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ERROR FREE WIRELESS SENSOR NETWORK WITH AN EFFICIENT DATA COLLECTOR

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ABSTRACT

Wireless Sensor Network consists of a sink and a number of stationary nodes. In WSN, there are two major problems namely, limited energy and fault occurrence. In the proposed system, to decrease the energy consumption, the nodes are randomly deployed over an area. This area is divided into NxN square grids. At the center of each grid, a Mobile Sensor is placed, which moves in a criss-cross manner so that all the nodes in the region comes within its range and can effectively collect the data. Routing is performed among the mobile sensors and the collected data is uploaded to the sink. The lifetime of the network is calculated and the efficiency is found. When compared to the normal deployment of the network without any mobile sensors, the energy consumption is less and lifetime is more. For addressing the fault occurrence issue, we use various fault prediction methods for both predictable and unpredictable faults such as out-of range prediction, habitat hazard and e-scan method. When a node is found to the failed node using the Hybrid swarm optimization method.

Keywords: mobile sensors, fault prediction, hybrid swarm optimization.

1. INTRODUCTION

Wireless Sensor Networks, composed of densely deployed, low-cost, low-power, multifunctional sensors, have emerged as a new information gathering paradigm. They are deployed over an area to do many applications like weather monitoring, surveying, defense applications, etc. The layout of deployment can be of many types like grid layouts, hexagonal layout, concentric circle layout, etc. The main factor that is the driving force of this system is the energy of the sensor nodes. If the energy is reduced the performance and lifetime of the system reduces. Typically, most energy of a sensor is consumed in two major tasks: sensing the field and uploading the data directly into the sink. The sink is the ultimate destination of the data collected by the sensor nodes. For data transfer single and multi-hop methods are usually used. In the case of data collected, provisions like a cluster head is usually used. Another device is a mobile Data collector that collects the data by moving towards the nodes. It helps in reducing energy and power consumption.

A mobile collector can move on its own in any path that is prescribed. It efficiently collects data from even the areas that are normally unreachable. The main problem that reduces the efficiency of the WSN is the occurrence of faults. Faults can potentially degrade the system or make it vulnerable to malicious entities or make it useless too. To overcome the faults, methods like fault prediction, fault detection and fault recovery are used.

Fault predication is a method of foreseeing the faults that can occur in the system by constantly monitoring the performance of the system, any degradation or anomaly or improper functioning of the nodes may be an indication to the future failure. Once the failures are predicted, it must be made sure that they have realistic chances of occurrence using the fault detection method.

Finally the fault is corrected using fault recovery. Fault tolerance is achieved using several fault prediction methods for predictable and unpredictable node failure so that a new node can be placed near the faulty node without any delay.

This method of deploying new node dynamically to correct the errors or to achieve high performance are done by many methods like optimization. Genetic placements, particle swarm optimization etc.

2. RELATED WORK

For data collection, [1] uses a data mule, which is a mobile device that can traverse a wireless sensor network field to move near stationary sensor nodes that are spatially dispersed for collecting data from them. Use of the data mule can significantly reduce energy consumption of sensor nodes compared to common multi hop forwarding schemes. However, it also increases the latency of gathering data of all nodes. The 2 main goals of this paper are: path planning for the data mule to move near every sensor node to collect data so that the data mule traversal time (or latency) is minimized, and to adjust the sensor nodes transmission ranges so that the total sensor node energy consumption is minimized. The constraint that is considered is that the data mule must move near each sensor node at least once for gathering data. The advantage of this paper is that they use Optimo-parental approach by using Genetic Algorithm. The main disadvantage is that increasing the transmission ranges leads to over power consumption and in turn less life time of the system. When the data mule moves towards each sensor the time and the path also get increased and efficiency is reduced.

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Similarly, in [2], mobile robots that periodically collect data from static wireless sensor network nodes are used.
From the static node's perspective the energy -efficient strategy to wake up and send/receive beacon messages is considered such a strategy must simultaneously. From the robot's perspective the location and orientation of the mobile collector for energy efficiency are considered.
The advantage is the robot's waiting time and number of beacon messages are minimized.

The disadvantages are the approximate locations of the static nodes, and the order with which the robot will visit these nodes needs to be known priory. No path plan is given.

As an improvement [3] computes the optimal trajectories of multiple data MULEs to achieve minimize data collection latency in wireless sensor networks. They consider 2 different problems, namely the k-traveling salesperson problem with neighborhood (k-TSPN)
The k-rooted path cover problem with neighborhood (k-PCPN).

Since both problems are NP-hard, a constant factor approximation algorithm is provided along with two simpler heuristic algorithm based on two cases.

Case-1: each MULE is connected to the sink only from their base stations.
Case-2: each MULE is connected to the sink directly at any time from any location.

The main advantage is that various cases are considered to achieve minimum latency. The disadvantages are there will be redundant, because a same node can send its data to all the visiting data mules.

The mules move towards every node to collect the data.
A mobile data collector, [4] used at anchor point and M-collector [5] works like a mobile base station and gathering data while moving through the field. A M-collector starts the data-gathering tour periodically from the static data sink, polls each sensor while traversing its transmission range, then directly collects data from the sensor in single-hop communications, and finally transports the data to the static sink. Since data packets are directly gathered in a single hop, the lifetime of sensors is expected to be prolonged.
The multiple M-collectors traverse through several shorter sub tours concurrently to satisfy the distance/time constraints.

The main advantage is that the single-hop mobile data gathering scheme can improve the scalability and balance the energy consumption among sensors.
It can be used in both connected and disconnected networks.

The disadvantage is that no steps are taken to avoid redundancy, multiple data collectors may have the information about a particular Identification and classification of faults of data were found by hidden Markov models [6]. For deploying nodes in places where holes were found, in [7], a new method of wavelet transform is used to find the holes and cat swarm optimization is used to fill up the holes. Similarly, in [8], the bee swarm is used to deploy the nodes by keeping nectar regions as the food source for the bees is that the nodes move to the specialized region.

3. PROBLEM STATEMENT

To find a way to effectively collect data from all the sensor nodes and upload them in the sink. To reduce the latency of the collector. To improve the lifetime of the sensor. To forecast the predictable and unpredictable faults in the network and find the actual errors and places of node failure. To place new nodes at the node failure spots to restore normal operations

4. PROPOSED SOLUTION

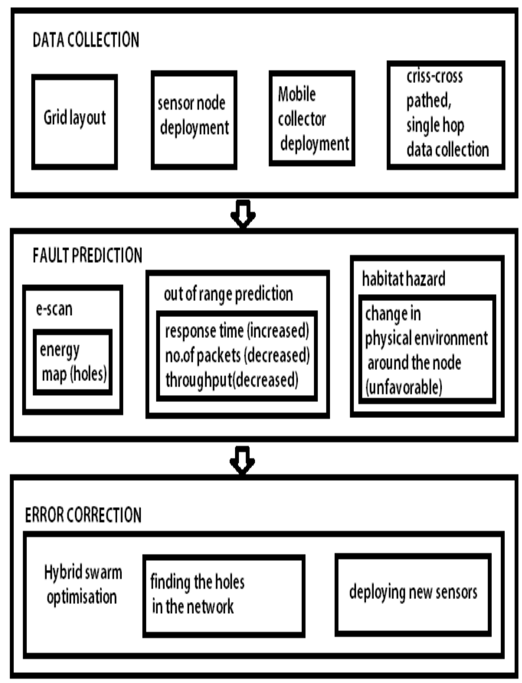

Figure-1. Overall architecture diagram of the proposed system.

a) Deployment of the network

The Wireless Sensor Network is a large area where no number of stationary nodes are randomly deployed. Each node is labelled. This area is divided into NxN square grids where a Mobile Data Collector (Data Mule) is placed at the center of each grid. Multiple Data Mules are used where each Data Mule collects data from a certain set of nodes within the grid. All mobile nodes act concurrently. Thus harvesting data from the entire network at the same time.

b) Data collection

The Data Mule moves in a top-bottom, left-right (criss-cross) manner so that all the nodes in that region come within its sensing range for data collection. It is made sure that the sensor node falls within the sensing range of the mobile collector and the latter collects data from the former. During the transmission of data from the node to the mobile sensor, some amount of energy is lost for both the sensor and the mobile collector.

The data is sent from each sensor to the collector in a single hop. Thus saving energy, as multi hop results in utilization of more energy at each hop. In single hop only transmission energy is coasted for each node in each round. The data collector has more energy compared to the normal sensor nodes and they receive data from the sensors and transmit them to the sink utilizing energy in both the processes. After a cycle of data collection from the sensors, the data mule returns to its original position i.e. the center of the grid and transmits the collected data to the next Mobile Sensor that is nearest to the sink in a single hop fashion and the data ultimately uploaded to the sink. It then resumes its next round of data collection. This proposed method has the advantages like, the path of the collector is clearly defined and monitored (i.e. It's not random) and ensures the collection of data from all the nodes and also proves to improve the lifetime.

By using the following equation, the lifetime is calculated

$$Lt=\frac{N*(Es-Etd)}{(Ps+(r*Etr))}+\frac{M*(Em-Etd)}{(Pm+(r*Etr))} \quad (1)$$

Where Lt is the overall lifetime, N is the total no. of sensor nodes, M is the total No.of mobile nodes. Es and Em are the initial energies of the sensor and mobile collector at the start of the round, respectively, and Ps and Pm are a power of sensor and mobile collectors, respectively, r is the rate of data collection and Etr is the energy used in data collection.

c) Error detection methods

There are several predictable and unpredictable errors that occur which leads to node failure. The existing system consists of actions to be taken after a node failure occurs. Our system proposes several fault prediction methods that detect failure of nodes prior to occurrence such as:

E-scan method: This method is a high priority fault detection method as energy is the most important parameter that decides a node to be alive or dead. In this method the energy of the entire system is obtained and a map is plotted where the region with the most and least energy is represented by a variation in color. The densely colored area has nodes with high energy and sparsely colored area ha nodes that have their energy draining fast and may fail in the nearest. It's an event driven process, we consider the event as the end of each data upload (to the sink) process. The map helps us to clearly locate the place where new nodes need to be placed.

Out-of-range prediction: In this method, we consider the World Standard range for the Response time, throughput and the number of packets delivered for the type of stationary sensor node used in our system. During every cycle of data collection, the values of the Response time of each sensor and the number of packets sent per round are obtained and hence the throughput is calculated as No. of packets per unit time.

If the value obtained are different from the range of values that are obtained usually from the sensors, that is if the response time exceed the usual range or no. of packets and throughput is reduced, then the performance of the node is said to be deteriorating and is continuously monitored because they have comparatively higher chances of failure, once they fall beyond the threshold of the standard range they are marked as faulty.

Habitat hazard: This method predicts a failure by considering the environment where the node is deployed. The change of the physical phenomenon being sensed (temperature, humidity, etc.) between two successive samples is computed. If the rate of change is so unfavorable to the proper working of the nodes the nodes may fail or degrade as they can't cope up with this sudden change in environment. For example, temperature escalation reduces radio transmission efficiency. It's a low priority prediction technique that may frequently occur in the node deployed regions. The faulty nodes are then detected and displayed.

d) Fault recovery

Once the area with faults or network holes are found using the above methods, steps are taken to compensate the failure. This is done by dynamically deploying new nodes that are mobile until they are deployed after which they are also stationary. The hybrid swarm optimization technique is used to deploy new nodes in the region where the old node has failed.

To obtain the hybrid a combination of two techniques, the 'Bee swarm optimization' and the 'Cat swarm optimization' are used.

Bee swarm optimization: This technique is used to detect the holes (faulty nodes) in the system which is considered the 'nectar' which the bees look for. It's based on the fact that bees are drawn towards nectar. Here we consider the area with the hole as the nectar that is found by the bees is that the sensor nodes.

Cat swarm optimization: This method consists of three stages - Initialization, Seeking and Tracing which is used to deploy the new node quickly in the place of the failed nodes. This is based on the fact that cats smells its food and reaches that pace quickly.

Using the combination of these two methods, the holes are found out and the new nodes are moved and placed near the failed nodes to resume the normal functioning of the network.

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5. RESULTS AND DISCUSSIONS

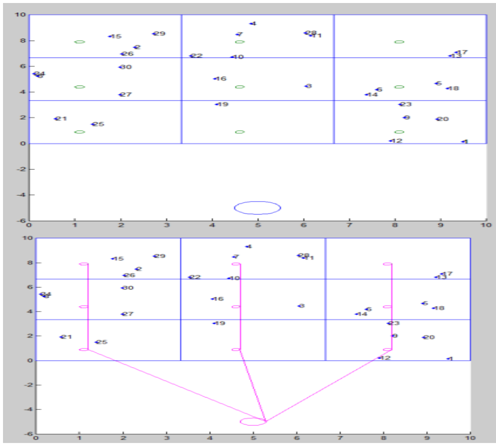

Figure-2. Network deployment and data collection.

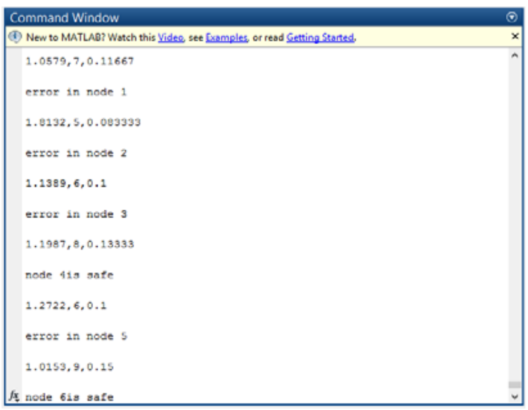

Figure-3. Fault detection.

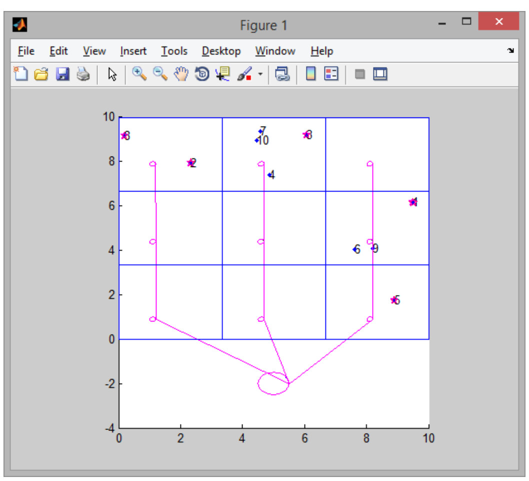

Figure-4. Failed nodes are indicated in pink.

6. CONCLUSIONS

Thus an efficient data collection method is proposed that is found to improve the network lifetime by 71.4 %. The fault prediction methods are very useful to avid unforeseen faults and makes the system ready for quick and effective recovery.

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