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Comparative Study of Fault Detection Techniques in Wireless Networks and Manets

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Abstract
The internet has dominated global communication for over three decades, largely due to the robustness and ease of deployment offered by wired networks. However, in recent years, the decreasing hardware costs associated with wireless networks have significantly boosted their popularity worldwide. Traditional wireless networks typically require a central device, such as a router (acting as a server), to which multiple devices (clients) connect wirelessly. In contrast, Mobile Ad-Hoc Networks (MANETs) and Wireless Sensor Networks (WSNs) operate without such centralized devices. MANETs are decentralized wireless networks where each node can function as both a host and a router, allowing for flexible and dynamic communication without relying on fixed infrastructure. WSNs consist of spatially dispersed sensor nodes that monitor environmental conditions and communicate wirelessly, often without a central server, to collect and transmit data. The objective of this study is to identify faulty readings in wireless networks, specifically in WSNs and MANETs, by utilizing local diagnostic messages to create a global diagnosis status table. This approach aims to detect both hard and soft faults and facilitate comparative analysis between WSNs and MANETs.

Keywords: WSN, Wireless Sensor Network, MANET, AD-Hoc

1. Introduction

Wireless sensor networks (WSN), in some cases called remote sensor and actuator systems, are spatially circulated autonomous sensors to screen physical or natural conditions, for example, temperature, sound, pressure, and so forth and to agreeably go their information through the system to the principle area. The cutting-edge systems are bi-directional, additionally empowering control of sensor action. The advancement of remote sensor systems are motivated by military applications, for example, war zone observation; today such systems are utilized in numerous modern and consumer applications, for example, mechanical procedure checking and control, machine well being observing, etc. A sensor node is a node in a sensor arranges that is fit for playing out some processing, gathering tangible data and speaking with other associated nodes in the system. Every sensor organize node has commonly a few sections: A radio handset with an inward reception apparatus, a sensor unit, simple to computerized encoder, processor, memory, power generator and so on. Essentially, a sensor node has five central squares are: Sensing unit, processing unit, transceiver unit, power unit and power generator as appeared in Fig 1.

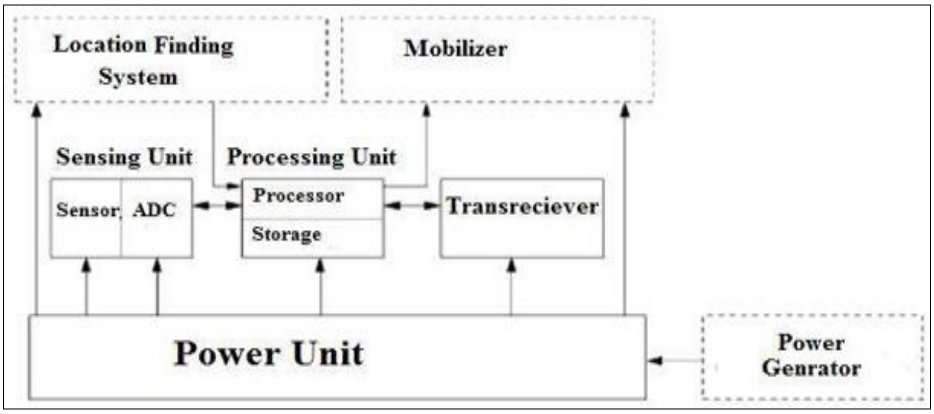

Fig 1: Wireless Sensor Unit

Wireless Communication System is assuming a major significant job in information systems and its administration is significant and crucial. Various types of administrations can be there, for example, configuration management, fault management, performance management and security management etc. Fault management is increasingly significant. A node becomes broken due to battery release, crash and constraint in age. The presence of faulty node influences the effectiveness and throughput of the system, and subsequently making the system inconsistent. Broken nodes can't communicate with different mobiles or behave unexpectedly and send unexpected outcomes. In this manner it superfluously consumes energy and cause irregularity.

2. Objectives

There are some objectives of this paper which is as follows:

1. Make a global diagnosis status table using local diagnosis messages.
2. To find out the hard fault as well as soft faults.
3. To make comparison analysis for WSN and MANETs.

3. Literature Review

To comprehend the trade-off in the present WSNs, it is useful to quickly inspect their history. In the same way as other trend setting innovations, the source of WSNs can be found in military and overwhelming modern applications, far expelled from the light industrial and consumer WSN applications that are common today.

Related work for the topic is as per the following:

X. Yang *et al.* [1, 4] Wireless sensor networks, named clustered agreement time synchronization (CCTS). This algorithm is created on the base of the Distributed consensus time synchronization (DCTS) algorithm. The CCTS incorporates two sections: 1) intra cluster time synchronization and 2) inter cluster time synchronization. The simulation results show that the future calculation lessens the communication traffic compared with the DCTS algorithm, and improve the convergence rate reasonable to the mix of clustering geographies. Y. S. C. Sun-Yuan Hsiesh *et al.* [3, 5] The proposed technique for fault detection depends on RTD time size of RTPs. RTD times of discrete RTPs are contrasted with threshold time with decide **f**ailed or breaking malfunctioning sensor node. Result examination in equipment and programming demonstrate that RTD time estimation brings about the two cases are a remarkable same, approving the continuous appropriateness of this technique. G. Y. Chang *et al.* [2, 7] The algorithm projected is based on the GD algorithm, with the aim to replace few sensor nodes that are not operative or have exhausted batteries, and to regenerate the greatest number of routing paths. These refinements will eventually reinforce the WSN. F. Koushanfar *et al.* [6] Mobile ad networks (MANET) represent distributed systems consisting of wireless nodes that can freely and vigorously configure themselves as temporary network services, allowing people and devices to easily access the Internet in areas without existing communication infrastructure, for example, disaster recovery environments. Y. Liu *et al.* [9, 10, 11] Pure wireless communication also has limitations in that radio signals are less disturbed and radio frequency above 100 MHz does not usually transmit above the optical line (LOS). The Mobil ad hoc network creates an appropriate framework to address the problems of dynamic nature of communication nodes by providing a multi-hop wireless network without pre-set infrastructure and connectivity over LOS.C. Jaikaeo *et al.* [8, 12, 13] Hybrid Energy Efficient Distributed Clustering is presented which is a multi-hop clustering algorithm for wireless sensor networks. The principle point of HEED is, distribute energy utilization to delay network lifetime, limit energy utilization during cluster head selection phase and to limit the control overhead of the network. P. Wang *et al.* [14, 17, 18] A productive and viable hierarchical algorithm for MANET, which is called Fault-tolerance Cluster Head based (FTCH) routing protocol. FTCH is proposed to give a certain packet delivery fraction guarantee and low routing overhead within the sight of misbehaving nodes. The FTCH directing convention is assessed through both analysis and simulations contrasted with Max-Min Multi-Hop routing convention (MMMH), AODV and DSR. The outcomes show that FTCH extraordinarily improves the ad hoc routing performance in the presence of faulty nodes. M. Asim *et al.* [15, 16] Failure detectors are significant building blocks for building fault-tolerant distributed system and are solution to the issue of failure detection in the sight of mobility in distributed systems. E. P. Duarate *et al.* [19, 20] Coordinated Diffusion for Wireless Sensor Networks was proposed. In Directed Diffusion information is named utilizing trait esteem sets. A node demands information by sending interests for named information. This information demand is communicated all through the network.

4. Types of Faults

Each node in the system can be in one of two states faulty or fault-free. In order to exchange information, a node requires multiple hops in the WSNs because of the restricted transmission power in the network. Due to constraints like unreliability of wireless medium, unpredictability of environment, resource constrained nodes and dynamic topology, WSN are prone to various types of faults. These can be classified as;

1. Based on the Duration- On the basis of duration faults can be of three types:

a) **Transient fault:** A transient fault can vanish with no noticeable function; it shows up in a network for brief timeframe. The recovery of transient faults from framework is addressed using repeated-round techniques. A probabilistic model utilized for the activity of defective periods, and a fault examination is utilized to get the ideal retry period.
b) **Intermittent fault:** It is problematic type of transient fault; can't anticipate its appearance and disappearance in the network. A discontinuous fault happens by various components. These components can only be recognized when any glitch occurs. Discontinuous shortcomings are difficult to recognize and fix.
c) **Permanent fault:** When it appears in the network, it stays till it is eliminated and fixed by some external administrator. Permanent faults are easier to deal.

2. Based on the Behavior-On the basis of behavior faults can be of two types:

a) **Soft Fault/Value fault:** Value faulted units can communicate with its neighboring units but with unexpected behaviors and often gives incorrect response.
b) **Hard fault/Crash fault:** Crash faulted units cannot communicate with its neighbors. It either sends or receives any data from the network.

3. Based on the Occurrence –On the basis of occurrence faults can be of two types:

a) **Static fault:** Every faulty node is faulty from the starting of diagnosis session. Any fault-free node can't be faulty during the diagnosis session.
b) **Dynamic fault:** Fault-free nodes may become faulty during the diagnosis session. It is not easy to perform diagnosis because a node may fail after it is diagnosed fault-free.

5. Fault Diagnosis

Fault diagnosis put additional weight on the sensor node other than with their standard task and it will likewise devour additional energy of the sensor nodes. Numerous strategies have been prescribed to take care of this issue, yet they actually can't fulfill the specific need of WSN fault identification. At the point when any changed conduct is appeared by framework or nodes of the network, a conclusion work is begun to discover which node(s) has (have) indicated unusual conduct. This is called as Diagnosis; diagnosis is classified based on the occurrence of fault. It is essentially delegated static diagnosis and dynamic diagnosis. In static diagnosis, the faults do not occur during the diagnosis session. In dynamic diagnosis, the faults occur during the diagnosis session, which is hard to deal with in light of the fact that node can be faulty after it has been diagnosed as fault-free by the other node.

The Heartbeat Approach: The heartbeat mechanism is the most general method [18] for monitoring crash faults. The ideal heartbeat approach depends on the persistent observing of a node to know if it is alive. In this way, every portable sends intermittently a ―I Am Alive‖ message to mobiles that screen its state. After the running out of a break, if a mobile x doesn't get such a message from one of the neighbors, say y, it is responsible for identifying its failure, at that point it begins speculating it as being faulty. Mobile x adds y to a list of suspected nodes, and will eliminate it from this list once it gets later y's with ―I Am Alive‖ message. The two main parameters by which the heartbeat mechanism can be characterized are as follows:

- The heartbeat period that signifies the time between two successive ―I Am Alive‖ messages.
- The timeout delay which signifies the time between the last gathering of an ―I Am Alive‖ message from v, and the time where u begins to suspect v, until u begins accepting again v's ―I am Alive‖ messages.
- The ideal heartbeat approach has two principle disadvantages. The first is that the detection time relies upon the last heartbeat. This disadvantage may negatively affect the exactness of the failure detector since untimely breaks may happen. The subsequent disadvantages is that it depends on a fixed break delay that doesn't consider the network and system's heap. That is, a node might be erroneously suspected as faulty if it slows down because of hefty workload or if the network suffers from links failure that may postpone the conveyance of ―I Am Alive‖ messages.

Hard Fault: The nodes that neither work nor respond to any kind of stimulus at all.

Soft Fault: The nodes which responds to the stimulus and communicates with the network but with an altered behavior.

6. Problem Formulation

As we had discussed in the introduction that WSN and MANET faults are of many types like transmission error, node or link failure, route breakage and congested node or links. Work done in the past was by finding the nodes that are faulty or fault- free in the wired network. In this paper, the issues faulty readings in wireless networks are determined i.e., WSN, MANET and then their results are analyzed. Which network is more beneficial for an application or which one is less? This is what will analyze in this paper.

7. Proposed Work

In this paper, it is focused to discover the readings which are faulty in wireless networks. Clearly, a gullible way to deal with this issue is to gather all readings to a sink, where numerical analysis is performed to figure out what readings are anomalies. But this centralized way may not be practical due to partial energy budget in sensor nodes. If readings are sent to sink all the points, sensor nodes may soon do in their energy, and then the clustering concept is used. The nodes store the data of all the nodes of cluster in the local diagnostic information, the entire data of all the nodes of network is stored in global diagnostic information. Heartbeat approach determines how the messages are sent or gotten among the nodes. The idea of timeout is utilized, which is the maximum waiting time by the initiator nodes to analyze defective mobile nodes. The general diagnostic message stores the entire data of nodes of complete network. The threshold value tells how much proportion of nodes is faulty or fault-free. Above this soft faults are also determined. Wireless sensor networks are established, at untimely on stage in the development, for being a practical dimension technology for natural monitoring applications. On the basis of their autonomy by accessible infrastructures, wireless sensor networks are organized in practically any area and provide sensor samples in a spatial as well as temporal motion, which in any case would just be possible at significant expense or include significant work by people. The probability of the utilization of wireless sensor networks in certifiable applications, however, is possible only if many technological difficulties are vanquished. Among these difficulties, to find out the faulty nodes in an efficient manner such that detection is optimum in terms of time as well as in terms of energy. Assistance to the solution of these challenge have been the objective of this paper.

8. Algorithm Steps

Below are the algorithm steps:

Step 1: The system having n number of nodes is classified into clusters of range always involution of 2.

Step 2: An assumption is made that initially at the start of the algorithm execution every node is fault free.

Step 3: An initiator node starts the diagnosis process by sending the request heartbeat message to the node which is tested.

Step 4: A tested node sends response heartbeat message to the tester node and then observed diagnostic value and the estimated diagnostic value are compared, if both the values comes out to be same then the node is fault free else the node is faulty.

Step 5: If the tester or we can say the initiator node do not receive the reaction heartbeat message from tested node then it is presumed that the node which is tested is faulty.

Step 6: Every initiator node has tested every other node and collected the diagnosis information through local diagnostic message.

Step 7, 8: A global diagnostic message is prepared and circulated with every node in the network for a consistent view of the entire framework by all the nodes.

9. Flow Chart

This flowchart shown in Fig 2 represents the flow of projected algorithm as mentioned above in this paper. This flow chart demonstrates the way how the work is processed and transformed into result. This flowchart is displayed to explain the functioning of algorithm in a straightforward manner.

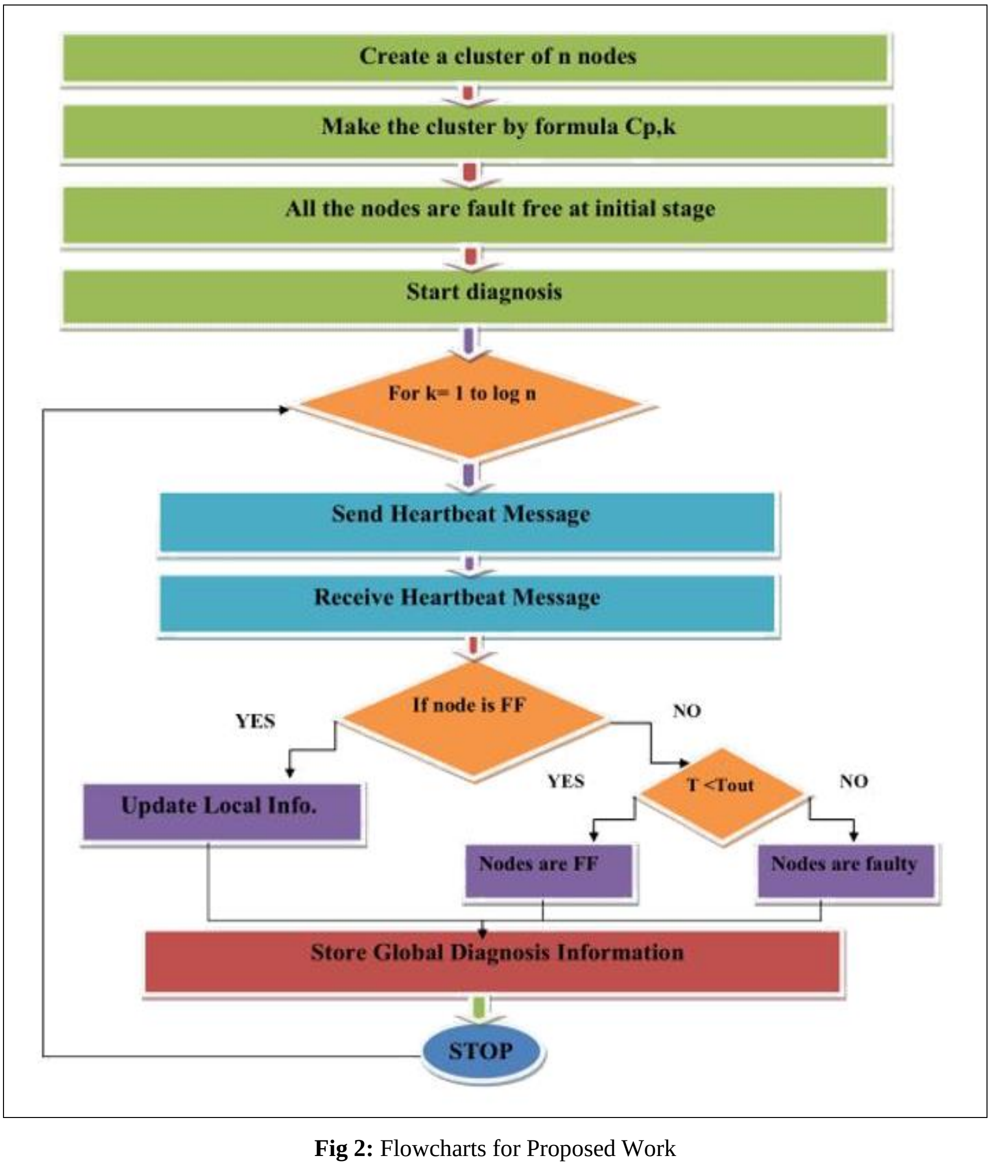

Fig 2: Flowcharts for Proposed Work

10. Implementation

To begin with, we assess the performance of these sensor based calculations. The length of reading vectors for a sensor node is set to 150 and the corresponding threshold is set to 0.6. Faulty nodes are shown in Fig 3.

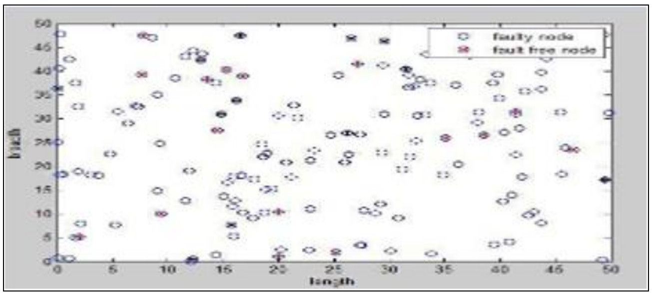

Fig 3: Faulty nodes detected by trust voting

11. Performance of Proposed Algorithm

Simulation of the Hi-ADSD algorithm was carried out using MATLAB or Matrix Laboratory which is mathematical computing environment as shown in Table 1 developed by Math Works. By using the algorithm described above, network is clustered. The values from diagnosis literature are expected for executing the diagnosis tasks, sending initiation time and time of propagation of the messages in the MANET.

Table 1: Values of Various Parameters Used in the Simulation

S. No	Parameter	Value
1.	Execution time of Diagnosis task	0.01 to 0.05
2.	Send time of initiation	0.002
3.	Requesting heartbeat/ Response delay of heartbeat	0.008 to 0.08
4.	Local diagnostic message /Global diagnostic message delay	0.012 to 0.12

In proposed diagnosis algorithm, the initiation heartbeat message goes from every initiator node and at the same time to a node of a cluster of size $C_{p,\,k}$ of one and waits for time out period of Tout. If the node in this cluster is free of any faults, the initiator node will receive heartbeat message in response from this fault free node and collects the diagnosis information about the complete network as of this node. In case the node in the cluster is faulty, the initiator node whichever will not receive the heartbeat message in response. The initiator will detect the fault most within the Tout. The initiator will then send another initiation heartbeat message to another node in the cluster of size 2 and the same process is repeated. In the worst case, an initiator node has to send an initiation heartbeat message to every node of the cluster of size $C_{p,\,k}$ comprising of only the faulty nodes.

For $C_{p,k}$: Firstly, a system having 8 nodes is grouped to create a cluster $C_{p,k}$. It performs the test sequentially until it finds fault free node or all other nodes are faulty. If a fault free node is found, node m copies the diagnostic information of all nodes in $C_{p,k.}$ as shown in Fig 4.

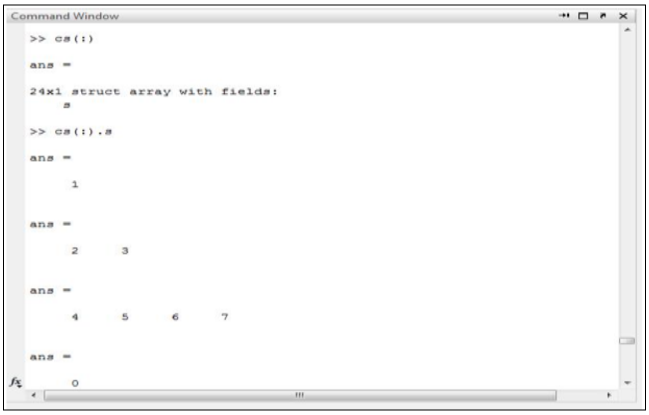

Fig 4: $C_{p,K}$ for the System

1. Diagnosis is done in a hierarchical fashion. As the same happen in basic approach ADSD in that when node find a faulty node, then it will check the next node in the ring, if it is fault free then it stops diagnosis otherwise test continue until it find out the fault free node. Here the diagnosis is done in a particular order, and that particular order is given by $C_{p,k}$. In first round node '0' tests the node '1', at the same time node '1' test the node '0', as shown in Fig 5. Also the node '2' tests the node '3' vice - versa. This way the execution speed increases very much as compared to ADSD. In second round node '0' tests node '2', node '3' respectively and at the same time node '1' tests node '3', node '2' respectively. In third round node '0' tests node '4', node '5', node '6', node '7'.

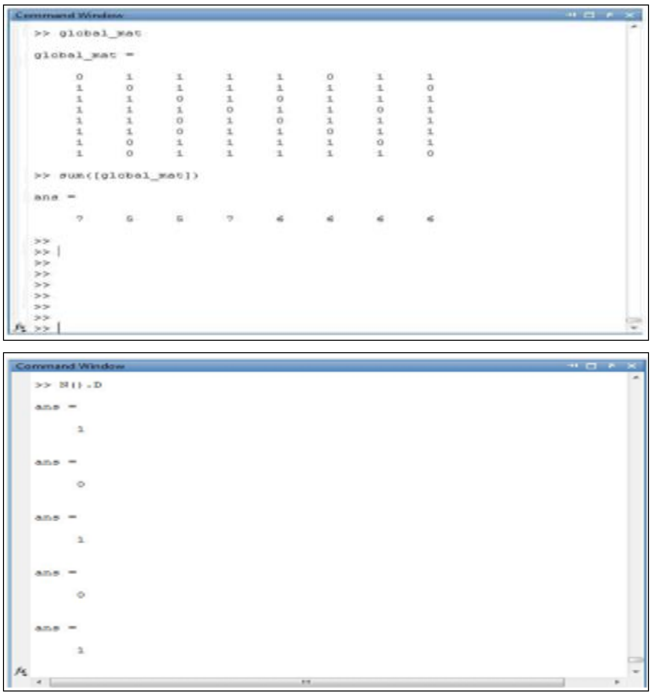

Fig 5: Diagnosis Information

2. Status table: To maintain the status of nodes about the whole network every initiator node maintains a vector known as Status Table (Fig 6). Which stores the status that is local diagnostic information of every node m in the network? Actually, every initiator node is a cluster head.

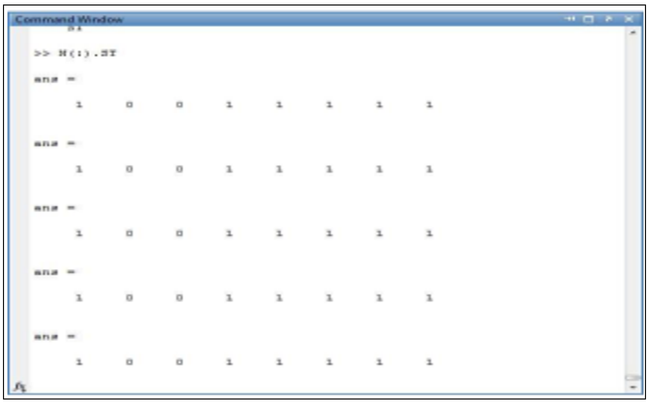

Fig 6: Status Table for Each Node

3. Threshold: Now for displaying faulty and fault free nodes, the threshold for every node is calculated and compared with an already assumed threshold value equal to 6, those nodes having threshold greater than or equal to 6 are considered faulty and the rest of the nodes are fault free as displayed by red circles.

4. Global diagnosis message: Each initiator node prepares a global diagnostic message shown in Fig 7, using local diagnostic message and further disperse the diagnosis information throughout all the nodes for providing a global and consistent diagnostic view by each fault free node of the entire WSN. First of all nodes exchange messages to each other, after every transfer every node check the received messages from all other nodes. If the received message contain shows the same status as the tester node have, then tester node update the status by assigning '0' otherwise update by assigning '1' in the status table.

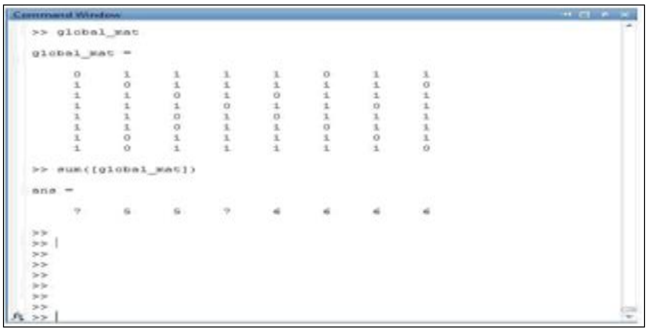

Fig 7: Global Diagnostic Information

12. Simulation Parameters

We have used different type of parameters in our proposed work. These parameters are often used to evaluate the proposed fault diagnosis algorithm.

Diagnostic Latency: The diagnostic latency for the proffered algorithm using clustering is shown in Fig 8. As the size of the network increases, the diagnostic latency using clustering increases but in general there is also a significant reduction in diagnostic latency by using clustering as compared to the diagnostic latency without using clustering. This shows that the proffered algorithm is suitable for larger MANETs deployed in hostile and harsh environments. The diagnostic latency of the algorithm depends the on number of messages such as initiation heartbeat message, response heartbeat message, local diagnostic message, global diagnostic message and message size.

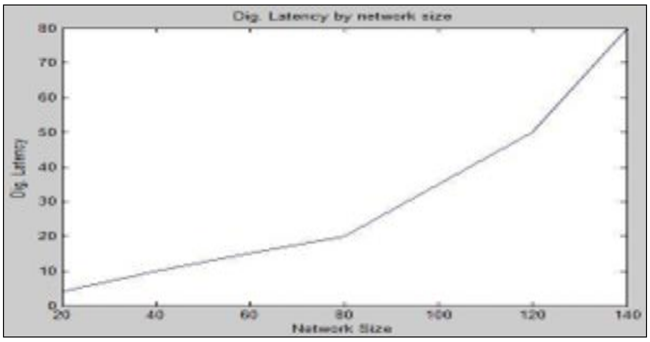

Fig 8: Diagnostic Latency Graph

13. Comparison Graphs

Now we determine the impact of the number of iterations to WSN based and MANET based algorithm

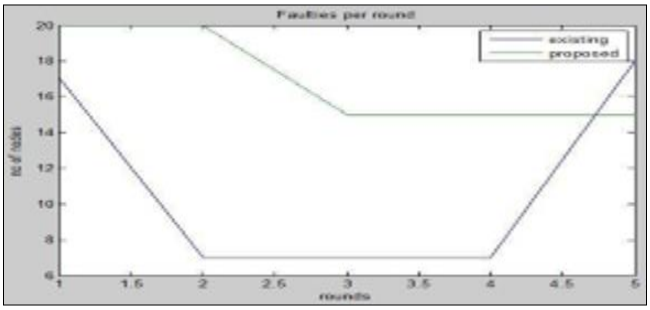

Fig 9: Faulty Nodes Per Round

The length of reading behaviors has been set to 5 and the similarity threshold. The experimental results are shown in Fig 9 and in Fig 10. As shown in Fig 9 when threshold value increases, the faulty detection rate also increases. This is due to the larger number of iterations; Sensor Rank is able to have more neighboring information. Furthermore, as the number of iterations increases false positive rate also increases.

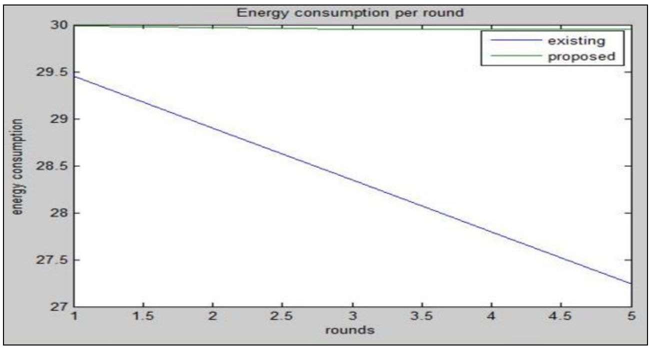

Fig 10: Energy Consumption per Round

14. Conclusion

The work in this paper is encouraged by the problem of fault detection for WSN and MANET. This work offered encouraging framework for fault detection to model faults and monitor the data to identify the existence of these faults. It is worth underlining that fault detection is not the end goal in sensor networks. The main goal is to attain clean data which can be examined to achieve the scientific objectives. Fault detection methods are used to make this goal possible. Along the existence of false readings, the precision of query results in wireless sensor networks may get significantly affected. Faults in WSN and MANET are the main aspects which must be diagnosed. Use the timeout concept for the heartbeat message for receiving and sending the message. The analysis model store the two kinds of information are local analysis message and global analysis message information. The value of threshold which tells how much information is false from whole global analytic message which is shown in Fig 7. The results for the different networks are taken. Graphs are formed for the both types of network. By the heartbeat message the capability of transferring the messages to nodes are increasing that also find whether the next node in the network is faulty or fault-free.

15. Future Work

Make a trusted or essential framework, by designing a primary network in such a way that the burden of piercing the information of all other nodes is reduced. The complete information will be stored in this trusted framework so that each bunch takes the data from this trusted framework and access the details, not store the details in discrete tabular form. The whole information is stored at a single place, every node of the cluster accesses the information from this central network and decrease the burden of the nodes. Make the grouping algorithm with dynamism by using the communication of nodes on the origin of the ideal state of nodes or the busy state of nodes. When the nodes are in the ideal state, the messages are sent additional, the data is collected additional to the busy state. When the nodes are in busy state the message are send less, the information is composed less.

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