ISSN: 2278 – 1323
International Journal of Advanced Research in Computer Engineering & Technology (IJARCET)
Volume 2, Issue 3, March 2013

Hybrid Movement Control Algorithm For Restoring Connectivity In WSAN

Tesmy George,Priyadharshini.C

[1] Post-Graduate Student, Department of Computer Science and Engineering, Karunya University, India
[2] Assistant professor, Department of Computer Science and Engineering, Karunya University, India

***Abstract*-Maintaining inter-actor connectivity is very important in WSAN. Failure of one or multiple actors may partition the inter-actor network and obstruct the network operation. This paper presents a combination of two algorithms namely DCR and PCR to tolerate the failure of actors.DCR proactively identifies critical actors and designates appropriate backup nodes. Backup node starts recovery process when failure is detected [3].PCR determines critical/non-critical actors based on localized information and designates each critical node with an appropriate backup [2].**

***Index Terms* -Critical actors, DCR, Network Restoration, PCR, WSAN.**

I. INTRODUCTION

Wireless sensor and actor networks (WSANs) refer to a group of sensors and actors related by wireless medium to perform distributed sensing and actuation tasks. In such a network, sensors collect information about the physical world, while actors take decisions and then carry out appropriate actions upon the environment, which allows remote, automated communication with the environment. Sensor nodes are small, inexpensive devices with narrow sensing, computation and wireless communication capability, actors are generally resource-rich devices equipped with better handing out capabilities, stronger broadcast powers and longer battery life. In WSANs, depending on the application there may be a need to rapidly respond to sensor input. Moreover, to afford right actions, sensor data must still be applicable at the time of acting. The number of sensor nodes deployed in studying a phenomenon may be in the order of hundreds or thousands. However, such a dense employment is not necessary for actor nodes due to the different coverage requirements and physical interaction methods of acting mission. Hence, in WSANs the number of actors is much lesser than the number of sensors. In order to provide effective sensing and acting, a distributed local management mechanism is necessary among sensors and actors.
This paper presents a combination of two algorithms namely DCR and PCR.DCR proactively determines potential critical actors and assign backup nodes. DCR assume single critical actor failure at time and no other node fails during the recovery process. PCR determines critical/non-critical actors based on localized information and designates each critical node with an appropriate backup (preferably non-critical). The pre-designated backup detects the failure of its primary actor and initiates a post-failure recovery process that may involve coordinated multi-actor relocation [3].

This paper is structured as follows. Section 2 discusses the problem statement. Section 3 describes the related works.Section 4 describes the DCR and PCR algorithms. Section 5 presents the analysis the proposed recovery algorithm. The performance of DCR and PCR is evaluated through simulation and presented in Section 6. The entire paper is concluded in Section 7.

II. PROBLEM STATEMENT

Inter-actor connectivity is the primary concern of this paper. It is assumed that sensors are stationary and can send their data to actors .Actors are mobile nodes that perform suitable actions. The impact of an actor's failure depends on the position of that actor in the network topology. A node is said to be critical, if its removal partitions the network into disjoint segments (MilenkoJorgic´ et al., 2004) [3].

In order to tolerate critical node failure, three methodologies can be identified: (i) proactive, (ii) reactive and (iii) hybrid. Proactive approaches create and preserve bi-connected topology in order to provide fault tolerance. This necessitates large actor count that leads to higher cost and becomes unworkable. On the other hand, in reactive approaches the network responds only when a failure occurs. Therefore, reactive approaches may not be appropriate for time-critical applications [3].

III. RELATED WORK

The existing work on using node mobility for failure recovery can be categorized into block and cascaded movement. Block movement often

All Rights Reserved © 2013 IJARCET

require a high pre-failure connectivity in order for the nodes to coordinate their response. Block movements often becomes infeasible in absence of higher level of connectivity. Therefore, few researchers have pursue cascaded node movement (Guiling etal., 2005) or shifted relocation (Li etal., 2007). The idea is to gradually replace intermediary nodes on the path instead of moving a node for a long distance. The idea of cascaded movement is to mitigate the holes occur due to failure of actors. The objective of this paper is to restore inter-actor connectivity [3].

Some approaches like DARA (Abbasi etal., 2007), PADRA (Akkaya etal.,2008) require each actor to maintain two network state information..Others, such as RIM (Younis etal.,2010), C3R, (Tamboli and Younis, 2009), VCR (Imran et al., 2010) reduce the increased overhead for tracking 2-hop neighbors. DARA requires more network state in order to ensure union. Although RIM (Younis etal.,2010), C3R (Tamboli and Younis, 2009) and VCR (Imran etal.,2010) use1-hop neighbour information to restore connectivity .But they are purely reactive and do not differentiate between critical and non-critical nodes. Akkaya et al. extended their work (Akkaya et al., 2008) by introducing a mutual exclusion mechanism called MPADRA (Akkaya et al., 2010) in order to handle multiple simultaneous failures [3].

IV. INTER-ACTOR RESTORATION ALGORITHMS.

The proposed DCR algorithm is hybrid .It consists of two parts, i.e. proactive and reactive. In the proactive part, critical actors are determined and they select and designate an appropriate neighbor to handle their failure when such eventuality arises in the future. Each backup starts monitoring its primary through HEARTBEATS. In the reactive part, a backup initiates a recovery process when the primary fails. The backup replace the primary and cascaded relocations are performed until the recovery is complete. PCR algorithm is hybrid in the sense it consists of two parts*:* pre-failure planning and post-failure recovery [3].

A. Critical actor identification

Failure of critical actor divides the inter-actor network into disjoint segments. DCR and RAM identify a backup for each of the critical actors. Based on neighbor’s position information each actor determines locally whether it is critical or not. It calculates the distance between neighbors based on their positions. The actor is considered non-critical if the distance is less than their communication range. The below fig shows the critical and non-critical actors [3].

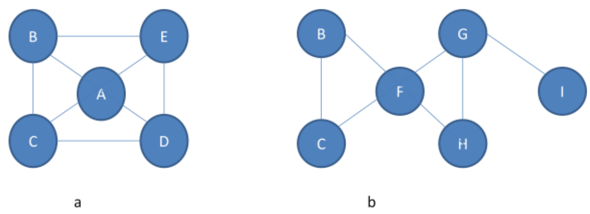

Fig.1 (a) Non-critical actor (b) Critical actor

B. Recovery from single critical actor failure

DCR algorithm is used to manage single actor failure [3].

1. Backup selection and primary monitoring

Once the critical actors are identified, the next step is to select and assign appropriate neighbors as backups. In the previous algorithm namely PCR pursues pre-failure planning to distinguish between critical/non-critical nodes and designates an appropriate backup for each critical actor. PCR prefers non-critical node as backup. If non-critical node is absent, the primary node move changes its location and select a non-critical node as back from the neighboring list. The selection of a backup among 1-hop neighbors is based on the following ordered criteria [3]:

(a)Travel feasibility: An actor that can relocate to the position of a failed node due to the presence of physical constraints, e.g., the presence of creek or rift, cannot serve as a backup.

(b) Neighbor actor status (NAS):A non-critical neighbour actor is preferred to serve as backup. This will limit the scope of the recovery, reduce incurred overhead and minimize the impact on coverage.

(c)Actor degree (AD): A non critical neighboring actor is a more suitable candidate for backup because moving that node will have minimum impact on inter-actor connectivity. If a non critical node is not available in the neighborhood, DCR prefers to choose a strongly connected critical node(with high degree)because there is more probability to have non-critical nodes in the neighborhood. This will limit the possibility of cascaded relocation and thus lower the recovery overhead [3].

(d)Interactordistance (ID): A close backup actor is preferred in order to reduce the movement overhead and shorten the recovery time [3].

Failure detection: Once an actor receives a BACKUP notification, it starts monitoring the primary through HEARTBEAT messages. The failure of the primary is detected by corresponding backup through successive misses of HEARTBEATS [3].

2. *Recovery process*

All Rights Reserved © 2013 IJARCET

The recovery process is initiated by the backup upon the detection of a primary failure. The scope of the recovery depends on the NAS. If the backup is a non-critical actor, it simply replaces the primary and the recovery would be complete. However, if the backup is also critical node, cascaded relocation is performed. Basically, relocation of actor Ai in response to the failure of Af will be interpreted by its backup Aj as if Ai is lost and Aj will thus move to replace Ai[3]. The recovery process consists of following steps:

(a)Primary recovery: When failure of the primary node is detected backup node initiates its recovery process. The scope of recovery depends on the position of backup actor and it contains the three scenarios. First, if the backup is a non-critical node, the backup actor moves to the position of the failed primary and exchange heartbeat messages with new neighbors. It selects and designate a new backup since it has become a critical node at the new position. This movement alert the other primary nodes (if any) at the previous location to choose a new backup for themselves. An example is provided in the below fig.2 where non-critical backup B simply replaces its primary and selects a backup for itself. The second situation is when the backup is also a critical node. In this case, the backup actor will alert its own backup so that the network stays connected. This scenario may prompt a series of cascaded repositioning of nodes. The third scenario is when the failed and its backup are both critical nodes and concurrently serving as backup for each other. This scenario is articulated in Fig. 3. Actor B detects the failure of F as both are mutually serving as backup for each other as shown in Fig. 3(a). Figure 3(b) shows that the actor B selects another actor''A'' as backup. Then B sends a movement notification message and moves to the position of F as shown in Fig. 3(c). This movement triggers a series of cascaded relocations as discussed below and is shown in Fig. 3(d), with A replacing B and C replacing A [3].

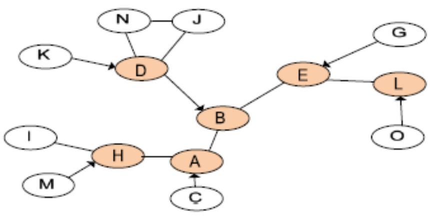

Fig.2 Recovery process when backup actor is non-critical

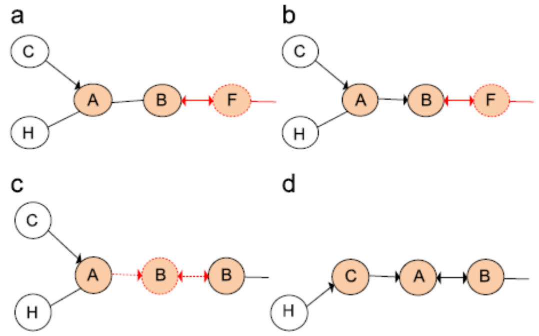

Fig.3 Recovery process when two actors are simultaneously primary-backup of each other.

(b)Cascaded relocation: The position of the backup determines the scope of the recovery. In particular, the recovery process of the Second scenario is repeated to handle the departure of a backup node. Basically, when the critical backup actor B moves to the location of the failed actor, it waits for receiving heartbeat messages from its own backup BB. Once node B receives a heartbeat message from BB, it selects and designates a new backup based on the new neighborhood that it has joined. This process may be again apply by BB and so on until a non-critical backup replaces a primary. Figure 3(a) illustrates this scenario where the backup actor is also critical and the recovery process continues in a cascaded manner. The failed actor B is replaced by another critical actor D (i.e. backup). Figure 3(b) shows the scenario where moving critical actor D further partitions the network, a cascaded relocation is triggered. The non-critical backup actor K replaces critical primary actor D and the connectivity is restored. Upon conclusion of the recovery, the backup designation will be updated to get the network ready for recovery in case a node fails in the future.

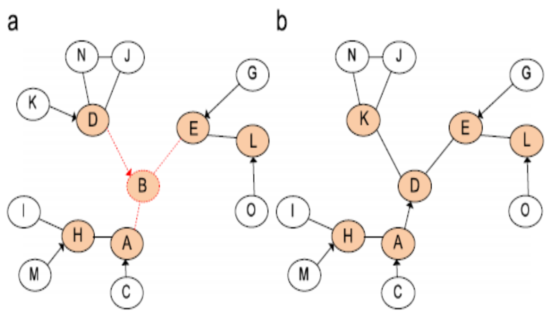

Fig.3 (a) the critical node D detects failure of primary B and (b) D replaces B and K replace D.

C. *PCR*

PCR algorithm contains three modules. It include

- Pre-Failure Planning
- Primary Monitoring and Failure Detection

All Rights Reserved © 2013 IJARCET

- Post-Failure Recovery

1. Pre-Failure Planning

Failure of a critical actor disconnects the neighbors and they are unable to coordinate because they have limited network information. Therefore, PCR pursue pre-failure planning to identify critical actors and designate them an appropriate backup [2].

2. Primary Monitoring and Failure Detection

Once each critical actor selects an appropriate backup, it is notify through regular heartbeat messages. The pre-designated backup starts monitor its primary through heartbeats. Missing a number of successive heartbeats at backup indicates the failure of the primary. After failure detection, the backup prompts the post-failure recovery process [2].

3. Post-Failure Recovery

The post-failure recovery process is initiated by the pre-designated backup upon failure detection. If the backup is a non-critical actor then it simply replaces the primary and the recovery would be complete. The pre-assigned backup immediately triggers a recovery process once it detects failure of its primary. First, if a backup is a non-critical node the scope of recovery will be limited because it does not require further relocations. The backup actor moves to the location of the failed primary and exchanges heartbeat messages with its new neighbors. It selects and designates a new backup since it has become a critical node at the new position. This movement alerts the other primary nodes (if any) at the previous location to choose a new backup for themselves [2].

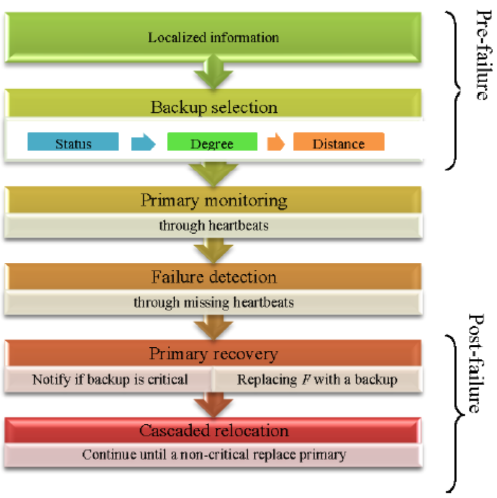

Fig.4.Flowchart of PCR

V. RESULTS AND ANALYSIS

The performance of DCR and PCR is validated through simulation.

A. Simulation setup and performance metrics

In the simulation experiments, inter-actor topologies are created that consist of a varying number of nodes (20–100). Nodes are randomly placed in an area of 1000m_600 m with no obstacles that hinder a node from moving to a new position. Varying transmission ranges are assigned to actors between 50 and 200m so that the topology becomes strongly connected. The performance is assessed using the following metrics:

- The total distance moved by all nodes involved in the recovery: this gauge the effectiveness of DCR and RAM in terms of energy efficiency and overhead involved in the recovery.
- The number of nodes moved during the recovery: this metric reflect the scope of the recovery process.
- The number of messages exchange among nodes: this metric indicate the energy dissipation and recovery overhead.
- The percentage of coverage reduction relative to the pre-failure level: although connectivity is the main purpose of DCR and RAM, node coverage is main for many setups. The loss of a node usually has a negative impact on coverage. This metric assess the efficiency of the proposed approaches in terms of mitigating the coverage loss.
- Average node degree: measures the level of inter-actor connectivity and accessibility of altered paths after the recovery is complete.

B. Performance evaluation

Randomly generated topologies with varying actor counts and communication ranges are involved in the experiments. The number of actors has been set to 20,40,60,80 and 100.The communication range of actors is changed among 50,100,150 and 200.When changing the node count, ‘‘r’’ is fixed at 100m; and‘‘N’’ is set to 60 while varying the communication range. The results of the individual experiments are averaged over 30 trials [3].

Number of moved nodes: Fig.5 shows the number of nodes that were involved in the recovery when DCR and PCR are applied. The performance graphs confirm the advantage of PCR which moves fewer actors than DCR. This is because PCR limits the scope of the recovery and avoids successive cascaded relocations by choosing non-critical nodes as backup. Moreover, PCR moves high degree critical nodes that often have non-critical nodes in the neighbourhood.

Number of exchanged messages: Fig. 6 reports the messaging overhead as a function of the

All Rights Reserved © 2013 IJARCET

network size and radio range. As the figure indicates, PCR incurs far less messaging overhead than DCR.

Percentage of coverage reduction: Fig.7 shows the impact on coverage, measured in terms of percentage of coverage reduction relative to the pre-failure level.

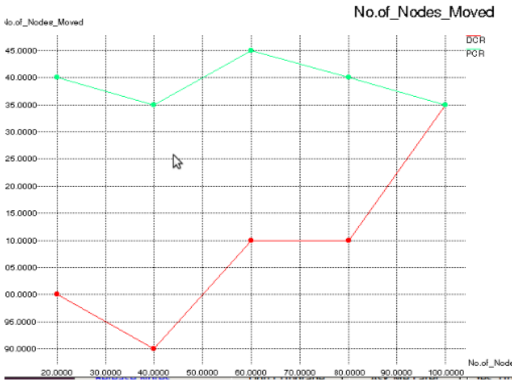

Fig.5. The number of nodes moved during the recovery

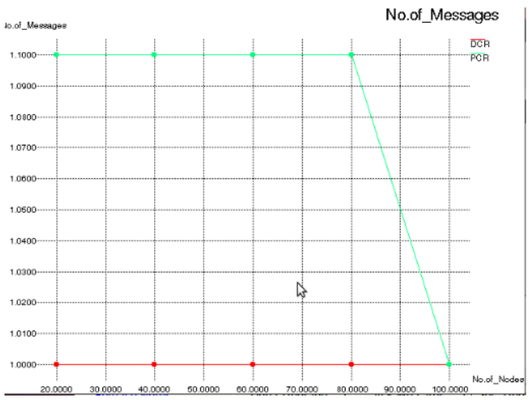

Fig.6.Number of messages exchanged during recovery

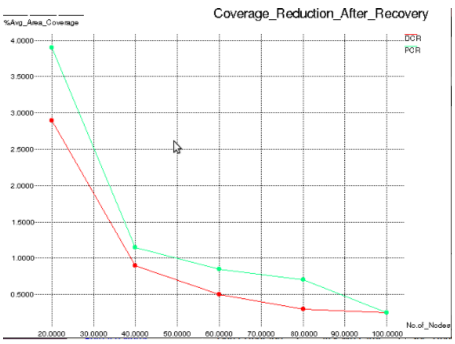

Fig.7.Percentage of coverage reduction

VI. CONCLUSION

This paper has presented a hybrid partitioning detection and connectivity restoration algorithm for mission-critical applications of WSANs. In the previous algorithm namely DCR determines critical actor and designates neighbouring critical nodes as backup nodes in absence of non-critical nodes. But, PCR pursues pre-failure planning to distinguish between critical/non-critical nodes and designates an appropriate backup for each critical actor. The pre-designated backup continuously monitors and triggers a recovery in case of primary failure. By adapting PCR, node failure rate can be reduced.

REFERENCES

[1] Abbasi, AA, Akkaya, K, Younis, M, “A distributed connectivity restoration algorithm in wireless sensor and actornetworks”, *International Proceedings of the 32nd IEEEconference on local computer networks (LCN 2007)*, Dublin, Ireland; October 2007.

[2]Imran, M, Younis, M, Said, AM, Hasbullah,H,“Partitioning detection and connectivity restoration algorithm for wireless sensor and actor networks”, *International Proceedings of the 8th IEEE/IFIP international conference on embedded and ubiquitous computing (EUC 2010)*, Hong Kong, China December 2010.

[3]Muhammad Imran,n, MohamedYounis , AbasMdSaid , HalabiHasbullah,” Localized motion-based connectivity restoration algorithms for wireless sensor and actor networks” Journal of Network and Computer Applications 35 (2012) 844–856.

[4] Muhammad Imran, MohamedYounis b, AbasMdSaid c, HalabiHasbullah, “Localized motion-based connectivity restoration algorithms for wireless sensor and actor networks” *Journal of Network and Computer Applications* 35 (2012) 844–856.

[5] Akyildiz IF, Kasimoglu IH,“Wireless sensor and actor networks: research challenges in Ad Hoc Networks”,2:351–67, 2004.

All Rights Reserved © 2013 IJARCET