# Heuristic Approach for Discovery and Recovery of Faulty Node in Wireless Sensor Networks

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Abstract - Wireless Sensor Networks (WSN) is one of high technology domains with large number of applications in various disciplines. WSN must need to provide a guaranteed Quality of Service (QOS) in real time application. To increase QOS large number of portable sensor nodes are deployed. These QOS get reduced because of increase in the failure of a sensor node due to battery failure, environmental effects, hardware and software malfunctions. So a novel approach is introduced for determining specific discrete Round Trip Path (RTP) which will improve the efficiency by enabling parallel analysis of such RTPs. During data analysis, the data will be excluded not only from faulty node but also from malfunction node. After detecting the faulty node it should be removed or replaced by nodes within the network. This will improve the QOS of the whole network. Also this proposed method is implemented to other topologies in this paper. The feasibility of the design has been proved by NS2 simulation.

Keywords – Round Trip Path (RTP); Round Trip Delay (RTD); Wireless Sensor Network (WSN); Quality of Service (QoS).

### I. INTRODUCTION

A wireless sensor network (WSN) consists of spatially distributed autonomous sensors to monitor conditions, such as temperature, pressure, movements, etc. and to transfer the data from source to destination through the network. In WSN each nodes collaborate with each other to process and communicate over wireless channel information about some physical phenomena as mentioned [2, 5]. The main characteristics of a wireless sensor network include: Power consumption using batteries, Overcoming node failures, Mobility of nodes, and Heterogeneity of nodes.

Sensors impaled onto structures, machinery, and the environment, combined with the effective delivery of sensed information, could provide remarkable benefits to community. Potential welfares include: lesser catastrophic failures, preservation of natural resources, higher manufacturing efficiency, enriched emergency response, and enhanced homeland security [1].

The more modern networks are bi-directional which enables control of sensor activity. The topology of the WSNs can vary from a simple star network to an advanced multihop wireless mesh network. Either the routing or flooding can Ms. R. Divya, Assistant professor, EEE Department, PSG College of Technology, Coimbatore, India.

be used as the propagation technique between the hops of the network. Energy is the scantest resource of WSN nodes, and it helps in determining the lifetime of WSNs.

The failure of sensor node is either because of communication device failure, battery depletion, environment and/or sensor device related problems. To verify the failed sensor node manually in such environment is tedious. To detect this failure, it should be checked for the node deployments which are classified under three classes: centralized, clustering and distributed [2, 3]. The sensor nodes in WSNs equipped with batteries for their energy source, but it is difficult to recharge or replace batteries because of the sudden giving off energy. For these reason, algorithms and protocols need to address the issues as Lifetime maximization, Robustness, fault tolerance and Selfconfiguration. The algorithm to find faulty node are based on clustering method. The detection of a fault node can be done in the range of few seconds which will minimize the data loss.

# II. ROUND TRIP DELAY

The round-trip delay time (RTD) or round-trip time (RTT) is the interval of time it takes for a data to be sent plus the interval of time it takes for an acknowledgment of that signal to be received. This delay consists of the transmission times between the two points of a signal: In the context of computer networks, the signal is usually a data packet, and the RTT is also known as the ping time. An internet user can determine the RTT by using the ping command; In space technology, the round-trip delay time or round trip light time is the time light (and hence any signal) takes to go to a space probe and return.

For calculating RTD time two methods are provided: Linear RTP and Discrete RTP. In the proposed system, discrete RTP is formed from the circular topology and Round Trip Delay (RTD) time for each discrete RTP is calculated. In a Linear RTP, the number of sensors is equal to RTP and it will increase the analysis time [3, 6]. Hence optimization is required which can be obtained by preferring discrete RTP which will reduce the analysis time.

#### A. Round Trip Path

RTD time mainly depends upon the numbers of sensor node present in the round trip path and the distance between them. The path consists of the neighboring nodes minimum of three or four nodes [3]. This is to increase the efficiency time to process the number of RTP's formed. As the RTD is using delay to find the different paths the processing time should be high for which also the nodes in a path is reduced.



Fig. 1. Wired network with 6 nodes in Circular topology

Fig. 1 shows a network of six nodes formed in circular topology. It is shown with connected wires, but it is actually network of wireless sensors.

1) Estimation of maximum numbers of round trip paths

The round trip path (RTP) in from sensor node 1 to node 3 from Fig. 1 is given as:

$$\tau_{\text{RTD}} = \{\tau(1,2) + \tau(2,3) + \tau(3,1)\}$$
(1)

Round Trip Paths for the given symmetrical network is formed with three nodes which starts and ends in the same node. For the same wireless sensor network the number of round trip paths will be as shown in Fig. 2:



Fig. 2. 6 RTP's in the network

The number of RTP's forming in a particular network has an estimated range of:

$$3 \le n \le (N-1) \tag{2}$$

where 'N' is the total number of nodes in WSN and 'n' is the number of nodes present in the round trip path.

# III. OPTIMIZATION OF ROUND TRIP PATHS

Fault detection by analyzing RTD times of maximum numbers of RTPs will require substantial time and can affect the performance. Therefore essential numbers of RTPs has to be selected for comparison purpose [6]. Optimization of RTPs can be done as explained below:

# A. Linear Selection of RTPs

Only few paths corresponding to the number of sensor nodes in WSNs are sufficient. The RTPs selected can be equal to the numbers of nodes in WSNs to reduce the analysis time. The linear RTPs in WSNs with N sensor nodes can be written as:

$$RTP_L = N$$
 (3)

where  $\text{RTP}_{\text{L}}$  is the number of linear RTPs. Since the linear RTP has the paths mostly equal to the number of nodes present in the network the analysis time taken for it will be high, which results in decrease of efficiency of the network. This will definitely affect the quality of service.

#### B. Discrete Selection of RTPs

In the second level, numbers of RTPs are decreased by considering only discrete paths in the whole network. Discrete RTPs are selected from linear RTPs. They are selected by ignoring the two consecutive paths, after each selected linear path as the nodes will be repeated in the paths. By selecting the discrete RTPs the compilation time will be reduced.

To select the discrete RTPs in a network is given by  $RTP_D = Q + R$  (4)

Q and C in above equation are expressed as below

$$Q = \lfloor N/n \rfloor$$
(5)

$$R = \begin{cases} 0 , if r = 0 \\ 1 , otherwise \end{cases}$$
(6)

where Q is the quotient, m is the numbers of sensor nodes in RTP, r is remainder, N is numbers of sensor nodes in wireless sensor networks, n number of nodes in the RTP and R is correction factor to be added.

# IV. ALGORITHM TO DETECT FAULTY SENSOR NODE

The algorithm used for finding the faulty node in a network is based on two factors: discrete RTP's and threshold value of the RTD time [3, 6]. RTD time is measured using the discrete RTP for the whole network by incrementing the sink value. After measuring it is tabulated for the further reference. By taking the highest time for a particular path, it is then considered as the threshold RTD. This is the phase one of the algorithm. Phase two is to compare the instantaneous RTD with respective threshold value. If the time of instantaneous RTD to be greater than the threshold value, then that path should be analyzed as the fault node takes higher time for transferring the data.

#### A. Threshold round trip delay (RTD) time of path

Appropriate selection of threshold RTD time is essential to detect the correct faulty sensor node in WSNs as according to the distance time varies [4]. Highest value of RTD time is the threshold value. The threshold time detection can be done by using only discrete RTPs in the network. With few RTPs it is sufficient to obtain the required result, thereby reducing the overall analysis time. The threshold time for respective round trip path is calculated as:

$$\mathbf{t}_{\text{RTD-Tr}} = \{ \hat{\tau}(1,2) + \hat{\tau}(2,3) + \hat{\tau}(3,1) \}$$
(7)

where  $\hat{\tau}(1,2)$  is the maximum delay between sensor nodes s1 and s2. Threshold values of all round trip paths in WSN are now stored in look-up table.

#### B. Confidence factor

Confidence factor of round trip path in network is estimated by using the instantaneous and threshold RTD. It is expressed as:

$$\Delta_{\rm RTD} = \begin{cases} 1, \ \tau RTD < \tau RTD - Tr \\ 0, \ \text{otherwise} \end{cases}$$
(8)

where  $\tau_{RTD-Tr}$  is the threshold value of round trip delay adjusted for the maximum value of time and  $\Delta RTD$  is a confidence factor for the selected round trip path in WSN. Based on the RTD value, this factor will be either 0 or 1.

*a)* Algorithm for estimation of Confidence factor:

[2] Initialize the network and select three nodes for the RTP (n=3).

[3] Determine the number of round paths in WSN (i.e. here n RTD = 6)

[4] Set the counter (C=6) for RTP's.

[5] Select the round trip path (e.g. s1-s2-s3-s1).

[6] The instantaneous round trip delay (RTD) time of this path is calculated by using the equation:

$$\tau_{\text{RTD}} = \{\tau(1,2) + \tau(2,3) + \tau(3,1)\}$$

[7] Confidence factor of respective path is calculated by using following condition

$$\Delta_{\rm RTD} = \begin{cases} 1, \ \tau RTD < \ \tau RTD - Tr \\ 0, \ \text{otherwise} \end{cases}$$

[8] Go to step 3, decrement the counter for RTD path and repeat till step 6 to determine the confidence factor of all paths in the WSN.

[9] Look-up table entries for all RTD paths is calculated and stop.

b) Flowchart for the look-up table: Look-up table is constructed to identify the faulty nodes with the comparison between instantaneous and threshold RTD time along with confidence factors of all round trip paths. Analysis of look-up table can be done for two cases.

First case is for sensor node failure. This can be done by comparing the delay in the RTP's. The second case is to replace the faulty node with the neighboring nodes with the RTP's formed. By using the delay it can be done [8]. These are presented in the form of flowchart shown in Fig. 3.



Fig. 3. Flowchart for Look-up table

#### V. CONCLUSION

Existing algorithm has been implemented to find only the faulty node in the network. But the proposed method, not only used to discover the faulty node in the network but also to replace the node from the neighboring area or reroute the data between the sink and destination. This will improve the efficiency of the network which in turn increases the QoS of the WSN. Real time applicability of method can be verified by comparing hardware and software results.

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