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Optimization using Particle Swarm in WSN for Fault Tolerance

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***Abstract*— Recent advancement in the area of MEMS, communications with wireless technologies, digital electronics have led for the emergence in WSNs, which having maximum of sensing devices which are capable in detecting, processing, transmitting some information like environmental changes etc. Every single sensor node equipped only with limitations in computation and also communicating capabilities; but WSN nodes, which are sensors, when properly configured, can combined perform tasks related to signal processing to get the information from a remote area that may be dangerous area in an untended, robust way. Applications including smart spaces, battlefield surveillance, biological detection, industrial diagnostics, environmental monitoring, etc. Many advancements are undergoing for the technologies with wireless communications. Since few years there had a sharp growth for the research in WSNs. In such networks communication happens with spatially distributed sensor node which are autonomous and powered to sense particular information. This paper explaining how it maximizes the coverage by identifying the fault node and covering the vacant area of the found node and to minimize the consumption of energy in WSN by optimizing the communication distance between the sensor-nodes and the data collector (sink-point) when node is mobile.**

***Index Terms*— WSN, energy depletion, nodes failure, cluster, fault tolerance, Particle Swarm.**

I. INTRODUCTION

A WSN consisting sensor nodes which are joined among them by the wireless medium for performing distributed sensing tasks. This type of networks are expected to be useful in different applications as environmental & health monitoring, surveillance, and security. Sensor networks having capabilities to compute, sense and communicate that allows to observe, instrument and respond for the changes in natural environment, and in cyber and physical infrastructure. There is immense range of sensors from smart dust to larger scale, weather- sensing platforms. Their communication infrastructure and the computation capabilities are radically different when compared to today's systems powered with internet, device reflection and systems with application driven nature. Main aspect in WSN comes from having many sensors generating sensed data with the events of same set. All of the envisaged applications require cheap sensors networks. The WSNs themselves must cost very little, and this means that the devices should have a small silicon area to reduce their cost. Of course, this small defunct area means that memory and digital computational circuitry will be limited. This constraint places a burden on the chip designer implementing security on the device, as

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approaches that consume a lot of die area cannot be entertained. Intelligent-Transportation-Systems (ITS) is a part of the sensing application, communication and control technologies to the road transportation system, with the aim of reducing crowding or improving road user's safety. It is the field in which WSN could make a valuable contribution.

II. Literature Survey

- Tamal Saha and Sudipta Mahapatra proposes a model for Distributed Fault Diagnosis in WSN in which an algorithm of the system level distribution fault diagnose is used for diagnosing the node and the type of fault in the faulty node. In this algorithm each of neighboring nodes exchanges their entry value for some in rounds and threshold value compared with delta which depends on application. If any of the comparison fails the node is diagnosed as faulty.
- E. Safavieh et. al. proposed technique i.e., dynamic geometric neighborhood, based on the Voronoi diagram in PSO. Voronoi perspective is the geometric sober method for determine neighbors with available set of particle. PSO algorithm is non-calculus-based, zero-order that can also solve multimodal, discontinuous, non-convex problems. At first, velocity vectors and particle positions are provoked randomly in space. Each particle accustoms its position and velocity along each dimension, basing on best position that it encountered and the best particle in the swarm. Particles continue this until they find best position.

III. Faults In Wireless Sensor Networks

WSN have large variety in applications and provides unlimited future potentials. Nodes in WSN face down to fail because of hardware collapse, malicious attack, communication link errors, energy depletion so on. Therefore, fault tolerance the specific of major issue in WSNs.
Five levels of fault tolerance were discussed here. They are physical layer, hardware layer, system software layer, middleware layer, application layer. On the basis of study, fault tolerance for WSNs is classified into four layers from system point view. The levels such as network layer, software layer, hardware layer, application layer.

IV. Energy Model

After optimization of coverage, all the deployed sensor nodes move to their own positions. Now our goal is to minimize energy usage in a cluster based sensor network topology by finding the optimal cluster head positions. For this purpose, we assume a power consumption model [3] for the radio hardware energy dissipation where the transmitter dissipates energy to run the radio electronics and the power amplifier, and the receiver dissipates energy to run the radio electronics. This is one of the most widely used models in sensor network simulation analysis. For our approach, both the free space (distance2 power loss) and the multi-path fading (distance 4 power loss) channel models were used. Assume that the sensor nodes inside a cluster have short distance dis to cluster head but each cluster head has long distance Dis to the base station. Thus for every sensor node inside a cluster, l-bit message is to transmit a distance dis to cluster head. The electronics energy, Eelec, depends on factors such as the digital coding, modulation, filtering, and spreading of the signal, here we set as Eelec=50nJ/bit, whereas the amplifier constant, is taken as fs ε =10pJ/bit/m2, mp ε = 0.0013pJ/bit/m2. Since the energy consumption for computation is much less than that for communication, we neglect computation energy consumption here.

V. Swarm Intelligence

Swarm Intelligence (SI) specify a modern computational and behavioral metaphor in solving distributed issues which originally took inspiration from biological examples in social insects and by flocking, swarming, herding behaviors in vertebrates.
Although the impression of swarm advice an aspect in space for collective motion, in swarm such as flock of birds, with all the collective behavior are considered here, not just spatial motion.

VI. ALGORITHM DESIGN

The fault-tolerance algorithm starts after the self organization coverage and one or some nodes get fault. The design of the algorithm flow follows.

- Random deployment of nodes takes place.
- Nodes with Uniform distribution takes place in which each node finds the nearest node and starts moving towards it which depends on sensing range and density of the nodes.
- Faulty node is identified based on Distributed fault diagnosis method and also dead nodes whose energy completely depleted are identified.
- After determining the location of a failure node, set the failure node as the center coordinates, and set a threshold as the radius. The nodes in the circle will move through this algorithm.
- Select the optimization in particle swarm fitness function considering both the coverage and connectivity.
- Re-calculation of coverage, and verify connectivity after optimal coverage.

VII. SIMULATION AND RESULTS

The simulation starts with disposal of sensors nodes which are randomly generated. Here we deploy 100 nodes in 200m*200m area. The node’s sensing radius is assumed 14m and communicating range as 70m with initial energy for each node as 5J.

After uniform distributing the nodes clustering will takes place in which the entire area is branched as four clusters. Figure 1 shows assigned sensing range of each node with the cluster. In the simulation the node which is having Blue face color represents the intermittently faulty node and the node which is having Red face color is permanent faulty node the type of fault is based on the threshold value defined in terms of wrong sensed temperature values, that has been sensed by each node and here we assume that the permissible deviation of temperature is 30C. Figure 2 shows the identified nodes which are faulty in the network and corresponding threshold values for all nodes is shown in the figure 3 in which threshold value to identify a node as permanently faulty is 0.55 and for intermittently faulty is in the range of 0.35-0.55.

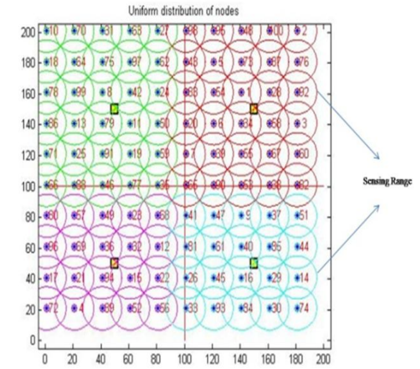

Figure 1. Assigned sensing range for each node in the cluster

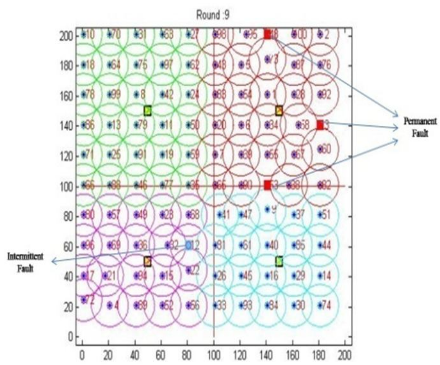

Figure 2. The identified faulty nodes in the network

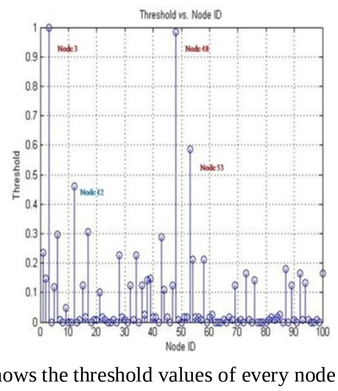

Figure 3. Shows the threshold values of every node against node ID

The corresponding sensed values for all nodes is as follows :-

The Temperature reading for node 2 is 26.056760

The Temperature reading for node 3 is 19.511607

The Temperature reading for node 4 is 24.912218

The Temperature reading for node 12 is 38.938752

The Temperature reading for node 48 is 19.387136

The Temperature reading for node 53 is 40.741807

The Temperature reading for node 99 is 22.732481

The Temperature reading for node 100 is 24.882315

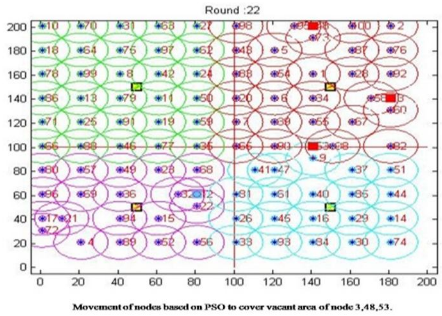

Figure 4. Resultant network after PSO execution

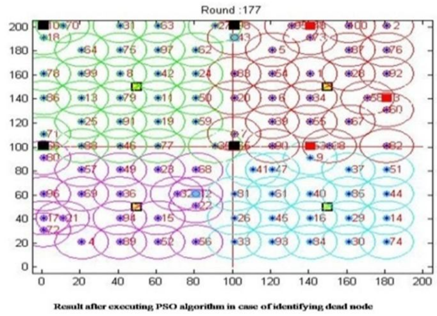

Figure 5 Shows the result executing PSO after identifying the dead node

As the iteration goes on the energy in the node goes on depleting due to communication and eventually node will die in that case once again PSO will be called to cover the vacant area which was previously served by dead node. Figure 5 shows result of executing PSO after identifying the deadnode in network.

The below figure 6 shows variation in the number working nodes in network according to the rounds. As in figure initially we identify some nodes as faulty nodes hence it has high percentage of working nodes in the initial stages as the round goes on, due to depletion of energy and sensing wrong values number of working nodes goes on decreasing exponentially. Similarly at initial stage number of nodes which are fault will be less as the rounds goes on the number of node faulty increases with the number of rounds shown in figure 7

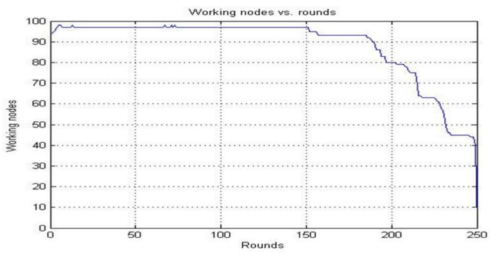

Figure 6. Variation of working nodes vs. round

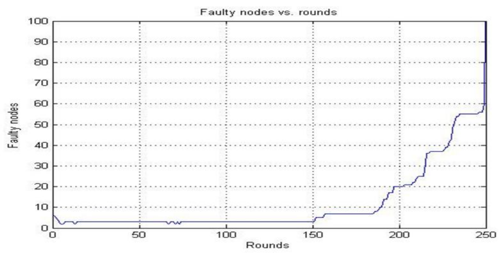

Figure 7. Variation of the faulty node vs. round

The figure 8 shows how the network coverage varies with number rounds. Initially all the nodes will be alive hence the coverage will be at its maximum value as the round progress the nodes gets faulty and eventually dies due depletion in its energy which creates a vacant area around the faulty or dead node leading to decrease in the coverage hence coverage decreases as the round progresses.

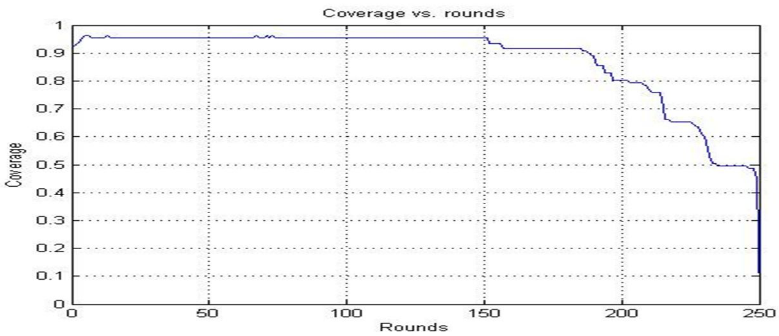

Figure 8. Variation of coverage as the round progresses

As rounds progress the energy in each of sensor node goes on depleting due to communication between the nodes, the cluster head, eventually all the energy in node will depleted and die. The figure 9 shows the variation of remaining energy value in the entire network with respect to round. Figure 10 shows the variation of coverage with the respect to sensing range.

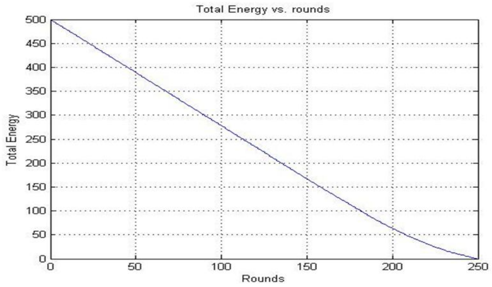

Figure 9 Shows the variation of remaining energy vs. Rounds

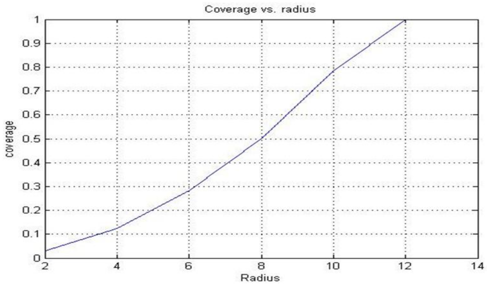

Figure 10 Shows the variation of coverage vs. sensing range

VIII. CONCLUSION

The coverage rate of WSN is an important indicator to appraise performance of WSN. Keeping greater coverage rate is better to exploit the recognition of WSN in the process of network maintenance and initial network deployment. But most of the fault tolerance algorithms deal with re-adjusting the structure of the network which is energy as well as time consuming. So we propose a wireless network fault coverage optimization algorithm based on PSO. This algorithm can quickly finish coverage repair after network failure happening. At the same time, the algorithm using global optimization just surrounding fault area can avoid lots of energy consumption which is produced by global self-organization and can save a huge amount energy.

IX. FUTURE WORK

In the proposed design static fixed cluster head is considered which can be improved to have mobile cluster head which can elected dynamically by the cluster members in the network. Also in the proposed design considered communication type is single hop communication to communicate the information from node to cluster head which can be optimized to have multi-hop communication between node and cluster head.

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