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Failure detection of sensor nodes based on Round Trip Delay and Paths in Wireless Sensor Networks

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Abstract - *In recent years, the applications of the wireless sensors networks (WSN) have increased tremendously due to its huge potential of connecting the physical world and the virtual world. Also, advancement in Microelectronic Fabrication Technology (MFT) decreases the cost of manufacturing portable wireless sensor nodes. It is a trend to deploy large number of wireless portable sensors in the WSNs to have an increased quality of service (QoS). The QoS of WSNs is hugely affected by the failure of the sensor nodes. The portability of failures in sensor nodes is directly proportional to increase in the number of sensors. In order to keep up better QoS under failure conditions, identifying and removing such faults are important.*

In the proposed method, the faulty sensor nodes are detected by calculating the round trip delay (RTD) time of different round trip paths and comparing them with the threshold value [13]. The scalability of this method is checked by simulating the WSNs with a large number of sensor nodes in Network Simulator 2 (NS2). Energy consumption is increased by redundancy and the network lifetime is reduced, cluster head failure to detect the faulty node has data loss problem. The necessity of the received signal strength measurement in the cluster head variation and assigning separate wavelength of each of the link in other fault detection techniques are overcome in this method.

Key Words: Sensor nodes, RTD (round trip delay), RTP (round trip path), RTDT (round trip dealy time), threshold, faulty, malfunctioning, packets, circular topology, QoS (quality of service, transmission, discrete RTP.

1. INTRODUCTION

Wireless Sensor Network (WSN) is a wireless network, which consists of hundreds and hundreds of sensor nodes that are deployed in any area to monitor the status of military applications, weather, forest surveillance etc. there is a huge advantage of using sensor nodes in many applications, we also find some disadvantages since, the sensor nodes are small in size and contains non-rechargeable batteries. This leads to battery constraint and reduces the lifetime of the network

Round trip delay (RTD) time measurement technique is an easy way to obtain the information regarding above issues in WSN. The method of fault detection is based on RTD time measurement of RTPs. RTD times of discrete RTPs are compared with threshold time to determine failed sensor node. Initially this method is tested on 6,30 sensor nodes Round-trip delay (RTD), also called as round-trip time (RTT), is the time required for a signal pulse or packet to travel from a specific source node thru path consisting other nodes and back again. The round trip delay time can range from a few milliseconds (thousandths of a second) under ideal conditions between nearby spaced sensor nodes to several seconds under adverse conditions between sensor nodes separated by a large distance.

Round trip delay time of the RTP will be change due to the faulty sensor node. Higher than the threshold value that we got. Faulty sensor node is detected by the RTD time of RTPs with threshold value [13]. The sensor node more than threshold value is detected has the failure sensor node. If this time is higher than the threshold value then this senor node is detected as faulty node. Detection time of faulty sensor node depends upon the numbers of RTPs and RTD time.

The different failure detection approaches in WSNs are centralized, distributed and clustering. We have used the discrete clustering approach to detect the faulty sensor node. Detection of fault is based on the discrete RTPs for their round trip delay (RTD) time. Few RTPs are analyzed

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during fault detection this will improve the lifetime as well as quality of service (QoS) of WSNs. Software tool NS2 is used to implement RTDT protocol. Faulty sensor node is detected by simulating circular topology WSNs with RTDT protocol.

In a network RTD time is affected by many criteria's. One of them is latency, which is the time between a request for data and the complete return of the data. The round trip delay (RTD) time depends on various factors including:

a) Sensor node Data transfer rate
b) Nature of transmission medium.
c) The Physical distance between the sensor nodes.
d) The Number of nodes in the RTD path.
e) Other requests being handled by intermediate nodes.
f) Intermediate nodes and source node functions speed
g) Interference in the circuit.

2. Related work

The faulty sensor nodes identification suggested in [1] is based on comparisons between neighboring nodes and dissemination of the decision made at each node. Algorithm proposed in this method can't detect the malicious nodes. Cluster head failure recovery algorithm used in [2] to detect the faulty node has data loss problem, occurring due to transfer of cluster head. Path redundancy technique to detect faulty sensor node is suggested in [3] and [4]. The exercise to use large numbers of sensor nodes will increases the probability of sensor node failures in such WSNs. Data analysis based on such faulty sensor node will become incorrect or deviate from the mean value. This will eventually degrade the quality of service (QoS) of WSNs [5].Redundancy increases the energy consumption and reduces the number of correct responses in network lifetime. Excessive redundant paths in WSNs will slow down the fault detection process. Better quality of service (QoS) is achieved by discarding the data from such faulty sensor nodes in the analysis [6], [7]. Excessive redundant paths in WSNs will slow down the fault detection process. In [14], link failure detection based on monitoring cycles (MCs) and monitoring paths (MPs) is presented. Three-edge connectivity in the network, separate wavelength for each monitoring cycle and monitoring locations are the limitations of this method.

3. Software analysis

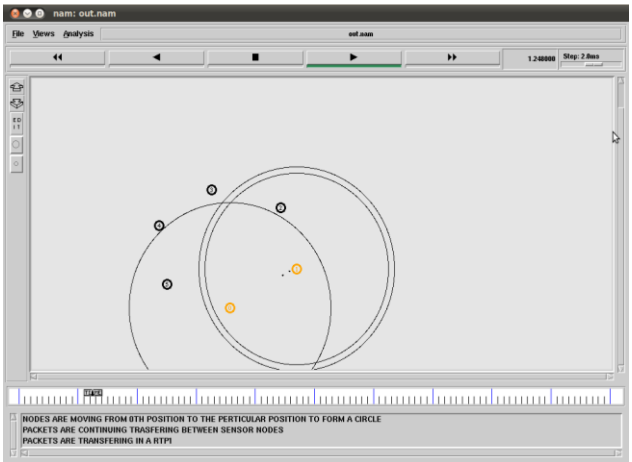
Circular topology WSNs having different sensor nodes (N) are implemented by using the open source software NS2.

In the proposed method round trip paths are formed by combining the adjacent three sensor nodes. RTDT protocol is developed and implemented to measure the RTDT time of such RTPs.

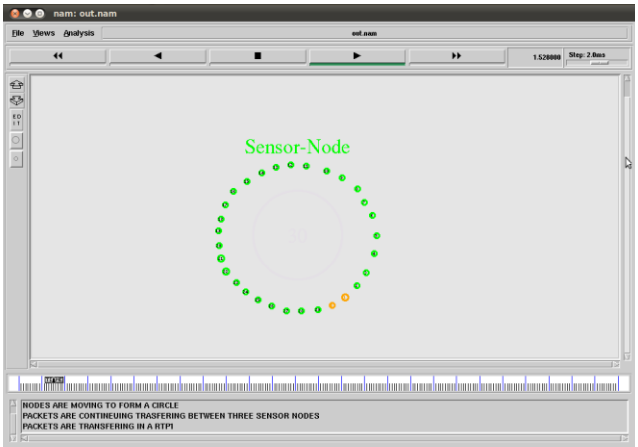
3.1 Proposed Protocol implementation

In this protocol a RTP is formed between the three sequential sensor nodes in circular topology of WSNs. A packet is routed in between these sensor nodes of RTP. It is routed in the round trip delay path by assigning the addresses of source, Forwarding and destination senor nodes in routing table. The circular topology of WSNs with six and thirty sensor nodes(N = 6,30) implemented and simulated in NS2 is shown in Figure 1 and figure 2.The sensor nodes in circular topology are placed at 1foot distance.

For N=6 Figure 1



For N=30Figure 2



Algorithm

Step1: Initially all the sensor nodes are in zeroth position.

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Step2: The Sensor nodes will move to their particular position to form a circular Topology.

Step3: Find RTP, i.e.

Pd = Q+C

Q = [N/M]

$$C = \begin{cases} 0 & \text{if } R = 0, \\ 1 & \text{otherwise} \end{cases}$$

Step4: Transmission starts between three sensor nodes,

Step5: Step4 continues until all the sensor nodes should be involved in the transmission. Then go to next step.

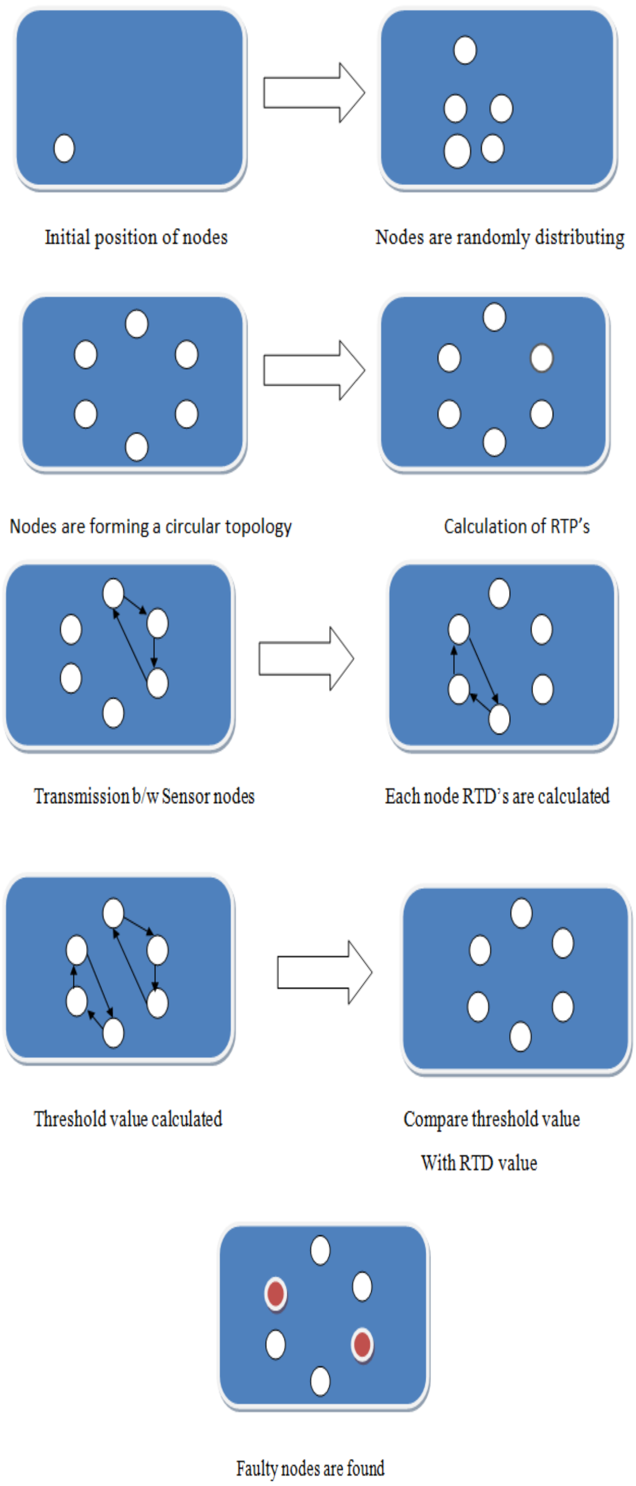
Step6: Find RTD of all the sensor nodes.

Step7: Find Threshold Value.

Step8:Compare each sensor node RTD with Threshold value, and then the nodes having RTD greater than Threshold Value means that node is consider as Faulty sensor node.

Step9: Performance graphs are found to show the Faulty sensor nodes.

System Design



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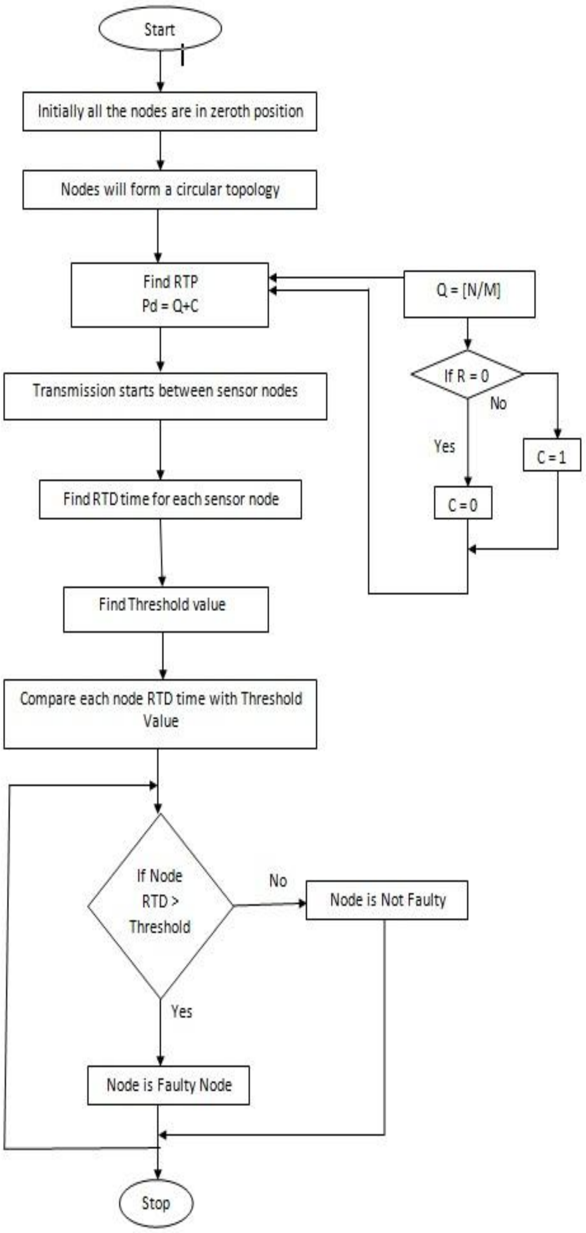
Flow Chart



4. Detection of Faulty Sensor Node Using Discrete RTPs

Specific sensor node in WSNs is declared as faulty in order to test and verify the suggested method. Faulty sensor node can be either failed or malfunctioning as shown in fig 3 and fig 4 hence two cases have to be evaluated separately. Failed (dead) sensor node Detection is done by declaring the particular node as dead in Tcl script. Similarly malfunctioning behavior is detected by adding certain delay in the RTPs of particular sensor node. To test the malfunctioning behavior of sensor node respectively.

4.1RTD and Threshold Time Estimation

Appropriate threshold RTD time is determined by simulating various WSNs. It is estimated by considering initially all sensor nodes in WSNs as working properly. The Tcl file with different numbers of sensor nodes as 6, 30 are simulated separately by using RTDT protocol. RTD time results of discrete RTPs simulated in NS2 for WSNs with senor nodes 6, 30, are shown in Fig. Here we have found that the average time span for round trip delay time and the highest value of RTD time Hence the Threshold value of RTD time for RTP is selected.

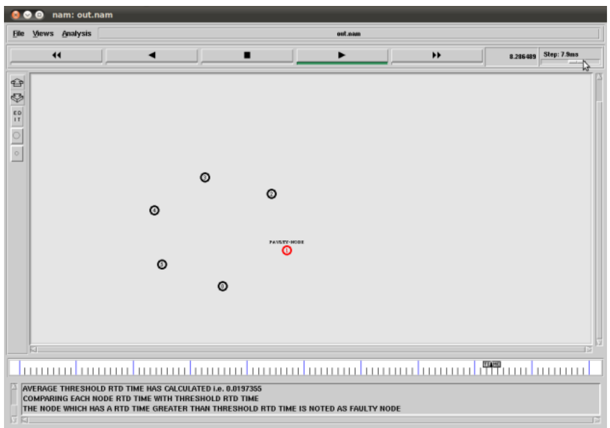


Figure 3: Screen Shot of Detection of Faulty Sensor Node Using Discrete RTPs for 6 nodes

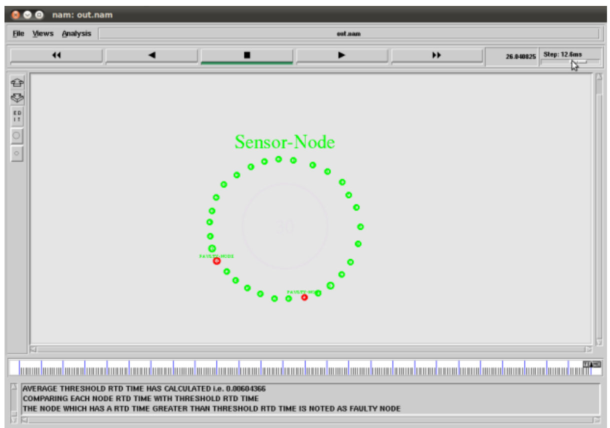


Figure 4: Screenshot of Detection of Faulty Sensor Node Using Discrete RTPs for 30 nodes

5. RESULT ANALYSIS

Method described to detect the fault is successfully tested in 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 like6, 30are

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implemented and tested in NS2 software. Packet delivery ratio, throughput and the comparisons graphs are shown in fig 5, 6, and 7 (for 6 nodes) and fig 8, 9 and 10 (for 30 nodes)

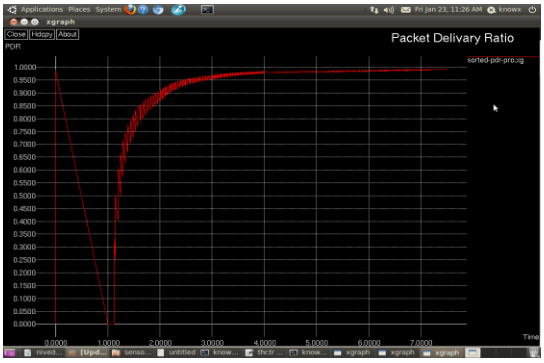

Figure 5: Packet delivery ratio for 6 node sensor nodes.

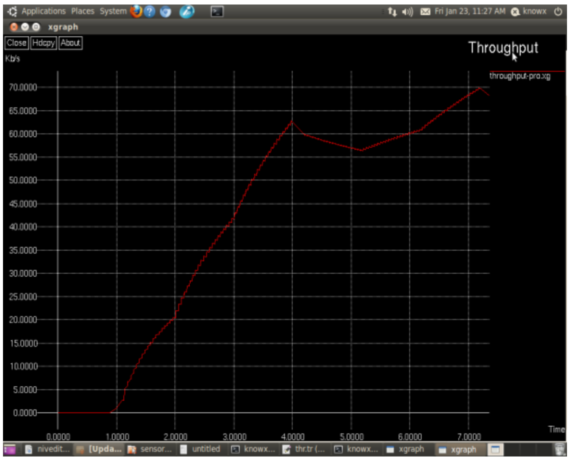

Figure 6: Throughput for 6 Sensor Nodes.

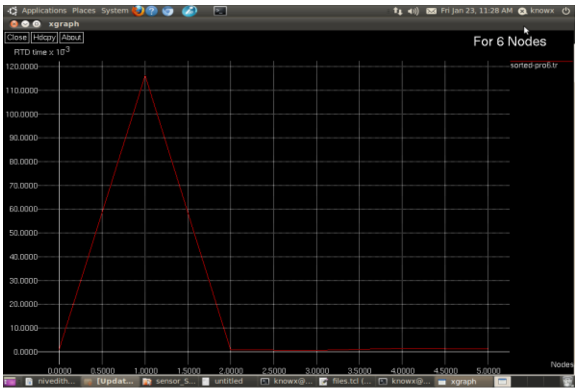

Figure 7: RTD time simulation results for different WSNs. RTD time results of discrete RTPs for faulty node S1 in WSNs with N = 6.

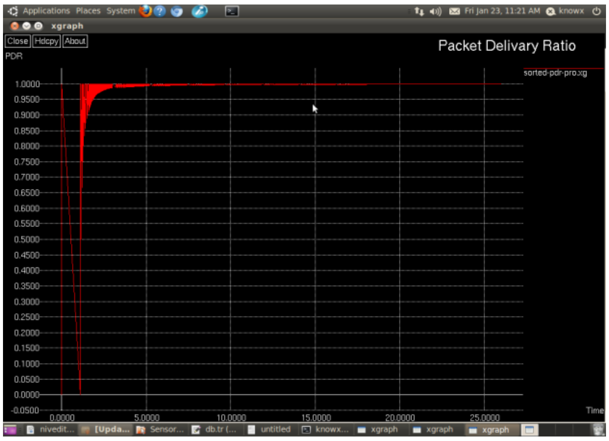

Figure 8: Packet delivery ratio for 30 node sensor nodes.

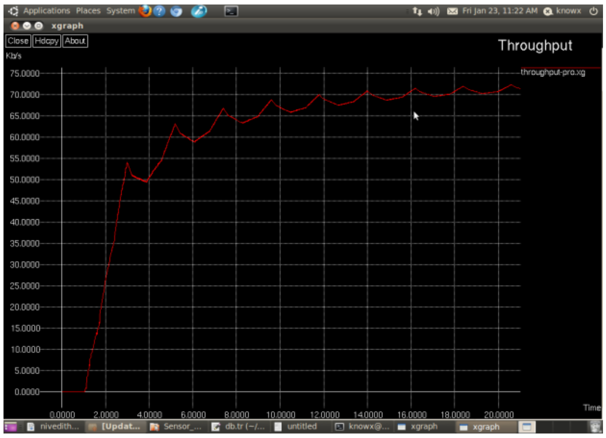

Figure 9: Throughput for 30 Sensor Nodes

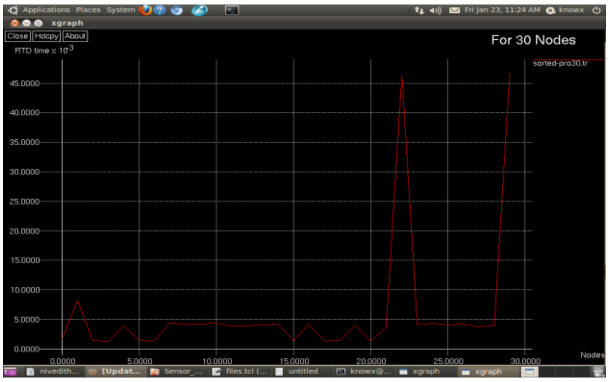

Figure10: RTD time simulation results for different WSNs time results of discrete RTPs for faulty node S22 and S29 in WSNs with N = 30.

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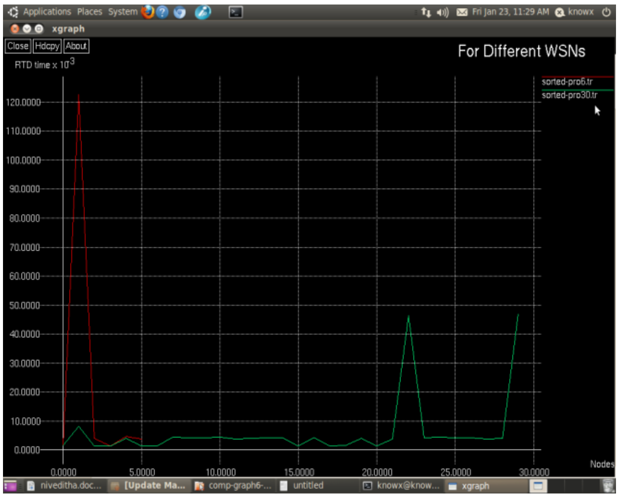

Figure **11: RTD time simulation results for different WSN's** i.e. for 6 and 30 Sensor Nodes.

Analysis time to detect fault is very much optimized by using the discrete RTPs. Simulation results obtained in WSNs with large numbers of sensor nodes are sufficient to prove the scalability of investigated method. Also it validates the real time applicability of the method and it is shown in fig 11.RTD time results obtained in software are to be compared to prove the real time applicability of investigated method. As various time delays are associated in hardware and software implementation of proposed method. These delays have to be deducted from actual measurement, to obtain the exact RTD time in hardware and software

6. Conclusion and Future Enhancement

In future work, we are implementing and testing the performance of suggested methods with different topologies of WSNs like triangular and rectangular. This will be useful to validate the complexity and applicability of investigated method to various types of WSNs.

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