International Journal of Innovative Technology and Exploring Engineering (IJITEE)
ISSN: 2278-3075 (Online), Volume-8 Issue-10, August 2019

Node Failure Handling Through Localized Relocation over Wireless Sensor Network

Jaspreet Kaur, Amit Kumar Bindal

***Abstract:** Communication over WSN under environmental hazards is a major issue. These constraints may have an impact over the behavior of the sensors/routing protocols and resource consumption; thus, may lead to the node failure condition i.e. software/hardware failure, security threats, excessive energy consumption, etc. It is necessary to analyze the impact of failure over network performance. In this paper, a node failure management solution is proposed, and its performance is analyzed using different protocols i.e. LEACH, AODV, and DSDV.*

***Keywords:** Reliability, WSN, Node Failure.*

I. INTRODUCTION

Sensors can be deployed over a large area. Multi-hop data forwarding is used by intermediate nodes, and there is no centralized monitoring node which can ensure the reliable end to end communication. Sensors based communication is prone to failures; thus, results in data loss, QoS degradation, link breaks, and network breakdown, etc. Fault finding and its diagnostics methods cause extra control overhead which can further degrade the network performance. Each node has limited transmission power, and it covers a specific region only. Node failure in a sensitive region can reduce the overall coverage area, and multiple node failures may also lead to the network partitioning [1-7] as shown in Fig. 1.

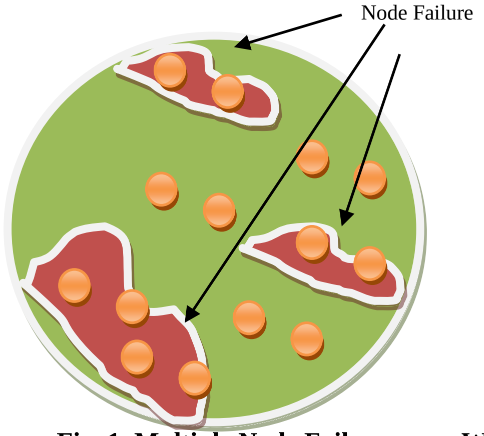

Fig. 1. Multiple Node Failures over WSN

Manuscript published on 30 August 2019.
*Correspondence Author(s)
Jaspreet Kaur, Research Scholar, Department of Computer Science & Engineering, Maharishi Markandeshwar (Deemed to be University), Mullana, Ambala, India.
Dr. Amit Bindal, Assoc. Professor, Department of Computer Science & Engineering, Maharishi Markandeshwar (Deemed to be University), Mullana, Ambala .India,

II. BARRIERS FOR FAULT DETECTION METHODS

Following are the constraints for fault detection and recovery provisions:

A. Node Energy:

Battery lifespan of each node is very limited, and energy is consumed by different network operations. If a fault detection and recovery scheme are introduced, it may further consume excessive energy, and may reduce the overall lifespan of the intermediate nodes.

B. Node Failure Types:

There may be different reasons for the node failure i.e. fault may occur at a hardware level, a node may transmit error-prone data due to software fault or node may be dead due to any physical damage or battery depletion. So, there is a need to develop different mechanisms to handle the different types of faults. Software faults can be rectified by overwriting the existing framework whereas, in case of a hardware fault, the node must be replaced.

C. Degree of Accuracy:

Accuracy of fault detection method also suffers from environmental hazards. Single node failure may lead to the multiple node failures; and thus, may degrade the overall network performance [29].

III. NODE FAILURE, FAULT TOLERANCE AND RECOVERY SOLUTIONS FOR WSN

Following are the solutions offered by different researchers in the relevant domain:Static sinks consume excessive energy due to the processing of huge volume of data which is forwarded by neighbor nodes, and link failure triggers the data loss as well as topology deformation. A. Hawban et al. [8] resolved these issues by replacing static sinks with mobile sinks and developed a scheme that uses trees to track the changes at a topological level, and these are updated as a mobile sink changes its location or any other mobile sink is used for data gathering. It regulates the load to various sinks as well as it can also merge the multiple paths to reduce the number of hops towards sinks. Nodes nearby base station are exhausted due to excessive load variations. Energy conservation and traffic scheduling both are prime concerns for sensor networks, and these parameters are affected by the

*Retrieval Number: J94460881019/19©BEIESP
DOI: 10.35940/ijitee.J9446.0881019
Journal Website: www.ijitee.org*

*Published By:
Blue Eyes Intelligence Engineering
and Sciences Publication (BEIESP)*

performance of routing protocol as well as clustering scheme being used. For each issue, researchers offer different solutions but S. Din et al. [9] combined these issues for software-defined sensor networks and developed a single solution for the same. It establishes a relation between the routing protocol and clustering scheme. All nodes are sub classified as forward/ non-forward/ backward/ backup/ decision maker. Inter and Intra clusters based routing is initiated using these node types and rotation of cluster heads is performed to reduce the energy requirements. The Simulation shows that fewer hop counts are required to form clusters with minimum delay. It also conserves the node's energy level.

A. Farhat et al. [10] investigated the impact of various network topologies (Hierarchical /Centralized / Distributed and decentralized topology) at the application level. Study shows that incompetent topology design not only results in less coverage/connectivity but also produces redundant data which further effects data aggregation process.

In the case of dynamic and heterogeneous environments, communication between SDN and ordinary sensors may produce extra control overhead. N. Abdolmaleki et al. [11] developed a fuzzy logic based topology discovery scheme uses the beacon to exploit the attributes (Address/Energy) of each neighbor to build routing rules. Cost of forwarding is estimated on the basis of the number of existing neighbor(s), current queue length, energy level Current sink extract the required information and that is finally forwarded to the controller. Data exchange under the constraints of control plan conserves energy, reduces packet loss and improves the life span of the network.

Jian et al. [12] investigated the clustering issues related to the transmission over the heterogeneous environment. The Study correlates these issues with a linear optimization problem. Authors suggested a centralized process to initiate the clustering and routing (jointly) in iterations. It explores for the factual clustering between nodes and constructs intra-cluster routing information simulation-based analysis shows that it can extend the network life span. The proposed method can also be improved to handle the contention at MAC Layer.

Quality of transmission is degraded due to weaker links/packet drops. All these factors initiate retransmission; thus, further consumes energy, and it may reduce the node's life span. X. Hao et al. [13] proposed a scheme which can identify the possible links, and then, perform sorting to amend the node's transmission power. Finally, it constructs a robust distributed topology with high superiority links. The simulation shows that it significantly improves the node's life span as well as reduces the packet retransmission.

J. Gui et al. [14] investigate the relationship between energy consumption and node's density and proposed a topology control scheme that performs under the constraints of node density, neighbor density, and network capacity/node's capacity by regulating energy and capacity as per requirements. The simulation shows that it can manage the above discussed-factors as compared to MST-based schemes, and it can be extended to meet the requirements of dynamic applications.

T. Muhammed et al. [15] studied the influence of hostile circumstances over network performance. It shows that hostile conditions may cause communication failure, hardware level faults, QoS degradation, and frequent updates at the topological level. Authors explored and compared the various fault detection/tolerance methods (Sequence Based Fault Detection/FIND/Centralized algorithm based on Native Bayes framework named/Hidden Markov Models/Detecting soft and hard faults/ distributed Bayesian algorithm) developed by researchers which can be classified as Centralize/Distributed/Hybrid.

Z. EnxingLiu et al. [16] proposed an ant colony based scheme for routing over sensor network that constructs the multiple paths using pheromone factor (used to select next hop) and it is updated through broadcasting. Instead of traversing entire topology, ants are used to initiate local search, and routing decisions are made under the constraints of shortest path/node's energy level. The simulation shows its performance in terms of improved network life span.

Topology control under the constraints of a hostile environment is a major issue. It includes excessive energy consumption at the node level, hardware failure due to environmental effects, and performance degradation due to security threats, etc. S. Hu et al. [17] focused on these issues, and introduced a hexagonal-based clustering method that offers fault tolerance capabilities against above-discussed issues, and it can be extended further by introducing the concept of backup nodes to handle network failure.

J. Zhu et al. [18] addressed the issues related to energy consumption and node recharging and introduced a method which can estimate the energy consumption rate dynamically. First of all recharging probability of the nodes is calculated, and then, candidates which have the smallest recharging interval are selected. The analysis indicates its performance in terms of low recharging delay, efficient management of node's failure, and optimal recharging cost.

S. Xia et al. [19] studied the impact of node failure over the network performance and suggested a framework to ensure reliable communication. Study discovers the association between the node's capacity and the overhead tolerance threshold, and the impact of these factors over the transmission. The analysis shows that the selection of node elimination scheme and the system complexity also act as barriers for network performance.

P. Sun et al. [20] investigated the issues related to network connectivity and developed a method to manage the node's failure. It uses different parameters i.e. frequency/ probability/ density of the node's failure over a given topology. The analysis shows that node density affects the ratio of connectivity/ failure. Even a single node failure can interrupt the connectivity; thus, may degrade the overall network performance.

P. Billand et al. [21] investigated the causes of network failure and found the critical factors, those are responsible for performance degradation i.e. failure of link/node/security threat, etc. Authors suggested a network formation model that can analyze the failure scenarios and connectivity conditions.

H. Ran Liu et al. [22] examined the network behavior under the effect of cascade failure and developed a scalable topology based method which can ensure robust communication under these constraints. It regulates the load distribution with respect to the node's load and their residual energies to cope with failures.

Retrieval Number: J94460881019/19©BEIESP
DOI: 10.35940/ijitee.J9446.0881019
Journal Website: www.ijitee.org

Published By:
Blue Eyes Intelligence Engineering and Sciences Publication (BEIESP)

The analysis found that the association between the node's degree and load pay against these failures.

S. Chouikhi et al. [23] investigated the concurrent node failure due to environmental hazards and developed a recovery scheme that utilizes relay nodes to overcome these types of failures. The faulty area is subdivided into multiple regions, and heuristic estimation is used to relocate the relay nodes. Each relay node recognizes its current neighbors and claims for the channel access. In case of multiple requests, the slot is reassigned to the relay node which has the maximum number of member nodes. The simulation-based comparison with an existing scheme (DROMS) indicates its performance in terms of efficient connectivity and maximum coverage under the hostile constraints. The current study can be further utilized to develop generic fault tolerance and recovery methods.

T. Stanzin et al. [24] proposed a solution to handle the single node failure using a minimum spanning tree (MST) which is used to exchange routing information between sender and receiver. In case of any fault, a replacement set is formed to swap the faulty nodes and analysis displays that it outperforms in terms of less control overhead with respect to node density.

More et al. [25] proposed a scheme to manage the node failure in sensor networks. It utilizes the energy depletion information to compute the back off time for the nodes. If a nearby node gets down only then its neighbor node becomes active. It also calculates the degree of redundancy to ensure the maximum coverage area but it does not resolve the connectivity issue, in case of any failure. The analysis shows that it can perform periodic coverage checks only and does not have any robust fault tolerance. Authors may extend the capabilities of proposed schemes.

B. Varghese et al. [26] introduced the swarm based fault tolerance capabilities to handle the single node failure using mobile agents. These agents can sense the environment/current location and hazards etc. and can traverse from one node to another node. These initiate the end to end probing and exchange the node failure information with neighbor nodes. It can manage the faults efficiently as compared to existing methods. It can be further extended to handle concurrent failures over large scale networks.

M. Salari et al. [27] studied the influence of node failure over the link flow inference and developed a solution which can ensure the least require node density for robust connectivity and objective function. Authors also found that the degree of node redundancy can be utilized to overcome from the node failure events. It can be further extended to develop an optimal fault tolerance model.

R. Begum et al. [28] did a survey of various factors, those triggers the failure events in sensor networks, their types, and the remedies. The study found that excessive computational load, energy consumption, and environmental hazards are the main causes of node failure. The fault may occur at the software and hardware level. In case first case, the node can exchange error-prone data with others but it will remain connected to the network. This fault can be rectified by software update whereas, in case of hardware failure, the node may be replaced. Faults can be detected using various methods i.e. neighbors can sense the faulty node, cluster heads can be used to analyze the member behavior, round trip pried, estimation of connected edges, etc.

S. Jia et al. [29] focused on the unfair utilization of the energy which may cause the node failure and introduced a fault detection method which uses a time/spatial correlation equation to detect the faulty nodes. Each node examines the collected data to identify the faults but nodes do not share the fault information with neighbor thus reduce the overall energy consumption. As compared to the traditional scheme, it outperforms in terms of fair resource utilization and accuracy. It can be further extended for efficient routing/transmission.

Y. Cheng et al. [30] developed a fault detection scheme which utilizes super vector regression to predict the faults. Multiple nodes produce the statistics which is further used to build a prediction model and an individual node is verified on the behalf of reliable nodes only. Results show its performance in terms of higher accuracy and fewer false alarms as compared to existing scheme (distributed Fault Detection).

R. Ranjan et al. [31] investigated the various types of faults (hard/soft/intermittent/transient) occur in a sensor network and introduced a MAC protocol that utilizes the time division for load balancing/transmission. Time out is used to identify the hard faults whereas variance test is conducted to find out soft faults. Results show its performance in terms of detection accuracy, fewer fault rates, etc. It can be implemented for Under Water Sensor Networks/ Vehicular Ad-Hoc Networks/ Body Area Sensor Networks.

R. R. Swain et al. [32] examined the causes of fault occurs due to the network environment and natural hazards and developed a solution which operates in multiple phases: initialization/ detection/ Classification/ tolerance. In the initial phase, nodes are deployed and links are established. In the detection phase, checksum method is used to recognize the faults and Gaussian method is used for classification purpose and finally, using regression prediction is done. Results show its performance in terms of detection accuracy, less false alarms, rate of classification/diagnosis, etc. However, the failure of the cluster head and classification rate may degrade the overall per romance. It can be further extended to support the IoT.

IV. NODE FAILURE HANDLING THROUGH RELOCATION OVER WSN

In this paper, we explored the issues and solutions related to node failure and recovery and developed a node failure management scheme which replaces the faulty nodes in local zones only. Following is the procedure for handling the node failure:

WSN Wireless Sensor Network
BS Base Station
D Dataset
n: a/b/c/d Sensor Nodes
Aan/Ban/Can/Dan Anchor nodes
Fn Faulty Node
Cn Candidate Node
Dpa Deployment Area
Cl Current Location
Ll Last known Location
R Range
Rg Region
Enl Energy Level

Published By:
Blue Eyes Intelligence Engineering
and Sciences Publication (BEIESP)

NNF Nearest Neighbor First
Z Zone
X Number of Zones Required
NN All Sensor Nodes
eTH Energy Level Threshold
nf Not Found

Algorithm

1. Initialize WSN
2. Initialize Nodes NN: (a/b/c/d)
3. Set Anchor nodes Anch: Aan/Ban/Can/Dan
4. Identify the Dpa, Define Rg and Z_i
5. Deploy (Dpa, NN, Anch)

   Divide the Dpa to four equal zones: Dpa/x, and NN/x is the number of nodes to be deployed over a particular zone. It is an assumption that at least one anchor node is required per zone for the reference of NN/x node population. If node density increases up to twice in a zone then twice number for anchor nodes will be required.

6. Start Localization (Anch)

   La=Get_Location(Anch)

7. for each NN->n

   Get Disti=1/2 {(ni->Rx,ni ->Tx)-(Anch ->Tx, Anch ->Rx)}
   Set ni->Cl=(Disti, La)
   End For

8. Update LocationData(Anch, NN)
9. Generate location dataset

   A1 = {a1, a2, a3, a4, …, an, Aan}
   B2 = {b1, b2, b3, b4, … , bn, Ban}
   C3 = {c1, c2, c3, c4,…, cn, Can}
   Dn = {d1, d2, d3, d4, .., dn, Dan}
   Set D {A1, B2, C3, Dn}

10. Update (BS->Dataset, D)
11. If (NN->ai.Reponse==NULL&&Bs->Dataset! = D)

    nf=Find(D, NN->ai.Cl, NN->ai.Ll)
    If (nf==1)
    Update (D, NN->ai.Location, ID)
    Send (D, BS)
    BS.invoke(node_relocation, D)
    End if
    End if

12. Node_Relocation (D)

For Each ai in Zi
If (minimum (ai->Cl, Fn-Cl)==True && ai->En, eTH)==True
&& (relocation (ai->Cl, Fn->Cl && ai->R==True)
ai-> NNF =True
ai->Relocation==True
Else
ai->Relocation==False
End if
If (ai->Relocation==True)
Set ai->Cl= Fn->Cl)
Update (D, NN->ai.Location, ID)
Send (D, BS)
End if
End For

As shown in Fig. 2, first of all, the entire region is subdivided into multiple zones, and nodes are deployed in each zone. In each zone, at least one anchor node is deployed which is responsible to support the localization process. Neighbor nodes localize themselves using anchor nodes. Finally, a data set is formed which contains the first known location of each node w.r.t. zones (step: 10).

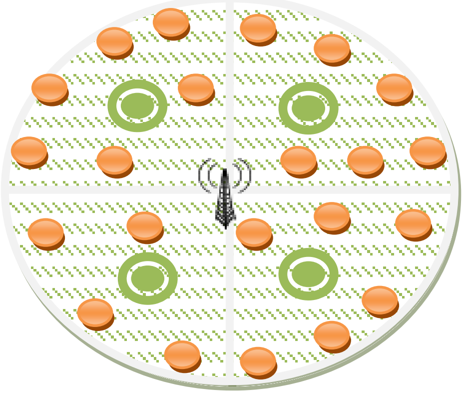

Fig. 2. Anchor based localization process

Each node participates in the localization process and starts data transmission. Node locates itself using location and distance of the anchor nodes. List of neighbor nodes is also maintained by anchor nodes, and it is updated periodically and matched with the previous list.If any node is not responding, this is considered as faulty node, and current and last known location datasets are compared and the missing node id with its last known location is obtained; then, base station is informed about this event, and if node failure reduces the overall coverage area; then, base station matches its dataset with the current one, and if there is any mismatch found; then, it invokes a relocation process to recover the coverage area. Nearest Neighbor First for relocation is calculated using the following parameters:

Neighbor node Minimum distance from faulty node location

- It must remain in the range after relocation
- It must have enough energy to afford movements
- After relocation, route discovery is initiated, if required.

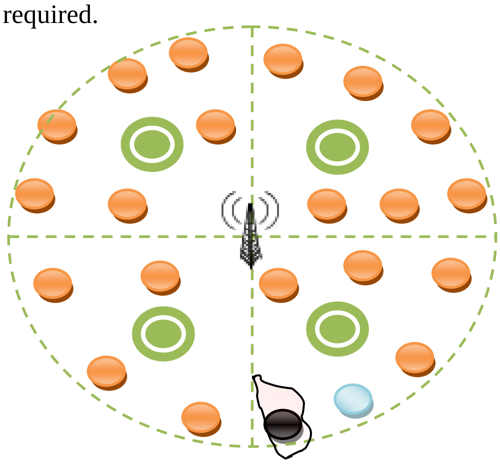

Fig. 3. Marking of a single Node Failure inside a region

Retrieval Number: J94460881019/19©BEIESP
DOI: 10.35940/ijitee.J9446.0881019
Journal Website: www.ijitee.org

Published By:
Blue Eyes Intelligence Engineering and Sciences Publication (BEIESP)

International Journal of Innovative Technology and Exploring Engineering (IJITEE)
ISSN: 2278-3075 (Online), Volume-8 Issue-10, August 2019

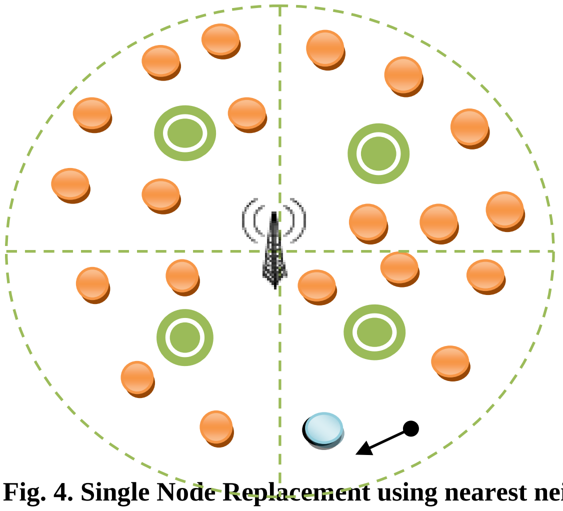

Fig. 4. Single Node Replacement using nearest neighbor w.r.t. current region

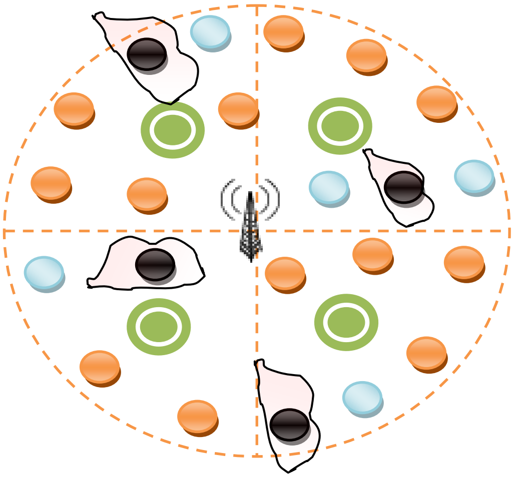

Fig. 5. Multi Node Failure scenarios

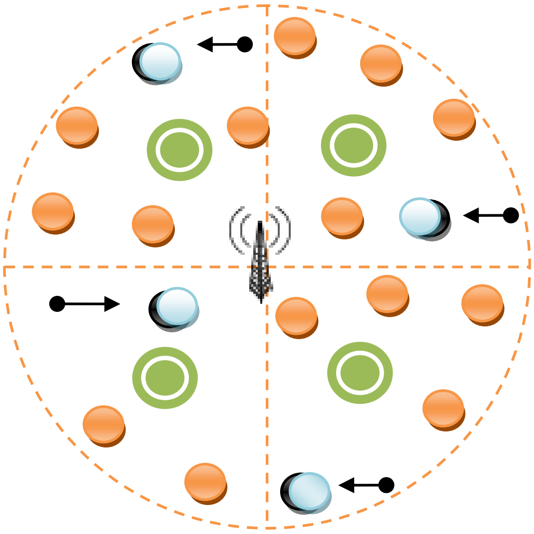

Fig. 6. Node Displacement To Handle Multi Node Failure

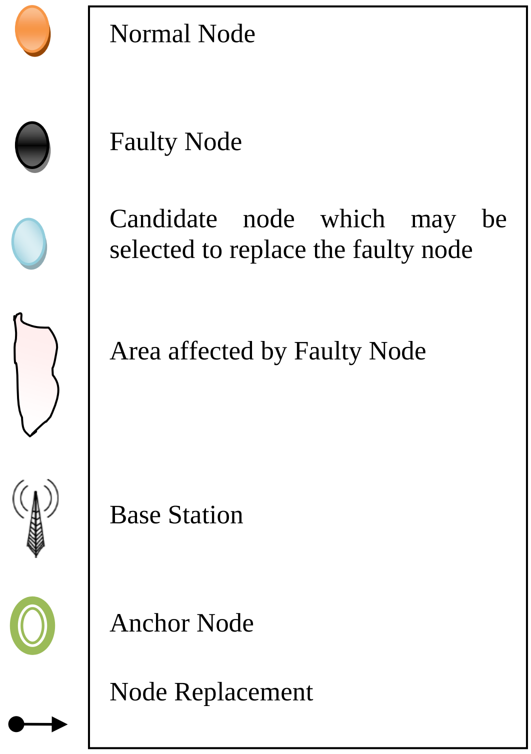

Table-I displays the simulation configuration for node failure scenarios. Network simulator I s Ns-2.34 for simulations with the different parameters i.e. Routing protocols (AODV/LEACH/DSDV), MAC 802.11, Data type is Temperature, sampling interval is 5.0ms, simulation time is 10 seconds, Initial Energy is 10.0j, receiving/transmission power is 0.5/0.5, Interface Queue length is 200 Packets, Antena Type is Omni and Mobility Model is RandomWay Walk, Node's Speed is 20ms, Propagation Model is TwoRay Ground, node density is 50/100 and Terrain is 1200x1200.

Table-I Simulation Configuration

Simulation Parameters	Parameter Values
Routing Protocol(s)	AODV, LEACH, DSDV
Terrain	1200x1200
MAC Protocol	802.11
Node Density	50/100
Propagation Model	TwoRay Ground
Data Type	Temperature
Sampling Interval	5.0 ms
Simulation Time	10 seconds
Network Simulator	NS-2.34
Initial Energy	10.0j
rxPower	0.5
txPower	0.5
IFQ	200 Packets

Retrieval Number: J94460881019/19©BEIESP
DOI: 10.35940/ijitee.J9446.0881019
Journal Website: www.ijitee.org

Published By:
Blue Eyes Intelligence Engineering and Sciences Publication (BEIESP)

Antena Type	Omni
Mobility Model	RandomWay Walk
Node's Speed	20ms
Simulation Scenario(s)	a. Normal Environment b. Node Failure c. Node Failure Management

Fig. 7. displays the variations of Throughput of various routing protocols under the constraints of node failure and recovery events using 50 nodes. In a normal scenario, approximately all protocols performed well but during node failure situations, their performance is degraded. In case of recovery, Recovery through Inward Motion (RIM) scheme tried to recover the network from failure and slightly enhanced the performance of routing protocols but NFR enhanced the overall performance of each protocol. It is highest for AODV, followed by DSDV, and it is lowest for LEACH.

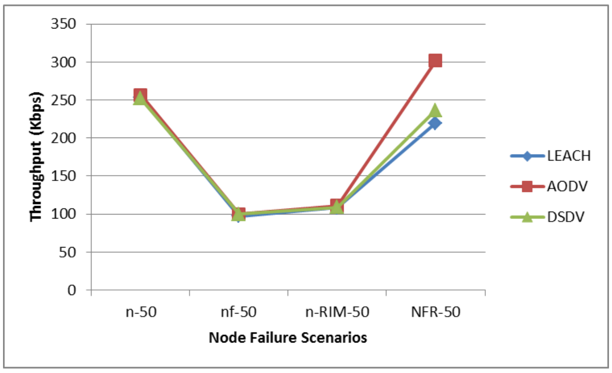

Fig. 7. Throughput-Nodes-50

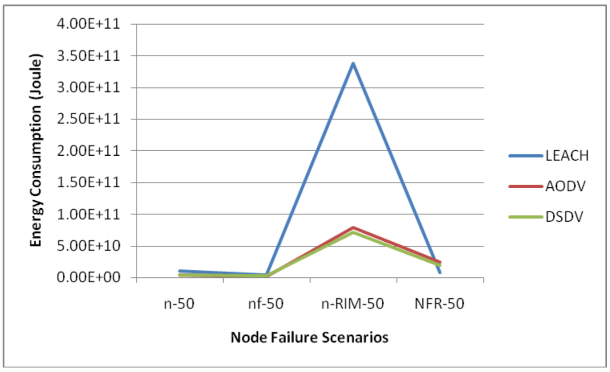

Fig. 8. Energy Consumption-Nodes-50

Fig. 8 shows the energy consumption of different routing protocols using various scenarios. In the case of a normal network environment, energy consumption is slightly less which is further reduced due to node failure. In the case of RIM, it reaches up to its peak value using LEACH as compared to AODV/DSDV whereas, in the case of NFR, it is reduced to the lowest level.

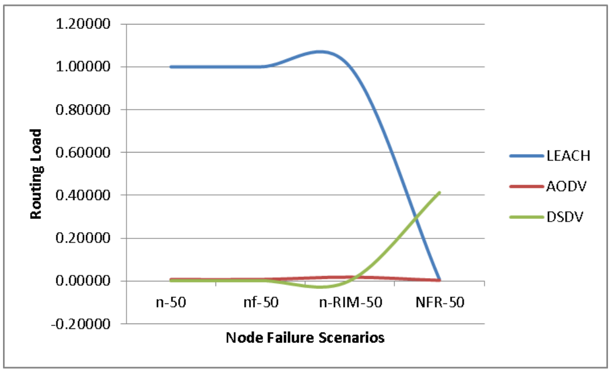

Fig. 9. Routing Load –Nodes-50

Fig. 9 shows the variations in routing load of different protocols using various scenarios. In the case of normal network environment/ node failure, it is almost negligible for AODV/DSDV and it is highest for Leach. Using RIM, it is further increasing and NFR reduces it to its lowest level for Leach/AODV and DSDV suffers from the moderate routing load.

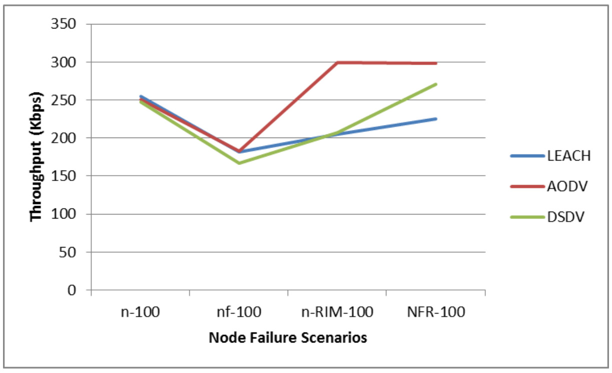

Fig. 10. Throughput-Nodes-100

Fig. 10 displays the variations in Throughput using different protocols with node density 100. In the case of normal scenario, all protocols delivered the highest Throughput which is degraded in node failure circumstances. RIM tried to improve, it is average for DSDV /LEACH but in the case of NFR, it is lowest for DSDV followed by LEACH, and it is the highest for AODV.

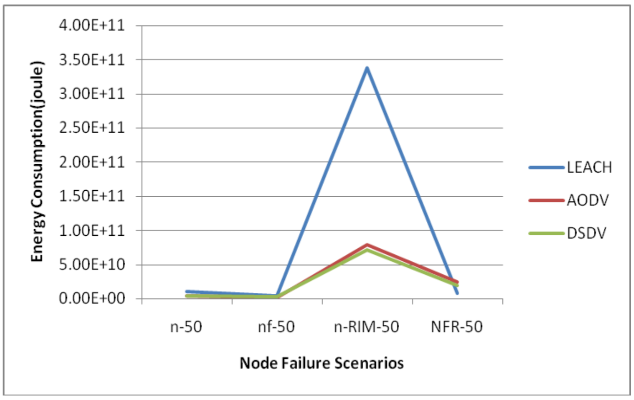

Fig. 11. Energy Consumption-Nodes-100

Retrieval Number: J94460881019/19©BEIESP
DOI: 10.35940/ijitee.J9446.0881019
Journal Website: www.ijitee.org

Published By:
Blue Eyes Intelligence Engineering
and Sciences Publication (BEIESP)

Fig. 11 shows the energy consumption of different routing protocols using various scenarios. In case of normal network environment/ node failure, energy consumption is slightly but in case of RIM, it reaches up to its peak value using LEACH followed by AODV and DSDV which consumed quite less energy. In the case of NFR, it is reduced to an optimal level.

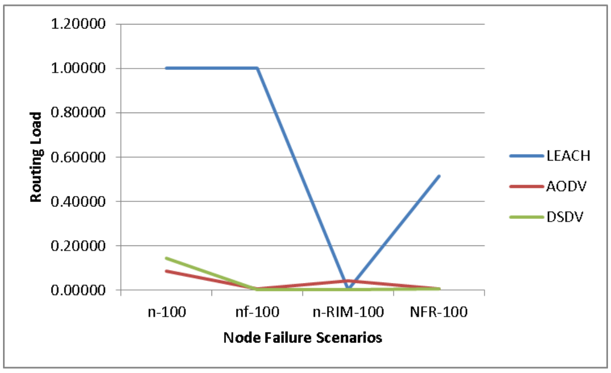

Fig. 12. Routing Load-Nodes-100

Fig. 12. shows the variations in routing load of different protocols. In the normal scenario, it is at an acceptable level. However, it is declined due to node failure situation. Using Rim, it little bit varies. In the case of NFR, Leach suffers from the highest routing load as compared to others.

V. CONCLUSION

In this paper, a node failure management scheme is introduced which can identify the multi-node failures in a given network and replaces the faulty nodes with its concurrent eligible candidate nodes. The simulation illustrates that routing overhead little bit varies but, it outperforms in terms of Throughput and energy consumption as compared to the existing scheme, called RIM under the constraints of node density. It can also be observed that behavior of each routing protocol changes under the node failure and recovery circumstances, as well as results, also vary under the constraints of node density. Under node density constraints (50/100 nodes) AODV outperforms as compared to others. LEACH could not perform well and DSDV is the average performer. It can also be observed that LEACH consumed excessive energy as compared to others. Node failure management scheme is a protocol independent scheme. Currently, it does not support the network partitioning caused by node failure, which will be implemented in the future.

REFERENCES

1. A. Hossain, "On the impact of node failure on network coverage in wireless sensor network" 5th International Conference on Computers and Devices for Communication (CODEC), IEEE-2012, pp.1-4
2. Dr. A. Verma, P. Kaur, J. Kaur, "Improved LeDiR technique for fault Node Recovery in Wireless Sensor Network" International Journal of Scientific & Engineering Research Vol.6 (7), IJSER-2015, pp.918-924
3. M. Younis, I. F. Senturk, K. Akkaya, S. Lee, F. Senel, "Topology management techniques for tolerating node failures in wireless sensor networks: A survey", Computer Networks, Vol.58, Elsevier-2014, pp.254-283
4. M. Imran, M. Younis, Abas Md Said, H. Hasbullah, "Localized motion-based connectivity restoration algorithms for wireless sensor and actor networks", Journal of Network and Computer Applications, Vol.35 (2), Elsevier-2012, pp.844-856
5. V. Jha, N. Prakash, A. K. Mohapatra, "Energy Efficient Model for Recovery from Multiple Nodes Failure in Wireless Sensor Networks", Wireless Personal Communications, Springer-2019, pp.1–21
6. R. Palanikumar, K. Ramasamy, "Effective failure nodes detection using matrix calculus algorithm in wireless sensor networks", Cluster Computing, Springer-2018,pp 1-10
7. P. Chanak, I. Banerjee, R. Simon Sherratt, "Energy aware distributed routing algorithm to tolerate network failure in wireless sensor networks", Ad Hoc Networks, Vol.56 Elsevier-2017, pp.58-172
8. A. Hawban, iXingfu Wang, Hassan KuhlaniSaleem KarmoshiRafia GhoulYaser SharabiEsa Torbosh, "Sink-oriented tree based data dissemination protocol for mobile sinks wireless sensor networks", Wireless Networks, Springer-2018, Vol.24 (7), pp.2723–2734.
9. S. Din, Anand Paul, Awais Ahmad, Jeong Hong Kim, "Energy efficient topology management scheme based on clustering technique for software defined wireless sensor network", Peer-to-Peer Networking and Applications, pp.1–9.
10. A. Farhat, Christophe Guyeux, Abdallah Makhoul, Ali Jaber, Rami Tawil, Abbas Hijazi, "Impacts of wireless sensor networks strategies and topologies on prognostics and health management", Journal of Intelligent Manufacturing, Springer-2017, pp.1–27.
11. N. Abdolmaleki, Mahmood Ahmadi, Hadi Tabatabaee Malazi, Sebastiano Milardo, "Fuzzy topology discovery protocol for SDN-based wireless sensor networks", Simulation Modelling Practice and Theory, Vol.79, Elsevier-2017, pp.54-68.
12. Jian, Ling Qi, Xiaolin Gui, Zhenlong Peng, "Joint design of hierarchical topology control and routing design for heterogeneous wireless sensor networks",Computer Standards & Interfaces, Vol.51, Elsevier- 2017, pp.63-70.
13. X. Hao, Weijing Liu, Ning Yao, Dehua Geng, Xida Li, “Distributed topology construction algorithm to improve link quality and energy efficiency for wireless sensor networks", Journal of Network and Computer Applications, Vol.72 Elsevier-2016, pp. 162-170.
14. J. Gui, Kai Zhou, "Flexible Adjustments between Energy and Capacity for Topology Control in Heterogeneous Wireless Multi-hop Networks", Journal of Network and Systems Management, Springer-2016, Vol.24 (4), pp.789–812.
15. T. Muhammed, Riaz Ahmed Shaikh, "An analysis of fault detection strategies in wireless sensor networks", Journal of Network and Computer Applications, Vol.78 Elsevier-2017, pp.267-287
16. Z. EnxingLiu Ranran, "Routing Technology in Wireless Sensor Network Based on Ant Colony Optimization Algorithm", Wireless Personal Communications, Springer-2017, Vol.95 (3), pp.1911–1925
17. S. Hu, Guanghui Li, "Fault-Tolerant Clustering Topology Evolution Mechanism of Wireless Sensor Networks", IEEE Access-2018, Vol.6, pp.28085-28096
18. J. Zhu, Yong Feng, Ming Liu, Guihai Chen, Yongxin Huang, "Adaptive online mobile charging for node failure avoidance in wireless rechargeable sensor networks", Computer Communications, Vol.126, Elsevier-2018, pp.28-37.
19. S. Xia, Lei Zhu, Lu Yu, Wei Tong, "Cascading failures model based on the node efficiency", Chinese Automation Congress (CAC), IEEE-2015, pp.270-274.
20. P. Sun, Nancy Samaan, "Random Node Failures and Wireless Networks Connectivity: Theoretical Analysis", IEEE Wireless Communications Letters, Vol.4 (5), IEEE-2015, pp.461-464.
21. P. Billand, Christophe Bravard, Sitharama S. Iyengar, Rajnish Kumar, Sudipta Sarangi, "Network connectivity under node failure", Economics Letters, Vol.149 Elsevier-2016, pp.164-167.
22. H. Ran Liu, Yan-Long Hu, Rong-Rong Yin, Yu-Jing Deng, "Cascading failure model of scale-free topology for avoiding node failure", Neurocomputing, Vol.260, Elsevier-2017, pp. 443-448.
23. S. Chouikhi, Inès El Korbi, Yacine Ghamri-Doudane, Leila Azouz Saidane, "Recovery from simultaneous failures in a large scale wireless sensor network", Ad Hoc Networks, Vol.67, Elsevier-2017, pp.68-76.
24. T. Stanzin, M. K. Murmu, "Minimum Spanning Tree in Cognitive Radio Networks: A Distributed Approach to Maintain for Node Failures", 9th International Conference on Computing, Communication and Networking Technologies (ICCCNT), IEEE-2018, pp.1-6.
25. A. More, V. Raisinghani, "A node failure and battery-aware coverage protocol for wireless sensor networks", Computers & Electrical Engineering, Vol.64, Elsevier- 2017, pp.200-219

26. B. Varghese, G. McKee, V. Alexandrov, "Handling single node failures using agents in computer clusters", Proceedings of the 2010 International Symposium on Performance Evaluation of Computer and Telecommunication Systems (SPECTS '10), IEEE-2010, pp.96-101.
27. M. Salari, L. Kattan, W. H. K. Lam, H. P. Lo, Mohammad Ansari Esfeh, "Optimization of traffic sensor location for complete link flow observability in traffic network considering sensor failure", Transportation Research Part B: Methodological, Vol. 121, Elsevier-2019, pp.216-251
28. R. Begum, ABID H SAYED, "sensor node failure detection in wireless sensor network: a survey", IJETCSE-2015, Vol.14 (2), pp.72-74
29. S. Jia, L. Ma, D. Qin, "Fault Detection Modelling and Analysis in a Wireless Sensor Network", Journal of Sensors, 2018, pp.1-9
30. Y. Cheng, Q. Liu,2 Jun Wang, S. Wan ,T. Umer, "Distributed Fault Detection for Wireless Sensor Networks Based on Support Vector Regression", Wireless Communications and Mobile Computing, 2018, pp.1-8.
31. R. Ranjan Swain, Pabitra Mohan Khilar, Sourav Kumar Bhoi, "Heterogeneous fault diagnosis for wireless sensor networks", Ad Hoc Networks, Vol.69, Elsevier-2018, pp.15-37
32. R. R. Swain, T. Dash, P. M. Khilar, "A Complete Diagnosis of Faulty Sensor Modules in a Wireless Sensor Network", Ad Hoc Networks, In press, accepted manuscript, In Press, Elsevier-2019, Article 101924.

AUTHORS PROFILE

Jaspreet kaur is a Research Scholar in Department of Computer Science & Engineering, M. M. Engineering College, M. M. (Deemed to be University) Mullana, Ambala, Haryana, India. Jaspreet Kaur received M. Tech from M. M. University. Jaspreet is in teaching and Research & Development since 2009. She has published about 4 research papers in International, National Journals and Refereed International Conferences. Her current research interests are in Wireless Sensor Networks.

Dr. Amit Kumar Bindal is an Associate Professor in Department of Computer Science & Engineering, M. M. EngineeringCollege, M. M. (Deemed to be University) Mullana, Ambala, Haryana, India. Dr. Bindal received PhD from Maharishi Markandeshwar University, M. Tech (Computer Engineering) from Kurukshetra University and B. Tech. in Computer Engineering .from Kurukshetra University Kurukshetra. Dr. Bindal is in teaching and Research & Development since 2005. He has published about 60 research papers in International, National Journals and Refereed International Conferences. His current research interests are in Wireless Sensor Networks, Underwater Wireless Sensor Networks, Sensors and IOT etc.

Retrieval Number: J94460881019/19©BEIESP
DOI: 10.35940/ijitee.J9446.0881019
Journal Website: www.ijitee.org

Published By:
Blue Eyes Intelligence Engineering
and Sciences Publication (BEIESP)