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Dynamic Runtime Reconfiguration of Sensor Robots in WSN to Support Disaster Management

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ABSTRACT: *In this paper, attention is focused on the controlled mobility of robotsduring the network deployment in case of disaster prone areas where nodes can fail. The set of sensor robots serves as mobility provision agents. The goal is to physically displace already deployed static sensors in the deployment field and thus increase the deployment quality. However, it cannot be guaranteed that in every WSN application, such an approach would improve the quality of the deployment while minimizing the deployment costs. A dynamic routing protocol for WSN is proposed that can be dynamically reconfigured and controlled by remote administrator. Main focus is to replace each faulty node by a new one in less configuration time so that efficiency of the network increases. This type of reconfiguration method is very important in WSN deployments in disaster prone areas.*

KEYWORDS – WSN System, Mobile sensor robots, Dynamic Reconfiguration System, Localization, Mobility Management etc.

I INTRODUCTION

A Wireless sensor network (WSN) is composed of a large number of sensor nodes deployed in an ad hoc manner. Each sensor node senses phenomena in the environment in which it is deployed, performs a local processing on the sensed data, and then transmits it to a sink. WSNs have been used in many application domains such as intelligent houses, intelligent agriculture, battlefield surveillance, integrated patient monitoring, environment monitoring, chemical/biological detection and other commercial applications [1]. The main task of a wireless sensor node is to sense and collect data from a certain domain, process them and transmit it to the sink where the application lies. Wireless sensor network is a self-organized network that consists of a large number of low-cost and low powered sensor devices, called sensor nodes, which can be deployed in harsh environment. Sensor nodes are prone to have faults [2]. It is thus desirable to detect and locate faulty sensor nodes to ensure the quality of service of sensor networks

The mobile nodes in WSN deployments are required due to their following functions:

1. Sensor robots may have the ability to resolve the problems that could appear in the WSN that couldn't be solved by static sensor nodes.
2. Automated sensor network servicing: Sensor robots increase the network robustness by automated node replacements where the damaged or discharged sensor nodes are replaced by new sensor robots.
3. The sensor robots can be easily adopted in unknown or dynamic environments
4. Increased lifetime of the WSN: the sensor robots can behave as a mobile recharging station which in turn prolong the lifetime of a network.

Different types of sensor nodes are listed as below:

1. Static (immobile) sensor Nodes. The sensors in the network donot possess any kind of locomotion or displacement capability. Furthermore, there is no facility available that could interact with or displace sensorsin the network.
2. Assisted sensor robots: This is known as Mobile Ad-Hoc network where sensor nodes are usually mounted on different types of Mobile agents (robots, vehicles, animals, people, etc.) that provide them with mobility.

3. ControlledSensor robots: The sensor nodes are mobile in nature which means that the sensor nodes can be provided manually or self-controlled. Here, the sensor nodes can be replaced with a new term called "Mobile Sensor Robots"
4. These types of mobile sensor robots allowincreasing the deployment quality in a way that suits the bestto the user or the application of the network.

Mobile sensor robot deployment Techniques:

All the approaches to sensor deployment that include controlled mobilitycan be classified into two deployment schemes: centralized and distributed deployments [3].

The centralized approach assumes a central entity or the administrator exists in such approach but that is not necessarily a part of the set of mobile sensors. This approach can achieve excellent results in the static environment, since the optimization algorithms can be applied in order to achieve the optimal deployment.

Functions of controller:

1. Collection of necessary information about all the sensors in the network and the deployment environment itself.
2. To process the information regarding the goal of the deployment andselect the optimal positions for each sensor in the network.
3. To direct each individual sensor towards its future destination.

Limitations of the centralized approach which make the centralized approach infeasible in most of practicalapplications:

1. Highcomputational overhead in energy, time, and storage space due to the necessity of the global network information which in turn increases the cost of sensors with the limited processing power.
2. Thecomplete network is dependent on the errors and failures that can happen inthe controller, which makes the network highly vulnerable.
3. Since the central entity has to manage ever increasing amount of information in real time, scalability of the network in this case represents another huge problem,

In distributed approach each sensor robot has the ability to calculate its own behavior and mobilitypattern depending on the perceived local neighborhood and environment information easily. In this manner, the computation complexity is reduced to a limitedset of locally perceivable neighboring sensors, whatever the size of thecomplete network is. The goal of the distributed deployment techniques isto combine all the movement decisions that are brought locally and combinethem in order to approach the optimal solution achievable by the centralized approach [4], [5]. The drawback of the distributed approach is that the lack of complete knowledge makes impossible to achieve the optimality. Controlled sensor robots have received much attention in recent years due to their different applications in disaster management notably area exploration and rescue Missions.

II. EXISTING RECONFIGURATION MODELS

1. DRRP Protocol: S. Gao et. al. [6] proposed a dynamic routing algorithm that provided the feature of dynamic reconfiguration in system. It provided the goal to meet different network requirements. It was done by use of potential fields. It performed a dynamic reconfigure of network by setting a parameter and then changing it dynamically. By this parameter, it could optimize this protocol. It provided a useful method for administrator to configure this protocol by application.

2. Localization technique: Martin K. Mwila et. al. [7] presented a localization technique that used the method of distance estimation. In this method, they included antenna radiation pattern and orientation of nodes that provided efficient localization. It developed a mathematical model to estimate distance and cost function and its gradient was calculated. It included a data fusion technique that combined antenna radiation pattern and orientation of nodes and also combined data from accelerometer.

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3. Mobility Enabled Protocol Stack: Fawad Nazir et. al. [8] provided a used mobility management protocol concept. It provided a study that was based on Session Layer Mobility and Host Identity Protocol so that it may provide complete solution. It worked on management of mobility of nodes and generalized its main principles. It developed a stack of protocol that combined some commonly used protocols.

4. Decentralized approach for reconfiguration: Fei Ding et. al. [9] presented an approach for network in smart systems. It was used for reducing power loss in system. In this work, it consisted of a test system and some intelligent agents that were built using MATLAB tool. It was used to different test systems for checking its performance. The results were presented and shown that the proposed technique achieved similar results as traditional one with reduction in computation time.

III. PROPOSED MODEL

This paper focuses on reconfiguration of WSN through centralized approach and reduces the localization error and that too in less time.

A good warning system can help to avoid the damages produced by expected disasters. Sensor nodes can be used to provide the circumstances of plants and animals in wild environment, as well as the ecological constraints of the habitat. Sensor can be deployed under water or on the ground to monitor the quality of air and water. Monitoring of Air quality can be used for air pollution control and water quality monitoring can be used in biochemistry field. Sensors can also be deployed to detect natural or non-natural disasters. For example, sensor nodes deployed in a forest can also detect the exact origin of the fire before the fire is spread uncontrollable. Seismic sensors can be used to notice the route and magnitude of earthquakes.

After the deployment of the sensor nodes, there is a Head node selection by polling method. Then head check the status of each node and collects the environmental data from sensor nodes. For this, there is a direct communication between head & nodes. Head asks the nodes about environment conditions, then reply back to head about status. Now if temperature goes above threshold due to any disaster effect, the nodes sense data and tells to the head and starts moving from their locations. Then they collect to any other location and when the disaster under control then head orders the nodes to repositioning or reconfigure their locations within minimum time.

Proposed Algorithm

Step 1: Generate no. of sensor nodes (N)

Step 2: Create a random topology

Step 3: Provide random movement in nodes

Step 4: Compute the shortest distance between nodes & all nodes are communicating with each other.

Step 5: Provide head in network for giving commands & monitoring the nodes.

Step 6: Head collect data about environmental conditions like temperature

Step 7: If attacks occur thenNodes move & change their locations

Else

Continue their work.

Step 8: If nodes get failed then controller checks for reconfiguration of the network.

Step 9: Compute localization error.

Step 10: End

IV. RESULTS

For Network of 50 Nodes: A network of 50 nodes is presented in area of 150*150 m^2. The localization response and location error of this scenario is shown in fig 2 and fig 3 resp. The response provides the initial location and final location values.

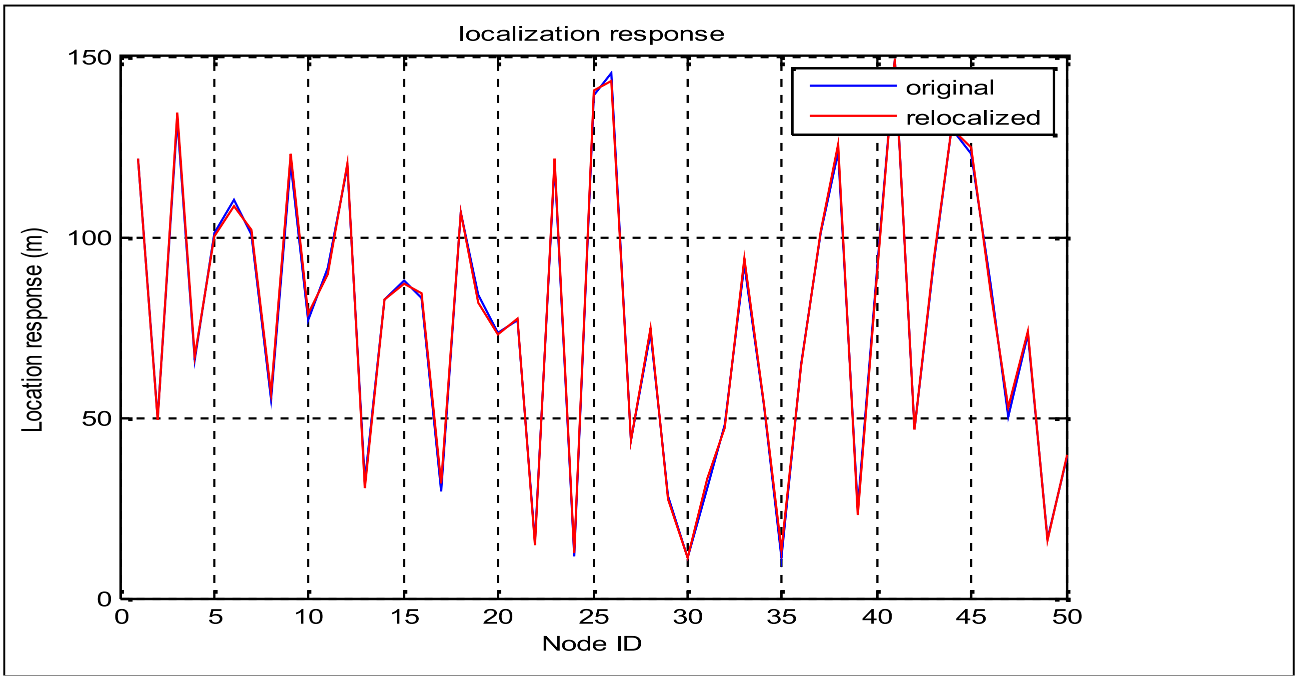

Figure 2: Location Response of Original Location and After Relocation for 50 Nodes

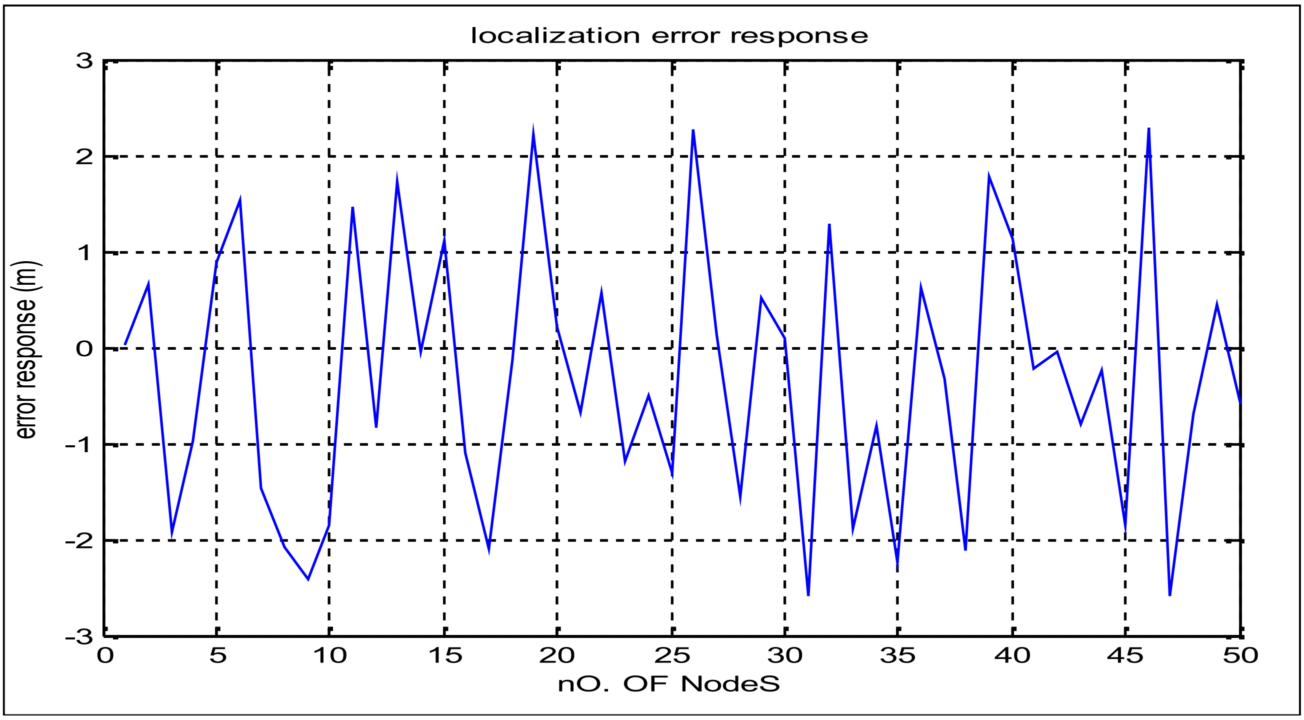

Figure 3: Location Error for 50 Nodes

For Network of 70 Nodes: Now, a network of 70 nodes is presented in area of 150*150 m^2. The localization response and location error of this scenario is shown in fig 4 and fig 5 resp.

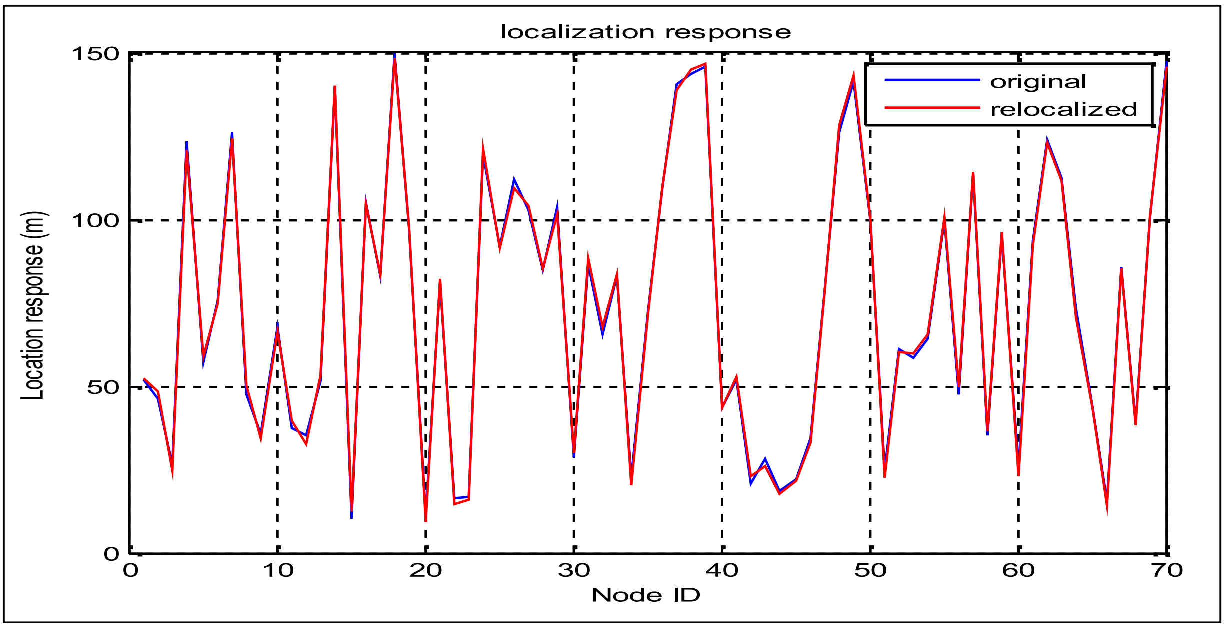

Figure 4: Location Response of Original Location and After Relocation for 70 Nodes

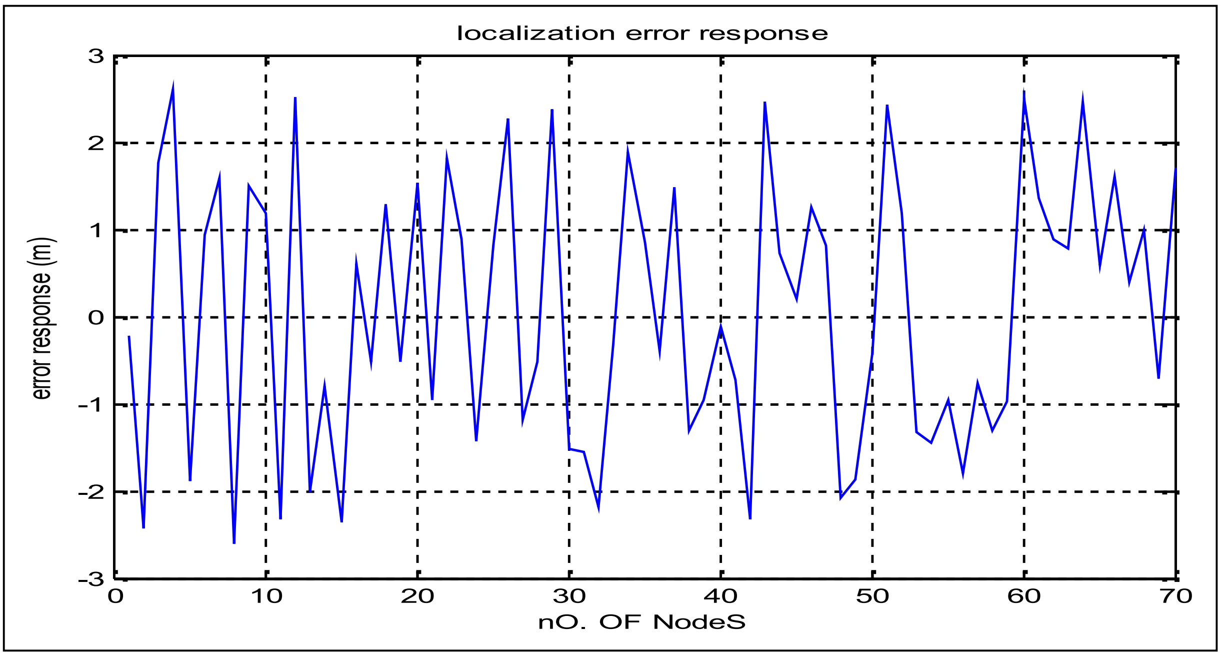

Figure 5: Location Error for 70 Nodes

Performance Comparison of System

Fig. 6 shows the performance comparison of proposed and actual DRRP system. The response of the proposed method is shown in red color whereas the response of DRRP system is represented by blue color. In actual system, the average localization error value lies between 4 and 10 m and proposed system provides the error value of 2.2 m approx. Hence, results provide the usefulness of proposed system.

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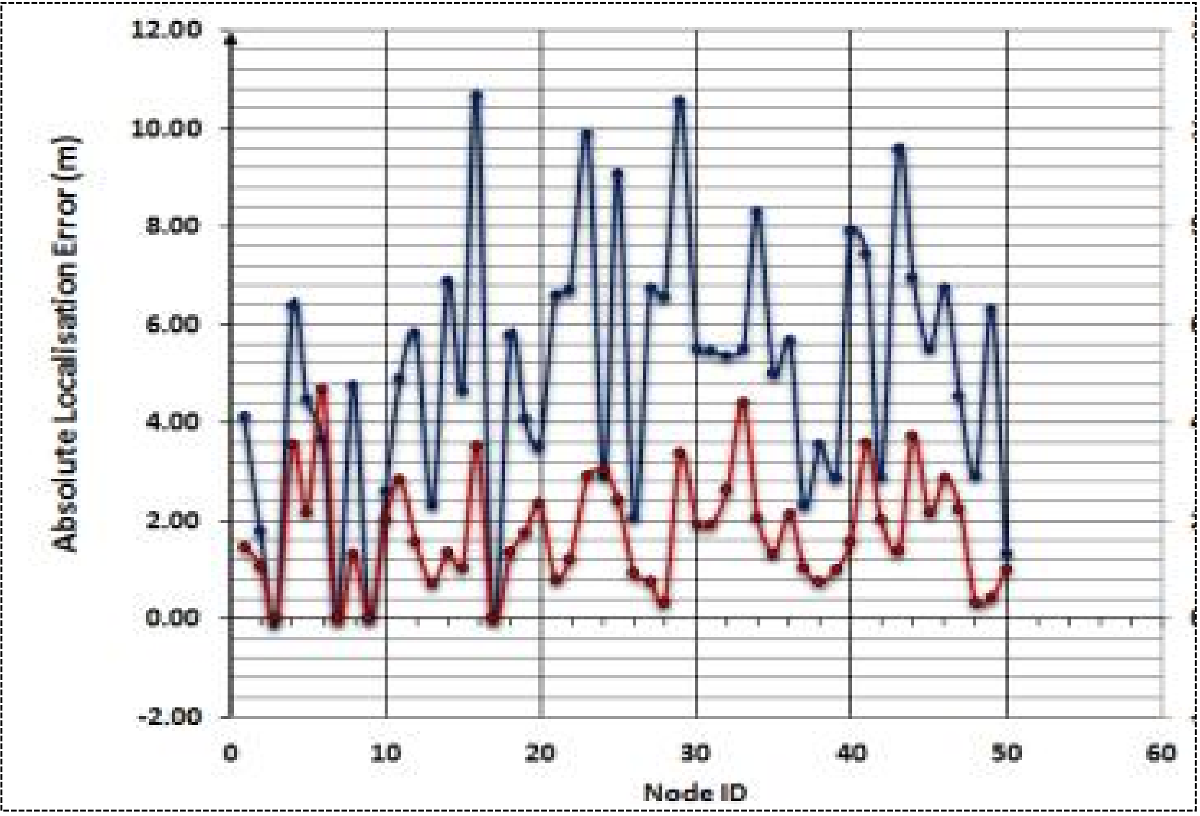

The Table 1 describes the performance comparison of proposed system having different no. of nodes in network with actual system described in [4]. It shows that the proposed system minimizes the location error by use of controller.

Table 1: Performance Comparison of System

Parameter	Existing Technique (DRRP)	Proposed (50 Nodes)	Proposed (70 Nodes)
Localization Error	**4-5**	**2**	**2.5**

V. CONCLUSIONS AND FUTURE SCOPE

This work provides a technique for reconfiguration of network nodes in WSN with the help of controller system. All scenarios of the dynamic reconfiguration have been evaluated by use of MATLAB software. In this, shortest distance is calculated between each node so that an optimal routing is performed in network and also direct communication between head to nodes is also provided. During reconfigure time, each faulty node is replaced by a new one so that network may work better. But in this, some localization error is present but its value is less than 3 m which is very efficient. The controller controls the movement of nodes and provides new area under suitable conditions. The time required for a particular network to reconfigure its components is around 15 to 20 seconds, which is very less when compared to the cost of restarting the application with the correct components. At last, proposed results are compared with actual results. It describes the performance comparison of proposed system having different no. of nodes in network with actual system. It shows that the proposed system minimizes the location error by use of controller. Now days, WSN is an important topic in today research field. Though, there are many probable directions needed to be explored. The future directions for WSN vary from network structure to application types to application demands.

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