techniques in HCR. In ¹⁰

reported that an optimal node replacement for a mobile node which will increase the coverage. The proposed Genetic algorithm determines the nodes participation in transmission between others. In ¹¹ studied on the wireless sensor network parameters such that data aggregation, node placement, network coverage and clustering. Nonlinear optimization of genetic algorithm improves the performance of mobile nodes.

In ¹² Introduced the Virtual Force Algorithm (VFA) with additionally novel probabilistic genetic algorithm for improving the coverage radius of sensor nodes after the initial node deployment. VFA algorithm improves the coverage field for mobile nodes after initial deployment. Repulsive forces, attractive forces these are the weight parameters should consider. VFA algorithm little bit different from the MCSDP. Maximum Coverage Sensor Deployment Problem (MCSDP) applicable only for static nodes in the sensing field.

In ¹³ discussed about the use of hierarchical clustering for reducing the long term communication. Clustering is the one of the best technique for improving network lifetime. A hierarchical clustering technique is a scalable approach, even the location of base station changes (mobile base station). However, coverage plays critical issues in wireless sensor networks. In ¹⁴ concentrated on minimizing the intersection area in sensor nodes by using genetic algorithm and also achieves higher sensing area by different nodes. Node failure model, information about location, synchronization time, scalability, robustness are the some other factors which affect the sensing range of sensor nodes.

In ¹⁵ discussed about various coverage techniques based on some random algorithm. In ¹⁶, discussed about the coverage in terms of connectivity. The communication range of sensor nodes is twice as the nodes sensing range. The both communication and coverage in wireless networks are tightly coupled approach.

3. Proposed Approach

3.1 Node Assumptions

Firstly the nodes are deployed randomly in a specified location. Total sensing range has been calculated. After initial deployment some area's are not filled by any of the nodes in the sensing field. Our proposed aim is to deploy a node in the sensing field such that improving the coverage deployment. Deploying all other nodes in the sensing field is a complicated issue, so that we implemented the Genetic Algorithm for selecting the best

nodes between them. Deployment starts with best nodes. We proposed gap cluster techniques for identification of uncovered region. The xy coordinates of gap cluster and radius are determined (Figure 1).

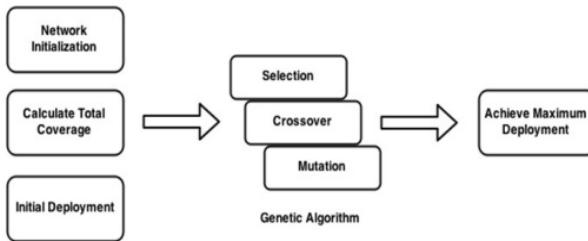


Figure 1. System Architecture.

3.2 Node Distance (DS)

It expressed to create transmission between two nodes as well base station and Cluster Lead (CL). A DS is identified as a coverage range of each node. Coverage referred in terms of radius.

3.3 Genetic Algorithm

Genetic algorithm developed by John Holland. It's a search based algorithm basics on 1. Natural selection 2. Nature Genetics. GA optimization algorithm is differentiated from the traditional search algorithm. Traditional techniques are calculus based (direct and indirect), enumerative (less possible solution) and random. Initially the number of population generated from the random samples. The basic performance of GA as shown in Figure 2.

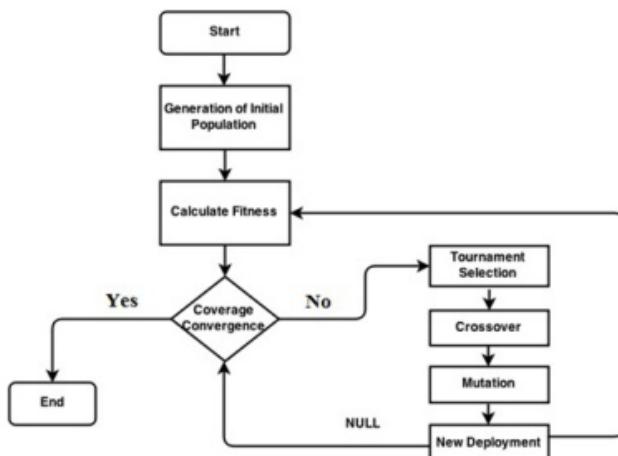


Figure 2. Flow chart for proposed technique using Genetic Algorithm.

3.4 Initialization of Nodes

In WSN the initialized nodes are deployed randomly. Initially gene length of each node taken as 20-bit string. First 10-bit of gene is determined based on the index of waiting node, remaining 10-bit assumed as an index of gap cluster.

3.4.1 Fitness Function

For calculating best nodes, the following formula is used. In this k -Type of Sensor, ks –Sensor sensing range or coverage area, t –Total no of sensor, tk –Total no of sensor for each type, α – Tightness ratio. A fitness value for each node is calculated as shown in Table 1.

$$\text{Fitness} = \sqrt{\frac{\sum_{ki}^{kn} ks_i / tk + 1 - ks_i / t_i}{t}} * \alpha \quad (1)$$

Table 1. Sample Fitness Values

S. no	Index	Gene (20 bits) Initial population	Fitness value	Radius of Nodes, Gap Cluster
1	0	0000000000	-0.37528470	3 5
		0000011010	752104744	
2	17	0000010001	-0.79056941	4 5
		0000010111	50420949	
3	29	0000011101	-0.53463383	5 7
		0000011000	10781813	
4	35	0000100011	0.081649658	8 3
		0000110001	09277261	
5	27	0000011011	0.489897948	3 3
		0000111011	55663565	

3.4.2 Tournament Selection

In our work Binary Tournament selection method is used. Two nodes are selected randomly and the fitness value of the node is evaluated. Generate the random number, if it's more than the tournament probability, then elects the highest fitness node for the next generation else select the least fitness node.

3.4.3 Cross Over

In this work we have used the two point crossover with the crossover probability with 0.8. During the cross over performance the index of a gene may exits. To overcome the problem index of the gene gets reduced by using mod function.

Samples

Gene1:00000000|0000|00011010 → NewGene1:00000001|0100|00011010
 Gene2:00000100|0100|00010111 → NewGene2:00000100|0000|00010111
 Gene3:00001000|1000|00110110 → NewGene3:00001000|1100|00110110
 Gene4:00001000|1100|00110001 → NewGene4:00001000|1000|00110001

3.4.4 Mutation

In this paper, we proposed mutation probability as 0.01. Generate the random number; if it's greater than the mutation probability, then the index of the gene is changed as 0 to 1 and vice versa.

Samples

Gene1:00000001010000011010 → 00000001010010011010
 Gene2:00000100000000010111 → 0000010000100010111
 Gene3:00001000110000110110 → 00001000110100110110
 Gene4:00001000100000110001 → 00101000100000110001

3.4.5 Termination Conditions

The termination condition applied to the algorithm when the number of iterations achieved or required network coverage rate is obtained.

3.5 Maximum Coverage Deployment

Basically coverage can be viewed as area coverage, target coverage, barrier coverage related to wireless sensor networks. Coverage model measured by sensing capability and the distance between them. Sensing range represents the range between the nodes to the point. Each node in the networks varies in different sensing range. 1. Sensing range is calculated by means of radius. 2. The communication range represents the communication between the two sensor nodes.

3.5.1 Gap Cluster Analysis

In a provided region 100x100m, 100 nodes are deployed in a dynamic manner. After initial placement of nodes, uncovered area radius is evaluated. Each and every point in the area is checked. Initially starts with zero radius, enlarge the radius up to it touches any of the node region. Group the uncovered region in the form of clusters. Overlap between two gap clusters is avoided by means of reducing the size of minimum radius gap cluster. Finally

the radius of gap cluster is calculated.

After initial deployment of nodes in a sensing area, uncovered areas are evaluated by using gap cluster. Those areas are clustered by means proposed approach. Now, the un-deployed nodes are ready to deploy in the sensing area based on the radius among these, best nodes are selected based on genetic algorithm. Each node in the waiting list is compared with the radius of gap cluster. In each stage a new node is deployed into the sensing range. After placement of each node uncovered area's are evaluated using our proposed technique called gap cluster. Once a best node placed into the gap Cluster, then the size of the gap cluster gets resized this will leads the maximum coverage deployment. This process will continue until achieving the maximum covered range.

Algorithm 1: Proposed approach using Genetic Algorithm

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Step 1: Deploy the nodes initially in Random locations
do
  Perform the Gap Cluster Analysis
  Population size=50
Step 2: Initialize the population with Index of waiting
nodes and index of gap cluster
do
  Find the fitness values all of the nodes in the
population
  Apply Binary Tournament selection operation and
select the best nodes in the population
  Select the best nodes in the population
  Apply the Two-point crossover with  $P_c=0.8$ 
  Apply the mutation operation with  $P_m=0.01$ 
  until(Termination Condition)
Step 3: Select the best node and deploy it
Step 4: Perform step 2 until uncovered area==null
  
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The above algorithm describes the proposed approach for achieving maximum coverage deployment.

4. Performance Results

Here, we examined the proposed approach by means of the coverage ratio and also maximize coverage node deployment. Our simulation results obtained Net Beans. Initially the network size is declared in Table 1. In our

experiment we use dynamic sensor nodes. We used three types of sensor radius such as s_1 , s_2 and s_3 respectively. The values of the radius calculated by the following conditions $s_1=0.8xs_2$ and $s_2=0.8xs_3$, $s_3=3$. Here we determine the total sensing area as 100x100m. Initial deployment of dynamic nodes can be done. Population size of nodes determined based on the size of the waiting nodes. During the simulation run, we used the following parameters:

Table 2. WSN Simulation Parameters

S. No	Description	Parameters
1	Total sensing range	100x100m
2	Total no of nodes	150
3	No of Deployed nodes	100
4	Selection	Binary Tournament Selection
5	Fitness evaluation	Tightness ratio
6	Cross over Probability	0.8 Two- point cross over
7	Mutation Probability	0.01

In each experiment, we used gap cluster to determine the uncovered area. After analyzing uncovered area, the proposed approach with genetic algorithm is used for achieving maximum coverage deployment. Now, our proposed approaches elaborate the coverage area in sensing range.

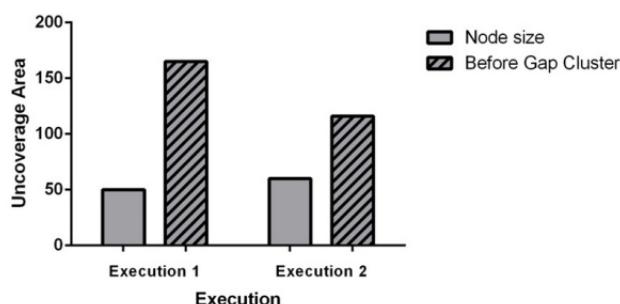


Figure 3. Performance uncoverage area before gap cluster.

In each iteration process best node selected based on fitness function and that node is ready to deploy in a sensing region. After deployment of every node the range (radius) of the uncovered region is re clustered. In Figure 3 the evaluations of coverage region are analyzed with the two different sensing regions. Results show that, node range and uncovered space radius.

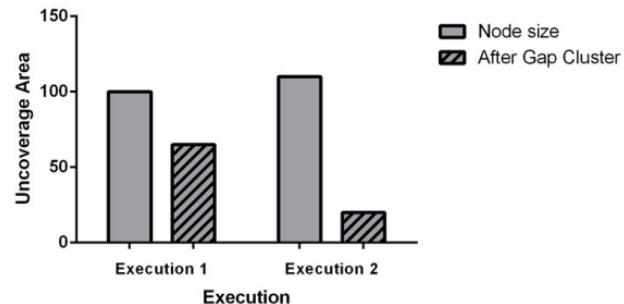


Figure 4. Performance uncoverage area after gap cluster.

Simulation results in Figure 4 shows, uncoverage area get reduced after gap cluster performance. When compared with Figure 3 and Figure 4 uncoverage areas getting reduced from 165 to 65. Also shows the new population nodes are deployed efficiently.

5. Conclusion

We have proposed gap cluster technique with a genetic algorithm to obtain an optimal solution for maximum coverage deployment for dynamic nodes. The gap cluster approach improves the coverage provided by an initial deployment. Performance results show the performance of gap cluster for allocating a different number of nodes. As a result, the simulation shows the improvement of coverage area for dynamic nodes and the efficiency of our proposed algorithm as well.

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