A Robust Mechanism For Detection Of Loss Of Community In WSN

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Abstract-- Wireless sensor networks are widely used in real world applications as they can sense surroundings and send valuable data to sink. However, the nodes in the WSN are resource constrained. For this reason some of the nodes may fail over a period of time. The failure of some nodes causes the network to be a set of connected components. This is known as "cut". Detecting such cuts is an important activity in WSNs. Recently Barooah et al. proposed a distributed algorithm for cut detection in WSN. The algorithm enables every node in the network to detect when connectivity to a designated node is lost. It also allows one or more nodes to detect the cut. In such network a node communicates with only other nodes which are in communication range. In this paper we built a custom simulator which demonstrates the proof of concept with respect to cut detection in WSN proposed by Barooah et al. The experiments reveal that the proposed cut detection mechanism is efficient and can be used in the real world applications.

Index Terms – Wireless sensor network, cut, cut detection, connected components

I. INTRODUCTION

For monitoring environments WSNs are best used. They are widely used in real world applications. The nodes in the WSN are resource constrainted. The life time of a node depends on the energy level it has. When the energy is lost, it fails in the network. Or else the failure may occur due to other reason also. The other reasons include hostime tampering, battery depletion, environmental degradation, mechanical and electronical problems, and so on. The widespread deployment of WSN in the real world has attracted research in the area of disconnected components that form a "cut". The problem of detecting cut in WSN is an active research area. Node failure is a common problem in WSN. This is because the nodes in the WSN have less energy resources. When there is not path between two nodes, it is said that they are disconnected and cut is formed. There is another important term that is "hole". The hole is typically an area in which the events occurred cannot be detected. It does mean that is an uncovered area.

When the source node is a designated node which is a sink or server, its presence is very important. A node in the network can detect the failure of its neighboring nodes. Every node is capable of detecting failure of other nodes in network. At the same time one or more nodes can detect cut in the network. To achieve this we implemented an algorithm which is distributed in nature. It does mean that the algorithm runs in every node. The nodes that can detect the cuts can alert the base station or the server or the source node to be careful while delivering packets to destination nodes. The problem with simply forwarding data to destination without considering cut is that the data will not actually reach the destination [1], [2], [3], [4]. For this reason it is very important to detect cut and alert the nodes that send data to other nodes. The source node when detects the cut or know about cut can take necessary steps to repair network. Therefore it is very important in the WSN [5], [6], [7], and[8] to have the ability to detect the cut. This is achieved by using the algorithm presented in figure. 2. Figure 1 shows the possible cuts and holes in the network. It illustrates visually the difference between cut and hole.

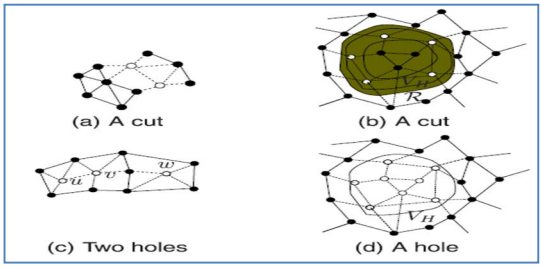


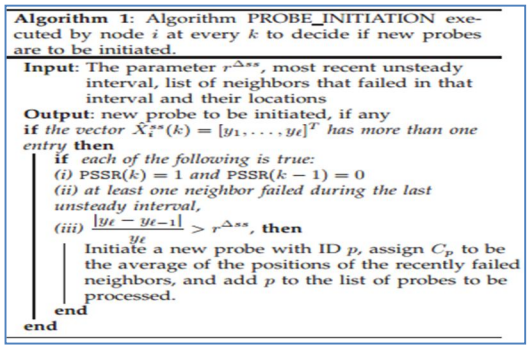
Fig. 1 – Illustrates cuts and holes (excerpt from [9])

When some nodes fail in WSN, it leads to multiple disconnected components. This is known as cut. The hole is an uncovered area where nodes cannot detect events in that area. Figure 1 illustrates both cuts and holes. The remainder of the paper is structured as follows. Section II presents proposed cut detection mechanism. Section III presents prototype

implementation. Section IV presents experimental results while section V concludes the paper.

II. PROPOSED CUT DETECTION MECHANISM

We consider a WSN with multiple nodes for studying the problem of cut detection. The proposed algorithm considers two important aspects of nodes in WSN [5], [6] and [8]. The first one is that every node in the network is capable of finding a node which fails. One or more nodes in the WSN are able to detect the cut which is nothing but the cause of disconnected components in WSN. The cut detection algorithm is presented in figure 2.



Algorithm 1: Algorithm PROBE_INITIATION executed by node i at every k to decide if new probes are to be initiated.

Input: The parameter $r^{\Delta ss}$, most recent unsteady interval, list of neighbors that failed in that interval and their locations

Output: new probe to be initiated, if any

if *the vector* $\hat{X}_i^{ss}(k) = [y_1, \ldots, y_\ell]^T$ *has more than one entry* **then**

  if *each of the following is true:*

  (i) $\text{PSSR}(k) = 1$ *and* $\text{PSSR}(k-1) = 0$

  (ii) at least one neighbor failed during the last unsteady interval,

  (iii) $\frac{|y_\ell - y_{\ell-1}|}{y_\ell} > r^{\Delta ss}$, **then**

    Initiate a new probe with ID p, assign C_p to be the average of the positions of the recently failed neighbors, and add p to the list of probes to be processed.

  end

end

Fig. 2 – Algorithm for cut detection (excerpt from [9])

As can be viewed in figure 2, it is evident that the cut detection is a distributed algorithm that takes failed neighbors and other parameters as input and detects cut in the area. This algorithm is useful in cut detection and thus taking necessary steps is possible in WSN. More technical details of the algorithm can be found in [9]. The algorithm works in every node and the cut detection takes place in distributed fashion. The fig. 3 illustrates cut detection in outdoor environment.

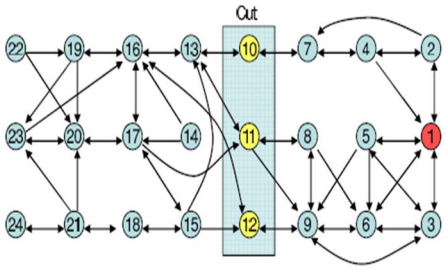


Fig. 3 – Illustrates cut detection

As can be seen in figure 3, cut occurs when nodes denoted by 10, 11 and 12 fail. It causes the disconnected components. Thus a cut is formed. The proposed algorithm is capable of detecting the algorithm. The convergence towards detecting the cut is shown in figure 3.

III. PROTOTYPE APPLICATION

We built a prototype application, a custom simulator, which is built in Java platform. The simulations are made using a sample WSN with 24 nodes. The environment used to build the application include a PC with 4 GB RAM, core 2 dual processor running Windows 7 operating system. The probing model used by the algorithm is presented in figure 4.

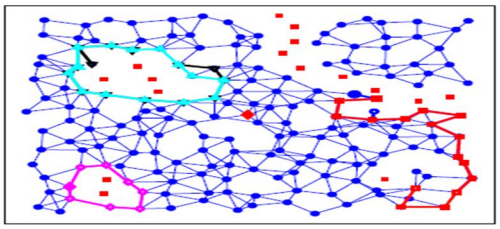


Fig. 4 – Illustrates probing paths

As can be seen in figure 4, it is evident that there are multiple paths denoted by circle, triangle, square etc. Each color represents a probe which will be used by the algorithm in order to detect the cuts in the network.

IV. EXPERIMENTAL RESULTS

We did experiments in terms of nodes failing and causing disconnected components to form cuts. The cut detection parameters are tested in the experiments. The following graphs show the experimental results.

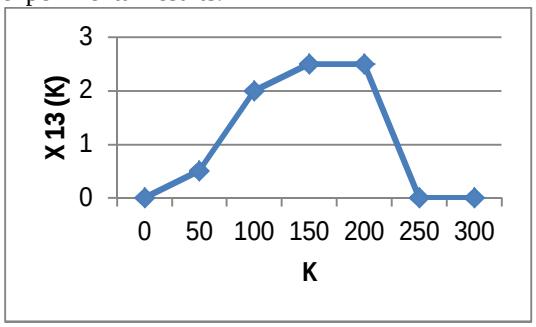


Fig 5 The states of two nodes u

As shown in the above figure the horizontal axis represents k while vertical axis represents x

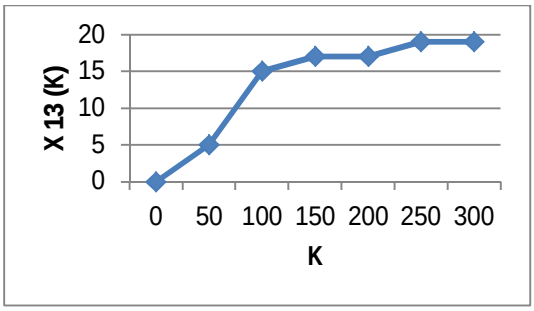


Fig 6 The states of two nodes v
As shown in the above figure the horizontal axis represents k while vertical axis represents x

V. CONCLUSIONS

In this paper we study the problem of cut detection in WSN. When a node or a set of nodes fail to live, they are out of network. This causes multiple disconnected components in the network. This is known as "cut". We implement an algorithm that is meant for detecting cut. The algorithm assumes that every node is capable of detecting a designated node when it fails. When cut occurs in the network one or more nodes are capable of detecting the cut. The algorithm is effective in irrespective of the size of network, and its structure. The algorithm is distributed in nature as it runs in every node and capable of detecting cut. We built a custom simulator to demonstrate the proof of concept. The empirical results revealed that the proposed algorithm is effective.

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