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CUT DETECTION DUE TO ENERGY FAILURE IN WIRELESS SENSOR NETWORK USING CLUSTER BASED APPROACH

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ABSTRACT

The major disadvantage of the wireless sensor network is that its efficient performance may be seriously degraded due to the death of the sensor nodes. When attempted to study and discover the various causes for the failure of the sensor nodes, there are many factors like atmospheric factors, technical factors, environmental factors, mechanical factors, natural calamities etc,. Here, the failure of the sensor node due to energy failure is considered. In this paper, a different kind of challenge for the wireless sensor networks is addressed. It is discovered that there is a need to monitor the sensor network itself and to detect when the network has suffered any ill situation. The task of cut detection does not end up consuming a large part of the network resources. In the proposed work the base station is able to check the energy level of the sensor nodes present in the network at considerable number of information exchange so that the base station can come to know whenever problems occur with the sensor nodes.\

Keywords: *Sensor, Cluster, Cluster Head, Energy, Cut.*

1. INTRODUCTION

Wireless technology has expanded the limits of our world. Through this innovation, people have been given freedom to work away from their desks or even outside. The new found freedom that people are beginning to enjoy with their computers has started making the world of technology and nature blend. Wireless Sensor Networks are the next stage of this technology-nature cohesion. Although a young technology, the applications have been varied and promise to be even more varied. These networks are collections of small devices, known as motes, with limited computational power. Each mote has approximately 1-100th of the computing power of a PDA, but when combined with hundreds of other motes, they combine to form an extremely capable system.

A wireless sensor network (WSN) of spatially distributed autonomous sensors to monitor physical or environmental conditions, such as temperature, sound, pressure, etc. and to cooperatively pass their data through the network to a main location. The more modern networks are bi-directional, also enabling control of sensor activity. The development of wireless sensor networks was motivated by military applications such as battlefield surveillance; today such networks are used in many industrial and consumer applications, such as industrial process monitoring and control, machine health monitoring, and so on.

A sensor node might vary in size from that of a shoebox down to the size of a grain of dust, although functioning "motes" of genuine microscopic dimensions have yet to be created. Motes are the individual computers that work together to form networks. The requirements for motes are extensive. They must be small, energy efficient, multifunctional, and wireless. Collections of motes communicate with each other to reach a common goal. The cost of sensor nodes is similarly variable, ranging from a few to hundreds of dollars, depending on the complexity of the individual sensor nodes. Size and cost constraints on sensor nodes result in corresponding constraints on resources such as energy, memory, computational speed and communications bandwidth. The topology of the WSNs can vary from a simple star network to an advanced multi-hop wireless mesh network. The propagation technique between the hops of the network can be routing or flooding.

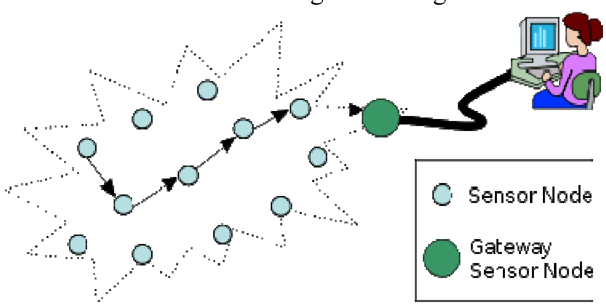

Fig.1 General Sensor Network Controlled By Base Station

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1.1 Components

- A radio transceiver with an internal antenna or connection to an external antenna
- A microcontroller
- An electronic circuit for interfacing with the sensors

An energy source, usually a battery or an embedded form of energy harvesting

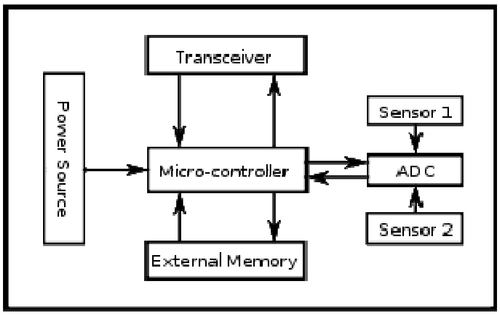

Fig.2 Components Of A Sensor Node

1.2 Applications

They are used in Area monitoring, health care monitoring, air pollution monitoring, forest fire detection, land slide detection, water quality monitoring, natural disaster prevention and industrial monitoring.

Wireless Sensor Networks (WSNs) often suffer from disrupted connectivity caused by its numerous aspects such as limited battery power of a node. The disruption of connectivity, often referred to as network cut, leads to ill-informed routing decisions, data loss, and waste of energy traditional mechanisms for network layers are no longer acceptable or applicable for these networks. Wireless sensor network can get separated into multiple connected components due to the failure of some of its nodes, which is called a “cut”. Existing cut detection system deployed only for wired networks.

2. EXISTING WORK

Many researchers have stressed the importance of network partition monitoring problem [16] [17] [18]. Chong et al. [17] considers the problem as a security issue, mentioning that cuts can be intentionally created in a hostile environment, and nodes must detect them. Cerpa and Estrin [18], in their self configuring topology scheme, emphasize that the cut detection problem is potentially crucial in many WSN applications, but leave it as future work.

The existing system of the wireless sensor networks have no significant methods to find out the dead nodes in the sensor network. The dead node is not recognized by the base station and it stays out of the reach of our knowledge. The base station does not realize the death of the sensor. This not even kept aware to the other fellow nodes of the wireless sensor network.

Consider the under shown wireless sensor network for instance. All the sensor nodes in the network are interconnected to each other in the way that they can favor duplex form of communication. The nearest node which is present to the base station is the one which is communicating with the base station and that which sends the detected messages to the eventual destination nothing but the base station. All the messages are being transmitted from one node to the nearest node of its only.

For instance have that a node in that network has very low amount of energy and it has dead due to it. Once the sensor node has dead it can no longer transmit or receive the messages. This is not known by the other nodes in the network. So, the other nodes, as soon as they get a message to send the base station, they start actively to send the message through their respective neighbor nodes. The node which is highlighted in light blue is the source node which has encountered a message and is sending to the nearest node. The node which has received the information from the source node now intends to pass on the message to its nearest node. But its nearest node has already lost all its energy and it had died. The node since it does not know it keeps sending the message to the dead node. Since it does not receive it, the sending node gets negative acknowledgement. The sending node sends the message continuously and hence it also loses its energy.

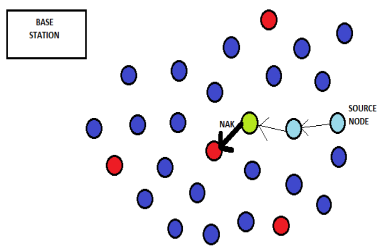

Fig.3 Simplified View Of The Existing System Of WSN

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2.1. Disadvantages

The principle disadvantage of the existing system is the exploitation of energy. Since the energy of the neighboring node is lost at a greater speed, there arises the greater possibility of the other nodes in the network also to die off. Similarly the other node which tends to send the information to the recently dead node also runs out of energy and it also tends to die and to act no more as a node. Similarly at an extent all the nodes in the wireless sensor network would die and the network itself would become extinct.

The need that was aimed at the network itself would ruin. This may also pave way for the hacker to deceive the other alive nodes causing the mal-usage of the network. Security is very low and unsuitable for dynamic network reconfiguration. Hackers can easily hack the data or interrupt the communication. Very time consuming process to finish the user requested jobs. Nodes can be easily compromised and perform malicious activities. Though wireless sensor networking has a wide range of applications in various fields, the disadvantage of it makes it diminished in the world of wireless technology.

So the basic problem for this is energy failure of nodes. So this paper proposes an algorithm that can efficiently detect the failure nodes at fast accuracy, thereby the lifetime of the entire network will be extended. This method basically uses cluster based approach for detecting the cuts due to energy failure and to extend the lifetime of the network

3 PRELIMINARIES AND PROBLEM FORMULATION

We consider a two dimensional network, represented as a connected graph $GV = (V,E)$, where $V = \{v1, v2, \ldots , vn\}$ is a set of deployed sensor nodes, and E represents the set of links between nodes in V . We denote the set of sink nodes (i.e., base stations) by $S = \{s1, s2 \ldots sn\}$, $S \subseteq V$. We assume that each node knows its location either from an onboard GPS or by employing node localization protocols [15]. We assume that a location-based routing protocol is available, such as GPSR [16]. A set $Ni \subseteq V$ denotes the immediate neighbors of a node $vi \in V$. $Cv(G)$ represents the connected component of G that contains a vertex v.

In the methodology proposed, the whole sensor network is approached as divided clusters. The number of clusters would rely upon the number of nodes in the sensor network. The clusters would contain a cluster head for each of them which would act as a leader and controller or a representative for all the nodes in that particular cluster. Any problem or reporting from the nodes of the network must be done only through the respective cluster heads of the cluster which the node belongs to. The cluster heads are connected to each other and the 1st cluster head is connected to the base station.

3.1 Architecture Description

In first step base station stores all node information like Node Id etc. Then it assigns energy level for each node and it selects the neighbor node from the base station. These neighbor node acts as cluster head1. Then it chooses the sub nodes (i.e., its neighbor nodes) from its coverage area.

Then cluster head1 chooses the distance node from its place that act as cluster head2. Then ch2 form its neighbor nodes. Similarly cluster head forms a group. In this diagram node N3 sends data to base station means first it sends data to cluster head1 then cluster head1 sends data to base station.

Suppose N6 sends data to base station means first it sends data to cluster head 2 then ch2 transfer the data to ch1 then ch1 transfer the data to base station. Similarly nodes are sends data to base station. Each node has some energy level to send data. Suppose node has less than 0.5J energy level means it goes to idle state. It also uses cut detector for identify which node act as sub node as well as cluster head after recycling.

3.2. Data Flow Chart

The sink forms the cluster heads and the respective clusters. Before it could form the clusters, it assigns the unique node id and the energy for all the nodes in the network. The base station also assigns the unique keys for every node. The node id is to identify the nodes with them. The unique keys are used to ensure secure transmission of the messages even when there are inactive or dead nodes in the network. The base station along with the nodes selects the cluster heads for the numerous sensor nodes present below the base station. After the selection of the cluster heads, the sub nodes are chosen by the cluster heads among the nodes present within the range of easy access of it.

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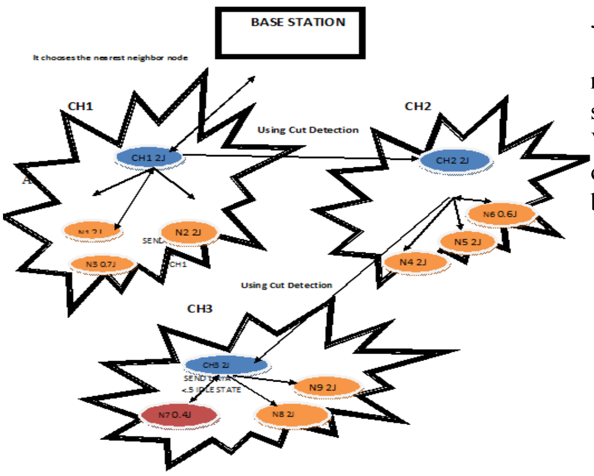

Fig.4 Architecture Of Cluster Head Approach

They form mini network with the cluster heads as their controller. After the entire network is formed favoring the new proposed type of data transmission, the energy of the nodes is checked before any data is getting transmitted. The threshold value of the energy level is taken as 0.5J in the present case. The threshold value will be varying depending upon the field where the sensor network is employed. Say, in places where we need large packets of data to be transmitted, we would prefer high threshold value. If the energy level is above the desired threshold value, the data gets transmitted along its path and reaches the destination. If the energy level of the node is found to be below the threshold value, that particular node goes to inactive state and further it is identified by the base station and its location is tracked and further they are eliminated from the network.

3.4. Requirement Analysis

Requirement analysis determines the requirements of a new system. The product requirement includes input and output requirements it gives the wants in term of input to produce the required output. The resource requirements give in brief about the software and hardware that are needed to achieve the required functionality

3.4.1. Minimum Hardware Requirements

Operating system: Windows XP/ Ubuntu
Processor : Intel Core 2 Duo processor (2.2 GHz)
Hard disk : 160 GB
RAM : 2 GB DDR

3.4.2. Software Requirements

Since the paper is based on Ad-hoc networks it makes use of NS2 simulator for this purpose. The simulator is an open source product. NS2 is a Window/Unix/Linux based application. The details of the simulator and the software used are given below,

- Red Hat / Fedora core 8 / Linux / Windows XP
- Network Simulator 2
- Network Animator
- Trace graph

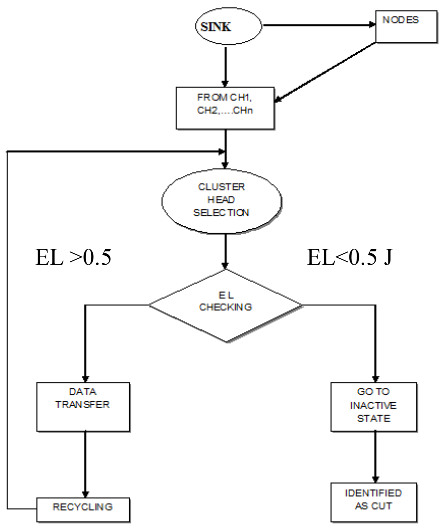

Fig.5 Data Flow Diagram Of The Proposed Work

Algorithms Used

- Low Energy Adaptive Clustering Hierarchy
- Sentinel Algorithm

4. *MODULES*

4.1 Network Construction Based On The Base Station

The nodes are placed in their position in the space for the wireless sensor networks. They are placed depending on the measurement of x and y axes. Each and every sensor node is connected to the base station for this instance alone. The base station first assigns. node id and energy level to all the nodes. The node id is to give a name or an identity to each and every node. The node ids are

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ensured that they are unique for every node so that the particular node can be addressed using its node id. Keys for all the nodes are also assigned for security of the message

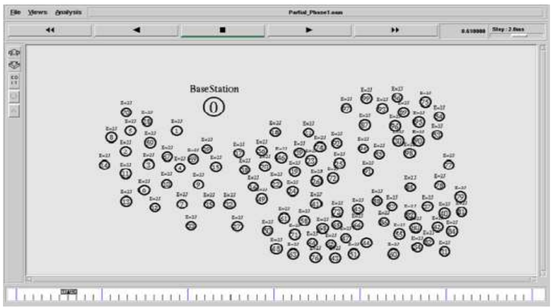

Fig.6 Base Station Assigning Energy And Node Id

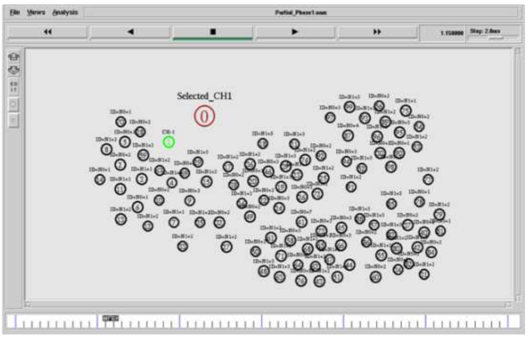

Fig.7 Base Station Selects Nearest Node As Cluster Head

Now the base station checks for the node which is nearer to it and that has the maximum energy and names it as cluster head 1. Now the cluster head 1 selects its sub nodes and form the network with them establishing communication path among them. Then the same cluster head 1 selects the cluster head 2 which has maximum energy level and nearer to the cluster head 1 at a particular distance.

Now the cluster head 2 will selects its sub nodes and form the network with them. In the similar manner cluster head 2 will select cluster head 3 which will selects its sub nodes and form the network. The cluster head 3 makes a network under it as a head and establishes communication path among them. The cluster head 3 in turn selects cluster head 4 at a particular distance with maximum energy and cluster head 4 chooses its own sub nodes and forms its network.

The fully formed network resembles the one in the figure 8. The clusters are distinguished from each other through their distinct colors. The ones in light green are the cluster no.1. The ones in blue are cluster no.2. The ones in red are cluster no.3. The ones in pink are cluster no.4. The ones in orange are cluster no.5. The ones in yellow are the common nodes between cluster 1 and cluster 2 and between cluster 2 and cluster 5.

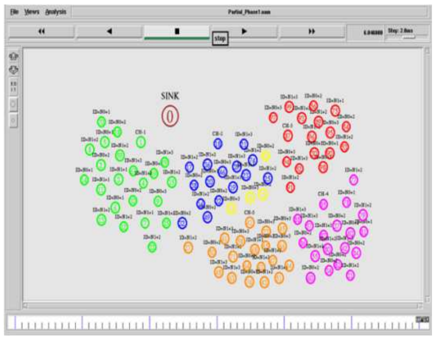

Fig.8 Fully Formed Clusters With Cluster Heads

4.2 Path selection and data transmission

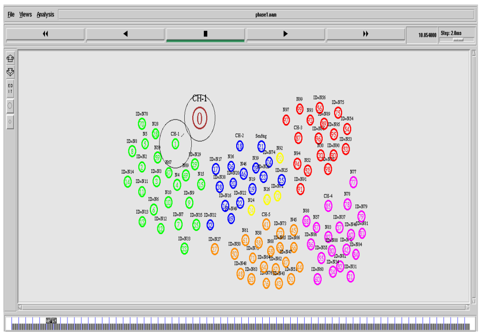

Fig.9 Data Transmission From CH 1 To The Base Station

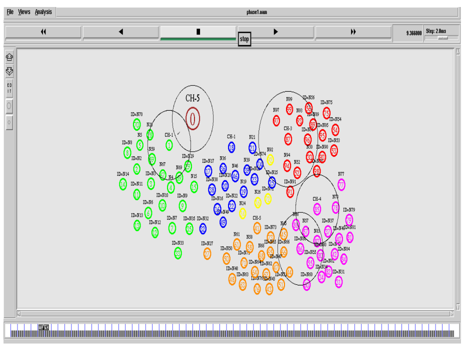

Fig.10 Data Transmission From CH 5 To Base Station

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As the base station has selected the cluster head 1 which is nearer to it and has maximum energy level, and cluster head 1 has selected its sub nodes and formed the network along them. As the cluster head 1 has selected its sub nodes and formed the network with them, and even the cluster head 1 will form the path with its sub nodes in which the data will be transmitted.

Now the cluster head 1 will select the cluster head 2 which is nearer to the cluster head 1 and has maximum energy level. And then the cluster head 2 will select its sub nodes and formed the network with them and even form the path with its sub nodes for the data transmission.

In the similar manner cluster head 2 will select the cluster head 3 which will selects its sub nodes and the network with them and even form the path for the data transmission. This process will continue till the cluster head 5. After the path is formed for the data transmission, the data or messages will travel in that path only. All the messages or data will reach to the cluster head with the help of its sub nodes.

Then the cluster head will pass that message or data to the base station. If the cluster head 2 wants to send any message or data to the base station, it will send to the cluster head 1 and then the cluster head 1 will send that information to the base station. In the similar manner all cluster head will send their information to the base station.

But if two cluster head has some sub nodes common in them, then they will pass the information with the help of that sub nodes and no need to follow the long procedure. For e.g. - If node id 56, 60 and 24 are common between the cluster head 5 and cluster head 2, then the message from cluster head 5 will be directly send to the cluster head 2 with the help of those common sub nodes and cluster head 2 will send to cluster head1 which will send to the base station, and then no need to follow the path direction.

If the sub nodes are not common between two cluster head then the message or data will follow its path, CH5–CH4–CH3–CH2–CH1–base station. But any cluster head can't directly send its information to the base station and only cluster head 1 send the message or data to the base station because it is nearer to the base station. Therefore all the message or data that should be sent to the base station should be first sent to the cluster head 1.

4.3 *Energy level checking*

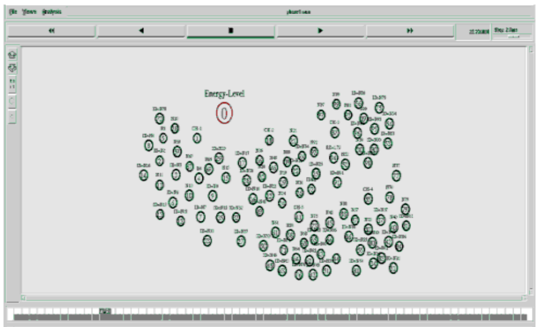

Fig.11 Checking The Energy Level Of Nodes

After considerable number of data transmissions among the nodes it is intended to check the energy level of each and every nodes present in the network. i.e., from all the cluster head to the base station, the base station will check the energy level of all the nodes of all the cluster head

4.4 *Cut Detection*

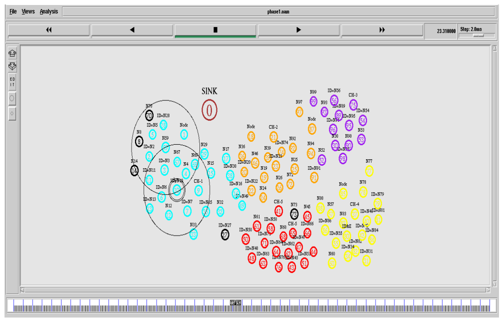

Fig.12 Nodes About To Die Sending Message To The Sink Through Neighboring Nodes

After the energy level is being checked for all the nodes, the nodes with energy level below the set threshold value are to be excluded from the network. Such nodes are denoted in black color. Before they could get excluded from the network, they send the information about their energy level to the nearest node of its.

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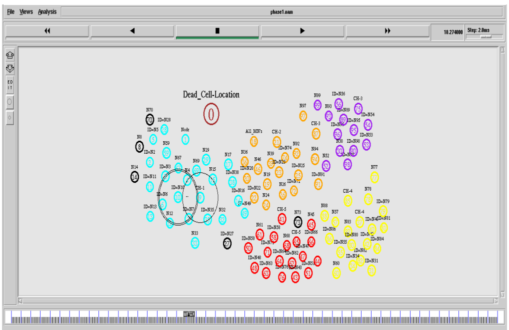

Fig.13 Sink Knowing The Location Of Dead Cell

Then the neighboring node will transfer this information to their respective cluster head. This information will reach to the base station with the help of the cluster head. This node is said as dead node. The base station identifies its location by it x and y axes which are already in its database. This is done by recognizing its node id.

4.5 Alternate Path Selection and Data Transmission

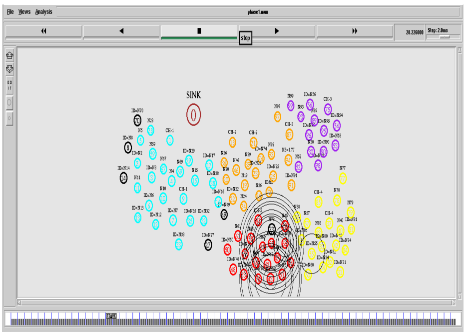

Fig.14 Formation Of New Clusters And Cluster Heads

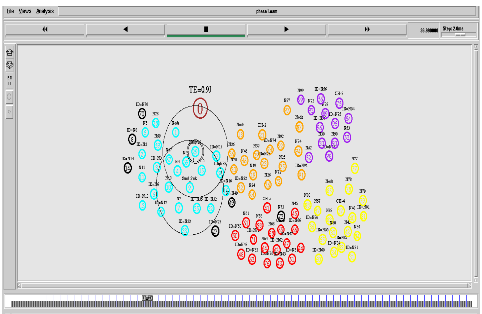

Fig.15 Transmission Of Message From The Sensor Network

After the cut is detected, the node which is dead node is now eliminated from the network. Now the base station will again select the new node which has maximum energy and even nearer to the base station, and it is named as cluster head 1. Now again the cluster head 1 will select its sub nodes and form the network with them. After the cluster head 1 is selected, the cluster head 1 will select the cluster head 2 which is nearer to the cluster head 1 and has maximum energy. Then the cluster head 2 will select its sub nodes and form the network with them. Similarly all the five cluster head will be selected and they all select their sub nodes and form their network of the data transmission. But in this new formed network, some of the old nodes which are dead node will not be there and they will be eliminated from the network because they have low energy level than the threshold level.

The base station has selected the new cluster head because the old cluster head does not have the maximum energy now but it is not below the threshold level also. Now this new cluster head will selects its new sub nodes and the previous cluster head will act as the sub node. But the nodes which are dead nodes will not be included in the new path formation because it is below the threshold level. With this new cluster head and their new sub nodes the message or data transmission will take place.

Similarly after the second round of data transmission the energy level will be checked. Some nodes which are below the threshold level will act as the dead node. Again the base station will select the new cluster head with maximum energy and which is nearer to the base station and that cluster head will select its new sub nodes and form the network with them, and data transmission will take place.

5. RESULTS AND DISCUSSION

5.1. Energy Consumption

The graph shown in the figure 16 is done to depict the energy consumption for the messages to get transmitted through the network to the base station. Here the time factor is taken along the x-axis and the energy consumed to transmit the messages is taken along the y axis.

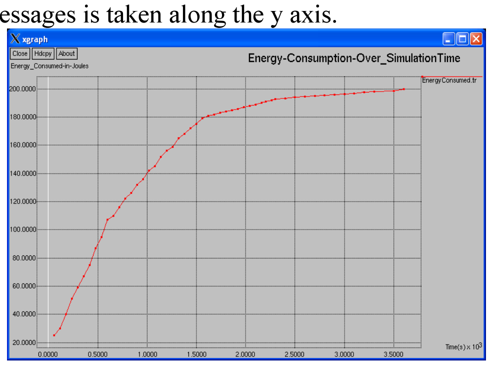

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Fig.16 Energy Consumption Over Time

The curve which progresses from a lower region to a higher region portrays that as the time goes on (from the time the sensor network is set to work) the energy consumption also increases. This is because as the time goes on the nodes would die one by one and hence the energy consumed by the other alive nodes to transmit their messages would increase. This is a demerit that would happen.

5.2 Message Overhead

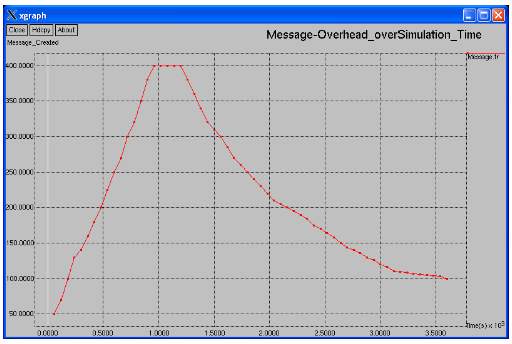

Fig.17 Message Overhead Over Time

The above graph shown in figure 17 depicts the message overhead in the wireless sensor network. Here, the time progression is taken along the x axis and the message overhead, otherwise called the number of messages is taken along the y axis. From the graph it can be seen that the curve plotted progresses very rapidly till a particular stage and then remains constant for few times and then bit gradually decreases till it goes ultimately to nothing. This means that when the sensor network is newly formed, all the nodes are very energetic and perform their assigned task actively. This is signified by the up progressing part of the curve. Later on the nodes lose some energy and few nodes die off causing only few messages to get transmitted. This is represented by the next part of the curve where the curve shows a flat physiology. Even later many nodes start to die due to energy failure and only very little message are transmitted. This is depicted by the swiftly degrading last part of the curve. When left unnoticed, at a particular time extent almost all the sensor nodes in the network would die without due care by the base station and the whole network would vanish.

5.3. Detection of Cut

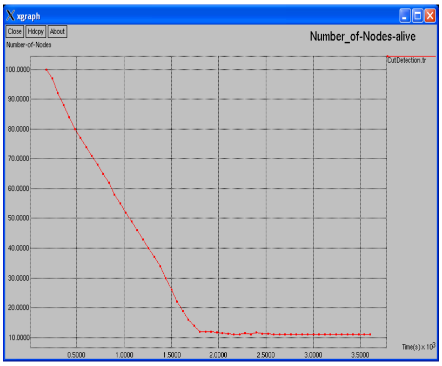

Fig.18 Number Of Nodes Over Time

The above figure 18 shows the graph drawn to portray the cut occurred in the wireless sensor network. Here, time progression is taken along the x axis and the number of nodes is taken in the y axis. The curve has the highest value in the beginning and later when the time progresses, the number of nodes get decreased which is shown further by the descending of the curve. When the network is newly set to work, all the nodes in the network are alive and they actively indulge in message transmitting task. Later as the time progresses, the nodes start dying gradually this is denoted in the graph. The gradually descending part of the curve signifies the cut in the wireless sensor network and the progression of the cuts.

5.4. After the Application of the Proposed Work

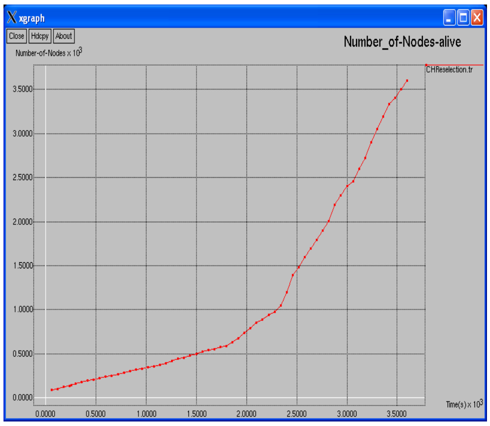

Fig.19 After Cluster Head Approach

The above figure 19 shows the graph for the depicting the increase of performance of the network after applying the proposed work. After the condition depicted in figure 18, the sensor network would have very less number of nodes.

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This is what represented at the start of the curve in figure 19 i.e. the curve starts from a very low value of number of nodes. As the cut is being detected using the cluster head approach, it is able to identify the node location of the inactive nodes and hence the nodes can be replaced with new nodes. This is why the number of nodes gradually increases in this graph and it finally reaches the previous stage. Through this the WSN may act as efficient as earlier irrespective of the time or node death factor.

6. SIMULATION RESULTS

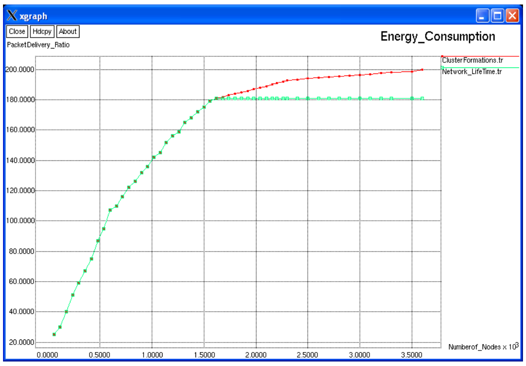

Fig.20 Energy Consumption

In the above graph the number of nodes is taken along the x axis and the packet delivery ratio is taken along the y axis. This depicts energy consumption. As more amount of cluster heads are formed along with their clusters, the network life time also increases. This is because when the cluster approach is carried out, the dead nodes are identified then and there.

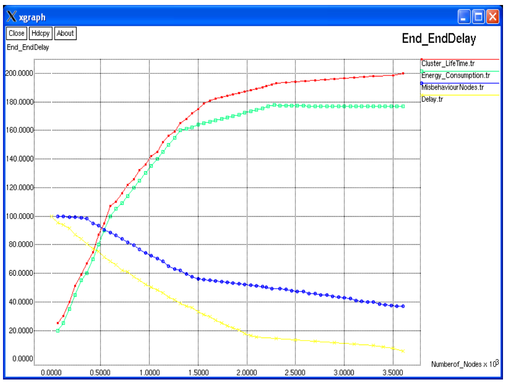

Fig.21 End To End Delay

In the above graph, the number of nodes is taken along the x axis and the end to end delay is taken along the y axis. When the misbehaving nodes are reduced, the delay also reduces. This causes the cluster life time to increase, which consumes energy

In the graph shown in fig.22, number of nodes is taken along the x axis and throughput is taken along the y axis. When the delay in transmisson decreases, the cluster formation and cluster head reselection increases

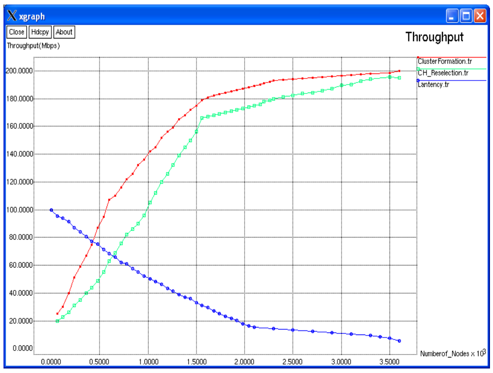

Fig.22 Throughput

7. CONCLUSION

From the above inferences, it is analysed that the wireless sensor network technology can be optimised a bit better through the work of cut detection, thereby the large amount of resources of the nodes are saved. The base station is able to check the energy level of the sensor nodes present in the network at considerable number of information exchange so that the base station can come to know whenever problems occur with the sensor nodes. Since the delay is reduced and the inactive nodes referred as cuts are located and eliminated from the network, the rest of the nodes are saved and the assigned task is accomplished without interruption.

FUTURE WORK

This work presented inthis paper(cut detection) can be extended to repairing the cuts using mobile nodes or robots. The base station can be assumed to have N number of mobile nodes. Whenever the base station detects any cut , immedietly it sends a mobile nodes to repair it, before the node is actuly failed. So the packet loss can be avoided and the lifetime of the nodes can be extended in a more convenent way.

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