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A SURVEY ON NODE FAILURE RECOVERY ALGORITHMS IN WIRELESS SENSOR-ACTOR NETWORKS

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ABSTRACT

This paper presents a review of node failure recovery algorithms in wireless sensor actor networks (WSANs). Due to wide area of innovation in wireless technology, WSANs have been the interesting area of application for last two or three decades in various fields. In WSANs, sensor node will explore the environment and transmit the gathered information to actor nodes. Actor node gathers or aggregates that information and performs specific operations in response to various events. Actors have to work together so it is essential to retain a strongly connected network topology at all the time. Since, actors perform in hostile environment, so they are prone to failures. Moreover a failure of an actor node leads to partition of the network into disjoint blocks and would thus violate the connectivity goal. For the recovery of faulty nodes, there is a requirement of location table for initiating the recovery process. There are several algorithms and methods that are proposed by various authors. The various algorithms implemented till date are Least Disruptive Topology Repair Algorithm (LeDiR),RIM(Reverse Invert Motion) algorithm, DARA(Divide actor recovery algorithm),PDARA(Partition detection actor recovery algorithm etc. These algorithms are based on two strategies of node repositioning and inward motion. This review paper deeply studies the methods that are proposed by various authors for the detection and recovery of actor failures in mobile sensor networks.

Keywords*: LeDiR, DARA, RIM, PDARA*

I. INTRODUCTION

Change is a part of nature and it represent in at most advance way. Similarly in Wireless Sensor Network the present scenario of technological advancement where exist plethora of incumbent opportunities in research on daily basis whether it is from communication to operating system, whether from 8bit to 128bit system or whether working on real time operating systems. One major field which is emerging everywhere is sensor based wireless system. A system where no physical contact or transmission unit is required from transmitter to receiver end, the only way is through waves. One big achievement was Wireless Sensor Network (WSN). Communication based on electromagnetic waves has plethora of advantages over obsolete wired network and it led us to unveil new feeble, economic, low power and multi-tasking sensing devices. These small devices have the strength of sensing, computing, and self realization of transceiver known as sensors. These are particularly used to sense the exact surroundings; collect data, and execute it to grab out some necessary data, which can be used to know the phenomena at the area of deployment of these nodes [1]. The assemblage of these alike or miscellaneous sensor nodes called wireless sensor network. These networks can be arranged to watchdog the physical conditions like pollution, temperature, pressure, sound, movement etc. The evolution of wireless sensor network was primarily inspired from military operations such as field surveillance and to discover the targets [2].

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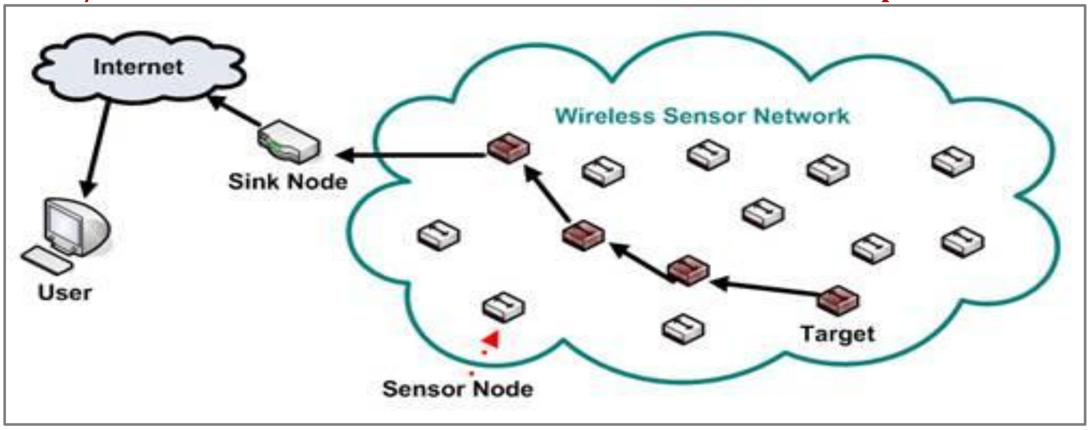

Fig. 1 Overview of Wireless Sensor Network

Nowadays wireless sensor network are at its optimal heights but on the other hand there are few shortcoming which cannot be ignored i.e. limited source supply. Saving energy main motive in WSN; nodes are dependent on limited battery power [3]. Every sensor node rely on energy for its operations, this has become major drawback in wireless sensor network. The synchronization of WSN mostly relies on the transmission power of the source nodes. If the power is less than the desired requirement, there may be single or multiple breakdowns. Excessive use of power reduces the lifespan of power source. Furthermore surplus transmission power is the necessity of each node to maintain the network connectivity and extend network lifetime.

II. RELATED WORKS

From few decades there is a drastic shift toward the use of WSANs, especially in those areas which are considered as the remotest one or which are not physically approachable, like space expedition and exploration, military application, search-and-rescue operation, and coastal and oceanography [4]. Sensing devices which are used in such fields are mainly dependent on power source and have confined processing and communication capacity. Giving emphasize on inter-node connectivity, sensors always notify their nearby nodes before acting so that networks can be adjusted in accordance with required hierarchy. Moreover, immediate fault in node, which can be caused by the environmental factors such as overheating, dust, moisture or exhaustion of the power source, which may obstruct network performance. When node is dead, there is a breakage in the communication path in the network and make some of the nodes not to achieve desired results [5]. In the inferior case, the network may get divide into many blocks which are not connected to each other and become malfunction. Therefore, device must be capable enough to find and recover from the fault of one of their associated nodes. Therefore WSANs operate automatically and their nodes are resource-ward, the recovery may be a scattered and self-healing process. The network is responsible to find out the events, so that the restoration process may also be featherweight and work cursorily, with least overhead**.**

Sensors are devices that serve the purpose of wireless data acquisition. The data is then processed and an appropriate response is put forward. In collaboration with each other, the nodes respond to achieve predefined application mission. This collaboration requires a robustly connected network topology at all times. Moreover, latency requirements are met by reducing the length of communication paths between the nodes. However, fault in a node causes separation of the network into separate blocks, thus, violating connectivity. One of the efficient recovery methods is to relocate a sub-group of actor nodes to reinstate synchronization.

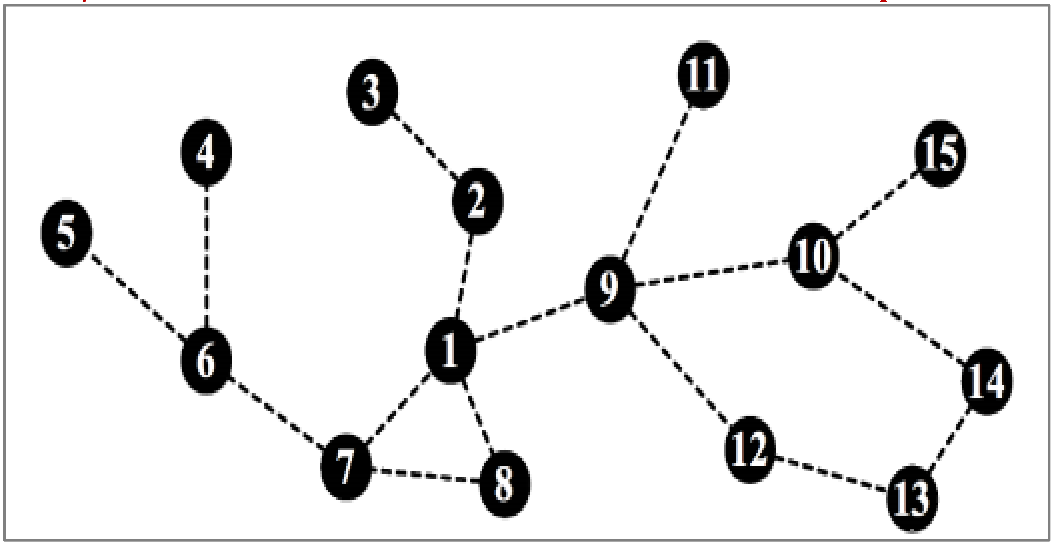

Fig. 2 Distribution of Sensors in a WSAN

A number of recovery schemes are proposed such as Distributed Actor Recovery Algorithm (DARA) [6], Partition Detection and Recovery Algorithm (PADRA) [7], Least Distance Movement Recovery (LDMR) [8], Recovery through Inward Motion (RIM) [9], and Least-Disruptive topology Repair (LeDiR)[10].

Many schemes have been proposed for network recovery and connectivity through node repositioning in sub-categorised WSANs. The recovery schemes differ on the basis of involvement of the actor nodes in the recovery process. To guarantee that recovery schemes lead in an adequate way, schemes need that every node in a network must have knowledge of their two hop neighbours. The failure of one or no of actors might divide the network into disjoint sub networks. This may happen in harsh events e.g., a fireplace and will need a speedy recovery process so that event wouldn't go out of hand and lead to adverse results. WSANs operate unattended and the deployment of spare actors might take time, the recovery ought to be performed through network self reconfiguration using existing resources. Not solely an actor failure might cause a loss of inter-actor connectivity; it also leads to degradation in coverage within the neighbourhood of the faulty node. Having good actor coverage is very important in WSAN in order to make sure that a sensor can report its finding to an actor and the actor responds in a timely manner.

Abbasi*et al.* presents DARA, [6] a Distributed Actor Recovery Algorithm, which prefer to conveniently restore the network connectivity of the inter-actor which has been tormented by the failure of an actor. Based on the connectivity two algorithms are considered, namely, DARA-1C and DARA-2C are made to address 1 and 2-Connectivity necessity. The goal is to determine the least number of actors that should be relocated in order to re-establish network connectivity. The best candidate (BC) is selected on the basis of node degree and the nearest to that of faulty node. The goal of DARA is to lessen the total distance travelled by the actor to restrict the overhead occurred due to the movement.

Akkaya*et al.* presents a distributed Partition Detection and Recovery Algorithm (PADRA), [7] which can wind up all possible partitioning in earlier and retain the connectivity in case of failures with minimum node movement and communication overhead. It is unknowing at the instant of failure that such a failure causes partitioning of the network, they present an approach based on Connected Dominating Set of the inter-actor network that select if a node is a cut-vertex or not. If a node detects that it is a cut-vertex, the nearest dominatee/neighbour has given authority to carry out failure recovery process on the favour of that node. The recovery process is executed by determining the nearest dominatee node and repositioned to the position of the faulty node in a cascaded manner.

Alfadhly*et al.* proposed a Least Distance Movement Recovery algorithm [8], which is an appropriate approach that exploits non cut vertices actors within the recovery process. The main goal is to set one hop neighbours of the faulty node to shift towards the location of the faulty node while its previous location is taken by nearest non cut vertex actor. The recovery process initiate with the phase where each neighbour broadcasts a message containing the ID of the faulty node, ID of the neighbour node and Time-to-Live. When a neighbour receives feedback, it chooses its BC based on the distance.

Younis*et al.* proposed an algorithm for Recovery through Inward Motion [9] (RIM), which retains the connectivity wireless sensor network via effective relocation of some of the nodes in the network. It is a localised algorithm that restricts the scope of recovery. The objective of this algorithm is, when a sensor node becomes dead, its neighbouring nodes move towards the position of the faulty node. It performs a network wide analysis to evaluate the effects of the node failure. It follows a simple process which recovers from both serious and non serious breaks in the network connectivity, without examining that the faulty node is a cut vertex. Rim triggers a local recovery operation by repositioning the neighbour of the faulty node. It reduces the communication overhead.

Abbasi*et al.* proposed an algorithm that overcome high node reposition overhead and prolong some of the inter actor paths known as Least-Disruptive Topology Repair Algorithm [10]. It is based on the local view of a node about the network to reposition the less number of nodes and assure that number path among any pair of affected nodes is prolonged with respect to its pre-failure. LeDiR is localized and distributed algorithm which influences actual route exploration activities in the network and put no additional pre-failure messaging overhead. After the node failure the best candidate is selected on the basis of distance i.e. it should be nearest neighbour and on the node degree.

Imran *et al.* proposed distributed algorithm for restoring connectivity which is lost due to actor failure. In this, [12] Partition Detection and Connectivity Restoration (PCR) determine the potential actors and restore the topology with minimum overhead. First of all actors proactively check which of the actor is a cut vertex in the network based on the local information. The restoration operation repeated again and again in a cascaded manner. Every critical actor nominate apt neighbour as its backup. Back up actor, discover the failure and initiate recovery process in order to restore the connectivity. The algorithm is pertaining to be executed till all actors become connected. The main objective is to employ actor to monitor each other, reduce recovery time and overhead.

Tamboli and Younis presented a different Coverage Conscious Connectivity Restoration (C^3R) method. [13] In this algorithm, topologies of the network reconcile by relocating some of the nodes. C^3R motivate to maintain the maximum of the network topology intact and localize the scope of the recovery. In this algorithm faulty node is replaced by its neighbour on temporary basis, one at a time. On finding the failure, neighbours coordinate a motive for each of the neighbour to reposition the failure node. After performing their own function for particular time node come back to its previous location and allow another neighbour of failure node to come forward and so on. They conclude that in C^3R, nodes retain a balance among temporal and spatial coverage to restore the connectivity.

Sir *et al.* presented optimum results for connecting multiple partitions of a wireless sensor actor network disconnected owing to massive node failures within which the total travel distance by the nodes is reduced [14]. This relies on the transportation network flow models. The author tend to read WSAN with n nodes as a transportation network where n-1 provides at selected actuator transported to the remaining actuators within the network i.e. each and every one receive one supply at end. If the network is connected, each actuator will be ready to receive the supply. The result indicates that best results in terms of travel distance, which can be achieved with a reasonable delay in terms of recovery time.

Alfadhly*et al.* investigated the resistance of actor failure in Wireless sensor actor networks [15]. The ability to move of actor nodes is exploited to restore communication links between disconnected neighbours and at the same instant reduce the coverage loss induced by the reduced actor count in the deployment area. Author formulates the problem of best self healing of a separated wireless sensor actor network as Integer Linear Program (ILP). In this they have taken DARA as a baseline for efficiency comparison.

Senel et al. author explored the distribution of the relay nodes to retain network connectivity between the disjoint partitions of a flawed WSN [16]. The main objective is to set up a network topology that be like a spider web and for which the segments are located at the perimeter. The resultant network topology shows a stronger connectivity and also attains improved sensor coverage and allows equitable distribution of traffic load on the deployed relay nodes. These specific features are supplied without boosting the number of relay nodes which a Steiner Minimum Tree (SMT) based solution will involve.

Younis explores various efficient methods for recovering from the node failure of the network in which the distance among the pair of nodes is longer than twice the communication range of a node [17]. Quality of Service (QoS) requirements has to be met. Authors propose a QRP, a polynomial-time method. That follows examining and decides to reduce the number of relays needed for setting up a connected inter segment network topology that meets the required QoS. QRP defines the deployment area as a grid shape of equal sized cells and defines the best neighbouring cell of segment which needs less relaying capability to connect to the segment. QRP operates in round; the best cells are selected and most populated with the Relay Nodes.

III. DISCUSSION

Recovery through Inward Motion (RIM) is based on the recovery process on the knowledge of the one-hop neighbours [11]. The neighbouring actor nodes of a node detect failure of the particular node, and then move toward the failed node until the hole created by node failure is compensated. The neighbour actor node (parent node) moves toward the failed node and all the nodes in the opposite direction of the Best Candidate, move towards the faulty node by same distance as parent node. The lost link during the recovery is thus re-established through cascaded reposition. The cumulative effect on network topology is shrinking inward of the network.

LeDiR is based on the principle of relocating least possible number of actor nodes to guarantee that no hole in network is created respective to its pre-failure status. LeDiR is scattered algorithm that is more efficient than other node failure recovery schemes and enforces no additional pre-failure communication overhead. When a node breakdown takes place, a virtual hole is created in the network. The BC (Best Candidate) will move towards the position of the failed node. The BC is selected on certain parameters:

- The node which is nearest to the failed node.
- On the node degree, i.e. BC should have smallest block of nodes.

The immediate actor node will replace the failed node and is referred to as Parent node. The nodes opposite to the direction of movement of the parent node and inside a predefined range from parent node are referred to as child node. These child nodes move by half the distance moved by parent node close to the parent node. Thus the hole is somewhat covered. Previously study is carried out to implement LeDiR for single node failure. When there is simultaneous multiple node failure, which is my proposed algorithm, the LeDiR is implemented exactly as above. The only difference is that the implementation is more dynamic. There are more than one parent node taking position of failed nodes and several child nodes moving about in the network at the same time.

RIM has a disadvantage of high relocation overhead. As the relocation involves movement of child nodes which include all the nodes, which are in the opposite direction of movement of parent node. Also, boundary of WSN shrinks in case of RIM. On the other hand, LeDiR includes movement of child node which are comparatively less. Further, LeDiR implemented on multiple node failure has the advantage of addressing more than one node failure at the same time. In addition to this, the actual boundary of the network remains unchanged.

IV. CONCLUSION

In recent years, WSANs have started to receive growing attention due to their potential in real-time applications. In this paper, we discussed an important issue in WSANs that is node recovery from a failure. As mentioned earlier, in WSANs 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 WSAN.

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

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