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A Survey on Node Recovery from a Failure in Wireless Sensor Networks

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Abstract

Since the start of the third Millennium Wireless Sensor Networks (WSNs) generated interest from industrial and research perspectives. Of particular interest are applications in remote and hard areas in which human intervention is risky or impractical. In WSNs, it is necessary to maintaining the internodes interaction and stalwartly connected network topology at all time. A breakdown of an actor-node may cause the network to partition into disjoint blocks and changes the routing path. In wireless sensor actor network, a number of schemes have been proposed for restoring the network connectivity. This survey analyse the node recovery from a failure in Wireless Sensor Networks. In wireless sensor network, node recovery and node restoration is an active area for research. In this paper, we classify the node recovery process into two broad categories: (i) Recovery by node reposition and (ii) Replace by relay node placement. There are many schemes has been published based on these two approaches. This paper also analyse the node recovery with consideration of topology changes. In this survey, paper we highlighting their strengths and limitation of each technique. This survey provides valuable ideas about node recovery in wireless sensor networks.

Keywords

Failure, Node Recovery, Restoration, Topology Management.

I. Introduction

Modern years have witnessed a mounting interest in the applications of wireless sensor-actor networks (WSANs). Of particular interest are applications in remote and hard areas in which human intervention is risky or impractical. Examples include space exploration, battle field surveillance, search-and-research, costal and border protection; today such networks are used in many industrial and consumer applications.

A WSN can be defined as a network of devices, denoted as nodes, which can sense the environment and communicate the information gathered from the monitored field by way of wireless links [1–2]. The data is forwarded, possibly via numerous hops, to a sink that can use it locally or is connected to other networks (e.g., the Internet) through a gateway. The nodes may be motionless or movable. Each node can be awake of their locality or not.

A sensor network is a network of tiny, lightweight, battery-operated devices, known as sensor nodes. Each sensor node in a sensor network is also equipped with wireless-communication devices. Sensor networks are usually deployed with an intention of monitoring some kind of physical phenomena from the territory of the deployment. For example, a sensor network may be deployed somewhere to monitor the humidity or the temperature of the surrounding area.

In wireless Sensor Networks (WSANs) it is necessary to maintain a powerfully connected network topology at all times. In most applications, the inter-actor Co-ordination is necessary to provide the best performance. There are several faults could lead to failures in wireless sensor networks. WSN node faults are usually due to the following causes: the failure of modules (such as communication and sensing module) due to fabrication process problems, environmental factors, enemy attacks and so on; battery power depletion; being out of the communication range of whole network. However, a failure of node may cause the network to partition into disjoint blocks and would, break such a network connectivity goal. Failed nodes may decrease the quality of service (Qos) of the entire WSN.

The main objective of this paper is to provide a complete survey on node recovery from a failure in wireless sensor networks. There are several schemes has been proposed for node recovery from failure. In this survey we analyze the in which technique was used in order to handle the node recovery .Moreover we also analyse the strengths and weakness of prior approaches.

This paper organized as follows. In section 2, discuss the related work in node recovery from a failure in WSNs. In section 3, discuss the recovery technique in wireless sensor networks. Finally this paper is concluded in Section 4.

II. Related Work

The subject of network replacement for wireless sensor networks has been an energetic area of research. There are two common ways to recovering a node from failure: (i) Recovery by node repositioning and (ii) the deployment of additional nodes to restore connectivity after failures have occurred. Based on above approaches, a number of schemes [3] have been proposed for reinstate the network connectivity in partitioned wireless sensor networks. Distributed Actor Recovery Algorithm (DARA) [4] proposed probabilistic scheme to identify cut vertices. A best candidate (BC) was selected from the one-hop neighbors of the failure actor as a recovery initiator and to replace the faulty node. The BC selection criterion is based on the least node degree and physical proximity to the failure node. In this approach the cascaded movement was used to sustain network connectivity. Connectivity Restoration by node Rearrangement (CRR) [5] avoids replacing the faulty node with a healthy node since the failure might be caused by hazards that may damage the substitute node as well. Instead, CRR rearranges the network topology in the vicinity of the faulty node. The network restoration is modeled as a Steiner tree approximation problem.

III. Recovery by Node Repositioning

The main objective of this category of node recovery schemes is to reposition the failure node by some of the healthy nodes in the network to reinstate strong connectivity. There are several approaches has been published and differ in the level of involvement expected from the healthy nodes, in the required network state that needs to be maintained, and in the goal of recovery process.

A. Recovery by Inward Moving

As mentioned, a node failure that results in a partitioned network is the most serious and challenging. The main issue for restoring connectivity in such case is that some nodes may not be able to reach others and a well-orchestrated non centralized recovery procedure becomes very difficult. The RIM [6] method aims to move the healthy node towards to failure position and replace the failure node. In this approach each and every node must have a 1-hop neighbor list and be aware of their neighbor's locality and proximity.

1. Failure Detection

In wireless sensor networks the failure node detected in the following manner. Each nodes will send HELLO messages or Heartbeat messages to its neighbors. After a certain time period the missing acknowledgement for HELLO message is used to detect the failure node. After detection the failure node the recovery process is initiating.

2. Node Relocation

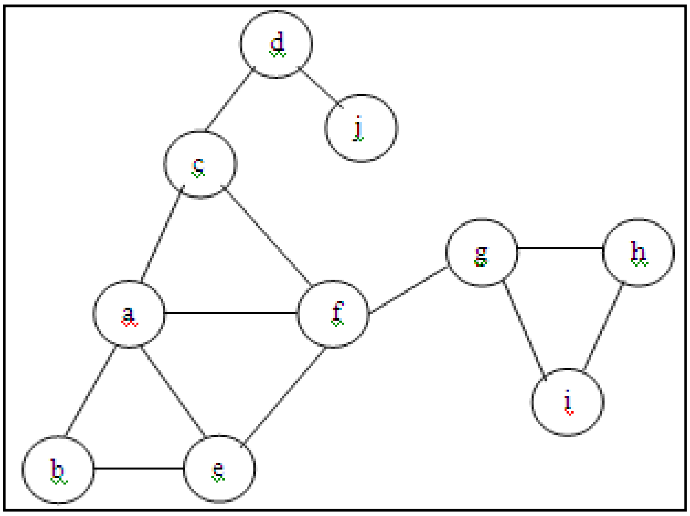

Fig. 1: Wireless Sensor Network

The above Fig. 1 shows the wireless sensor network with the failure node. In fig-1, node 'f' is a failure node. Its neighbor's node 'g' and 'e' send notification messages to its 1-hop neighbor's entire node about failure. Then initiating the recovery process.

Fig. 2 shows the node recovery process. Node 'g' and 'e' is neighbor for failure node 'f'. The failure node will replaced by one of the Best Candidate (BC) node. The selection criterion for BC nodes is based on its healthy condition and distance from the failure position. The neighbors node move towards to the failure position. So nodes 'g' and 'e' send the notification messages to its children node about their movements. The children nodes (nodes 'i' and 'h' children node for 'g') are move according to their parents nodes. This movement is happen by individual cascade movement. If two nodes are best node, then use node id to select the BC node

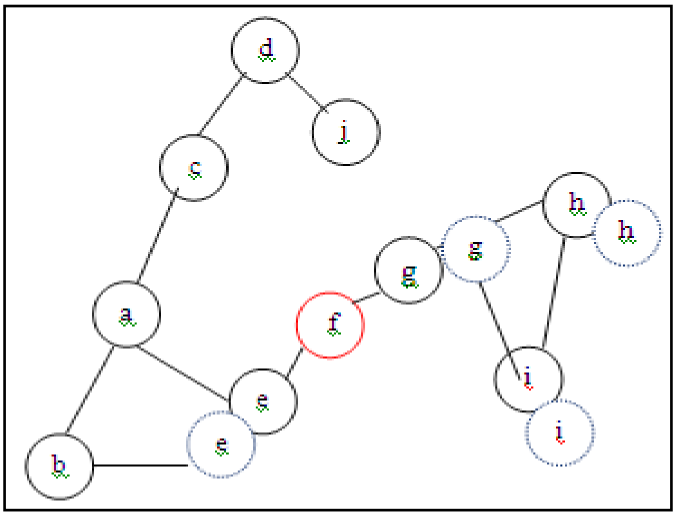

Fig. 2: Node Repositioning by RIM

The main advantages of RIM are its simplicity and effectiveness. RIM employs a simple procedure that recovers from both serious and non serious breaks in connectivity. The entire recovery process is distributed, enabling the network to self-heal without any external supervision. RIM is mathematically analysed and is shown to correctly converge.

Recovery through inward motion has certain limitation. First, the life time of network depends on many factors like mobility, traffic generation frequency and application level co ordination. The importance of load balancing during the recovery varies. Second, this approach designed to recovery from a single node failure only. This recovery schemes does not focus on the chances of multiple node failure. This scheme increases the network connectivity it may affect the node coverage.

B. LeDiR

The above mentioned approach discussed only how to recover a node from a failure. But not discuss how to handle the topology changes while recovering node from a failure. This LeDiR [7] approach discuss the recovery from a node failure with minimal topology changes. LeDiR recoveries process same as RIM. This approach considers the block movement instead of individual cascade movement. It assumes the connectivity restoration with path length constraints. In LeDiR, every node be aware of the entire network topology prior to the failure and thus can build the shortest-path routing (SRT) table for every nodes.

The failure detection processes same as RIM [6]. In Fig. 3 shows the WSNs with totally 19 nodes. Consider node 1 is a failure node and marked as red. Once failure has been detected, the neighbor node should determine the impact of node failure. Then check whether the failure node will break the network connectivity or not. If failure node is a leaf node, such as node 17, it does not make huge impact on the network. If a failure node is a cut vertex, such as node 1, 11, and node 12, it will partition the network and break the connectivity goal.

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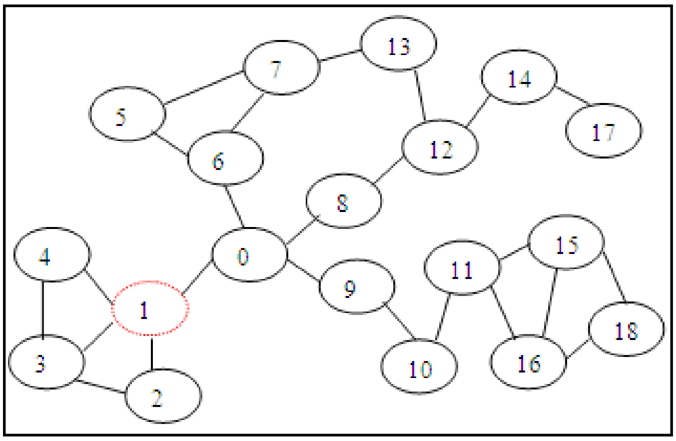

Fig. 3: Wireless Sensor Network with faulty node

1. Recovery Process

Least Disruptive Topology Repair (LeDiR) approach assumes block movement instead of individual node movement. LeDiR starts its recovery process from smallest block among several disjoint blocks. The smallest block is one with the minimum number of nodes. Node 1 is a failure node its children nodes 2,3 and 4 will not communicate with other node in network. This node act as an individual disjoint block.

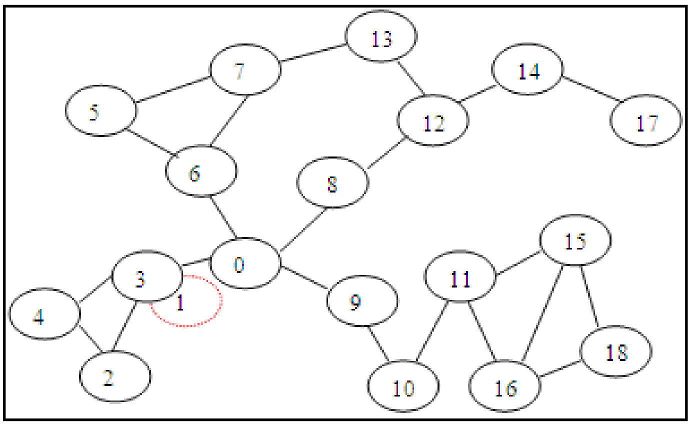

Fig. 4: Replacing Failure node by LeDiR

Above Fig. 4 shows the node recovery by LeDiR. If node 3 and 0 is neighbor of failure node 1, that belongs to smallest block. Node 3 is gateway of remaining nodes in the smallest block and assumed node 3 as 'parent' node. Why we choose smallest block movement means, it has the fewest nodes among all blocks and easy to move during the recovery. When the node 3 moves to replace the faulty node, there is possibility to its children nodes will moves towards its parent's node.

Comparing with the previous approaches, LeDiR has individual block movement not an individual not movement. In this method, we periodically we can't change the routing table. There is a chance of changing the topology but we will maintain the same topology with least number of changes for entire network.

Each and every approach has certain limitations. LeDiR also has limitations. First it could not discuss the occurring the multiple node failure. Considering such a problem collocated node failure is more complex and challenging one.

C. Relay Node Placement

In recent years, a number of research papers have focused on the deployment of relay nodes in wireless sensor networks. The main purpose of such deployment may be summarized as follows:

- Extending the lifetime of sensor networks.
- Energy-efficient data gathering in sensor networks.
- Balanced data gathering in sensor networks.
- Placement of relay node while recovering from failure.

In this survey we focused on placement of relay nodes while recovering a failure node in WSNs. Relay node replacement is another approach for restore the network connectivity when failure occurred. The deployment of relay nodes (RNs) to restore connectivity among the disjoint partitions of a damaged WSN.

There are many approaches has been published and discussed based on relay node placement. The idea of deploying relay nodes in sensor networks was first introduced in [8], which was based on flat architectures. They have introduced relay nodes within the network to provide connectivity so that transmission power of each sensor node can be kept low. The parameters that are considered for the optimization are the total-per-node minimum power needed to maintain connectivity.

As in [9], the relay nodes called as gateway nodes. They have proposed a two-phase fault tolerant approach, detect and recover. For the gateway nodes, they have considered different type of failures including complete failure, link failure and range failure. Their idea is to perform periodic check on the status of the gateway nodes so that the system can learn about the failure of any gateway node. Their scheme includes creation of backup information during the clustering phase, which can be used to re-assign sensor nodes managed by the any failed gateway node, therefore eliminating the necessity of a full-scale re-clustering involving the entire network.

The main idea of the [10] was inspired from the behavior of a spider, which establishes a web for spanning gaps between objects. As far as the connectivity metric is concerned, the optimal solution was found by forming an SMT whose Steiner vertices will be the RNs. However, we need to ensure that the length of each edge in this tree is at most R, i.e., transmission range. This approach is referred to as the Steiner minimum tree with a minimum number of Steiner points and bounded edge length (SMT-MSP).

1C-Spider Web Heuristic restore 1-connectivity and provide the desirable topology features by utilizing the way a spider creates its web. The idea behind the 1C-SpiderWeb deployment strategy is to place the relays inward to yield better network connectivity and coverage. To balance the intersegment path length in terms of the number of hops, RNs are placed toward the estimated CoM of the segments. Basically, from each partition to the CoM, we gradually deploy nodes until all the partitions are connected. This way, we not only increase the total coverage of the network but reduce the possible number of cut vertices in the network as well.

Before the placement of RNs starts, we first need to identify the outer segments in the area of interest. To do this approach, we randomly pick representative nodes from each partition and run a convex-hull algorithm [11]. The 1C-SpiderWeb algorithm exploits this case to optimize the deployment.

Before terminating the execution of the 1CSpiderWeb algorithm, a segment needs to be connected to two neighboring segments: 1) one neighboring segment to its right and 2) another neighboring segment to its left. Because we consider the segments on the convex hull, every segment will have a neighbor to its right and another segment on its left. This 1C-spider web approach was extended and described the 2C-Spider web heuristic for 2-vertex connectivity.

The main advantages of a RN placement approach not only guarantees the connectivity but provides the topology features such as extended coverage, balanced traffic load. RN placement exhibits stronger connectivity than a minimum spanning tree achieves better sensor coverage and enable balanced distribution of traffic load. Relay node placement has some limitations. First, node replacement does not consider energy as a metric in placing the RNs. Second, although connectivity among sensors and relays is considered, these nodes belong to a single network, where all the RNs communicate with the same base station.

IV. Discussion And Conclusion

In recent years, Wireless Sensor Networks have started to receive growing attention due to their potential in real-time applications. In this paper, we discussed an important issues in WSNs, that is node recovery from a failure. As mentioned earlier, in wireless sensor networks the node restoration and recovery from a failure is an active area for research. This survey provides a valuable ideas and suggestions about node recovery process after failure in wireless sensor network.

From this survey, we studied, there is some common problems in all the above mentioned approaches and other previous method has been analysed and discussed only single node failure and does not focus on multiple node failure. All the schemes do not have any idea about simultaneous node recovery. Another major thing is many of the approaches could not consider the topology management while recovering a node from a failure in WSNs.

From this survey, we get some important points for future work. In future we discuss the chances of occurring the multiple node failure and analyse how to recover the all failure node at a time i.e. simultaneously in wireless sensor networks with the use of movable nodes.

V. AcknowledgEment

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References

[1] *Akyildiz, I.; Su, W.; Sankarasubramaniam, Y.; Cayirci, E. "A survey on sensor networks". IEEE Commun. Mag. 2002, 40, 102–114.*

[2] *Rajaravivarma, V.; Yang, Y.; Yang, T. "An Overview of Wireless Sensor Network and Applications". In Proceedings of 35th Southeastern Symposium on System Theory, Morgantown, WV, USA, 2003; pp. 432–436.*

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

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

[5] *M. Younis and R. Waknis, "Connectivity restoration in wireless sensor networks using Steiner tree approximations," in Proc. IEEE GLOBECOM, Miami, FL, pp. 1-5, Dec. 2010.*

[6] *Mohamed F. Younis, Sookyoung. Lee, and Ameer A Abbasi, "A localized algorithm for Restoring Internode Connectivity in Networks of Moveable Sensors," in Proc. IEEE trans. On Computers, Vol. 59, No.12, Dec. 2010*

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

[8] *X. Cheng, D-Z. Du, L. Wang, and B. B. Xu. "Relay Sensor Placement in Wireless Sensor Networks". IEEE Transactions on Computers, 2001.*

[9] *G. Gupta and M. Younis. "Fault-tolerant clustering of wireless sensor networks". In Proceedings of IEEE WCNC, pages 1579–1584, 2003.*

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

[11] *T. H. Cormen, C. E. Leiserson, R. L. Rivest, and C. Stein, "Introduction to Algorithms," Second Edition. MIT Press and McGraw-Hill, 2001.*