ISSN(Online): 2320-9801
ISSN (Print): 2320-9798

International Journal of Innovative Research in Computer and Communication Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 5, May 2015

Efficient Cluster based Fault Detection and Recovery in Wireless Sensor Network

S. Gayathridevi [1], Dr. R. Gunavathi [2]

Research Scholar, Sree Saraswathi Thyagaraja College,Thippampatti, Tamil Nadu, India[1]

HOD, Department of MCA, Sree Saraswathi Thyagaraja College, Thippampatti, Tamil Nadu, India[2]

ABSTRACT: In recent years, applications of wireless sensor networks (WSNs) have been increased due to its vast potential to connect the physical world to the virtual world. Also, an advance in microelectronic fabrication technology reduces the cost of manufacturing portable wireless sensor nodes. It becomes a trend to deploy the large numbers of portable wireless sensors in WSNs to increase the quality of service (QOS). In order to maintain the better QOS under failure conditions, identifying and detaching such faults are essential, we proposed a fault recovery corrupted node and Self Healing is necessary. In this proposed system round trip delay techniques used to identify the fault node and maintain the cluster structure in the event of failures caused by energy-drained nodes. Initially, node with the maximum residual energy in a cluster becomes cluster heed and node with the second maximum residual energy becomes secondary cluster heed. Later on, selection of cluster heed and secondary cluster heed will be based on available residual energy. We use NS2 software as simulation platform quantities. Like, energy consumption at cluster and number of clusters is computed in evaluation of proposed algorithm.

KEYWORDS: Wireless sensor network; Fault Node Detection; Cluster Head; Residual Energy.

I. INTRODUCTION

Wireless sensor networks (WSNs) are composed of massive, small and low-cost sensor nodes deployed in a monitoring region, forming a multi-hop self-organized network system through wireless communication. The target is to cooperatively sense, collect and process the information about objects in the coverage area, and then sends it to the observer for processing and analyzing. It is a system with multi-functional and low energy consumption. WSN node faults are usually due to the following causes: the failure of modules (such as communication and sensing module) due to fabrication process problems, environmental factors, enemy attacks and so on; battery power depletion; being out of the communication range of the entire network.

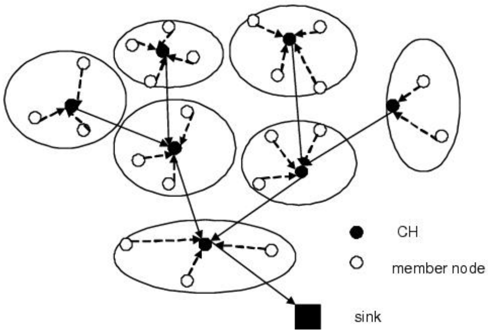

Fig. 1.1 Cluster Topology

The node status in WSNs can be divided into two types [7-8] normal and faulty. Faulty in turn can be “permanent” or “static”. The so-called “permanent” means failed nodes will remain faulty until they are replaced, and the so-called “static” means new faults will not generated during fault detection. In [7, 9] node faults of WSNs can be divided into two categories: hard and soft. The so-called “hard fault” is when a sensor node cannot communicate with other nodes because of the failure of a certain module (e.g., communication failure due to the failure of the communication module,

ISSN(Online): 2320-9801
ISSN (Print): 2320-9798

International Journal of Innovative Research in Computer and Communication Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 5, May 2015

energy depletion of node, being out of the communication range of entire mobile network because of the nodes' moving and so on). The so-called "soft fault" means the failed nodes can continue to work and communicate with other nodes (hardware and software of communication module are normal), but the data sensed or transmitted is not correct.

Failures in sensor networks due to energy depletion are continuous and may increase. This often results in scenarios where a certain part of the network become energy constrained and stop operating after sometime. Sensor nodes failure may cause connectivity loss and in some cases network partitioning. In clustered networks, it creates holes in the network topology and disconnects the clusters, thereby causing data loss and connectivity loss.

II. RELATED WORK

Good numbers of fault tolerance solutions are available but they are limited at different levels. Existing approaches are based on hardware faults and consider hardware components malfunctioning only. Some assume that system software's are already fault tolerant. Some are solely focused on fault detection and do not provide any recovery mechanism. The existing review the related works in the area of fault detection in WSNs. The existence of faulty sensor measurements in WSNS will cause not only a degradation of the network quality of service, but also a huge burden on the limited energy. The existing investigates using the spatial correlation of sensor measurements to detect faults in WSNs. An approach of weighting the neighbors' measurement and presents a method to characterize the difference between sensor measurements are introduced. A weighted median fault detection scheme (WMFDS) is proposed and evaluated for both binary decisions and real number measurements.

The existing distributed fault-tolerant decision fusion in the presence of sensor faults when the local sensors sequentially send their decisions to a fusion center is addressed. Collaborative sensor fault detection (CSFD) scheme is proposed to eliminate unreliable local decisions when performing distributed decision fusion. Based on the pre-designed fusion rule, assuming identical local decision rules and fault-free environments, an upper bound is established on the fusion error probability. According to this error boundary, a criterion is proposed to search the faulty nodes. Once the fusion center identifies the faulty nodes, all corresponding local decisions are removed from the computation of the likelihood ratios that are adopted to make the final decision. An energy efficient fault-tolerant detection scheme is proposed to introduce the sensor fault probability into the optimal event detection process. The optimal detection error was shown to decrease exponentially with the increase of the neighborhood size. They attempted to disambiguate events from both noise related measurement error and sensor fault and limit the effects of faulty sensor on the event detection accuracy. The measurement noise and sensor faults are likely to be stochastically unrelated, while event measurements are likely to be spatially correlated. The Bayesian detection scheme to selects the minimum neighbors for a given detection error boundary such that the communication volume is minimized during the fault correction. The existing did not explicitly attempt to detect faulty sensor instead the schemes they proposed improve the event detection accuracy in the presence of faulty sensors.

In wireless sensor networks, multi-hop routing is commonly performed through a routing tree. Eventually, the routing tree needs to be rebuilt to accommodate failures, balance the energy consumption, or improve data aggregation. Most of the current solutions do not detect when the routing topology that needs to be rebuilt. The existing shows it is important to provide failure recovery and avoid unnecessary traffic when the routing topology needs to be rebuilt. It presents an inference engine, called Diffuse, designed to detect when the routing topology needs to be rebuilt based on different goals, such as to recover from routing failures, improve data aggregation, and balance the energy consumption. Diffuse approaches efficiently avoid unnecessary topology constructions. The authors use information/data fusion to detect routing failures, which is a different and promising approach. As information fusion techniques can reduce the amount of data traffic, filter noisy measurements, and make predictions and inferences about a monitored entity by exploiting the synergy among the available data.

III. PROPOSED ALGORITHM

Initially a set of cluster sensor nodes are dispersed in the terrain. We assume that sensor nodes know their location and the limits S and D. Algorithms for estimating geographic or logical coordinates have been explored at length in the sensor network research.

A set of sensors are deployed in a square terrain. The nodes possesses the following properties

- The sensor nodes are stationary.

ISSN(Online): 2320-9801
ISSN (Print): 2320-9798

International Journal of Innovative Research in Computer and Communication Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 5, May 2015

- The sensor nodes have a sensing range and a transmission range. The sensing range can be related to the transmission range, Rt> 2rs.
- Two nodes communicate with each other directly if they are within the transmission range
- The sensor nodes are assumed to be homogeneous i.e. they have the same processing power and initial energy.
- The sensor nodes are assumed to use different power levels to communicate within and across clusters.
- The sensor nodes are assumed to know their location and the limits S and D.

A. *Round Trip Path Optimization:*

Round Trip Path is the time required to send the data from source node to destination node and get the acknowledgement from destination to source through the specified path. The Round Trip Delay Time can be measured by comparing the present RTT with the actual RTT, if the present RTT is greater than or less than the actual RTT, then we can say delay was occur. After specifying delay was occur in the RTP then this system can assume Faulty and malfunctioning Sensor Node can be occur in the network. To find the Faulty and malfunctioning Sensor Node, this system uses discrete path selection technique to find the Faulty and malfunctioning Sensor Node. In this technique grouping four sensor nodes as a group and then we can find the Fault.

Fault detection by analysing RTD times of maximum number of RTPs will require large time and can affect the performance. Therefore essential numbers of RTPs has to be selected for comparison purpose. RTPs Optimization can be done as explained below. In order to reduce the RTPs in the fault detection analysis instead of considering maximum numbers of RTPs, only some paths corresponding to the number of sensor nodes in WSNs are sufficient. This optimization uses discrete round trip path technique. In the first level of optimization the analysis time is restrict up to certain limit, still now the numbers of RTPs are high. WSNs with huge numbers of sensor nodes the fault detection time is significantly high. So again there is need to minimize the RTPs in WSNs.

In the second level of optimization we are decreasing RTPs and RTD time, so they are selecting minimum four sensor nodes as a group for detecting faulty sensor node. To find the Faulty and malfunctioning Sensor Node in the network, this system are creating a circular topology with eight sensor nodes. In this network communication is done between the wireless sensor nodes. The Round Trip Delay Time can be measured by comparing the present RTT with the actual RTT, if the present RTT is greater than the actual RTT, then we can say delay was occur. After specifying delay was occur in the RTP then we can assume Faulty and malfunctioning Sensor Node is occur in the network. To find the Faulty and malfunctioning Sensor Node, this system uses discrete path selection technique to find the Faulty and malfunctioning Sensor Node. In this technique groups four sensor nodes as a group and then find the Faulty and malfunctioning Sensor Node by comparing the RTT.

B. *Cluster Heed Failure recovery:*

The cluster head employ a back up secondary cluster heed which will replace the cluster heed in case of failure. no further messages are required to send to other cluster members to inform them about the new cluster heed. Cluster heed and secondary cluster heed are known to their cluster members. If cluster heed energy drops below the threshold value, it then sends a message to its cluster member including secondary cluster heed. Which is an indication for secondary cluster heed to stand up as a new cluster heed and the existing cell manager becomes common node and goes to a low computational mode. Common nodes will automatically start treating the secondary cluster heed as their new cluster heed and the new cluster heed upon receiving updates from its cluster members; choose a new secondary cluster heed. Recovery from cluster heed failure involved in invoking a backup node to stand up as a new cluster heed.

C. *Fault Node Detection Algorithm:*

Round-trip delay (RTD) also called as round-trip time (RTT) is the time required for a signal to travel from a specific source node through a path consisting other nodes and back again. The round trip delay time for the path consisting three sensors i,j and k expressed as

$$\tau_{RTD} = \tau(i,j) + \tau(i,k) + \tau(k,j) \qquad \text{eq. (1)}$$

Where $\tau(i,j)$ is time delay between the sensor pair (i, j). RTD time is a function of various parameters of the wireless network and it can be expressed as

ISSN(Online): 2320-9801
ISSN (Print): 2320-9798

International Journal of Innovative Research in Computer and Communication Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 5, May 2015

RTD time = f (speed, distance, medium, noise, nodes
In RTD path &request handled)

$$= T_s + T_d + T_m + T_n + T_n RTD + T_{oreq} \qquad \text{eq. (2)}$$

Thus round trip delay time is the summation of various time delays associated with the respective parameters of the WSN. This time can range from a few milliseconds to several seconds. As round trip delay time is affected by several factors of WSN, it is necessary to determine the proper maximum time. Also to place the sensor node at equidistance is not possible in large network. Because of it the delay time associated with each sensor node and it will change the round trip delay time too. The maximum value of this time will be the threshold value of the corresponding path.

RTD time mainly depends upon the numbers of sensor node present in the round trip path and the distance between them. Proposed fault detection technique accuracy can be increased by reducing the RTD time of RTP. It can be decreased only by reducing the sensor nodes in RTP because the distance between sensor nodes in WSNs is determined by particular applications and can't be decided. Selecting minimum numbers of sensor nodes in the RTP will reduce the RTD time. The round trip path (RTP) in WSNs is formed by grouping minimum three sensor nodes.

Faulty sensor node is detected by comparing the specific RTPs to which it belongs. More numbers of sensor nodes in the round path will reduce the RTPs created. But due to this individual sensor node will be present in more RTPs. While detecting faults, comparisons of all such RTPs become necessary. This will delay the fault detection process. The fault detection analysis time will increase exponentially with increase in numbers of sensor nodes N in WSNs. Also the maximum numbers of RTPs produced are not required for comparison to detect the fault. Such selection of RTPs is not an adequate solution to speed up fault detection. Hence optimization of RTPs in WSNs is essential to speed up the fault detection.

Discrete Selection of RTPs: In the first level of optimization the analysis time is curtail up to certain limit. Still the numbers of RTPs are high. For WSNs with large numbers of sensor nodes the fault detection time is significantly high. So again there is need to minimize the RTPs in WSNs. In the second level of optimization, numbers of RTPs are reduced by selecting only discrete paths in WSNs. Discrete RTPs are selected from sequential linear RTPs only. They are selected by ignoring the two consecutive paths, after each selected linear path. In this way RTPs are selected in discrete steps of three as each RTP consists of three sensor nodes.

IV. PSEUDO CODE

Step 1: Select any sensor rnode NP from WSN with sensor rnodes, the value so.

$$Fp = 1,2 \ldots 3s(N_1 \leq N_s \qquad \text{eq. (3)}$$

Step 2: RTP_P form has sensor sequence as.

$$NP - NP + 1 - NP + 2 \qquad \text{eq. (4)}$$

Step 3: Call subroutine "RTD Time". RTD Time subroutine.

i) If NP+1=NS then replace NP+2 by N1.
else if
NP+1>NS then replace NP+1 by N1and NP+2 by N2 respectively.
ii) Measure the round trip delay time of corresponding RTP. Initially it is RTP_P.
iii) Return to main program.

Step 4: If DRTD_P=DTHR then increment NP by 3 (NP=NP+3).
If
NP+3>NS then reset NP+3 to NS and goto Step 2 else go to Step 2.
Else
Call subroutine"RTDTime". Measure RTD time of RTP (P+1) having sequence as NP+1–NP+2–NP+3.

Step 5: If DRTD_ (P+1)=DTHR then goto step 7.
else if
DRTDP=∞ then NP node is failed(dead). Otherwise NP node is malfunctioning.

Step 6: go to Step 4.

Step 7: Call Subroutine "RTDTime". Measure RTD time of RTP (P+2) having sequence as NP+2–NP+3–NP+4.

Step 8: If DRTD (P+2)=DTHR then go to step 5.
Else if
DRTD_P+1=∞then NP+1node is failed (dead). Otherwise NP+1 node is malfunctioning

Step 9: go to step 4.

Step 10: if DRTD (P+2) = ∞ then NP+2 nodes is failed (dead).

ISSN(Online): 2320-9801
ISSN (Print): 2320-9798

International Journal of Innovative Research in Computer and Communication Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 5, May 2015

Otherwise NP+2 nodes are malfunctioning.
Step 11: if NP+2>NS then go to step 4.
Step 12: Stop

V. SIMULATION RESULTS

Network Simulator (NS-2) is used to simulate the algorithm. Figure 1 show the circular topology for six node and here the packet will be send to the RTP created and Round Trip Time is calculated for each RTP. Method described to detect the fault is successfully implemented and tested in hardware and software. Due to complexity in hardware implementation, WSNs with large numbers of sensor nodes can't be realized to verify the suggested method. WSNs with various numbers of sensor nodes like 10, 20, 30, 40, 50 and 100 are implemented and tested in NS2 software.

Table 1 Comparison of Delay time with no of nodes

Algorithms	**No of Nodes**					
	10	20	30	40	50	60
Round trip delay	10.8	9.5	8.4	7.8	6.3	5.1
Cluster fault node detection	8.4	7.9	6.3	5.4	4.3	3.1

The table 1 calculate delay time with different type of node deployment.

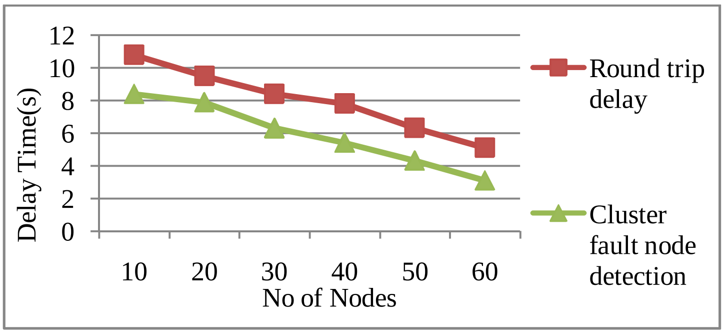

Fig. 1. Compare the Delay time Vs No of nodes

The figure 1 show the comparison delay time vs no of nodes of existing system and proposed system .the proposed system take less delay for packet routing between source to destination.

Table 2 Comparison of RTD Time with no of nodes

Algorithms	**No of Nodes**					
	10	20	30	40	50	60
Round trip delay	0.05	0.04	0.034	0.8	0.1	0.12
Cluster fault node detection	0.04	0.03	0.21	0.07	0.08	0.091

Table 2 to compare the existing fault node detection with proposed algorithm cluster based fault node detection.

 DOI: 10.15680/ijircce.2015.0305082

ISSN(Online): 2320-9801
ISSN (Print): 2320-9798

International Journal of Innovative Research in Computer and Communication Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 5, May 2015

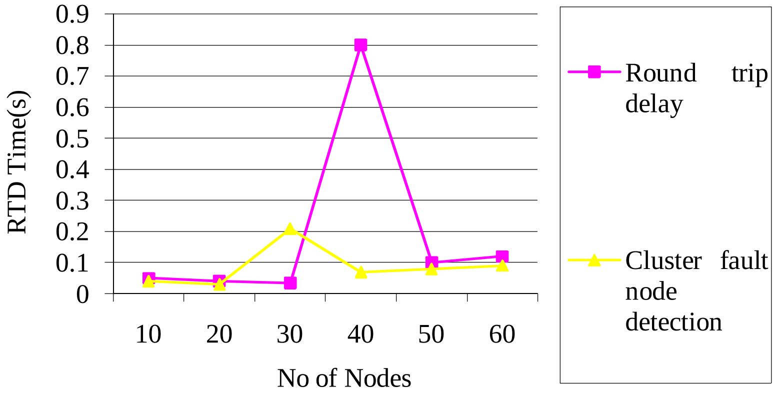

Fig. 2 Compare the RTD time Vs No of nodes

The figure 2 show the comparison RTD time vs no of nodes of existing system and proposed system . The proposed system less RTD time taking for fault node detection with cluster based routing.

VI. Conclusion and Future Work

In this paper, we have proposed a cluster-based recovery algorithm, which is energy-efficient and responsive to network topology changes due to sensor node failures with RTD. The faster response time of our algorithm ensures uninterrupted operation of the sensor networks and the energy efficiency contributes to a healthy lifetime for the prolonged operation of the sensor network. RTD is calculated to make it efficient optimization for RTP is done and finds that Discrete RTP is optimized analysis time is low compared to linear. Fault node present in the network is efficiently identified by calculating RTD for each RTP created. Here the RTD time calculation is executed with different number of sensor node in NS2.

References

1. Akyildiz, I.F., Sankarasubramaniam, Y and Cayirci, E., “Wireless sensor networks: a survey”, Comput. Networks vol.38, pp.393-422. 2002.
2. Feng Xia., “QoS Challenges and opportunities in wireless sensor actuator networks”.,vol. 8,pp. 1099-1110., 2008.
3. Sun, L.M., Li, J.Z., Chen, Y. and Zhu, H.S., “Wireless Sensor Networks”, Tsinghua Publishing House: Beijing, China, 2005.
4. Xia, F., Tian, Y.C., Li, Y.J. and Sun, Y.X. “Wireless sensor actuator network design for mobile control applications”, vol.7, pp.2157-2173., 2007.
5. Chen, J.R., Kher, S., Somani, A., “Distributed fault detection of wireless sensor networks”, In Proceedings of the International Conference on Mobile Computing and Networkings, Los Angeles, CA, USA; ACM: New York, USA, 2006, pp. 65-72.
6. Koushanfar, F., Potkonjak, M., Sangiovanni-Vincentelli, A., “On-line fault detection of sensor measurements”, In Proceedings of the IEEE, Sensors. IEEE Press: Toronto, 2003, Vol. 2, pp. 22-24.
7. Chessa, S., Santi, P., “Comparison based system level fault diagnosis in Ad hoc networks”, In Proceedings of IEEE 20th Symp. on Reliable Distributed Systems (SRDS), IEEE Press: New Orleans, 2001, pp. 257-266.
8. Chessa, S., Santi, P., “Crash faults identification in wireless sensor networks”, Comput. Commun. 2002, vol.25, pp.1273-1282.
9. Elhadef, M., Boukerche, A, Elkadiki, H., “Performance analysis of a distributed comparison based self-diagnosis protocol for wireless ad hoc networks”, In Proceedings of the 9th ACM International Symposium on Modeling analysis and simulation of wireless and mobile system, ACM: NY, USA, 2006, pp. 165-172.
10. Gao, J.L., Xu, Y.J., Li, X.W., “Weighted-median based distributed fault detection for wireless sensor networks”, J. Softw, vol.18, pp.1208-1217., 2007.
11. Wang, T.Y., Chang, L.Y., Dun, D.R., Wu, J.Y., “Distributed fault-tolerant detection via sensor fault detection in sensor networks”, In Proceedings of the IEEE 10th International Conference on Information Fusion, Quebec, Canada, 2007, pp. 1-6.
12. Krishnamachari, B., Iyengar, S., “Distributed Bayesian algorithms for fault-tolerant event region detection in wireless sensor networks”, IEEE Trans. Comput., vol.53, pp.241-250., 2004.
13. Wang, P., Zheng, J., Li, C., “An Agreement-Based Fault Detection Mechanism for Under Water Sensor Networks”, In Proceedings of the Global Telecommunications Conference, Washington, DC, 2007, pp. 1195-1200.
14. Luo, X., Dong, M., Huang, Y., “On distributed fault-tolerant detection in wireless sensor networks”, IEEE Trans. Comput., vol.55, pp.58-70., 2006.
15. Lee, M.H., Choi, Y.H., “Fault detection of wireless sensor networks”, Comput. Commun., vol.31, pp.3469-3475., 2008.

ISSN(Online): 2320-9801
ISSN (Print): 2320-9798

International Journal of Innovative Research in Computer and Communication Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 5, May 2015

16. Nakamura, E.F., Figueiredo, C.M.S., Nakamura, F.G., Loureiro, A.A.F., "Diffuse: A topology building engine for wireless sensor networks", Signal Processing, vol.87, pp.2991-3009., 2007.

BIOGRAPHY

S. Gayathridevi is an M.Phil Research Scholar in the Computer Science Department, College of Sree Saraswathi Thyagaraja College, Thippampatti, India. She received Master of Computer Application (MCA) degree in 2010 from bharathiar university, Coimbatore, India. Her research interests are Computer Networks (wireless Networks), data mining, computer graphics and etc.