

Sensor Node Failure Detection Using Round Trip Path in WSNs

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Abstract— Now a days, applications of wireless sensor networks (WSNs) has been increased due to its vast potential to connect the physical world to the practical world. Also, advancement in microelectronic fabrication technology reduced the cost of manufacturing convenient wireless sensor nodes and now it becomes a trend to deploy the large numbers of wireless sensors in WSNs so that to increase the quality of service (QoS). The QoS of such WSNs is mainly affected by the faulty or malfunctioning sensor nodes. Probability of sensor node failure increases if number of sensor node increases in the network. For maintaining the better QoS under failure conditions such faulty sensor node should be detected and it should be removed. In this proposed method, faulty sensor node is detected by calculating the round trip delay (RTD) time of round trip paths and comparing them with threshold value. This proposed method is tested with three sensors Nodes designed using microcontroller, sensor and ZigBee. The main server section which will display the failure sensor node is also designed using microcontroller and ZigBee.

Keywords- *Faulty sensor node, quality of service, round trip delay, round trip paths, WSNs.*

I. INTRODUCTION

Wireless Sensor Network (WSN) is a network contains thousands and thousands of sensor nodes. Sensor nodes are deployed in many areas to monitor the status of military applications, weather, earthquake, forest surveillance etc in real world applications. There are many advantages of sensor nodes. Due to the rapid advancement in the electronic fabrication technology cost of sensor node has been reduced and hence large number of portable and light weighted sensor nodes used to increase the quality of service (QoS) of such Wireless Sensor Network. Sensor node consists of microcontroller, sensor, zigbee and power supply. Sensed data is transmitted from one sensor node to next sensor node and then display the real time parameter of all sensor node on the LCD of main sever station. if number of sensors in a WSN increases the probability of sensor node failure will also increase because the nodes are battery powered and batteries are non – rechargeable. The node batteries cannot be replaced ultimately. This will eventually degrade the quality of service of WSNs. Sensor network can become failure due to various reasons such as sensor failure, battery failure, environmental effect, and hardware or software malfunctions etc.

Quality of service (QoS) can be improved by discarding the data from such faulty sensor node. Therefore detection of faults in WSNs is important because node failures degrade performance of WSNs. In this

method we will detect the faulty sensor nodes in a WSN by a method of measuring the Round Trip Delay time of Round Trip Paths formed by combination of nodes. Round-trip delay (RTD) is the time required for a signal to travel from a specific source node to other through a path and back again. RTD time of round trip path is measured and it will be compared with a threshold value and faulty nodes will be detected. Round trip delay time of the round trip path will be change due to the faulty sensor node. If RTD time is greater than threshold value then this sensor node is detected as faulty node.

II. LITERATURE REVIEW

Satyajeet S. Ahuja, R. Srinivasan, and M.Krunz (2009) Single-Link Failure Detection in All-Optical Networks based on Monitoring Cycles (MCs) and Monitoring Paths (MPs) for identification of the link failure[1] and it can be used detect the network failure. Three edge connectivity is used in WSNs, separate wavelengths for monitoring cycles and locations are the draw backs of this method.

Abolfazl Akbari1 , Arash Dana(2011) proposed cluster-based recovery algorithm[2], which is energy-efficient and responsive to network topology which changes due to failure or malfunctioning of sensor node. Inactive nodes miss their communication in network hence we have to split the network. But for avoidance of splitting the network a fault recovery corrupted node and self- healing is proposed. Cluster head failure-recovery mechanism recovers the

connectivity of the cluster in almost less time than that of the time taken by the fault-tolerant clustering proposed by Venkataraman. Venkataraman cluster heed failure recovery procedure consumes more energy as it exchange energy messages to select the new cluster head. But in this method they employ a backup secondary cluster heed which will replace the cluster heed in case of failure. Here initially maximum residual energy in a cluster becomes cluster heed and the second maximum residual energy becomes secondary cluster heed and then selection of cluster heed and secondary cluster heed will be based on available residual energy. The drawback of this method was it must require a self-healing property

A.Mojoodi, M.Mehrani, F. Forootan, and R. Farshidi(2011) This method uses path redundancy technique[3] to detect the sensor node failure. This method is not widely used as it consumed more energy because of the redundancy. The network speed and the number of correct results throughout the lifespan of the network decrease on using this method.

Ravindra N Duche and N.P.Sarwade, (2012) proposed method is used to detect the sensor node failure or malfunctioning. This method used confidence factors [4] to detect faulty node. Confidence factor of round trip path in network is evaluated by using the round trip delay (RTD) time. This method detects the failure in sensor node for symmetrical network conditions. It detects failed or malfunctioning sensor, which can be used to get correct data in WSN. The confidence factor of round trip path is calculated with the help of threshold and instantaneous round trip delay time. Confidence factors of all round trip paths were stored in lookup table and then by analyzing the status of confidence factor of all paths from the look-up table, failed or malfunctioning sensor node was detected easily. Confidence factor was calculated with the help of instantaneous round trip delay time of respective path and threshold time. This method was able to detect only one faulty node present in any path in an easy and efficient way. That was the drawback of this method. Therefore this method has to be modified to optimize the number of round trip paths in WSN and the number of sensor nodes in the corresponding paths. Then it will reduce the detection time of faulty sensor node in WSN.

M.Arun Sathyal,V. Nellai Nayaki(2015) proposed Fault or dead node detection and recovery algorithm. That algorithm was a combination of discrete round trip path algorithm and genetic algorithm [5]. These combinations of algorithms worked well and provided better fault detection accuracy and replaced the node efficiently. This algorithm provided better throughput, less delay and packet loss. After

detecting the failure nodes chromosomes are formed with genes. Chromosome is nothing but a gene that containing some length. The chromosome gene having the value 1 represents the node be good and -1 represents the node to be failure. Then fitness function was calculated. The chromosomes with lowest fitness function was selected and applied to cross over process. In this two chromosomes are selected and the value of that is selected by using selection and mutation process. Finally the mutation process provides which failure must be recovered. After that the failure node must be recovered and the data will be transmitted without any loss.

Nevidhitha Bonnita. P, Dr.Nalini.N, Mohan.B.A (2015) proposed discrete clustering approach [6] to detect the faulty sensor node. Detection of faulty node was based on discrete RTPs for their round trip delay (RTD) time. RTD times of discrete RTPs were compared with threshold time to determine failed sensor node. That detection of faulty node using RTPs detection was improved the lifetime as well as quality of service (QoS) of WSNs. Software tool NS2 was used to implement RTDT protocol. Faulty sensor node was detected by simulating circular topology WSNs with RTDT protocol. Analysis time to detect faulty node was very much optimized by using the discrete RTPs. Faulty sensor node was detected by the RTD time of RTPs with threshold value. The sensor node more than threshold value was detected the failure sensor node. If calculated time is higher than the threshold value then that sensor node was detected as faulty node. Detection time depends upon the numbers of RTPs and RTD time. It detects the faulty node but it does not address recovering process of failure node.

III. PROPOSED SYSTEM

In the proposed method the sensor node failure detection is based on round trip path and round trip delay. Round trip delay is the time required to transfer the sensed data to next sensor node though a specific path and back again to the same sensor node. Faulty sensor node is detected by measuring Round trip delay (RTD) time of discrete round trip path it may be infinity or higher than threshold value. If the round trip delay time is infinity then the sensor node is detected as failed and if the round trip delay is higher than the threshold value then sensor node work as a malfunctioning. The sensor node common to particular round trip paths with infinity round trip delay time is detected as failed. As round trip delay time calculation is mainly based on number of sensor nodes present in a RTD path. If the sensor node increases in a path then round trip delay time also increases. RTD time depends on the number of sensor nodes present in the round trip path and distance between sensor nodes. Therefore fault detection method can

be improved after reducing the number of sensor nodes in round trip path which will decrease round trip delay time of round trip path.

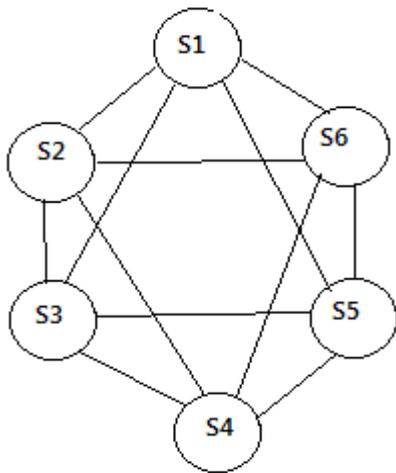


Fig 1: Circular Topology of Wsn With Six Sensor Nodes.

Round trip path is formed by grouping minimum three sensor nodes. The minimum round trip delay time of round trip path is given as :

$$\tau_{RTD} = \tau_1 + \tau_2 + \tau_3$$

(1)

Here τ_1 is the time delay between nodes 1 and 2, τ_2 is the time delay between nodes 2 and 3, τ_3 is the time delay between nodes 3 and 1. Sensor nodes are arranged in circular topology as shown in Figure 1. So that three consecutive sensor nodes in an RTP will be almost at equal distances from each other. That means $\tau_1 = \tau_2 = \tau_3 = \tau$. Therefore the minimum round trip delay time is:

$$\tau_{RTD} = 3 \tau$$

(2)

Round trip delay time depends on the distance between the node pairs. Efficiency of the proposed method can be increased after reducing the round trip paths in WSN.

A. Evaluations Of Round Trip Paths

Consider a wireless sensor network having N sensor nodes. Let m be the number of sensor nodes in a round trip path. Then the total number of round trip paths in a WSN is given by:

$$P = N(N - m)$$

(3)

Where P is the total numbers of RTPs in WSNs. Total analysis time with P numbers of RTPs is given by:

$$\tau_{ANL}(m) = \tau_{RTD} - 1 + \tau_{RTD} - 2 + \dots + \tau_{RTD} - P$$

(4)

All round trip paths has only three sensor nodes, therefore RTD time of each RTP will be the same. Hence we can write equation (4) as:

$$\tau_{ANL} = P * \tau_{RTD}$$

(5)

After putting equation (2) and (3) in equation (5), we will get

$$\tau_{ANL} = N(N - m)3 \tau$$

(6)

After analyzing the above equation we conclude that if the RTPs increase in WSNs. Then analysis time will also be increase therefore we have to optimized the RTPs.

B. Optimization Of Round Trip Path

Optimization of RTPs can be done in two ways to reduce the analysis time. Therefore we have to select proper RTPs which will reduce the analysis time.

1) Linear selection of RTPs

Instead of considering maximum numbers of RTPs we have to reduce the RTPs. only few paths corresponding to the number of sensor nodes are consider. Select the RTPs equal to the numbers of nodes in WSNs as shown in Fig.2 Here selected RTPs are called as linear RTPs because of its linear relationship between N and P.

$$PL = N$$

(7)

Where PL is the number of linear RTPs. the analysis time $\tau_{ANL}(L)$ for linear RTPs is given by:

$$\tau_{ANL} = N * 3\tau$$

(8)

But if sensor node N increases in the network then linear path will be increase and it will not reduce the analysis time therefore we have to optimize the RTPs.

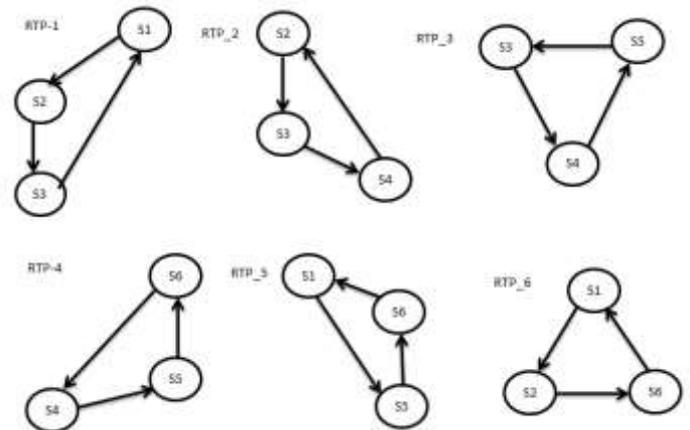


Fig.2 Linear selection of RTPs

2) Discrete selection of RTPs

In the above level of optimization the analysis time is restricted up to certain limit still the numbers of RTPs are more. Therefore for minimizing the analysis time we have to minimize the RTPs and this can be achieved by considering discrete RTPs as shown in Fig. 3.3.

Discrete RTPs are selected from sequential linear RTPs by ignoring the two consecutive paths, after each selected linear path. In this way RTPs are selected in discrete selections which are given by:

$$PD = Q + C$$

(9)

Q and C in above equation are expressed as below

$$Q = \lfloor N/m \rfloor \quad (10)$$

$$C = \begin{cases} 0 & \text{if } R=1 \\ 1 & \text{otherwise} \end{cases} \quad (11)$$

Where Q is the quotient and m is the numbers of sensor nodes present in RTP. R is remainder, N is numbers of sensor nodes and C is correction factor to be added in wireless sensor networks. Correction factor will be 0 if the value of remainder is 1 otherwise it is 1.

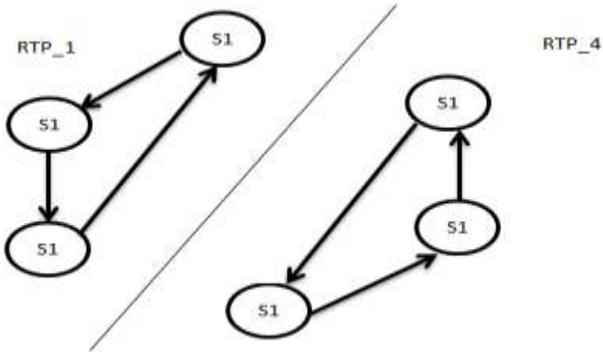


Fig.3.3 discrete selection of RTPs

The time taken for the fault detection is given by:

$$\tau_{ANL(D)} = (Q + C) * 3\tau \quad (12)$$

Additional two RTP's are needed along with the discrete RTP's in WSN to locate the fault present at second and third levels. Therefore the total number of RTP's required to find out the fault is given by

$$PT = PD + L \quad (13)$$

Here L is the number of sensor nodes in each RTP excluding the source node ie $L=m-1$

IV. CONCLUSION

In this paper for detecting the faulty sensor node discrete clustering approach is consider. This approach is more effective than others proposed system to reduce the sensor node failure detection time. Hence we can improve the quality of service of the WSNs. This method is only applicable to circular topology. This method can be used to monitor the status of the sensor node in WSNs such as in military applications, weather, earthquake, forest surveillance etc.

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