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Grid Pattern Based Energy Efficient Routing Algorithm for Fixing Connectivity in Mobile Robotic Sensor Network

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ABSTRACT
In Sensor Network, topography and stability of the environment is absolutely important. For stable environment, connectivity and reliability has to be maintained in network communication. Proposed System involves robotic sensor which offers new solutions to maintain connectivity. It includes four phases i) message sharing ii) failure node location identification iii) Selecting highest energy path iv)Moving neighbor nodes using MRSN. Grid based routing algorithm and heartbeat message sharing is developed in the proposed system. Presence of the node is indicated by the heartbeat message. Wireless connection can be established by sensing the heartbeat sharing message. Heartbeat message is shared to the neighbor node to identify if and when the neighbor node fails or is no longer available. Grid based routing algorithm is suitable for location-based application and it is used to restore the network connectivity with efficient time delay. The proposed algorithm is efficient in finding the location of the failure node. The failure node is analyzed by using heartbeat message sharing. An efficient highest energy path is selected to recover from failure. Also in case of cut vertex movement of neighbor nodes by MRSN are used to handle the connectivity restoration problems with minimized message overhead. Proposed work is efficient in avoiding obstacles, and it is efficient in reducing the movement distance in the restoration process.
Keywords: Mobile Robotic Sensor Network, Grid based routing, Cut vertex

I. INTRODUCTION

A WSN consists of spatially distributed autonomous sensors to monitor physical or environmental conditions, such as temperature, sound, pressure, etc. and to cooperatively pass their data through the network to a main location. The more modern networks are bi-directional, also enabling control of sensor activity. The development of wireless sensor networks was motivated by military applications such as battlefield surveillance; today such networks are used in many industrial and consumer applications, such as industrial process monitoring and control, machine health monitoring, and so on.

Mobile Robotic Sensor Network

Mobile Robotic Sensor Networks (MRSNs) can simply be defined as a Wireless Sensor Network (WSN) in which the sensor nodes are mobile. MRSNs are a smaller, emerging field of research in contrast to their well-established predecessor. MRSNs are much more versatile than static sensor networks as they can be deployed in any scenario and cope with rapid topology changes. However, many of their applications are similar, such as environment monitoring or surveillance Commonly the nodes consist of a radio transceiver and a microcontroller powered by a battery. As well as some kind of sensor for detecting light, heat, humidity, temperature, etc.

The Mobile robotic sensor networks are changing the way of life just as the Internet has revolutionized the way people communicate with each other. Mobile sensor networks combine distributed sensing, computation and wireless communication. New technology expands sensing capabilities by connecting the physical world to the communication networks and enables a broad range of applications. Observing microclimate changes is one of the most popular applications of mobile robotic sensor networks. Sensor nodes can be deeply embedded and densely deployed to enable up-close monitoring of various indoor or outdoor environments. However, some environments are often too dangerous or inaccessible to humans. For example, a building on fire or a suspected hazardous material leak. Although monitoring of sensitive wildlife and habitats has few potential hazards, the intrusion of humans is always a bothersome problem. Some environments cannot be by humans or large robots because of terrain and space limitations. In all these situations, mobile sensor network users will face many challenges, such as deployment, network maintenance and repair.

In recent years, the interaction of distributed robotics and wireless sensor networks has led to the creation of mobile sensor networks. It is considered that augmenting static sensor networks with mobile nodes can solve many of the research challenges that exist in static sensor networks. A mobile sensor network is composed of a distributed collection of enhanced nodes. Each node has sensing, computation, communication and locomotion modules. Compared to the conventional static wireless sensor networks, mobile sensor networks have more powerful network capabilities such as self-deployment, network repair and event tracking. Each mobile senor node is capable of navigating autonomously or under control of humans. Large numbers of mobile sensor nodes can coordinate their actions through ad-hoc communication networks.

Some research groups have begun to design mobile nodes for wireless senor networks and have made some prototypes. The Robomote is introduced as a tabletop platform for experiments on mobile sensor networks. It is more than 1,300 times smaller than Pioneer robots which are commonly used in laboratories across the world. CotsBots is another modular robot platform for research in distributed robotics. It is built entirely from off-the-shelf components and requires minimal assembly. Some additional sensor modules need to be added to the CotsBots platform in order to get better performance in a sensor network environment.

Need For Mobile Sensors

Mobile Sensors are needed for the following reasons

- Power Resilient to failures
- Reactive to events
- Support disparate missions

The advantages of mobile wireless sensor network over static wireless sensor networks include better energy efficiency, improved coverage, enhanced target tracking, and superior channel capacity. Commonly, the sensor nodes consist of a radio transceiver and a microcontroller powered by a battery, as well as some kinds of sensor for detecting light, heat, humidity, temperature, etc. Meanwhile, other mobile devices, like mobile phones, tablet, and laptop computers, can nowadays be seen as general-purpose mobile computing and sensing platforms.

II. RELATED WORKS

In [1] Abbasi A.A., YounisM.F. andBaroudi U.A. discussed wireless sensor-actor networks, sensors probe their surroundings and forward their data to actor nodes. Actors collaboratively respond to achieve predefined application mission. Since actors have to coordinate their operation, it is necessary to maintain a strongly connected network topology at all times. Moreover, the length of the inter-actor communication paths may be constrained to meet latency requirements. However, a failure of an actor may cause the network to partition into disjoint blocks and would, thus, violate such a connectivity goal. One of the effective recovery methodologies is to autonomously reposition a subset of the actor nodes to restore connectivity. Contemporary recovery schemes either impose high node relocation overhead or extend some of the inter-actor data paths. LeDiR relies on the local view of a node about the network to devise a recovery plan that relocates the least number of nodes and ensures that no path between any pair of nodes was extended. LeDiR is a localized and distributed algorithm that leverages existing route discovery activities in the network and imposes no additional prefailure communication overhead. The performance of LeDiR was analyzed mathematically and validated via extensive simulation experiments.

In [2] Akkaya K., Senel F., Thimmapuram A. and Uludag S. introduced mobility to the sensor networks through the deployment of movable nodes. In movable wireless networks, network connectivity among the nodes is a crucial factor in order to relay data to the sink node, exchange data for collaboration, and perform data aggregation. However, such connectivity can be lost due to a failure of one or more nodes. Even a single node failure may partition the network, and thus, eventually reduce the quality and efficiency of the network operation. To handle this connectivity problem, PADRA to detect possible partitions was presented, and then, restore the network connectivitythrough controlled relocation of movable nodes. The idea was to identify whether or not the failure of a node will cause partitioning in advance in a distributed manner. If a partitioning is to occur, PADRA designates a failure handler to initiate the connectivity restoration process. The overall goal in this process is to localize the scope of the recovery and minimize the overhead imposed on the nodes. The approach, namely, mdapra strives to provide a mutual exclusion mechanism in repositioning the nodes to restore connectivity. The effectiveness of the proposed approaches was validated through simulation experiments.

In [3] Almasaeid H.M. and Kamal A.E. proposed restoration of network connectivity and deals with the network as a general graph of N nodes with the edge cost being the number of nodes needed to establish connectivity between the two ends of the edge. Repairing connectivity and achieving a certain level of fault tolerance are two important research challenges in wireless sensor networks .It ignores the topological properties of the network, especially the overlap between sensors' communication ranges, and the node-failure pattern that caused the disconnection.

In [4] Basu P. and Redi J. proposed a few simple algorithms for achieving the baseline graph theoretic metric of tolerance to node failures, namely, bi-connectivity. Autonomous and semi-autonomous mobile multi-robot systems require a wireless communication network in order to communicate with each other and collaboratively accomplish a given task. A multihop communications network that is self-forming, self-healing, and self-organizing is ideally suited for such mobile robot systems that exist in unpredictable and constantly changing environments. However, since every node in a multihop (or ad hoc) network was responsible for forwarding packets to other nodes, the failure of a critical node can result in a network partition. Hence, it is ideal to have an ad hoc network configuration that can tolerate temporary failures while allowing recovery. Since movement of the robot nodes is controllable, it is possible to achieve such fault-tolerant configurations by moving a subset of robots to new locations. For one-dimensional networks, the problem of achieving a bi-connected network topology can be formulated as a linear program; the latter lends itself to an optimal polynomial time solution. For two-dimensional networks the problem was much harder, and an efficient heuristic approach for achieving bi-connectivity was proposed.

In [5] Chung J.M., Nam Y., Park K. and Cho H.J. defined Robot Sensor Network (RSN) as a network of sensor that are equipped with robots and sensor nodes (that are deployed by the robots) that wirelessly communicate for remote-control, mission-cooperation, and to report sensed information to the Control And Reporting Center (CRC). RSNs use real-time video communication support (in addition to various sensor data communication) for mission-cooperation and remote-control of its multi-robots. The Hybrid Data-Type Clustering (HDC) and Subnet-Divided HDC (SHDC) algorithms are proposed to maximize the RSN lifetime and enable more efficient multi-robot mission-cooperation.

III. FIXING CONNECTIVITY IN MOBILE ROBOTIC SENSOR NETWORK

Proposed system includes Grid pattern based routing algorithm and heartbeat message sharing method. Location-based application uses grid based routing algorithm.Heartbeat message is passed between the neighbor nodes to identify the failed neighbor node.

Advantages of Proposed System

- Variation in the communication range does not disturb the connectivity.
- Grid pattern based routing algorithm works very well in dense networks.
- Optimal performance is achieved even when nodes are partially aware of the network topology.

SYSTEM ARCHITECTURE

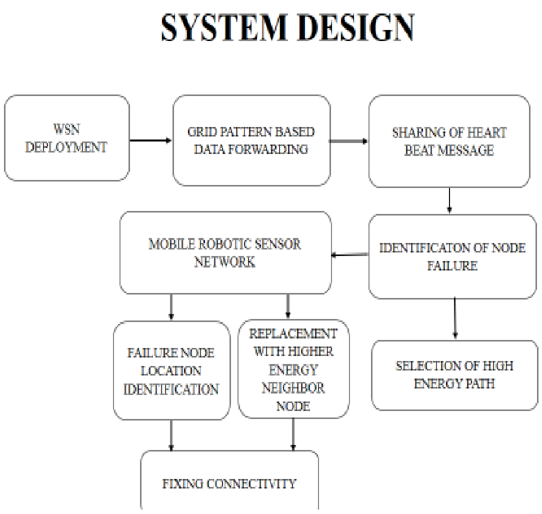

Fig 1 System architecture

Fig 3.1 represents system architecture. Wireless sensor node is deployed using grid pattern based routing algorithm.It is suitable for location-based application and it is used to restore the network connectivity with efficient time delay. Heartbeat message is shared to the neighbor node to identify the energy level,next node to transfer data and destination node. Data cannot be further transferred if node is failed.Re-routing is done in case of failure. Next highest energy path should be taken for data transfer.In case of cut-vertex, the network will be partitioned into disconnected segments. With the help of Mobile robotic sensor network failure node location is identified and neighboring nodes are relocated to the failed position.

A.Wsn Deployment

Nodes are deployed using grid pattern based routing algorithm. Maximum coverage is guaranteed by efficient deployment.in grid pattern based deployment the field is partitioned into square grid.The sensors are deployed in each square grid. This guarantees excellent coverage with maximum connectivity.

B.Failure Detection

After sensor deployment, before forwarding message from source to destination heart beat message is exchanged. This message contains information like node id,position,energy level. Neighbor node upon receiving the information sends back the acknowledgement to the node. If the node does not send back acknowledgement it is considered as the failed node.

C.Selection Of Higher Energy Path

Path selection depends on reliability and energy cost of the path.When a node is failed data cannot be forwarded through that path.Sonext path has to be selected.The path with less hop count and nodes with maximum energy is selected. The energy of a path for end to end packet traversal is the total energy consumed by the nodes to transfer the packet to the destination. In Low Energy Adaptive Reliable Routing, the energy of a path is the battery power of the nodes to transfer a packet from the source to the destination.

D.Cut Vertex Failure

Cut vertex failure causes the network to split into two disconnected segments.When the cut vertex fails there will be no other path to reach the destination. The data loss occurs. Hence failure node has to be replaced

E.Replacement Of Failure Node

Data cannot reach the destination because of the cut vertex failure. In such case the failure node has to be replaced.

MRSN identifies the position of node failure using heartbeat message.after failure identification MRSN selects the neighbor node with high residual energy.Node with high energy is identified using Low Energy Adaptive Reliable Routing.

Once the highest energy neighbor node is selected, MRSN moves the neighbor node to the failure node position.Now data paase through the replaced node and connectivity is fixed.

IV. SCREENSHOTS

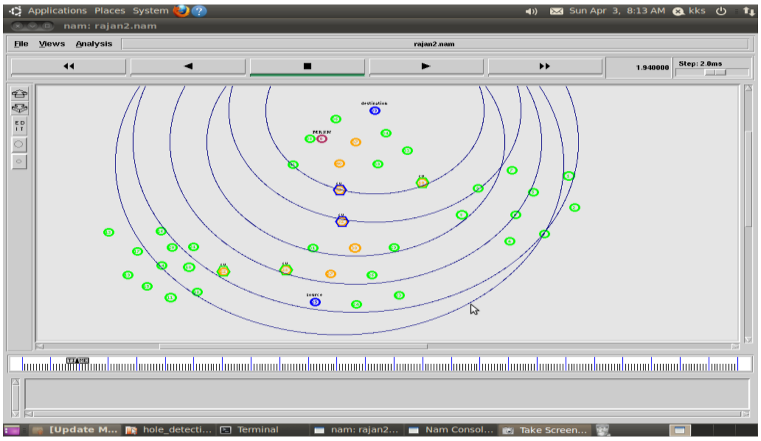

Fig 2 Deployment of nodes

Fig 2 illustrates deployment of nodes. Nodes are deployed randomly.Source and destination are placed and a MRSN is also placed.Data transfer takes place between source and destination.

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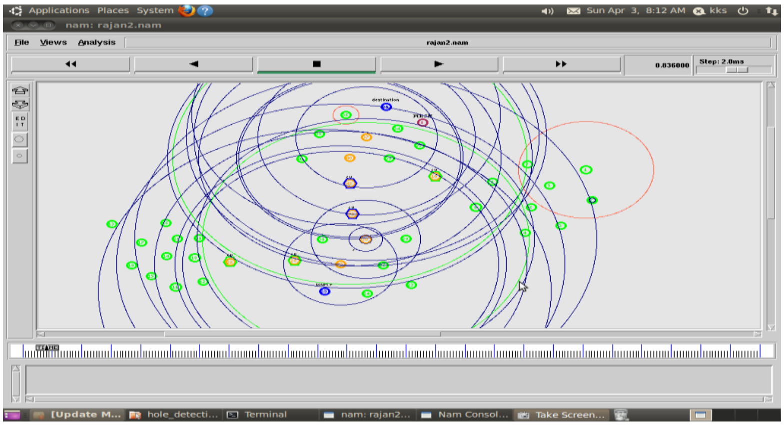

Fig 3 Data transfer between nodes

Fig 3 illustrates data transfer between nodes. Connectivity between nodes is checked by transferring heart beat messages. Node which is ready to receive data will give acknowledgement.Upon receiving acknowledgement data transfer takes place. The data transfer between nodes.After receiving acknowledgement from the nodes data transfer takes place. MRSN keeps monitoring the network.

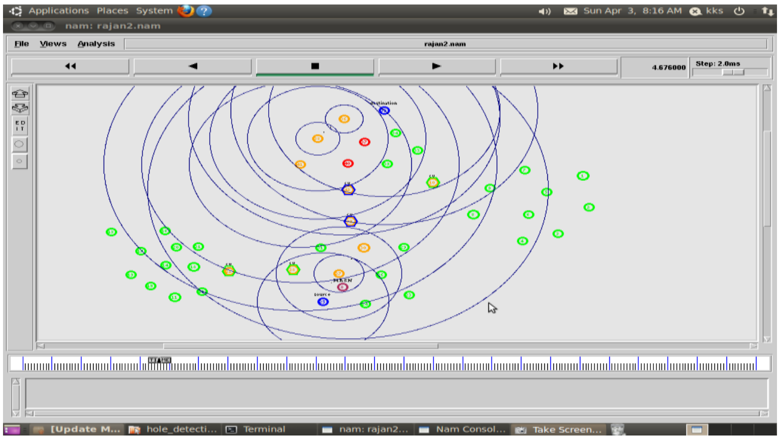

Fig 4 Failure of a node

Fig 4 shows failure of node.During data transfer the node is failed because of less energy and so data will transferred along different path. Red color node indicates failed node.

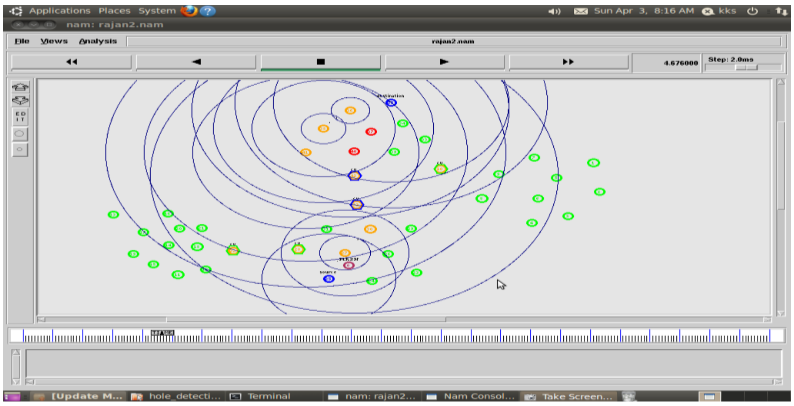

Fig 5 Selection of High Energy Path

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Fig 5 illustrates selection of high energy path. When the node is failed data cannot paas through the same path. Next available higher energy path is selected and data passes through the new path.

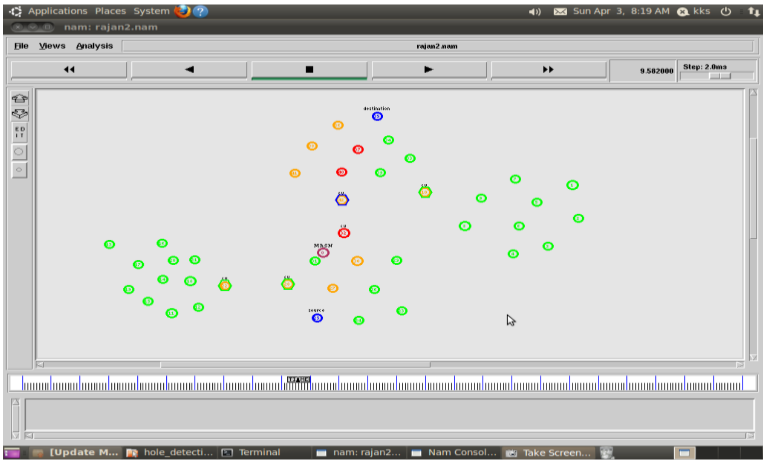

Fig 6 Cut Vertex Failure

Fig 6 shows cut vertex failure. Now there is no alternate path for data to transfer.

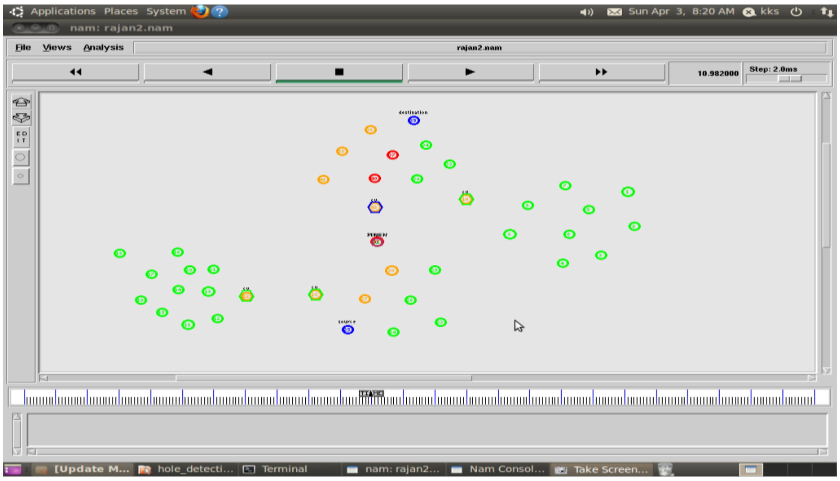

Fig 7 Neighbor Node Replacement

Fig 7 illustrates neighbor node replacement.MRSN Selects the neighbor node with high energy and moves the node to the position of failed cut vertex.

Comparison

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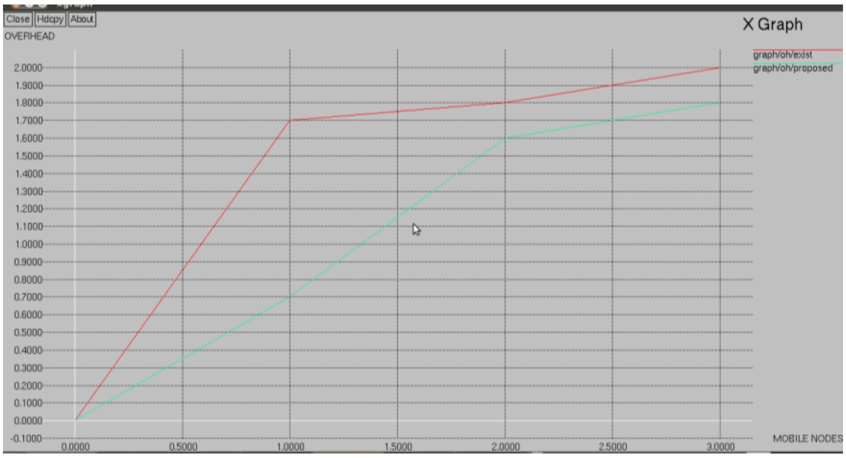

Fig 8 Comparison of overhead

Fig 8 illustrates overhead comparison between existing and proposed system. Nodes are plotted along x-axis and overhead is plotted along y-axis. Overhead of the proposed system is less when compared to the overhead of the existing system.

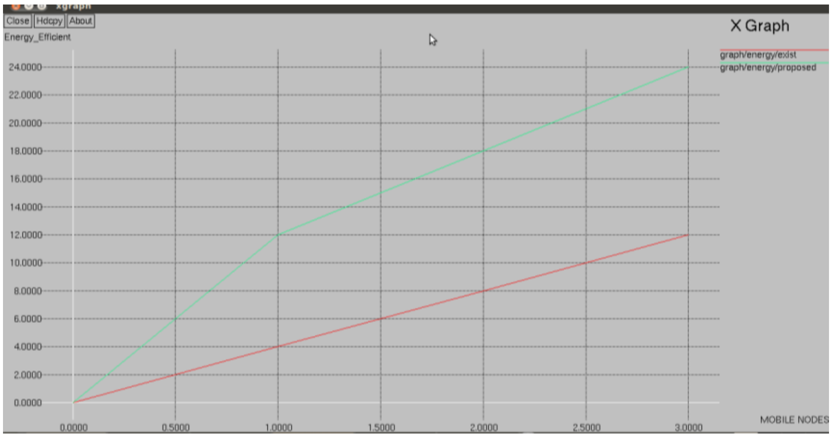

Fig 9 Comparison of energy consumption

Fig 9 illustrates comparison of energy consumption between existing and proposed system. Energy consumption of the proposed system is less when compared to the existing system

V. CONCLUSION AND FUTURE ENHANCEMENT

The proposed system is able to restore the connectivity subjected to the failure of a single cut-vertex sensor and other nodes. In Proposed work categorization of connectivity in WSNs is done by focusing on weak connectivity.Least energy consumption is considered.The experimental evaluation of the system verified its correctness and efficiency in avoiding surrounding obstacles.

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