An Algorithm for Overlap Nodes That Provides Better Coverage Efficiency than PEAS Protocol

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Abstract— Wireless Sensor Networks constitute a wide range of applications related to national security, military, surveillance, health monitoring environment. The main constraint in wireless sensor network is its energy consumption and limited battery life of the sensor nodes. Coverage provides good quality of service but it is very important especially when combined with connectivity and energy efficiency. This paper provides some existing coverage protocols with their limitations. The proposed algorithm for the overlap area provides better coverage efficiency of 91.354% than the existing robust PEAS protocol that provides coverage efficiency of approximately 80% to 88% thus allowing minimum number of sensor nodes to be in the active state in order to conserve energy thereby increasing the lifetime of the sensor node.

Keywords—Coverage, Connectivity, Coverage protocols, Energy Conservation, Coverage efficiency.

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I. INTRODUCTION

Wireless Sensor Networks are densely deployed low cost, low processing power, less memory and limited energy resource networks. In recent years WSN found a large number of applications in the fields of both research and academics. In WSN, the nodes are called sensors which sense the data like temperature, humidity, noise or sound, pressure, soil variety, movements of objects, stress levels, detection of objects around and other properties from the surrounding and send this information to the base station or sink as shown in the Fig.1 for further analysis and decision making.

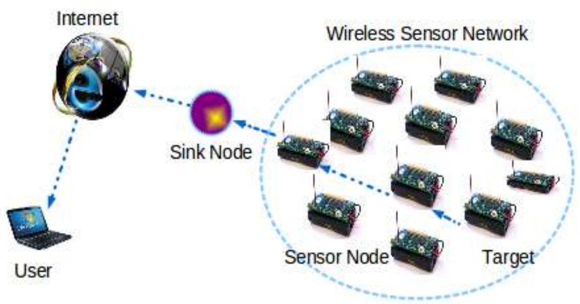

Figure 1: Typical wireless sensor network [1]

Although used in such crucial applications, like military and surveillance the sensor nodes are severe resource constraints, such as restricted energy, memory, battery and lifetime etc., hence it can sense only a small portion of the environment. As a result energy conservation, reliability, and quality of services is necessary to meet application requirements.

Coverage is an essential research issue in WSN because it can be considered as the measure of Quality of Service (QoS) of sensing function for a sensor network. Different applications require different degrees of sensing coverage. The coverage requirement may also change after a network has been deployed, for instance, due to changes in application modes or environmental conditions. Thus energy conservation is very important as replacement of the battery is costly and even impossible in some applications, such as military, battle field surveillance etc. A method that is frequently used to reduce energy consumption is scheduling, where a minimum number of sensor nodes are activated to satisfy the K-coverage requirement and the remaining nodes are set to sleep to conserve the energy.

This paper presents an algorithm that provides better efficiency as compared to the PEAS protocol. The proposed algorithm will try to reduce the number of active nodes placed in an area alongwith obtaining complete coverage of the assigned area and increase the number of sleep nodes to conserve the energy that will further prolong the battery life of the sensor nodes

The remainder of the paper is organized as follows: section II describes the different existing coverage protocols in section III and IV, an outline on the proposed algorithm and software simulation respectively. Results are discussed in section V and further conclusions are drawn in the last section VI

II. DIFFERENT EXISTING COVERAGE PROTOCOLS

There are various protocols for effective coverage in sensor networks. The different coverage schemes for wireless sensor networks, the approach followed by them and their limitations are explained below:

1. Probing Environment Adaptive Sleeping (PEAS)

Approach: This is a distributed protocol based on probing to extend the network life by turning minimum number of active nodes. It is location independent protocol.

Limitation: The drawback of this protocol is that there is frequent waking of nodes due to use of the exponential distribution function. It also cannot ensure complete coverage.

2. Coverage Configuration Protocol (CCP)

Approach: This protocol is based on verification whether the intersection points within the sensing areas are k-covered in order to make sure k-coverage is achieved.

Limitation: When the transmission range exceeds twice the sensing range, there is possibly no connectivity in the network.

3. Adaptive Self-configuring Sensor Network Topologies (ASCENT)

Approach: In this protocol, the topology will be automatically established that makes the redundant sensors undergo sleep for enhancement of coverage.

Limitation: The main drawback is that the working nodes get back to sleep which may affect the coverage.

4. Optimal Geographical Density Control (OGDC)

Approach: This protocol is based on decentralization of the sensor nodes and establishing the density control.

Limitation: The accurate information of the location of the node and requirement time synchronization forms a major drawback of this protocol.

5. Random Independent Scheduling (RIS)

Approach: The aim of this protocol is to achieve k-coverage while the nodes being allowed to sleep for maximum time.

Limitation: The unexpected node failure occur which cause destruction of sensors till they completely run out of energy.

6. Light weight Dependent Aware Scheduling (LDAS)

Approach: The redundant nodes in the sensor field are analyzed. The exceeding of number of working nodes results into threshold node turning off and tickets are sent to it.

Limitation: The tight under-bound of likelihood of obtaining complete redundancy and the analysis of redundant areas is difficult.

7. Connected Dominating Coverage Set (CDCS)

Approach: Sensors are divided into disjoint sets such as that every set completely covers all the points.

Limitation: It targets only on total target area coverage and less on battery life

III. PROPOSED ALGORITHM

Among the different existing protocols Probing Environment and Adaptive Sleeping (PEAS) protocol is considered to be one of the robust and distributed protocol as it covers the remote areas where humans cannot reach manually. Ye, F., Zhong, G., Lu, S., & Zhang stated that the PEAS protocol whose transition diagram is as shown below in the Fig. 2., each node in PEAS undergoes in three modes of operations: Sleeping, Probing and Working. Each node is initially in the sleep mode. It sleeps for some exponentially distributed duration. Once the node wakes up after a random duration in sleep mode it enters into probing mode from where it sends a PROBE message to detect whether any active node is present within the probing range, if it receives REPLY message from any node it re-enters the sleep mode.

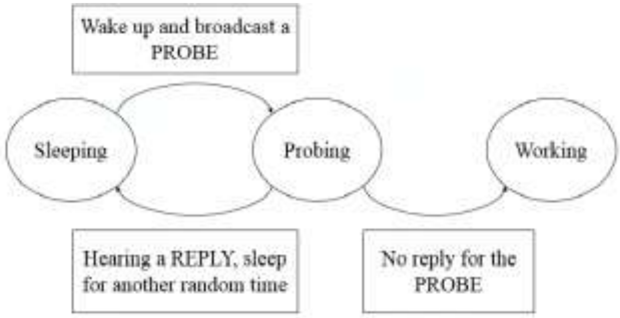

Figure 2: State transition diagram of PEAS

If it doesn't receive any REPLY it enters into working mode and functions until it fails or consumes all its energy.

The Proposed algorithm is a modification in PEAS protocol. The sensor nodes in PEAS sleep for a random period of time and again enter the probe state. The proposed algorithm will also continue to remain in the same three states but the sleeping period will be an estimated period of time with respect to the active node's working period. Fig.3 gives the flow chart for the proposed system.

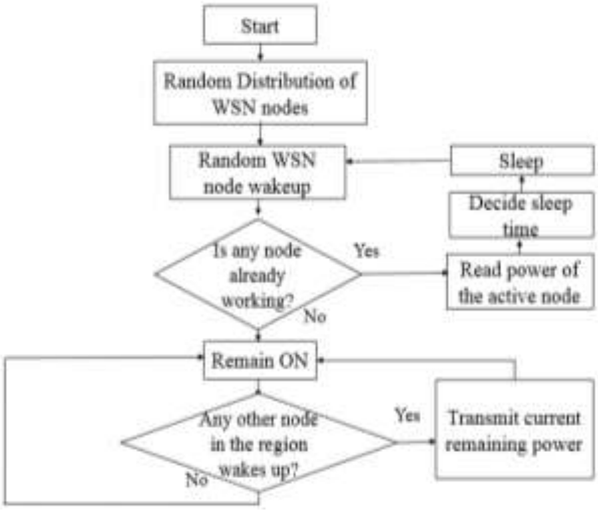

Figure 3: Flow chart for the proposed system

In the proposed algorithm, the node will check whether any other node is in the working state, if yes it will read the power of the active node and based on which it will decide its sleep time accordingly and then go back into sleep mode, if no, then it will enter into active state and check whether any other node with high power is there in the same region, if yes, it will transmit its current remaining power to that node and continue to remain in working state until it fails

IV. SOFTWARE SIMULATION

The proposed algorithm is simulated in MATLAB R2013. As Network Simulator-2 (NS-2) has an inbuilt energy model which cannot be used to implement our algorithm thus it is not possible to import any new energy model and node failure model.

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Hence MATLAB is used in order to get the node probability failure and the estimated battery life of the nodes.

Starting with MATLAB, the code consist of four parameters i.e, Number of nodes (N), Sensing range (rs), Length (l), Width (w) and also variable is assigned for overlap nodes alongwith the x co-ordinates and the y- coordinates of the graph. The nodes are deployed using the Euclidean distance of the nodes based on which the nodes are placed in the intended coverage area. Once the overlap nodes are determined, multiple nodes with similar sensing range will go to sleep mode thereby keeping only one node in the active state.

The Fig. 4, Fig 5 and Fig.6 shown below are the stimulated output obtained on MATLAB for our proposed algorithm. It indicates the total number of nodes plotted in an area in which length & width are at Y axis and X axis, the sleep nodes and the actual total number of live nodes respectively.

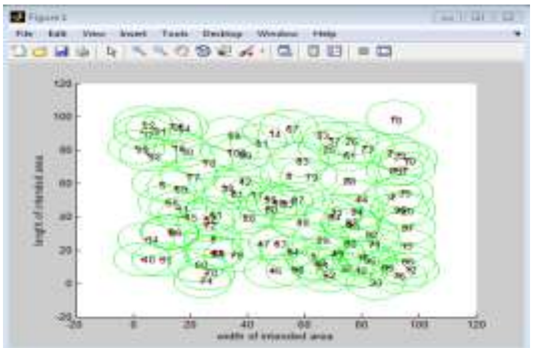

Figure. 4: Stimulated output result for deployment of total number of nodes

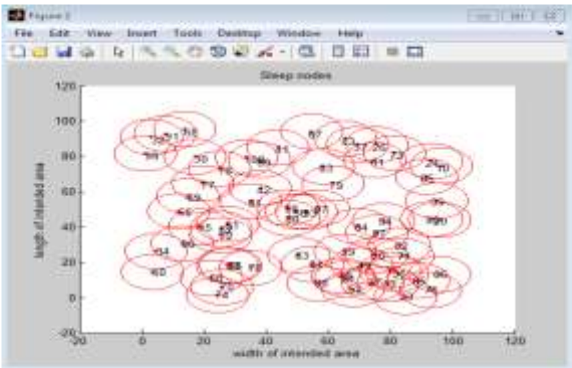

Figure.5: Stimulated output results for the sleep node

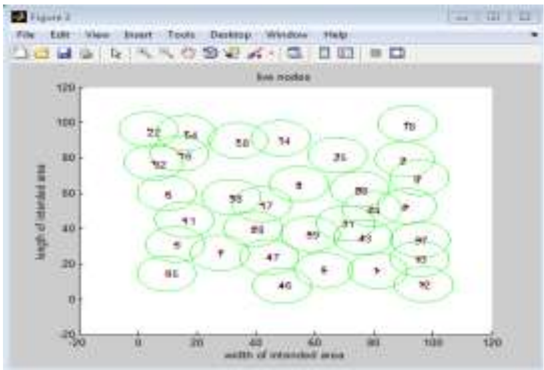

Figure.6 Stimulated output results for the live nodes

V. RESULTS

By keeping one parameter constant out of the three parameters different outputs are obtained for different cases giving different percentage of coverage efficiency based on the formula [9]

$$\text{Coverage} = \frac{n*(\pi*Rs^2) - \text{Overlap Area}}{\text{Area}(L \times W)}$$

Based on different cases we can say that the proposed algorithm can give coverage efficiency more than 90%.i.e. 91.354%. Sensing range is also flexible varied from 10 to 20 meters (proposed algorithm) with a random deployment of nodes. Based on these few characteristics it is possible to compare our proposed algorithm with the existing coverage protocol like PEAS.

Table1: Comparison of different characteristics between the proposed algorithm and PEAS

Characteristics	**PEAS**	**Proposed Algorithm**
Deployment	Random	Random
Coverage Efficiency	Above 70% to 90%	Above 90% , (Approximately 92.97%)
Sensing range/Probing range	3 to 10 meters	10-20 meters
Frequent failures	Yes	No
Known location	No	No

The Table.1 given above illustrates the comparison of different characteristics of the proposed algorithm with PEAS protocol. From the table we can say that the proposed algorithm is better as compared to the PEAS protocol with respect to coverage efficiency also there are no REPLY messages received by the active node as that in PEAS. Hence multiple REPLY messages from various nodes at the same instant also leads to traffic because of which there can be node failure in PEAS

VI. CONCLUSION

Energy consumption is one of the important constraint in wireless sensor network and is more crucial when used for critical applications like military and surveillance. Hence it is essential to conserve and save energy in order to prolong the battery life of the sensor nodes.

In this paper we investigated that the proposed algorithm provides better coverage efficiency in a large scale wireless sensor networks. In the proposed work we varied multiple parameters at every instance keeping one of the parameter same and thus achieved different area coverage for different combinations. Thus we achieved a good coverage efficiency of 91.354% for our algorithm with respect to PEAS protocol giving efficiency of almost 80% to 88% using same combinations.

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