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RESEARCH ARTICLE

Sleuthing and Resolving Sensor Node Failure in WSNs

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Abstract***: WSN is one of elevated technology domain with large number of applications in various disciplines. Sensor nodes are used in diverse applications to collect variety of information. To increase (Quality of Service) QoS huge number of sensor nodes are deployed in WSNs. The QoS get condensed because of increase in the failure of a sensor node due to battery failure, ecological effects, hardware and software malfunctions. These sensor nodes have to identified and recovered to maintain the good quality of service (QoS). In this paper, the concept of RTD is implemented which is used to calculate the round trip time (RTT). A novel approach is introduced for determining specific discrete RTP which will improve effectiveness by enabling parallel analysis of such RTPs. To maintain the better QoS under failure conditions, identifying and removing such fault sensor nodes are necessary. Hence QoS will be maintained by using energy model technique with the help of Network Simulator (NS2) tool.***
Keywords***: Quality of Service (QoS), Round Trip Delay (RTD), Round Trip Paths (RTP), Faulty Sensor Nodes.***

I. INTRODUCTION

Our inspiration is to ease system's charge by analysis work of faulty sensor node detection. Additionally, we look for making the system a considerable measure of positive and guaranteed. This can be communicated by the standard of administration that is given unhesitatingly and precision measures [3]. A few related works have high rates of failure [5]. Normal types of failure are node failure, join failure, and node raise because of the asset requirements of sensor nodes [9]. The anticipated WSN issue location calculations either accept intermittent transmission of node standing information or inducing node standing upheld inactive data variety. The past methodology significantly lessens system time period, while the last accomplishes poor exactness in dynamic or titan systems [9]. It forecasts well to regard failures as vital just if a small amount of the system is falling flat. It will be enticing to inspire plans that discover failure of sensor nodes, regardless of the system size. This requirement is driven by the framework for inadequacy disclosure is predicated on RTD time measurement[1] of RTPs. RTD times of RTPs diverged from point of confinement time with see good or faulty nodes. In Proposed method Failure of node is identified by creating Round Trip Paths (RTP) for sensor node. Round Trip Delay is measured (RTD) from RTP created [1]. Discovery of fault is based on the discrete RTPs for their round trip delay (RTD) time. Few RTPs are analyzed during fault detection this will improve the lifetime as well as quality of service (QoS) of WSNs. Software tool NS2 is used to implement RTD protocol. Faulty sensor node is detected by simulating circular topology WSNs with RTD protocol [2]. To check the unsuccessful sensor node manually in such atmosphere is troublesome. This paper presents a new methodology to notice the sensor node failure or defective in such atmosphere. The planned methodology uses the trip delay (RTD) time to estimate the boldness issue of RTD path. Supported the confidence issue the unsuccessful or defective sensor nodes are detected. Here by selecting minimum number of sensor nodes in the RTP will reduce the RTD time. This method [1] the round trip path (RTP) in WSNs is formed by grouping minimum three sensor nodes. So in this technique the round trip paths (RTP) are high and round trip time (RTT) is increased.

This Paper includes VIII sections. Section I deals with Introduction to WSNs and challenges, need of failure detection etc, Literature Survey is provided in Section II, Section III consists of RTD time estimation. In section IV Computation of RTPs. Section IV Algorithm steps and Flow charts in section V. In section VI Working Principle. Section VII deals with various Test cases, Section VIII contains the experimental results.

II. Literature Survey

P. Jiang [8] has recommended the neighbor nodes learning investigation. In this method the fault identification exactness will diminish quickly if the numbers of neighbor nodes to be analyzed are minute and failure ratio is high. Confidence factor quantity based neighbor statistics analysis anticipated by Zhipeng et al. [9] to identify the faulty node has burdens due to the imprecise algorithm. S.S.Ahuja et al. [6] suggested the link failure discovery based on monitoring cycles (MCs) and monitoring paths (MPs).Different wavelength and monitoring areas of each monitoring cycles have disadvantage because of three edge connectivity [6]. Ing Ray et al. [10] expected with the objective to fulfill application QoS needs while expanding the sensor lifetime. In query based sensor networks a user would get a query within the point in time response is must be come. The consequence of redundancy on the Mean Time To Failure(MTTF) of request based cluster-structured WSNs, defined as the mean number of questions that a WSN is capable to answer properly until it fails because of channel failures [10], sensor issues, or sensor energy diminution. Ravindra N Duche et al. [4] arranged a totally significant technique for particular discrete RTP that has the ability to improve quality by enabling parallel examination of RTPs at some stage of examination, information from failed node to be evaded hence QoS will be protected in WSN. Initially consider all nodes working properly estimate RTD value highest RTD time is measured as Threshold RTD time.

III. RTD TIME ESTIMATION

For determining the fault detection analysis time in WSNs is done by using discrete RTPs detection time of failed or malfunctioning sensor node depends upon the numbers of RTPs and RTD time [4]. Therefore, evaluation of RTD time and RTPs is must be minimize in the process of sensor node failure detection. Round-trip delay (RTD) is the time required for a packet to transfer from a source node thru path which contain other nodes and back again. This RTD time varies from few milliseconds under standard conditions between nearby sensor nodes to several seconds under downside conditions between sensor nodes which are separated by a long distance.

The minimum round trip delay time (τRTD) of RTP with three sensor node is given by equation

$$\tau RTD = \tau 1 + \tau 2 + \tau 3 . \qquad (1)$$

where $\tau 1$, $\tau 2$ and $\tau 3$ are the delays for sensor nodes.

Let 'τ ' be the uniform time delay for all sensor node pairs in RTPs i.e. $\tau = \tau 1 = \tau 2 = \tau 3$. Round trip delay time for RTP with uniform sensor node pair delay is obtained by referring equation (1) as $\tau RTD=3\tau$.
(2)

IV. COMPUTATION OF RTPs

Round Trip Paths are may be computed with the help of Linear selection of paths or Discrete selection of process [4]. Following section describes the both two techniques.

1. Linear RTPs Selection: In order to reduce the RTPs in the fault detection analysis, instead of considering maximum numbers of RTPs, only few paths corresponding to the number of sensor nodes in WSNs are sufficient. Hence comparison of such three linear RTPs is sufficient to detect the faulty sensor node. The linear RTPs in WSNs with N sensor nodes can be written as

$$Lp = N \qquad (3)$$

where Lp is the number of linear RTPs. Measurement of RTD times of such paths is essential. Analysis time $\tau ANL(L)$ for linear RTPs is given by

$$\tau ANL(Lp) = N * 3\tau \qquad (4)$$

In linear approach for six sensor nodes in circular topology as shown in Figure1, Six Round Trip Paths are computed as shown in Figue2 they are:

RTP 1=S1-S2-S3
RTP 2=S2-S3-S4
RTP 3=S3-S4-S5
RTP 4=S4-S5-S6
RTP 5=S1-S6-S5
RTP 6=S1-S2-S4

Further reduction in the numbers of RTPs is must to increase the efficiency of proposed method. Disadvantages of this approach are redundancy is increased, energy exploitation and reduces number of exact responses in network. Redundant paths in WSNs will slow down the fault detection process.

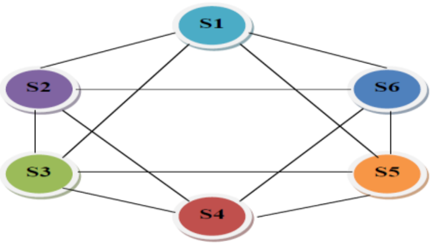

Figure 1: Circular Topology

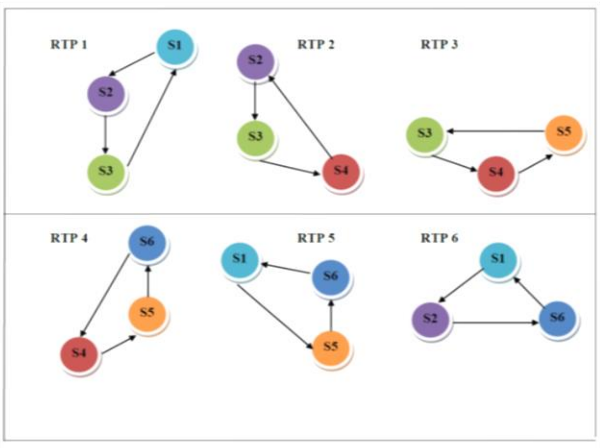

Figure 2: Linear RTPs Selection.

Figure 1 Shows the six sensor nodes organized in circular fashion and Figure 2 depicts how the RTPs are elected using the equation (1) Lp=N, means the number of nodes are equal to linear RTPs.

2. Discrete Selection of RTPs: 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. 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. The Discrete RTPs in WSNs sensor nodes can be Computed using following equation.

$$Dp=Qt+Cf \quad (5)$$

$$Qt=[N/m] \quad (6)$$

where Dp is discrete paths in WSNs and Qt is Quotient, it is calculated as N is nodes present in the WSNs, m indicates nodes in Round Trip Path i.e m=3.
Cf is Correction factor to be added It will be 0 if remainder is 0 otherwise it is 1.
The analysis time is computed with the help of below
equation:

$$\tau ANL(Dp)=([N/3]+Cf)*3\tau \quad (7)$$

where N is the nodes present in the WSNs. τ is Round Trip Delay (RTD), 3 is nodes in RTP.

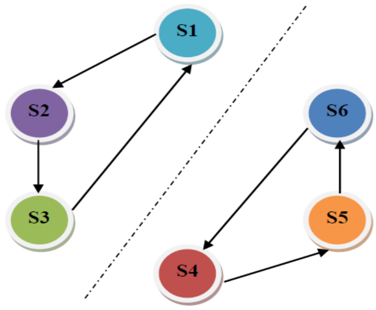

Figure 3: Discrete RTPs Selection

Analysis of particular selected discrete path will be sufficient to monitor the fault. Selection of discrete RTPs will save the analysis time to a large extend. Advantages of selecting discrete RTPs are decreased analysis time, fautly sensor nodes are detected and it maintains the Quality of Service (QoS) under failure conditions.

IV. ALGORITHM

This section depicts various steps involved for detection of failed nodes in WSNs [4]. Also second algorithm describes how the node failure can be resolved to higher the QoS.

1. Algorithm Steps for Detection of failed nodes in WSNs:

Step1: Node deployment.
Step2: Formation of circular topology.
Step3: Calculate the number of Round Trip Paths in network.

$$Dp=Qt+Cf$$
$$Qt = [N/m]$$
$$Cf= 0 \{ \text{ if } Rm=0,1 \text{ otherwise } \}$$

Where Qt= quotient, Rm= Remainder, Cf=Correction factor, N=number of nodes and m=3.

Step4: Packet Transmission in Round Trip Paths.
Step5: Calculation of Round Trip Delay for sensor nodes.

$\tau RTD = \tau 1 + \tau 2 + \tau 3$ where $\tau 1$, $\tau 2$ and $\tau 3$ are the delays for sensor nodes

Step6: Threshold RTD time Computation.
Step7: Comparison of node RTD time with Threshold RTD time.
Step8: Detection of faulty nodes based on higher threshold RTD value.
Step9: Data or packet Loss at failed node.

2. Algorithm Steps for Resolving Node Failure in Network.

Step1: Finding energy level of neighbouring nodes.
Step2: Compare energy level of neighbouring nodes.
Step3: Nodes which have higher energy level are elected as recovery nodes.
Step4: Packet or data transmission.

V. FLOW CHARTS

In this section two main concerns are used first is for detection of failed node in WSNs another is to resolve failure in WSNs.

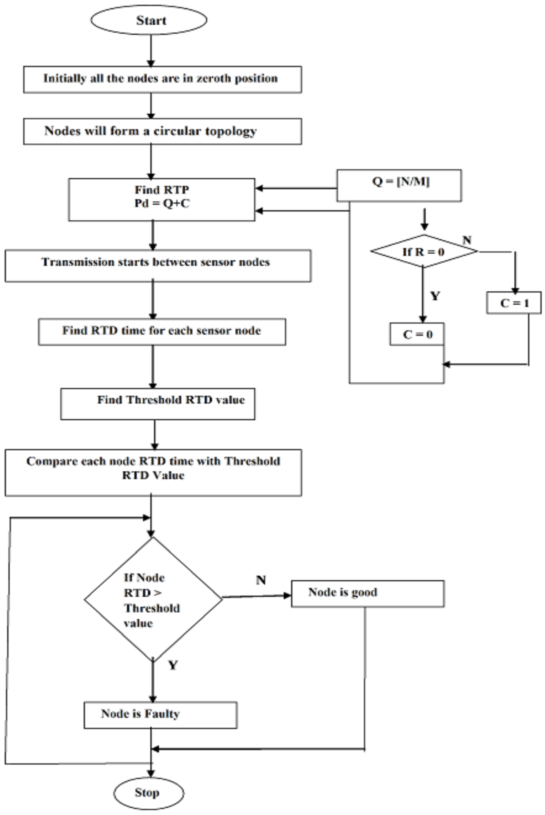

Figure 4: Failed Sensor Nodes Detection

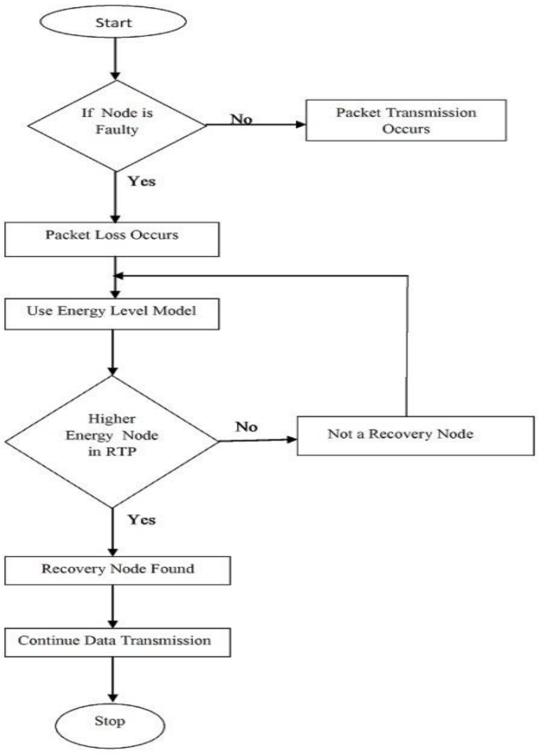

Figure 5: Resolving Failure in WSNs.

Figure 4.The selection of discrete RTPs is calculated using the formula Dp=Qt+Cf, where Qt=[N/m], Cf={0 if Rm=0,1 otherwise}.N is the nodes in network, m is the nodes used to form Round Trip Paths, i.e m=3,Cf is Correction Factor to be added it will be 0 if remainder is 0 otherwise 1.In Figure 5 shows the flow chart for Resolving Failure in WSNs with Energy model origination the energy level of neighboring nodes are contrasted with get a recuperation node for the fizzled node. The node which has most extreme energy level that node is picked as recuperation node for the dead node.

VI.WORKING PRINCIPLE

To recognize flawed sensor nodes in WSNs the calculation lives up to expectations with two sections such that in first part all nodes are situated to be working appropriately. Discrete RTPs are chosen and RTD time of each RTPs are processed. The time evaluated among operation of first part is picked as limit RTD time for each RTPs in WSNs. Later partially broken sensor nodes are identified. On the premise of RTD time the discrete RTPs are recognized with edge RTD time the RTPs whose RTD quality is more than limit RTD then investigation happens into three stage prepare as portrayed underneath.

Part I: RTD is intended & maximum value is considered
as threshold value.
Part II: 3 Stage process.
The not working node can be located at any position.
RTP x =SNx-SNx+1-SNx+2
RTPx+1= SNx+1-SNx+2-SNx+3
RTPx+2= SNx+2-SNx+3-SNx+4

Where RTP is Round Trip Path, RTD is Round Trip Delay, SNx indicates source node. The value of x varies from x = (1, 2, 3...N).

Stage 1:

In this stage the two distinctive Round Trip Paths are contrasted to identify definite position of fizzled node. The Round Trip Delay of RTPx is higher than limit esteem also, RTPx+1 is equivalent to limit esteem consequently the node SNx is distinguished as fizzled node. On the off chance that RTPx is ∞ then SNx is noted as fizzled node.

Stage 2:

In this stage the two diverse Round Trip Paths are contrasted with find definite position of fizzled node. The Round Trip Delay of RTPx and RTPx+1 are higher than limit quality and RTPx+2 is equivalent to edge esteem hence forth the node SNx+1 is distinguished as fizzled node. On the off chance that RTPx+1 is ∞ then SNx+1 is noted as fizzled node.

Stage 3:

The Round Trip Delay of RTPx, RTPx+1 and RTPx+2 are higher than threshold value and RTPx+1 is equal to threshold value hence the node SNx+2 is identified as failed node. If RTPx+2 is ∞ then SNx+2 is noted as failed node. Similarly RTD value is compared with end node SN in the WSNs. The algorithm steps works until all the RTPs in WSNs are computed.

- *For Resolving Failure in WSNs:*

once detection of faulty sensing node in network is done the system should be capable to resolve failure in network. Recovery mechanism is employed that's finding recovery nodes for faulty nodes by victimization of the energy model ideas the node that has higher energy is elected as recovery node. The efficiency of the framework can be measured by considering distinctive execution measurements, for example, RTD proportion, Packet conveyance proportion and throughput. The investigation time for recognizing fizzled node in the system can be diminished by choosing just discrete Round Trip Paths in WSNs. RTD time essentially relies on the nodes show in the round excursion way and the separation among them.

VII. TEST CASES

After fulfilment of our task, few experiments were made that served to check the effective execution of the project. The following Table I shows the different test cases for detecting faulty sensor nodes.

Table I: Test Cases for Detecting Faulty sensor nodes.

Test Cases	Description	Input Data	Expected Results	Status
1.	Initialization of sensor nodes	Defined Location(X,Y)	Nodes are initialized with zero[th] position.	Pass
2.	Circular Topology Formation	Sensor nodes	Nodes will move to form circular topology.	Pass
3.	Calculate the number of Round Trip Paths in network.	Pd=Qtr+Cf Qt= [N/m] Number of Sensor nodes	Number of Round Trip Paths in network must be calculated.	Pass
4.	Calculate Round Trip Delay of sensor nodes.	Delay for each node(τ1,τ2, τ3) in RTPs.	RTD Time for each RTP nodes must be calculated. RTD = τ1 + τ2 + τ3.	Pass
5.	Acknowledging Threshold value.	RTD time of Each RTPs.	Threshold Value.	Pass
6.	Detection of faulty nodes based on higher Threshold RTD value.	RTD value of each RTPs and threshold value.	Faulty nodes are found.	Pass

For resolving node failure in Wireless sensor network the following test cases are made. The table II shows the test cases.

Table II: Test Cases for Resolving Failure in network.

Test Cases	Description	Input Data	Expected Results	Status
1.	Packet Transmission in Network.	Topology and data	Data loss at faulty sensor nodes.	Pass
2.	Find energy level of neighboring nodes.	TCL file Energy Model	Energy level Calculated.	Pass
3.	Selecting recovery nodes.	Sensor nodes	Highest energy level node must be selected.	Pass
4.	Resolving Failure in network.	Highest energy level node.	Packet transmission.	Pass

VIII. EXPERIMENTAL RESULT ANALYSIS

Method represented to notice the fault is implemented and tested in software package. WSNs with giant numbers of sensing element nodes can't be complete to verify the urged methodology. WSNs with Sensor nodes 6,30and50 square measure enforced and tested in NS2 tool. This section shows the snapshots of outcomes.

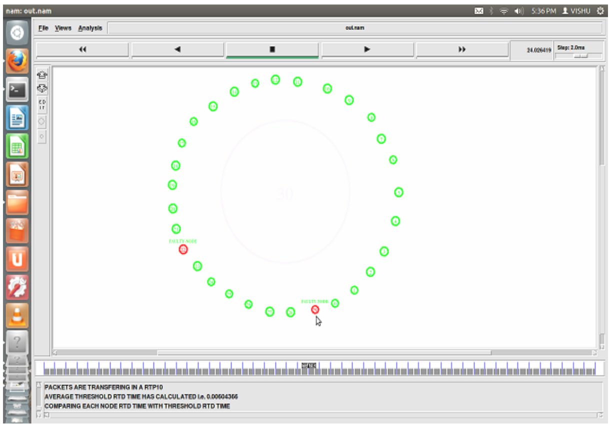

Figure 7: Faulty Nodes Detection

Figure 7 shows RTD Time Computation and correlation of edge RTD worth happens the nodes that have greater than Threshold RTD Time identified as flawed nodes in RTPs that are hued as red nodes.

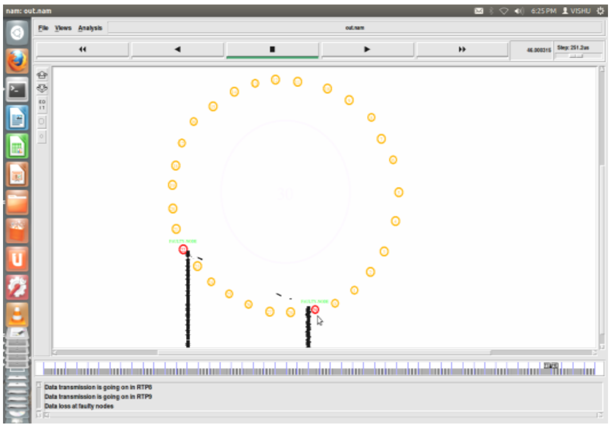

Figure 8: Data Loss at Faulty node

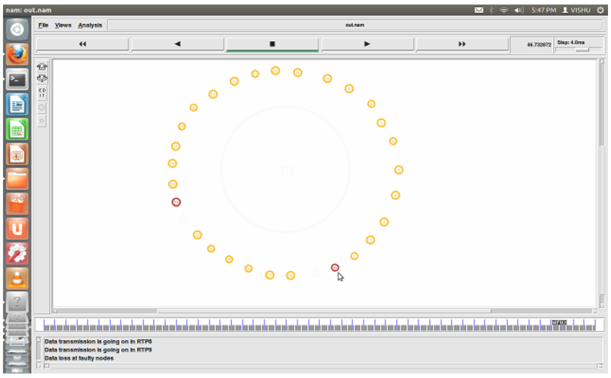

Figure 9: Recovery nodes for Failed nodes.

Figure 8 Dark shading modest squares demonstrates the dropped packets at broken nodes. Figure9 shows that recovery mechanism is employed that to find recovery nodes for faulty nodes by victimization of the energy model ideas the node that has higher energy is elected as recovery node. Nodes which have higher RTD are elected as faulty nodes. Node 22 and node 28 have privileged RTD since these two nodes are recognized as faulty nodes as shown in Figure 10.

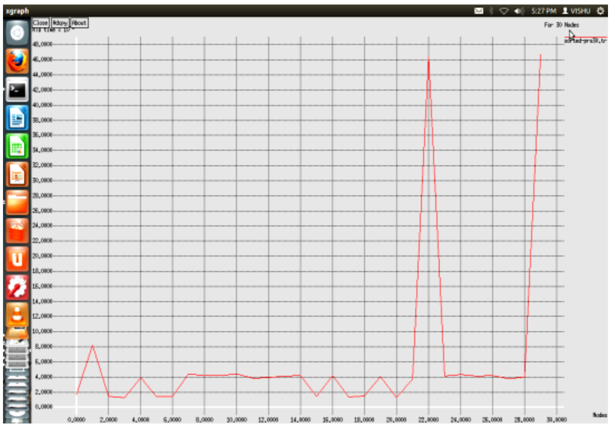

Figure 10: Round Trip Delay.

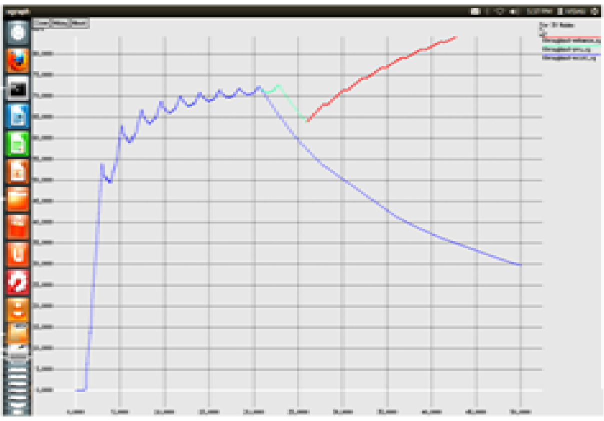

Figure11: Throughput Comparison

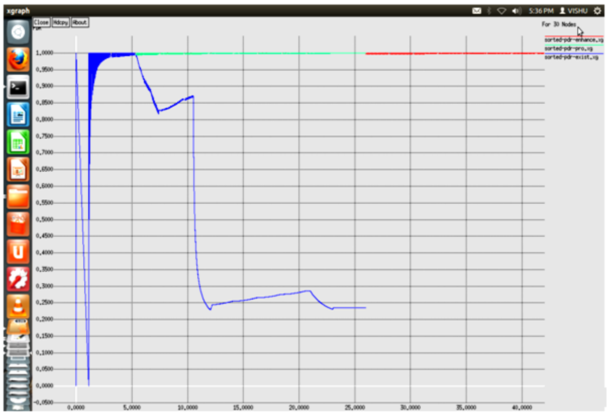

Figure12: Comparison of Packet Delivery Ratio

Figure11 shows the comparison graph of throughput the blue color line shows the existing system, green line shows proposed system and red color line indicates enhanced system. And Packet delivery ratio is shown in Figure 12.

CONCLUSION

This methodology will increases system responsiveness by considering solely distinct RTPs from WSNs, reduces the investigation time of fault node discovery method.

To resolve node failures in Wireless Sensor Networks projected methodology uses energy model. Therefore to stay up the prime quality of services below failure conditions, recognizing and detaching node failures in WSNs is become terribly essential. It reduces energy consumption and provides magnified life span for sensor nodes. The planned work is enforced on circular topology the long run work includes testing this work on numerous topologies and implementing this method on real time applications.

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