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TECHNIQUES FOR TOLERATING NODE FAILURES IN WSN

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Abstract-WSN have tremendously huge count of small, low power sensors, that senses environmental conditions, performs data processing and wireless communication components. These nodes operate on synergetic way to do specific tasks. In general, sensor nodes are deployed densely in critical environment where these nodes cannot be charged. Due to this reason sensor nodes may die because of high energy consumption therefore, WSNs are expected to look for network's connectivity and consent to certain amount of node failures. Reestablishment of the whole WSN connectivity because of nodes' failure is very complicated. This paper classifies the recovery process for the sensor nodes in two ways. First is repositioning of sensor nodes and second way is to replace the sensor nodes using relay node placement approach. This paper also presents many existing approaches for performing sensor nodes' recovery process in WSNs.
Keywords-Topology Management, Node Failure Connectivity Restoration, Fault Tolerance, Multi-Path Routing

1. INTRODUCTION

In WSN, sensor network includes sensor nodes referred as multiple detection stations in which group of nodes works in synergetic fashion to perform various actions such as monitoring environmental conditions, determining absence or presence of undeniable objects, speed direction, vehicular movement, performing disaster relief tasks, battlefield surveillance and many more[1]. In spite of its various applications, WSN suffers from many drawbacks. Fault occurrence is one of the major issues. Various fault tolerance techniques are proposed which helps in maintaining connectivity inside a WSN. When sensor nodes receive the data from neighbouring nodes, the connectivity provides aid to process the received data for achieving a particular task i.e. to forward the processed result to the base station. [2].

The sensor nodes may be failed by the following reasons [3]:

- Energy Depletion: sensor nodes may be broken easily and thus fails due to exhaustion of batteries.
- Link Availability: Because of partitioning of network and intense changes link failure may occur that can be either permanently or temporal failure.
- Packet Loss: Due to changeable topology and inaccurate communication, packet loss may occur.
- Network Congestion: Number of nodes continuously transmitting data to the base station leads to network convection.
- Node Failure: A node failure may occur because of software failure or hardware failure.

Fault detection is designed to find out the feasible faults depending on various parameters, and fault recovery algorithm aims at treating fault facilely with less energy depletion. The cluster based detects fault while recovery algorithms detects node failure on the basis of energy consumption, failure of link and damaged node:

Two ways to recover a node from failure:

(i) Deployment of extra nodes to reconstitute connectivity in case of failures.

(ii) Node repositioning

On the basis of these approaches, various schemes are proposed for establishing the network connectivity in case network gets partitioned. Based on above approaches, number of schemes is proposed for establishing the network connectivity in case network gets partitioned.

For topology in WSNs can be categorised as follows [17]:

- Discovery of nodes: Detection of nodes and their positions is an essential not after the initial distribution but also for combining latterly added nodes.
- Sleep Cycle Management: For conserving energy and extending the network lifespan, few redundant nodes in a network can be turned off.
- Clustering: For achieving measurability, nodes is collected along to create a hierarchal topology so nodes will send their information to a cluster-head that successively integrates and forwards the information to base station.
- Power Control: Transmission reflects the outside distance from a receiver to sender. Elongated the vary, the lot of the ability consumption.
- Movement Control: Mobile relays with more capabilities as compared to sensors are used as data forwarders for prolonging the lifespan of a network of stationary sensors or to join disjoint groups of nodes.

This paper focuses upon various single node failure techniques in detail and fault tolerant routing techniques, which involves fault recovery process with fault detection scheme.

2. TYPES OF NODE FAILURE

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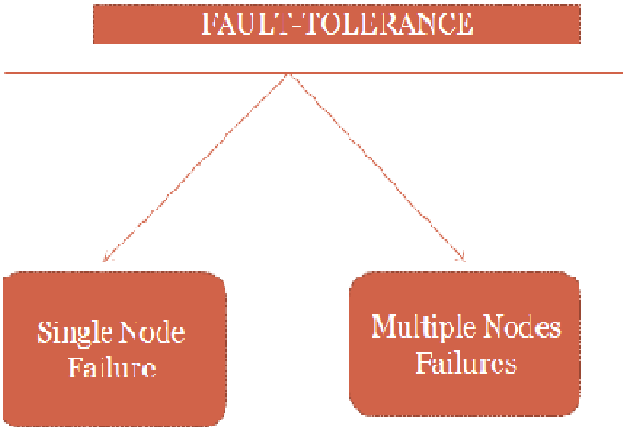

Fig.1 Types of node failure

In WSN, few nodes behaves like cut-vertices and once any of the nodes fails the network is split into disjoint blocks. A cut-vertex is that vertex that divides the graph into multiple connected graphs if it's removed. In alternative words, a cut-vertex node within the network plays the role of a entry between 2 sub-networks.

In Fig. 2, nodes M1, M2, M6, M7, M9 and M10 area unit cut-vertices and area unit examined as exigent for property. This failure therefore affects the network operation and will take for the network useless. clearly the impact of the partitioning depends on the scale of the network and also the quantity of traffic changed among the nodes..

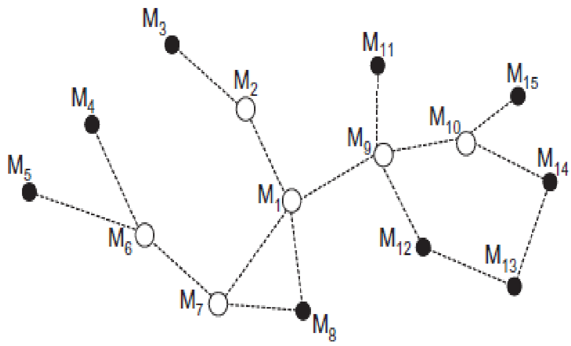

Fig.2 Single node failure scenario

In this type, only one node in networks fails.

In multi-node failure however, two or more than two nodes fails simultaneously leading to connectivity issues inside a network. An alternative of the multi-node failure is an arrangement of spatially-independent single-node failures. For example, multiple nodes may get damaged from various parts of the network simultaneously. However, these failures can be handled independently. These are more common as compared to single node failure. Autonomous repair (AuR), Cell-based Optimized Relay node Placement (CORP), etc. are multi-node fault tolerant techniques.

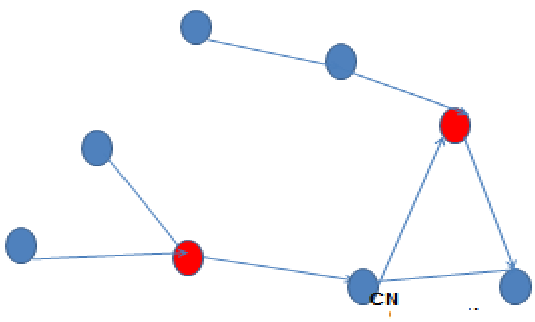

Fig.3(a) Scenario of multi node failure as failure of two nodes(red nodes) introduces a conflict for node CN since in many single node failure recovery schemes it has to be engaged in the recovery process for both of them.

There are various steps that are involved in recovery of node failure:

- Generating originating message
- Store information and forwards it to all other nodes
- Transmit data
- Check for reply
- Generate new testing message to a single node
- Check for failure of node
- Send information to BS
- Reposition the neighbour node in case failure is confirmed.

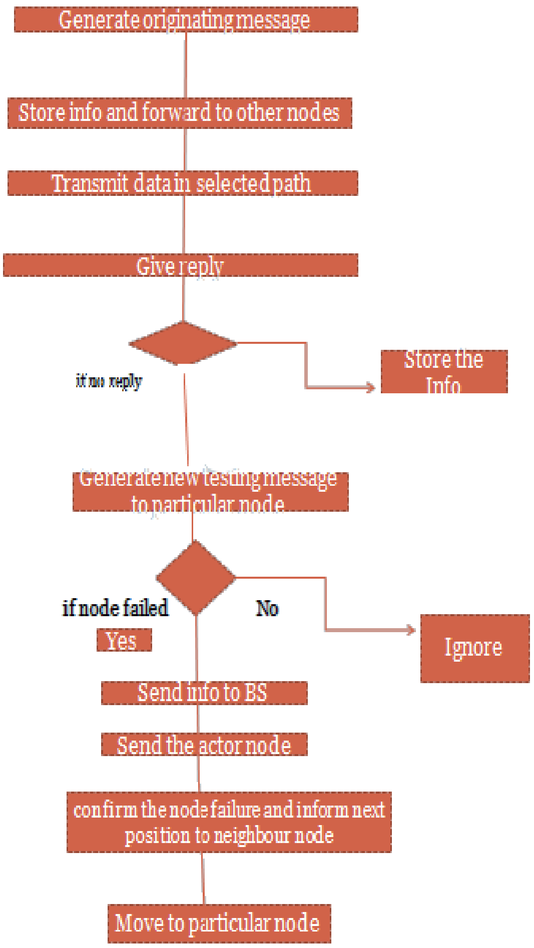

Fig.3(b) Multi-node failure in WSN

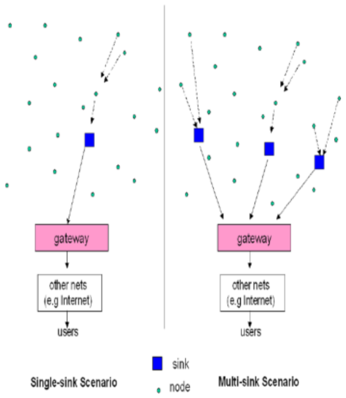

Fig.3 Single sink and Multi sink scenario

3. TECHNIQUES OF SINGLE NODE FAILURE

PADRA (Partition Detection-Recovery Algorithm), RIM(Recovery By Inward Motion),Volunteer-instigated Connectivity Restoration (VCR), LeDir(Least-Disruptive Topology Repair Algorithm), Least-Movement Topology Repair (Le-MoToR), K-Connectivity are few techniques of single node failure. This paper illustrates all these techniques in detail.

3.1 Partition Detection-Recovery Algorithm (PADRA)

This technique spots a connected dominating set (CDS) for the network. PADRA assigns for every cut-vertex Ai that acts as a failure operator that starts the method of recovery if Ai fails [10]. The perfect handler can act as dominate neighbour for Ai which may simply substitute Ai. If a dominate is unprocurable, the dominator that is closet is picked because the failure handler of Ai. Re-substituting the failure handler at the placement of Ai can then cause cascaded placement till and unless a dominate is detected. No set of rules area unit followed for locating highest dominate to the failure handler as how of under reckoning the whole lined distance for all convoluted nodes. Instead, a greedy heuristic is adopted within which a highest dominator is chosen if a dominate is unprocurable.

In the example below, circle nodes ( ) are 'Dominators'and rectangular nodes area unit 'Dominates( ).When node A2 Fails, A3 acts as a failure handler and begins the recovery method. A3 substitutes A2, A5 substitute A3, and eventually A8, a dominate, substitute A5 and property is maintained.

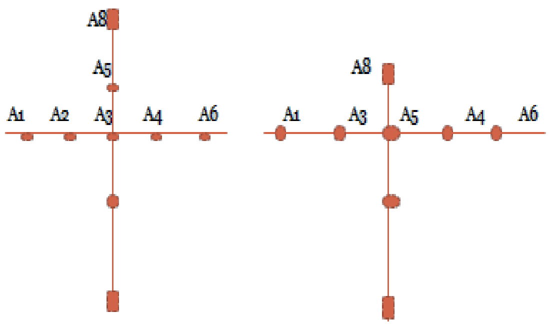

Fig.4 Partition Detection-Recovery Algorithm(PADRA)

3.2 Recovery By Inward Motion(RIM)

This technique needs only one-hop information and uses localized arrangement that restricts the extent of the recovery process. The key plan is to shift the neighbours of a failing node Af inwards towards the place of Af to be able to reach one another [11].

The figure illustrates RIM (a) A1 fails, then its neighbours A2, A8, and A9 applies RIM.

(b) A2, A8, and A9, move inward towards A1. The motion triggers repositioning of A3 to maintain connectivity with A2, and then repositioning of A10, A11, and A12, to maintain their links with node A9.

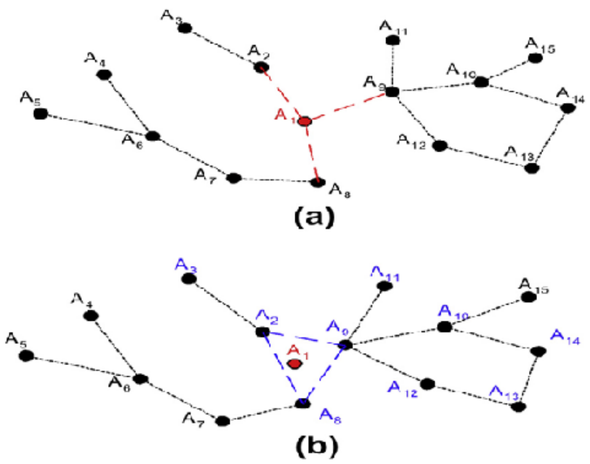

Fig.5 Recovery by Inward Motion (RIM)

The major benefits of this method are its simplicity and effectiveness. RIM follows an easy method that recovers serious also as non-serious breaks in property of the network while not crucial whether or not the failing node may be a cut vertex or not. Although, nodes with higher densities RIM tends to reposition many nodes and will increase the motion overhead on the network, however the overhead on each node will still build it a best approach because it helps in levelling the load among numerous nodes.

3.3 Volunteer-instigated Connectivity Restoration(VCR)

In VCR, the acquaintance of the failing node volunteer to mend property by imposing their part used communication vary and by change neighbouring to the failing node. These neighbours volunteer by multiplying their communication power and effective towards the failing node Af. To avoid hyperbolic medium access collision within the proximity of Af, VCR applies a diffusion force between volunteer nodes supported their carrying vary in order that they extent whereas maintaining connectivity [9]. The recovery method involves 2 phases. Firstly, volunteer actors' area unit known Volunteer declaration takes place on the idea of assorted parameters like proximity, legibility issue. Secondly, topology repair is carried through uncoordinated position of volunteer actors whereas manipulating part used communication vary and actor diffusion.

3.4 Least-Disruptive-Topology-Repair Algorithm(LeDir)

The aim of LeDiR is to revive network's property while not extending the gap of the shortest path among nodes that distinguished to the pre-failure topology. This algorithm overcomes the deficiencies of high node re-motion overhead and distension of inter-actor data paths comparative to its pre-failure status. This method relocates the smallest count of nodes and there is no extension of data paths. This algorithm recognizes the faulty one and finds out if it is a cut vertex or not by applying the moderately populated Shortest-path Routing Table and invoking the recovery process then block with lowest count of nodes are found for repositioning which restricts the recovery overhead. Faulty node is replaced by the near node of the unsuccessful node that is a section of the littlest block [13]. After that offspring nodes which are directly linked to the super node are also repositioned thereby recovering the connectivity. The figure illustrates LeDiR, restoring the network connectivity ones the failure of a cut vertex occurs.

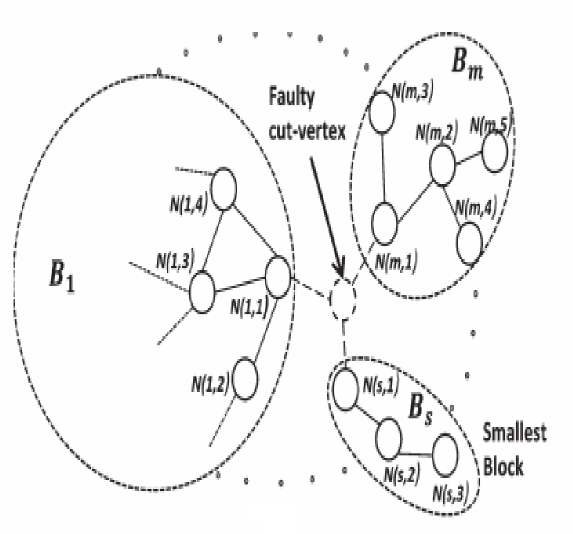

Fig.6 (a) WSAN before a cut vertex fails

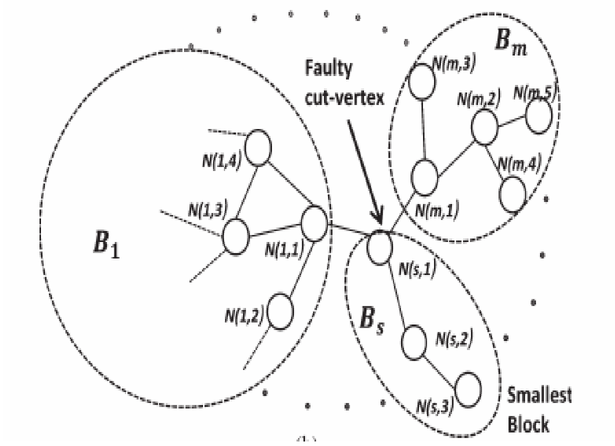

Fig.6 (b) WSAN topology after applying LeDiR

3.5 Least-Movement Topology Repair (Le-MoToR)

It repositions a node Aj in an exceedingly phase on a distinct distance path by moving parallel to the road AiAf. This change lessens the count of nodes and maintains the analysis gained by the node within the smallest phase by not shifting the topology towards Ai when it replaces Af [8].

Fig 6 illustrates the operating of Le-MoToR formula. Solely three nodes are indulged within the recovery method. Fig (a) shows node A10 fails. (b) Node A14 substitute node A10. (c) Node A15 substitute node A14 and node A18 initiates replacement of A15. (d) For constant condition, more nodes (indicated as grey nodes) are concerned within the recovery method once RIM is applied. This is often the key advantage of Le-MotoR over RIM. Fig.7 shows the operating of Le-MoToR.

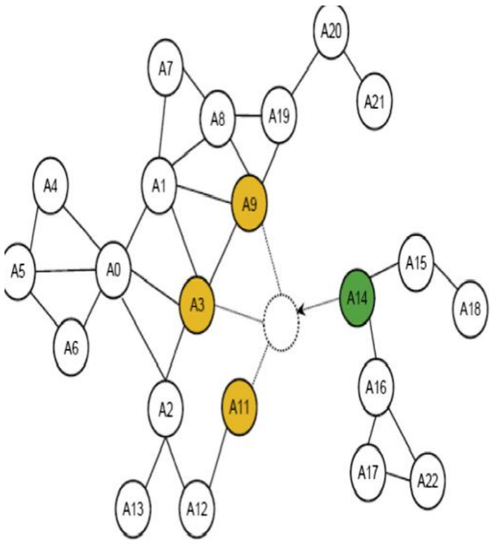

Fig.7(a)

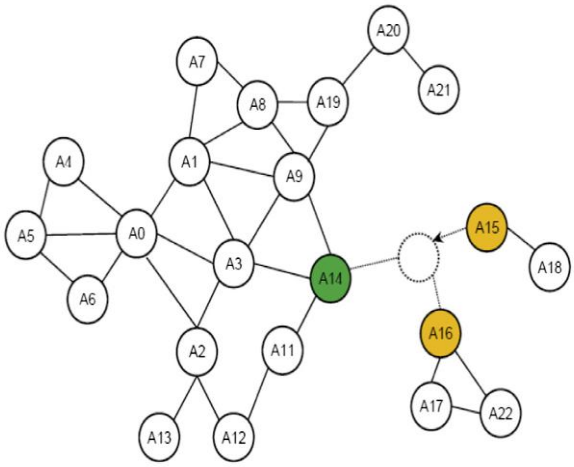

Fig.7(b)

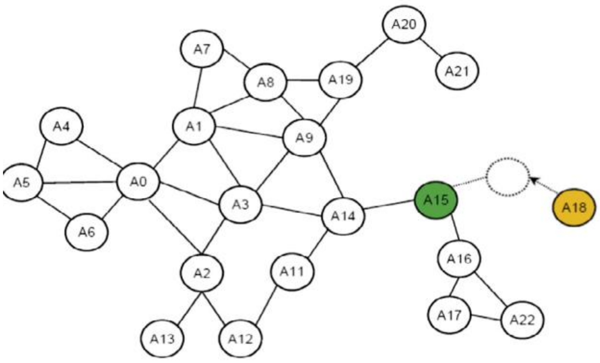

Fig.7(c)

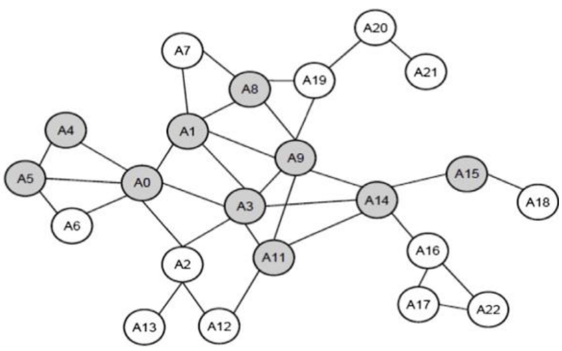

Fig.7(d)

3.6 k-Connected Hybrid Relay Node Placement(CHRNP)

This approach helps in maintaining the federation problem either by placing of relay nodes or relocating the existing node for establishing the connections again. For every portion, single stationary relay nodes are positioned on the line connecting to CoM. Thus these nodes forms the ring .Mobile data collectors are positioned to connect the segments in the network. Convex hull algorithm is used to find the evocative node from every segment. Therefore the ring topology is created around the CoM. Here every node is k-connected, so traffic load is distributed evenly and it therefore ensures robustness, Average end to end delays, Packet Delivery Ratio, Throughput (Bits/sec) are optimized while maintaining connectivity within the network. .

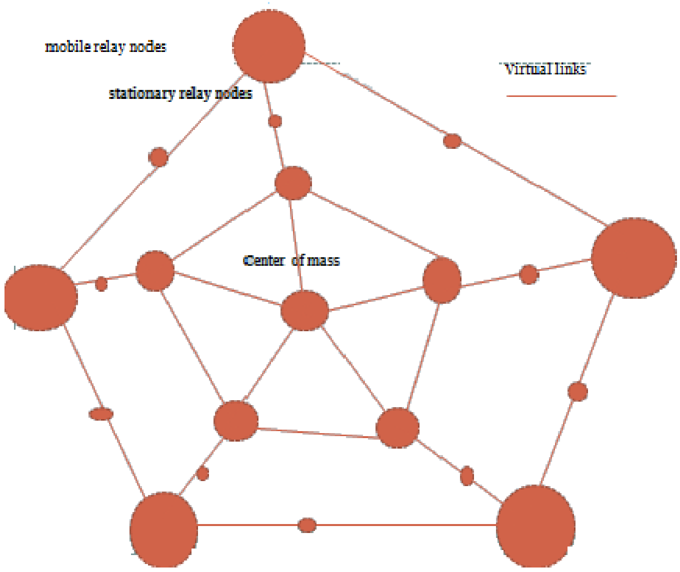

Fig.8 (a) k-connected topology

For avoiding node failure, relay nodes are placed so just in case if any harm happens to the prevailing nodes, the functioning of the network continues to be not affected. Fig. 5. Since these sensing element nodes u and v have dissimilar radio ranges, for building associate uneven transmission link between them additional relays are required, as shown in Fig. 5(b).

Between 2 sensor nodes u and v, the minimum number of relay nodes (black circles) is placed to create (a) a one-way or (b) two-way steinerized path. The idea is to have every relay reach 2 consecutive Steiner points on the path so that u and v stay connected even if any relay is lost.

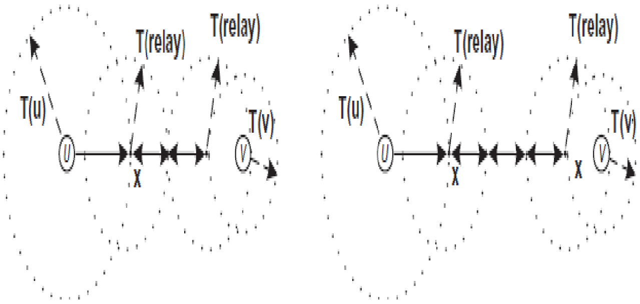

Fig.8(b)

3.7 Fault Tolerant Multipath Routing scheme (FTMRS)

For node fault identification and recovery in WSN, theme of multipath routing is planned. Only one shortest path is employed for routing the info associate alternative two backup ways square measure treated as an uncommon track for faulty network and for handling burdened traffic at main channel. This shortest path information routing guarantees energy effectiveness information routing.

In this technique, every and each cluster member node delivers information to CH. Cluster head aggregates all cluster member information and transmits it to base station[16]

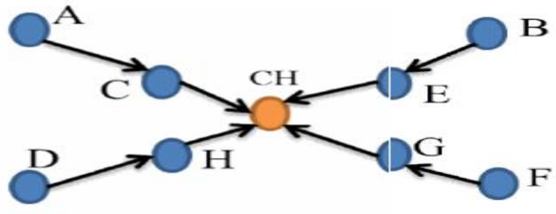

Fig.9 (a)

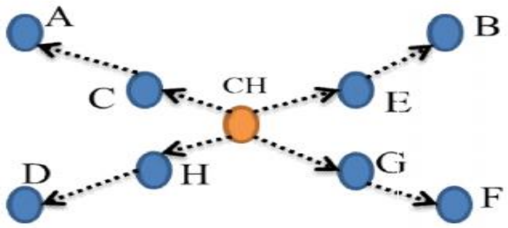

Fig.9 (b) Data transmission policy in FTMRS technique

In Figure 9(a) Nodes A, B, D, F sends their knowledge to CH that's nearest to nodes C, E, H, and G severally. If node failure or communication fault doesn't happens, then when knowledge received by the cluster head's nearest nodes C, E, H, associate degree G sends an acknowledgement (Fig (b)). Similarly, cluster head nearest nodes C, E, H and G send their knowledge to cluster head CH.

Recovery method In FTRMS takes place as follows:

In the FTMRS if communication fault or node fault happens , then supply nodes A, B, D or F doesn't receive any acknowledgment message thus they sends their knowledge through various path. In Fig 10(a) A to C node communication fault happens, thus 'A' transmits once more sensing knowledge to node D .Also, if node fails, node 'B' transmits its knowledge to node 'F'. Although, node F doesn't get any acknowledgment message from G; so it transmits it once more to D node (Fig 10.b). Similarly, CH transmits their knowledge to the BS [6].

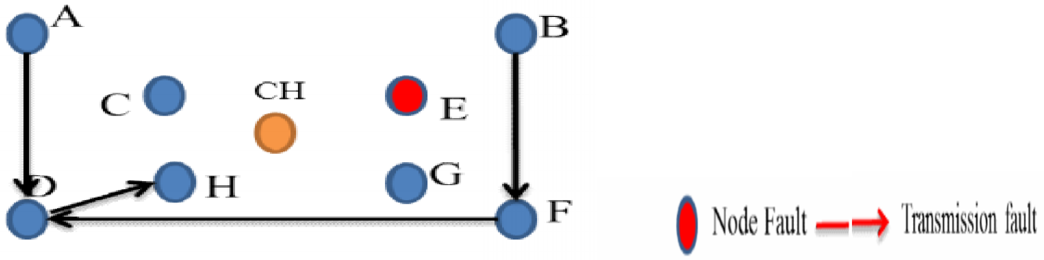

Fig.10(a)

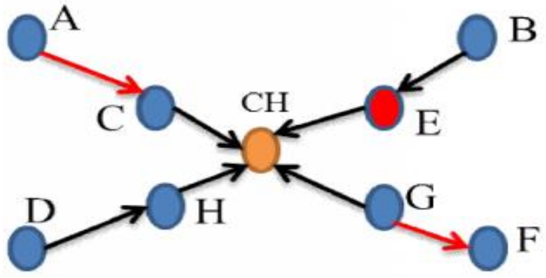

Fig.10 (b) Fault recovery policy in FTMRS technique

In Fig 11(a) once node 'E' sends knowledge to cluster head then transmission fault takes place. Owing to that 'E' transmits knowledge to node 'C'. Once 'C' receives E's message then it sends knowledge through accessible shortest path, as is shown in Fig (b), through node 'H'. Rather than initial multipath propagation of, it sends the info by one shortest path [5]. However, if transmission faults happens therein route then it sends the info through various backup routine. Therefore, energy spread for multipath knowledge propagation is saved in FTMRS.

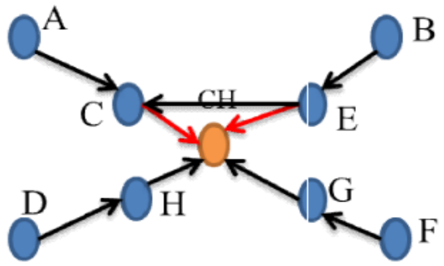

Fig.11 (a) Data Traffic management in FTMRS technique

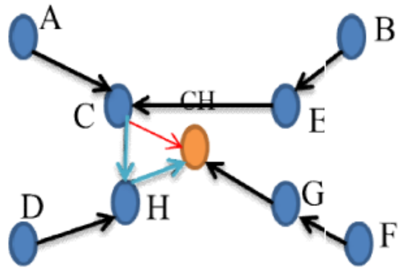

Fig.11 (b) Data Traffic management in FTMRS technique

4. CONCLUSION

In many cases WSNs operate in inhospitable setups, for example battlefield, and the node becomes bounded to expand the risk of getting impaired. A convincing research has been done in this direction to restore connectivity in partitioned WSNs, though there are several directions that need further exploration. A summary of published schemes under these categories has been provided. Within each category, further analysis has been made to highlight the different features. Based on these features, the advantages and disadvantages of the recovery approaches have been discussed. The paper also enlists a number of open issues, unexplored ideas and variants of the recovery problem that warrant further investigation.

5. REFERENCES

[1] I.F. Akyildiz, W. Su, Y. Sankarasubramaniam, and E. Cayirci, "A Survey on sensor networks," IEEE communications Magazine, vol. 40. no. 8, pp. 102-114, August 2002.

[2] Yuanjiang Huang, José-Fernán Martínez, Vicente Hernández Díaz, and Juana Sendra," Localized and Energy-Efficient Topology Control in Wireless Sensor Networks Using Fuzzy-Logic Control Approaches" Volume 2014, Article ID 973163, 11 pages.

[3] G. Vennira Selvi 1, R. Manoharan 2," Cluster Based Fault Identification And Detection Algorithm For WSN- A Survey," International Journal of Computer Trends and Technology (IJCTT) – volume 4 Issue10 – Oct 2013.

[4] Ameer Ahmed Abbasi, Kemal Akkaya, Mohamed Younis," A Distributed Connectivity Restoration Algorithm in Wireless Sensor and Actor Networks" 32nd IEEE Conference on Local Computer Networks.

[5] PrasenjitChanak,TuhinaSamanta,Indrajit Banerjee,"Fault-Tolerant Multipath Routing Scheme For Energy Efficient Wireless Sensor Networks" International Journal of Wireless & Mobile Networks (IJWMN) Vol. 5, No. 2, April 2013.

[6] G Siva Kumar, Dr. I. SanthiPrabha," Node Failure Recovery in Wireless Sensor and Actor Networks (WSAN) using ALeDiR Algorithm" International Journal of Engineering Research and General Science Volume 2, Issue 6, October-November, 2014

[7] Vijayvignesh Selvaraj1 and A. Pravin Renold2," k-Connected Hybrid Relay Node Placement In Wireless Sensor Network For Restoring Connectivity" ICTACT Journal On Communication Technology: Special Issue On Advances In Wireless Sensor Networks, June 2014, Volume: 05, Issue: 02

[8] A. Abbasi, M. Younis, U. Baroudi, A least-movement topology repair algorithm for partitioned wireless sensor-actor networks, Int'l Journal of Sensor Networks 11 (4) (2012) 250–262.

[9] Muhammad Imran,Mohamed Younis ,Abas Md Said, and Halabi Hasbullah," Volunteer-instigated Connectivity Restoration Algorithm for Wireless Sensor and Actor Networks.

[10] K. Akkaya, A. Thimmapuram, F. Senel, S. Uludag, Distributed recovery of actor failures in wireless sensor and actor networks, in: Proc. of the IEEE Wireless Comm. and Networking Conf. (WCNC'08), Las Vegas, NV, March 2008.

[11] M. Younis, S. Lee, A.A. Abbasi, A localized algorithm for restoring inter-node connectivity in networks of moveable sensors, IEEE Transaction on Computer 59 (12) (2010) 1669–1682.

[12] A. Abbasi, M. Younis, U. Baroudi, Restoring connectivity in wireless sensor-actor networks with minimal topology changes, in: Proc. Of the IEEE Int'l Conf. on Comm. (ICC 2010), Cape Town, South Africa, May 2010.

[13] A. Abbasi, M. Younis, U. Baroudi, A least-movement topology repair algorithm for partitioned wireless sensor-actor networks, Int'l Journal of Sensor Networks 11 (4) (2012) 250–262.

[14] L. Paradis and Q. Han, " A survey of fault Management in wireless Sensor Networks," Journal of Network and System Management, vol. 15, no. 2, pp. 170-190, June, 2007.

[15] Che-Aron. Z, Al-Khateeb, W.F.M., Anwar.F, "ENFAT-AODV: The Fault-Tolerant Routing Protocol for High Failure Rate Wireless Sensor Networks", in Proc. 2nd International Conference on future computer and communication (ICFCC), 2010, pp.467 -471

[16] AzzedineBoukerche, Richard Werner NelemPazzi, Regina Borges Araujo, "Fault- tolerant wireless sensor network routing protocols for the supervision of context-aware physical environmental", Journal of Parallel and Distributed Computing, vol. 66, no. 4,pp. 586–599, April 2006.

[17] Mohamed Younis, Izzet F. Senturk , Kemal Akkaya, Sookyoung Lee , Fatih Senel," Topology management techniques for tolerating node failures in wireless sensor networks: A survey", Computer Networks 58 (2014) 254–283.

[18] S.Sathish,A. Lawrance, Ramesh, G. Sarath Kumar," A Survey on Node Recovery from a Failure in Wireless Sensor Networks" International Journal of Advanced Research in Computer Science & Technology Vol. 2 Issue 1 Ver 2 Jan-March 2014.