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Artificial Routing Protocol for Cut Detection of Cut Vertices

Ms. Rini Mathew [1], Mrs. Annadevi. E [2]

[1]*PG Student, M.E.Embedded Systems, Department of Electronics and Communication Engineering, Sathyabama University, Chennai, India*

[2]*Assistant Professor, Department of Electronics and Communication Engineering, Sathyabama University, Chennai, India*

Abstract : *A Wireless Sensor Network can break into a number of disconnected paths due to failure of some of the nodes known as cut vertices. In this paper, we propose an efficient algorithm to detect vertices. The neighbor node gets failure intimation from the cut vertex so that the information can be passed to source and destination so that the source can initiate data transmission through alternate path before the cut vertices get breakdown completely. In this way, data loss can be minimized and the cut can be detected truly. The algorithm is distributed and asynchronous so that every node needs to communicate with only those nodes that are within their communication range. The most important advantage is that this method can be used to reduce the time delay needed in detecting cut.*

Keywords – *alternate path, cut vertex, disconnected paths, intimation and detection, wireless network*

I. INTRODUCTION

A wireless sensor network is a collection of nodes organized into a network such that each node having sensing and processing capabilities. Each node has an RF transceiver, sensor, memory, powered by battery. Nowadays sensors are widely employed in various research fields since they can monitor temperature and hence whether forecasting can be made easier.

They are randomly deployed in areas with sensors attached according to the applications for which they are being used. Since they are being powered up by batteries, energy consumption should be minimized in order to prolong the life of sensor nodes. In a network, sensor nodes communicate with each other so that results are obtained as part of their cooperatively combined work. Since each node needs to communicate with all the other nodes, wireless links are established between them. A cut is defined as the failure of node. It can separate the network into disconnected paths incapable of communicating with each other. Since they are randomly deployed, loss of connectivity can be quite disastrous as they will lead to the breakdown of entire network.

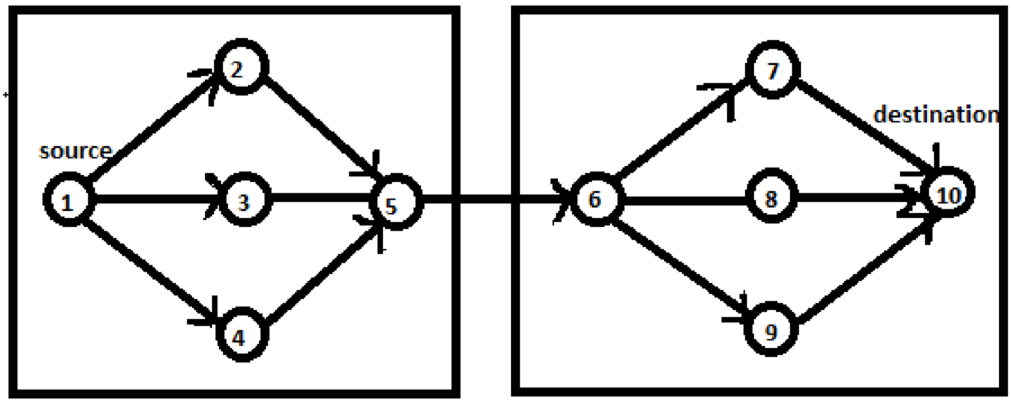

Fig. 1 A wireless sensor network showing network connectivity and cut vertices

Here in the fig. 1, we have taken node 1 as source and node 10 as destination. For the information to reach from node 1 to node 5, there are three possible paths, through node 2, node 3 or node 4. Hence even if any of these three nodes fail, data from node 1 can reach node 5. But if we consider the given network as two distinct networks, node 5 and node 6 serve as critical nodes. Since if any of these two nodes fail, the network gets breakdown into two disconnected networks. Hence these two nodes are termed as cut vertices. Considering the second section of the above network, data on reaching node 6 can reach node 10 by three possible ways, through node 7, node 8 or node 9. Hence if any of them fail also, the data can reach destination.

This paper focuses on cut detection of cut vertices. Although there have been methods to detect cut vertices, previous approaches are either difficult or impossible because they consume large amount of energy which limits the energy of the nodes, which is a limiting factor or spend a lot of time which can be otherwise used for fruitful applications. A previous approach CVD [1] employs interval coded spanning tree to find out cut vertices. Therefore challenge is to reduce the time delay incurred in the previous algorithms.

II. RELATED WORK

In DCD [2], algorithm allows each node to detect DOS events and subset of nodes to detect CCOS event. The involved only local communication between neighboring nodes and is robust to temporary communication failure between node pairs. So here the detection of cuts takes place. But when the cut detected is of cut vertex, and then it can lead to the reconstruction of the damaged network by informing it to the source.

A distributed algorithm CVD [1] scans the nodes of WSN parallel and edges are colored on the interval coded spanning tree for cut vertex detection. Here only the cut vertices are detected. It can be modified to include network reconstruction by informing source about the failure.

A BFS based algorithm for cut edge detection is proposed in [5] but the cut edge detection is different from cut vertex detection. It should be noted that if a node is a cut vertex, then none of the edges incident on it is a cut edge and reversely if an edge incident on a node is a cut edge, that node is not a cut vertex.

DDFS [6] is a tree based approach in which each time the message visits a node, a counter is incremented. Each leaf node sends it to parent node and parent node collects all indices received from its children. If the indices received by parent node are smaller than that of parent node, then that parent is called cut vertex. Time delay is much larger since DDFS has to traverse the edges serially. DDFS is sensitive to link/node fails due to serial nature.

Previously an algorithm [4] was developed to repair network partitions. They have employed mobile nodes to replace the position of the failed nodes to establish network connectivity. They have considered wireless sensor network partition into two types-safe partition and isolated partition. Safe partition will have base station whereas isolated does not. So a mobile node will take a proper position in between safe parti partition and isolated partition to establish connectivity between them. After detecting the network partitions, base station sends a fresh number called epoch. Safe partition which is in contact with base station will receive the new epoch whereas isolated partition will be holding the epoch. Mobile node will adjust itself to a position to establish the connection between safe partition and isolated partition.

Network was considered as a unidirectional graph in [3]. Each node sends probe message and a node was detected as cut vertex based on the reply message. Detection, computation, and neutralization are the steps involved in this approach. Cut vertex candidate sends message to different connection. If two such messages meet, then an arrival message is sent back to the issuer. At computation, stage, CAM graph was constructed including the connections/nodes. If a node receives two arrival messages of different components, then an edge is added to the graph and a node was decided as cut vertex based on the graph. In neutralization stage, detected cut vertex was made as a non cut vertex. Disconnected components are made connected thus reducing cut vertices.

III. ENERGY BASED CUT VERTEX DETECTION

In this method, vertex node is found out by the dynamic source routing. Then the cut vertex itself before dying out send information to the nearest neighbor that it is going to die out based on its energy level. Threshold energy is set up if it exceeds the current energy level (i.e. current energy level lower than the threshold level), that moment itself vertex node sends that information to the nearest neighbor node. This neighbor node then sends that information to the source and destination nodes through the shortest possible path so that time consumption will be reduced.

In this method, the cut vertex node detects itself that it is going to fail based on the energy level so that trueness of the cut detection can be improved in this way as compared to previous methods of detecting a node as cut based on the time delay incurred in receiving the data by the neighbor node from the cut node. So the new method proves to be promising technology if implemented in fixed wireless sensor networks.

The entire methodology can be explained in three modules for better understandability. Each module consists of several sub stages provided with a heading. Each heading is followed with description for easy learning. The main idea behind this approach is to help the readers well versed with contents.

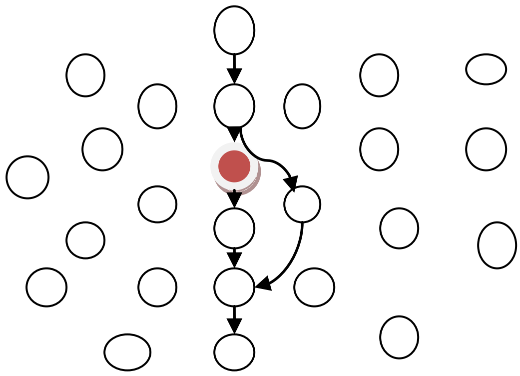

Fig. 2 Energy based cut vertex detection

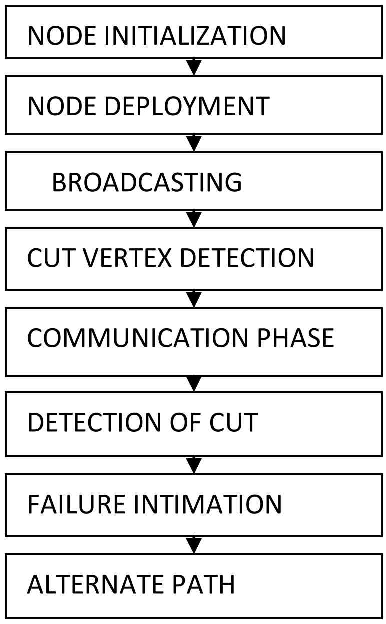

Fig. 3 Flow chart for the proposed method

3.1 MODULE 1 ALGORITHM

It includes three stages as explained below:

3.1.1Node Initialization

It includes initialization of real time parameters associated with each node such as qlength, communication, initial energy etc.

3.1.2 Node deployment

Nodes are generated and aligned in specific locations according to the requirement. After fixing each node to a specified, a wake up message will be sent by each node indicating a change in their position.

3.1.3 Broadcasting

Within the communication range of each node, neighbor node detection and updating of each node with its nearest neighbor will be done. Broadcast by choosing different sources and destination in order to form the routing table and choose routing in the shortest possible path.

3.2 MODULE 2 ALGORITHM

It includes the following two stages:

3.2.1 Cut Vertex Detection Phase

Based on the information about which node is found in more number of routing tables, cut vertex is detected. In this way, three cut vertices have been determined.

3.2.2 Communication Phase

After finding the cut vertex, source continuously communicate with the destination with the available path.

3.3 MODULE 3 ALGORITHM

It includes the following three stages:

3.3.1 Detection of Cut in the Cut Vertex

After finding out the cut vertices, a single path has been selected with two cut vertices. After reaching a threshold energy level (here 91J) compared with the full energy level (100J), a message about node failure has been sent from the cut vertex to the neighboring node. The neighboring node then passes this message of node failure to source and destination.

3.3.2 Failure Intimation to Source and Destination

After obtaining the message from the cut vertex about failure,, the neighboring node informs to source and destination via the shortest possible path.

3.3.3 Employment of Alternate Path

After the source receives the information about the occurrence of a cut in the cut vertex, it then makes provision for path regeneration by employing an alternate path replacing the failed cut vertex path with a new one.

IV. Simulation And Experimental Results

Simulations were carried out in NS2 simulator. Two methodologies were followed for cut vertex detection. Firstly, the cut vertex was detected by removing each node and seeing whether network is disconnected or not. If the network is disconnected, then that node is termed as cut vertex else not. But this method consumed more time and energy and it increases depending upon the network size. So this method was practically not feasible. So we went for the second approach in which cut vertex was detected based upon the routing table findings. This method seemed to be more effective and this method was slightly modified to find out the cut in the cut vertices and then informing the source and destination so that source can initiate the regeneration of a new path. This avoids packet loss to the maximum extend thus improving the efficiency in data transmission.

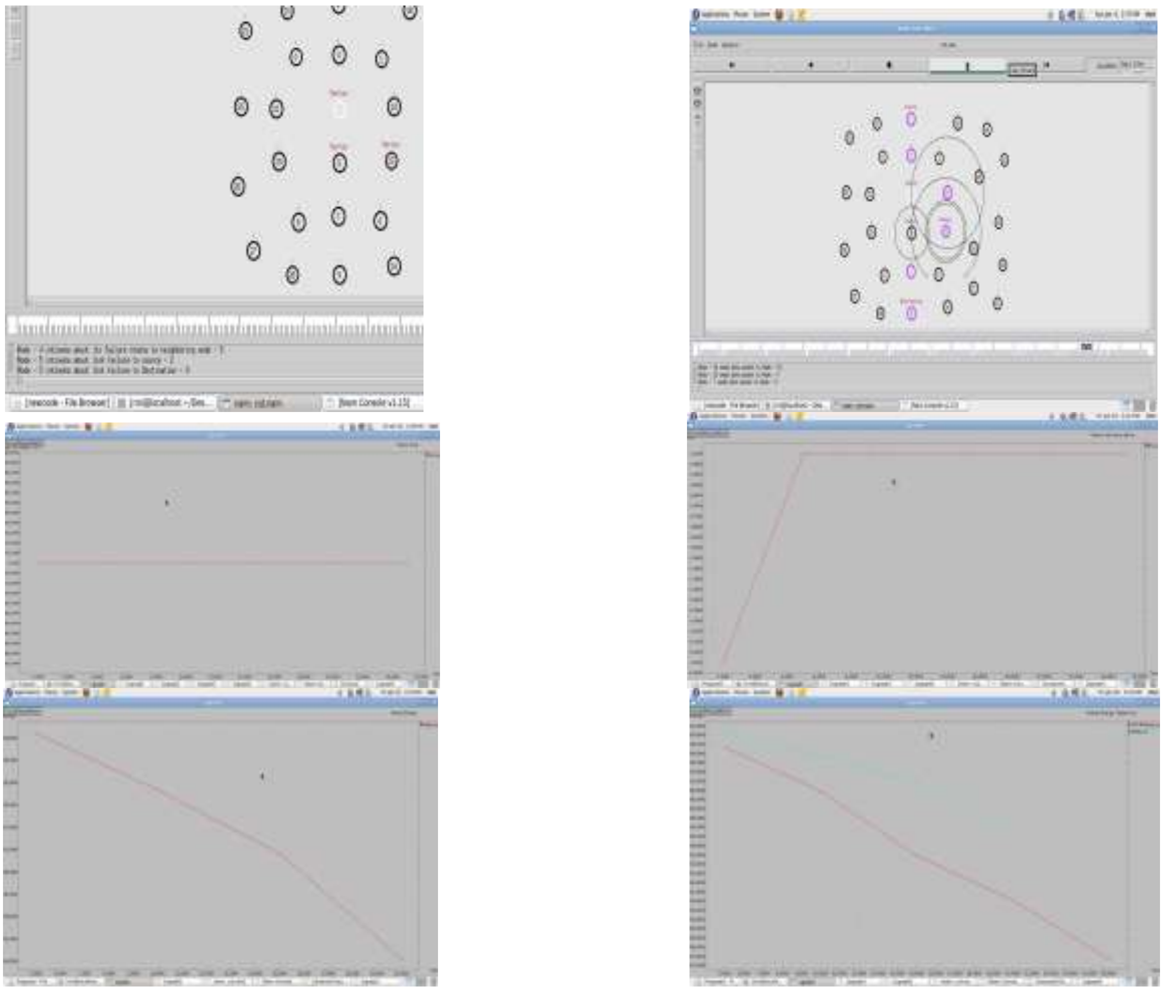

Fig. 4 Graph showing various parameters obtained in simulation for the propose method and comparison of average energy with previous method

V. Conclusion

An artificial routing algorithm for cut detection of cut vertices is proposed for wireless sensor network in this paper. It has been found out that this method can be implemented in less time and cut vertices can be found out using less iteration compared with the former method. This method can be optimized to improve the efficiency and time management in the future. The main drawback of this method is that it can be applied to only immobile nodes

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AUTHOR INFORMATION

RINI MATHEW: She has completed her B.Tech in Electronics and Communication Engineering from Government Engineering College, Idukki, Kerala in 2011 and now doing her final Semester M.E in Embedded Systems at Sathyabama University, Chennai, Tamil Nadu.Her interests are in the field of Wireless Sensor Networks and Communications.

ANNADEVI.E: She has completed her B.E in Electronics and Communication Engineering from CAPE Institute of Technology, Nagarkovil, Tamil Nadu in 2005 and M.E in Communication and Networking from Madras Institute of Technology, Anna University, Chennai in 2009.She is working as Assistant Professor in Sathyabama Univesity, Chennai from 2009 and doing her Ph.D in Wireless Sensor Network in Sathyabama University. Her interests are in the area of Wireless Sensor Networks.