INTERNATIONAL JOURNAL FOR ADVANCE RESEARCH IN ENGINEERING AND TECHNOLOGY
WINGS TO YOUR THOUGHTS…..

HETEROGENEOUS NODE RECOVERY FROM A FAILURE IN WIRELESS SENSOR ACTOR NETWORKS

M.Srinivasaperumal[1], V.Bhanumathi[2], S.Sathish[3]

[1]PG scholar(ECE), [2] Assist Professor, [3]PG scholar
[1, 2, 3]Anna University Regional Centre Coimbatore
Coimbatore, Tamil Nadu
[1]sriniprf@gmail.com, [2]vbhanu_02@yahoo.com, [3]sathescool@gmail.com

***Abstract**: The effectiveness of wireless sensor-actor networks deployed in search and rescue, battlefield reconnaissance, surveillance, and other applications depends on inter-node interaction. In WSAN, sensors probe their information from the physical world and forward their data to actor nodes then actors collaboratively respond to achieve predefined application mission. The network can be partitioned into disjoint blocks if an actor suddenly fails and violate such a connectivity goal. The simultaneous recovery scheme imposes a high node relocation overhead and bunch of topology changes and also extent inter-actor data paths. Our approach explore the simultaneous node recovery from a multi-node failure with maintain the nominal topology change by using the Least Disruptive PILOT (Pre-defined Intelligent Lightweight topology management) Node (LDPN) algorithm. LDPN algorithm, use a set of PILOT nodes that can be used whenever a link failure between two sensor nodes. This approach removes the faulty node by using the best PILOT node and it act as a bridge between two neighbors of failed node. The LDPN algorithm can reestablish the network connectivity and make sure that the minimal topology changes within the network.*

***Keywords:** wireless sensor-actor network (WSAN), Connectivity restoration, sensor networks, topology repair, node relocation, fault recovery.*

1. INTRODUCTION

The growing interest in the applications of wireless sensor-actor networks (WSANs) has motivated lots of research work during recent years. Applications, such as battle field surveillance, chemical and biological attack detection, coastal and border protection, combat field reconnaissance, space exploration, and search and rescue, it is envisioned that a set of mobile sensor nodes will be employed to collaboratively monitor an area of interest and track certain events. The sensors can operate in harsh environments and avoiding risk to human life. WSAN consist of a set of low cost sensors that are collects information from their surroundings and forward their data to actor nodes that process and forward an appropriate response. The practical examples of actors are Robots and unmanned vehicles and it works autonomously to achieve the application mission.

Given the important of inter-actor connectivity a sensors usually inform their neighbors prior to moving so the topology can be adjusted accordingly. However, sudden failure of actor nodes can break communication path in the networks and network can be partitioned into disjoint blocks. In WSAN the replacement of failed actor is an impractical and repositioning of node becomes the best recovery option. The WSANs comprise two types of nodes such as actors and sensors. Sensors are inexpensive and limited processing capacity and highly constrained energy. Actors are more capable nodes with relatively better processing capabilities, higher onboard energy richer communication resources and computation. Each sensor and actor nodes are equipped with power unit, processing unit, communication unit, storage resources sensing unit and actuation unit respectively [1].

Due to limited onboard energy sensor nodes are inclined to failure and to mitigate the risk of reduced degree of connectivity and loss of coverage that a faulty node may cause and the network deployment usually engages iterative nodes that can either act as a passive spare or pick additional load if some nodes fail. In essence, such a strategy provisions the tolerance of node failure at the time of network setup and other approaches for recovery from a node failure pursue more reactive strategy by reposition of some nodes to restructure the network topology [2]. In this paper, the proposed system analyze and investigate the heterogeneous (simultaneously) node recovery from a multiple node failure with minimal topology management changes in WSANs and our approach presents a Least-Disruptive PILOT Node (LDPN) algorithm for recovering from a multiple node failure. In this approach make use of a set of lightweight nodes in order to bridge failing connections between two sensor nodes is about break in WSANs. The next section describes the overview of related work. Section III describes the problem identification in the previous approaches. Section IV explains the LDPN algorithm in detail. Section V describes the results. The paper is concluded in Section VI.

2. LITERATURE REVIEW

A numerous schemes have been recently proposed for restoring the network connectivity in partitioned wireless sensor actor networks [2]. All of these schemes have focused on reestablishing furnished links without considering the effect on the length of pre failure data paths and some schemes recover the partitioned network by repositioning of the existing sensor nodes, while others carefully place additional relay nodes. On the other hand, some approaches on sensor node relocation focuses on the metrics other than connectivity, e.g., network longevity, coverage and asset safety.

2.1 Node Repositioning:

The main idea of this node repositioning schemes is to reposition some of the healthy nodes in the network and to maintain a strong connectivity. The Least-Disruptive topology Repair (LeDiR) [3] fits in this approach. LeDiR relies on the local view of nodes and ensures that data path between any pair of faulty nodes is not extended relative to its pre-failure status. The LeDiR algorithm assumes that only non-simultaneous or multiple node failure will take place in the network. The LeDiR is to pursue only block movement instead of individual nodes in cascade movement. It identifies the smallest among the disjoint blocks.

In Figure 1 shows that the node failure in wireless sensor and actor networks. Each nodes will periodically send Heartbeat messages or HELLO messages to their neighbor's to ensure that they are functional. Then only starts the transmission of data or massages. In the above figure-1 the node 14 does not send any acknowledgement for its heartbeat or hello message to its neighbors. Therefore, the nodes 13 and 15 assumed that node 14 has failed and breaks the network connectivity and also the network stays strongly connected after the loss of a non-leaf node like18.

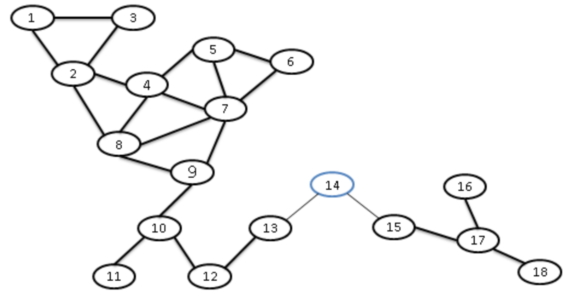

Figure 1: WSANs with faulty node.

Meanwhile, the failure of the cut vertex node 14 leaves nodes 13 and 15 was isolated from the rest of the network. The figure-1 shows that the node failure in wireless sensor and actor network and figure-2 shows that the node recovery from a node failure by using Least Disruptive topology Repair (LeDiR). The node 15, node 17, node 16 and node 18 do not make any communication with other nodes in the network. These nodes are act as a individual block. This block moves towards to the 13th node and makes the connectivity based on the LeDiR algorithm. This approach is used to recover only non-simultaneous or multiple node failure only. It does not opt to heterogeneous node failure.

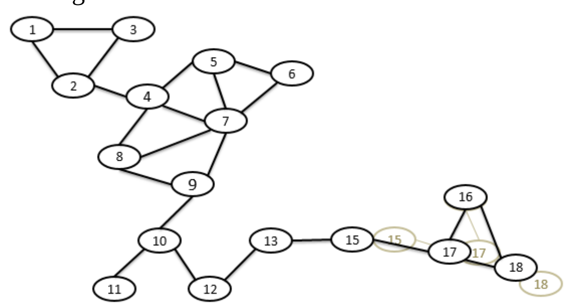

Figure 2: Replacing the failure node by LeDiR.

There are several approaches was published and differ from the level of node repositioning involvement expected from the best nodes, in the required network state that needs to be maintained and the goal of sensor node recovery process. The Distributed Actor Recovery Algorithm (DARA) [4] requires every node to maintain their two-hop neighbors list and also determine the scope of the recovery process by checking whether the failed node is a cut vertex or not. It pursues that a probabilistic scheme to identify the cut vertices node. The best candidate (BC) is selected from the single-hop neighbors of the failure actor as a recovery initiator and also to replace the failure node. The PArtition

Detection and Recovery Algorithm (PADRA) [5], it identifies a connected dominating set to determine the dominate sensor node. The dominate node does not directly moves to the location of the faulty node; instead of a cascaded movement is pursued to share the burden of individual sensor node.

The recovery through inward motion (RIM) [6] approach provides the nodes mobility and also requires only single-hop or one-hop neighbors information to be recover from a single node failure. The sensor node restoration process was both distributed and localized execution and also it does not requiring network wide coordination among the sensor nodes. In each node can be independently decide its role of the restoration process and also where to move if needed. The RIM requires only each node to be aware of the location of its single-hop neighbors list. It was designed to recover from a single node failure only. The contemporary node failure may cause conflicting conditions for RIM approach to converge successfully. The probability for contemporary node failure is very small and it would not be a concern for LeDiR and RIM approach. Then finally, RIM approach tends to shrink the network through inward around the faulty node. While such a recovery scheme only increases the connectivity of network and it may negatively affect the node coverage of sensor network.

In Connected Dominating Set [7] process was based on the distributed recovery of a node failure in WSAN. The main idea is each actor node to determine whether the node failure causes a partition or not in advance and also to take the necessary precautions before the node failure happen. Since the network partitioning was caused by the sensor node failure which is serving as a node is cut vertex (i.e., a gateway), but our approach is utilize the connected dominating set of the entire network in a distributed manner to identify such a node is a cut-vertex or not. Once cut-vertex nodes are determined, the each node designates appropriate neighbors to be handling its failure when such a thing arises in future. In Connected Dominating Set the transmission range increases, surprisingly the travel distance is also increases and also the CDS based algorithm does not retain the similar topology managements.

2.1 Recovery by a Placement of Relay Nodes:

The Relay node replacement is another approach for restoring the network connectivity when a node failure is occurred. A relay Node method was a more capable node with significantly higher energy reserve and longer communication range than the normal sensor node. Although it can be equipped with sensor circuitry and the relay nodes are mainly perform data aggregation and data forwarding. Unlike normal sensor nodes, relay nodes may be mobile and also it has some navigation capabilities. The relays are favored in a recovery process, because it is easier to accurately place them relative to sensor nodes and their communication range was larger compared to normal sensor nodes so which facilitates the network connectivity restoration among the disjoint blocks. Intuitively, the relays are more expensive than normal sensor nodes. Therefore, the larger number of engaged relay nodes should be minimized.

Due to the harsh environments and violent nature of wireless sensor and actor network (WSAN) applications, the network sometimes suffers from large scale damages that involves several nodes and thus creates multiple disjoint partitions in a network. In Bio Inspired Relay node [8] investigates a network strategy for recovering from such damages through the placement of the relay nodes. The deployment of relay nodes to be restores network connectivity among the disjoint blocks of a damaged WSAN. It given the cost of Relay Nodes and the logistical challenges in deploying them, it was normally desirable to minimize the count of required relay nodes. The Bio-Inspired sensor node replacement does not consider the energy as a metric in placing the Relay Nodes then the connectivity among sensors and relays are considered. In these types of nodes belongs to a single network, where all the Relay Nodes communicate with the same sink node or Base station. The Effective QoS Aware Relay Node Placement Algorithm [9] For connecting disjoint blocks. In EQAR, the best of our knowledge it was the first approach, that exploits the deployment Relay Nodes in order to federate disjoint block sensors subject to QoS constraints. It opts to efficiently populate the least number of Relay Nodes such that the desired Quality of service goals is satisfied and also the connectivity among disjoint blocks are established. As mentioned earlier, the additive Quality of service requirements, e.g., the bandwidths are assumed in order to simplify the presentation.

2.1 Topology Management in a WSANs:

The Topology management [10] issues are very important in the context of wireless networks such as an actor networks. It ensures that the various network connectivity parameters are managed and also to ensure that the parameter values are within the certain bounds. In each and every sensor nodes in a sensor network to have a pre-defined number of neighbors node. It can be requirements of a higher sensor information processing applications in order to make ensure that the sensor nodes are distributed evenly over a network region and the topology management has been addressed from a various perspectives such as energy conservation in a WSAN. The Topology management based protocols uses the principle that every nodes in a sensor network to maintains the topology information and the process of network protocol operation was based on the topology of the network.

3. PROBLEM STATEMENT

To the best of our knowledge, node recovery schemes found in the literature assumed that no simultaneous failure. In LeDiR algorithm assumes that only non-simultaneous node failure will take place in the sensor network. All of these schemes have only focused on the reestablishing of severed links without considering the effect of the length of pre-failure communication or data paths in a sensor network and some schemes recover the network connectivity by repositioning of the existing nodes with in a network. The existing systems consider the network connectivity restoration problem subject to the data path length constraints. A Least-Disruptive topology Repair relies on the local view of nodes and ensures that the no data path between any pair of nodes is extended relative to its pre-failure network status. There are some major issues in LeDiR approach; initially contemporary node failure may cause conflicts conditions for LeDiR algorithm to converge successfully and then LeDiR tends to shrink the smallest block inward through the faulty node; it may negatively affect the node coverage in a sensor network. The main focus of the LeDiR is on connectivity the non-simultaneous node failure only and does not factor in the impact on coverage. The topology management issues are very important for contemporary node recovery from a multiple node failure.

4 LEAST DISRUPTIVE PILOT NODE

In Wireless Sensor and Actor Networks, it is necessary to maintain an inter-node connectivity sensor nodes at all time. There are several schemes was developed for network restoring and all these schemes focused on restoring only a non-simultaneous nodes at a time. In our approach proposes to deploy a PILOT (Predefined Intelligent Lightweight tOpology managemenT) nodes with Least-Disruptive algorithm to restore the network connectivity and then retain the desired topology. The PILOT node forms a logical ring network among them to help address issues of network topology management. These Light-weight nodes are capable of motion could be directed to a position themselves at the appropriate locations. In order to achieve this objective, assumed that all sensor nodes (both wireless-node and PILOT nodes) are location aware. The wireless nodes and PILOT nodes have distinct functionality to support a topology management in network. Each wireless node monitors the status of its communication links and in order to avoid the duplicate efforts in tracking link status and each link is monitored by only one node. The network link failure can be detected relatively whenever an acknowledgement message is not received in response to a simultaneous transmission of either a control messages or a data packet.

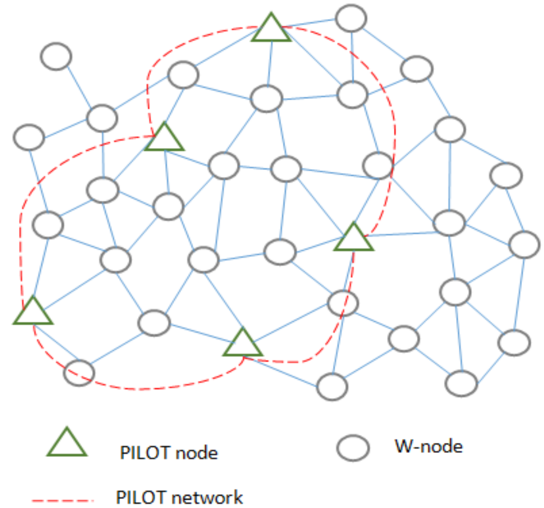

Figure 3: Construction of PILOT nodes with WSANs

4.1 *Contemporary Node Recovery:*

In LDPN algorithm, the PILOT nodes that can be used whenever a link failure between two sensor nodes. The Actor nodes are periodically send hello messages to their one-hop neighbors to ensure that they are available and functional and also report changes to the one-hop neighbors. After a certain time period the missing acknowledgement for heartbeat message is used to detect the failure node. Once a failure node is detected in the neighbourhood the recovery process is initiating. The Wireless nodes send that request to a PILOT node. PILOT node exchanges the request information with other PILOT nodes available in the PILOT network. The PILOT nodes are collaboratively determines the best PILOT node to assist in topology management in the network. The selection of the PILOT node is based on factors such as power available with the two nodes associated with a failure link and possible predicted movement in a future time; and the distance between location of PILOT node and the target node. The PILOT node information is communicated back to the requesting w-nodes. The assigned PILOT node moves to occupy the computed position to act as a bridge connection between the one-hop neighbors of failure node and transmit the information maintain and the network connectivity. In LDPN algorithm, ensures that the contemporary node recovery from multiple node failure with maintain the nominal topology changes.

5 PERFORMANCE ANALYSIS

LDPN is validated through a simulation and this section discusses the simulation environment and results.

5.1 *Simulation Environment:*

LDPN algorithm is validated through simulation. In this section discusses the simulation environment and results. The experiments are performed on WSAN simulator developed in a Tool Command Language. In this experiments, we have create a connected topologies consisting of a varying number of actors (50 to 100) with fixed communication range (r = 100 m). All nodes are assumed to be transmitting at the maximum power set for an individual experiment and also the detection of failure of a critical node would justify the invocation of Least-Disruptive topology Repair. The following parameters are used to varying the characteristics of network topology in different experiments:

- Number of actor node (N): This parameter affects the WSAN connectivity and the node density. If increasing N makes the network is highly connected.
- Communication range (r): All actors in a network are assumed to have the same communication range r. The value of r affects the initial WSAN network topology. While a large r boosts the overall connectivity and small r creates a sparse topology.

In the following metrics are used to measure the performance of the LDPN algorithm in terms of recovery overhead.

- Total travelled distance: It reports the distance of involved nodes collectively travel during the node recovery process. This can be envisioned as a network wide assessment of the efficiency to applied node recovery scheme.
- Number of relocated nodes: It reports the number of nodes that moved during the recovery process. This metrics can assess the scope of the connectivity restoration within the network.
- Number of exchanged messages: tracks the total number of messages that have been exchanged during the node recovery process. In this metrics captures the communication overhead.

5.2 *Simulation Result:*

In LDPN, strives to restore the connectivity while minimizing the node recovery overhead and also maintaining the path lengths at their pre-failure value. Then we group the results into two sets: 1) path length validation metrics and 2) overhead related metrics. We also compare the performance of LDPN with DARA [3] and RIM [4], these are the most effective published solutions for the tolerance of single node failure in WSAN. The initial set compares LDPN, which runs in a distributed manner and centralized version therefore it provides the least traveled distance. We also compare LeDiR to RIM in terms of node recovery overhead. LDPN selects the smallest partition and tries to maintain the existing communication links between nodes.

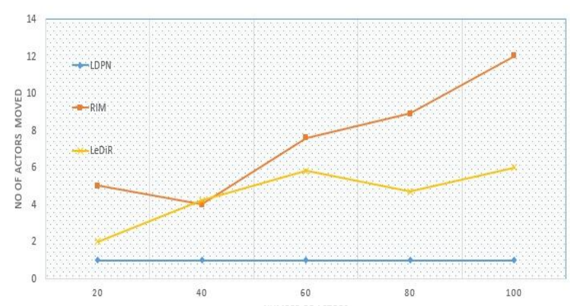

Figure 4: Number of moved actors vs. Network size

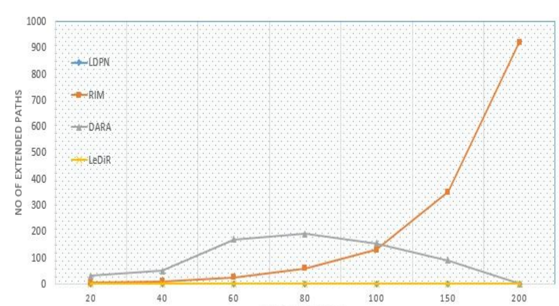

Figure 5: Number of Extended Paths vs. Network Size

Fig. 4 clearly indicate that LDPN outperforms RIM by moving lesser nodes during the recovery process, particularly for dense network. In Fig. 5 indicate that in highly connected topologies the cut vertices are found at near the network periphery. It is particularly advantageous for a DARA since the network would be partitioned into a large blocks and few small blocks and DARA would select the BC node. The node movement and operation are closer to RIM; in other words, the RIM can achieve the same objective but DARA cannot guarantee it. Therefore, we compare LDPN with RIM and not DARA. In addition to the centralized version of LeDiR and RIM the next set of simulation experiments compares LeDiR to DARA. The main reason is that both DARA and RIM are designed to restore the network connectivity. However, DARA and RIM do not care whether a pre-failure communication path gets extended or not. Therefore, the data path length validation metrics would assess how the communication paths are affected by contemporary schemes and LDPN contribution to sustaining the pre-failure data path lengths.

6 CONCLUSIONS AND FUTURE WORK

In recent years, Wireless Sensor and Actor Networks (WSANs) have started to receive growing interest due to many real-life applications. Our project has discussed an important problem in WSANs that is reestablishing the network connectivity after heterogeneous node failure at contemporarily without extending the length of communication paths. The proposed LDPN algorithm restores the network connectivity by use of a PILOT nodes with LDPN algorithm ensured that the contemporary node recovery from heterogeneous node failure with maintain the nominal topology changes. It also works very well in dense networks and provides optimal performance even when nodes are partially aware of the network topology. The LDPN algorithm investigated only simultaneous node recovery from a failure but not discussed about the nodes life times.

In our future work includes the energy consumption of PILOT nodes for a large scale network environment.

References

[1] **F. Akyildiz and I. H. Kasimoglu, Oct. 2004, "Wireless sensor and actor networks: Research challenges," Ad Hoc Netw. J., vol. 2, no. 4, pp. 351–367.**

[2] **M. Younis and K. Akkaya, Jun. 2008, "Strategies and techniques for node placement in wireless sensor networks: A survey," J. Ad Hoc Netw., vol. 6, no. 4, pp. 621–655.**

[3] **Ameer A. Abbasi, Mohamed F. Younis and Uthman A. Baroudi, Jan. 2013, "Recovery from a node failure in wireless sensor-actor networks with minimal topology changes,". IEEE Transactions on vehicular technology, vol. 62, no. 1.**

[4] **A.Abbasi, M. Younis, and K. Akkaya, Sep. 2009, Movement-assisted connectivity restoration in wireless sensor and actor networks," IEEE Trans. Parallel Distrib. Syst., vol. 20, no. 9, pp. 1366–1379.**

[5] **K. Akkaya, A. Thimmapuram, F. Senel, and S.Uludag, Mar. 2008 "Distributed recovery of actor failures in wireless sensor and actor networks," in Proc.IEEE WCNC, Las Vegas, NV, pp. 2480–2485.**

[6] **M. F. Younis, Sookyoung Lee, and Ameer Ahmed Abbasi, Dec. 2010, "A Localized algorithms for restoring internode connectivity in networks of movable sensor," IEEE Trans. On computers, vol. 59, no. 12.**

[7] **K. Akkaya, F. Senel, A. Thimmapuram, and S. Uludag, Feb. 2010, "Distributed recovery from network partitioning in movable sensor/actor networks via controlled mobility," IEEE Trans. Comput., vol. 59, no. 2, pp. 258–271.**

[8] **F. Senel, M. Younis, and K. Akkaya, May 2011, "Bio-inspired relay node placement heuristics for repairing damaged wireless sensor networks," IEEE Trans. Veh. Technol., vol. 60, no. 4, pp. 1835–1848.**

[9] **S. Lee and M. Younis, Jun. 2009, "QoS-aware relay node placement in a segmented wireless sensor network," in Proc. IEEE ICC, Dresden, Germany, pp. 1–5.**

[10] **Nikolaos A. Pantaziz, Stefanos A. Nikolodakis and Dimitrios D. Vergados, Jun.2010, "Topology Management wireless sensor network," IEEE Communications survey Vol. 15 no. 2.**